Czech University of Life Sciences Prague
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http://online.agris.cz

ISSN 1804-1930
XIV, 2022, 2

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

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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, 2
30th of June 2022
Prague

Agris on-line
Papers in Economics and Informatics

ISSN 1804-1930

XIV, 2022, 2

Agris on-line Papers in Economics and Informatics

Volume XIV | Number 2, 2022

Content:

Towards Compromise User Experience Design in Ambient Intelligent Environment

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Abstract

Building, testing and evaluating UX for applications for Agricultural Ambient Intelligence Environments can be a difficult and time-consuming job. It can be an even longer and more challenging process due to their complexity and area of scope for complex intelligent systems. Many studies address the issue of UX design and evaluation of website user interface, mobiles, tangible equipment, wearable equipment and other, but it is necessary to look for UX deficiencies in all possible functions, every possible task. Depending on the structure of expert teams, experts' opinions can vary broadly vary or may even contradict. This paper presents possibilities of use the Best-Compromise-Mean (BeCoMe) method for evaluation UX design. BeCoMe was not used for UX evaluation yet. Verification of whether the BeCoMe method is suitable for UX evaluation is carried out on a tablet using two prototypes of control panels of an intelligent environment.

Keywords

User experience, interaction design, user interface, eye-tracking, BeCoMe, usability.

Ander, V., Cihelka, P., Tyrychtr, J. and Novák, D. (2022) "Towards Compromise User Experience Design in Ambient Intelligent Environment", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 2, pp. 3-13. ISSN 1804-1930. DOI 10.7160/aol.2022.140201.

Introduction

One of the main goals of the user-controlled software should be always a high user usability. Due to the diversity and different user experiences user interface design is a complex and often time and money consuming discipline. In the field of ambient intelligent systems, the demands on the user interface increase even more, because the systems can be controlled in various ways: by voice, movement, touch or keyboard.

The use of Ambient Intelligent Environment in agriculture or as a support for life in the countryside is actual and current topic. After Smart Cities, Intelligent Landscape, ie Agricultural Ambient Intelligence, is one of the next evolutionary steps. Fully autonomous or semi-automatic agricultural technology is now a common feature of agricultural companies. With the development of IoT devices and other sensor technologies, a large amount of data is available that can be used to support decision-making, forecasting or safety in agriculture or planning within municipalities. With the amount of this data and the demands on the simplicity and intuitiveness of the interface through which users communicate with ambient systems increase. In this case, the communication is two-way, ie not only from the user to the system, but the ambient systems actively communicate with the user. An important aspect that needs to be considered is the different experiences of the users who interact with the given systems. Communication and reaction in every direction must be clear enough. In the field of agriculture, the harsh environment (eg dust, dirt, moisture) in which communication terminals can be located is also an aspect.

Users make decisions based on previous experience when communicating with smart environments. These decisions are the first step in user interaction with the system. Interaction with a contemporary technological system goes far beyond usability, extending to one's emotions before, during, and after using the system, and cannot only be understood through research into the fundamental usability, attributes of efficiency, effectiveness, and satisfaction (Ntoa et al., 2021). Researchers in their endeavor are trying to answer what makes technology usable and user-friendly with a positive effect in intelligent environment (Augusto et al., 2010; Rymarczyk, 2020, Norman, 2013; Bibri, 2015; Ntoa et al., 2019). The growing possibilities of digital technologies allow using their advantages successfully both in business and private purposes (Kovacs & Vamosi Zarandne, 2022; Roshchyk et al., 2022). The objective of intelligent environments is to support users; as such, a main thrust of research should emphasize whether and how this goal is achieved, while in this context it is important to consider the implications of user evaluation (Augusto et al., 2010). Interface in intelligent environment needs to react in a way that feels logical, natural, helpful, and most importantly focuses on one´s individuality.

When the interaction target is not merely a technological system or application, but a whole intelligent environment, the measurement of UX becomes difficult (Hartson et al., 2012; Ntoa et al., 2021). It is appropriate to use a multimethod evaluation approach to evaluate user experience in intelligent environments, as it is not simply a matter of adhering to specific guidelines by individuals, but about the functioning of the whole intelligent system about identifying potential problems and solving them (Ntoa et al., 2021). The limitations of current evaluation methods are that they are target only on one application or web site, but intelligent environments are big cooperating systems. There is a need to search for UX flaws in all possible features every possible task, every possible screen etc. and it is not an easy task. Systems are also affected by many circumstances that make planning and decision making in the system difficult. Decision-making procedures are therefore often based on the options of experts who express their views, each from their own perspectives (Vrana et al., 2020). Using the BeCoMe method (Best-Compromise-Mean method), it is possible to find the optimal decision in group decision-making that corresponds to the best agreements (conformity) of all experts. The optimal decision is the result of a computationally complex fuzzy mathematical model (Vrana et al., 2020). The BeCoMe method was demonstrated in a case study about decision making COVID-19 (Vrana et al., 2020). It also has applicability in various other fields where a problem needs to be decided as agriculture economics and management, decision making in field rural development, drought/flood measures, energy self-sufficiency issues, IT contracts and etc.

Krug (2010) stated that users do not read but view, therefore the first impression is often the most important thing, and we agree. What users view can be tracked using the Eye-Tracking method. Eye-Tracking is a method used for evaluation UX design to record the participant´s eyes movement during an experiment while solving a given scenario. Recording is performed using a special device (eye-tracker). It determines which places on the screen the participant focuses on the most and for how long (Berger, 2019; Holmqvist et al., 2015). It is assumed that human works cognitively with what they see. The main advantages of using Eye-Tracking are the possibility of obtaining data in real time, where fixations directly correlate with how a person works with information cognitively (Orquin and Mueller Loose, 2013). In particular, in research on decision-making processes, it is considered as useful tool for examining various aspects (Brunyé and Gardony, 2017; Zuschke, 2019). To better understand cognitive decision-making processes, it is therefore necessary to combine Eye-Tracking with other methods that will help to understand the broader context of the participant's actions and allow validation of the data obtained by Eye-Tracking (Gidlöf et al., 2013; Berger, 2019). Eye-Tracking can be combined with the questionnaire for example.

The purpose of this paper is to verify whether the BeCoMe method can be used for UX evaluation.

Related work

Rapid development of new technologies in all areas of living; from applications, facility management, smart homes to smart cities or smart rural areas is reflected in high demand on the quality of user interfaces used to control devices. Methods for usability research and UX, the level and integrity of the collected metrics also constantly growing, leading to the possibility of an even more detailed understanding of user behavior (Çakar et al., 2017; Oguego et al., 2019).

The evaluation of user interface quality is an integral part of the design process (Johnson, 2010; Preece et al., 2011). Existing testing and evaluation methods of UX are for example: User Testing, Cognitive Walkthrough, Feature Inspection, Heuristic Evaluation, Split–Run Testing, Card Sorting, Eye-Tracking, Co-Discovery Learning, Performance Measurement, Question-Asking Protocol, Retrospective Testing, Thinking-Aloud, Focus Group, Field Observation, Interviews, Logging Actual Use, Questionnaires, Surveys, A/B Testing, Personas, Prototype, Standards Inspections etc. (Hartson et al., 2012). Depending on the circumstances, it is important to choose the appropriate method of testing and evaluation.

Nielsen (1993) wrote that Thinking-Aloud method may be the single most valuable usability engineering method. With this method, users can explain their intentions, what they are doing or are intent on doing, and their motivations, the reasons why they are performing any particular action, with this method. Additionally, the think-aloud technique can be used to assess emotional impact since an individual's feelings are internalized and this is what the technique allows access to.

Xu et al. (2007) focused on evaluating of tangible user interfaces for children using Think Aloud method, Peer Tutoring. Evaluating of UX by children must be approached differently than by adult participants. They found it crucial in what environment the evaluation takes place. They use a new method called Drawing Intervention, which helps them to get more information from children who could not find out by classical methods. The method is based on the fact that children draw anything related to what they have done and learnt so the evaluators involve the children in discussions about previous activities.

Schall (2015) focused on Eye-Tracking evaluation of UX on large-scale displays. He studied layout of elements on the screen of financial television networks, such as a main content, a dedicated box for news stories and stock information on one large-scale display.

Rim et al. (2013; 2017a) presented a usability evaluation of adaptive web interface which focuses on how users can learn to achieve their goals. They present adaptive web interface using a Bayesian networks approach to make inferences about the preferences of users. They found that Bayesian networks can be used to represent uncertainty in user modeling (Nguyen, 2009) and can be effective in diagnosing a user´s preferences. Later on, Rim et al (2017b) used a GOMS model approach to evaluate their adaptive web interface. A similar approach is developed by Lamminen et al. (2021) in their D-TEO method to analyze the information about the performance of users and diagnose problems and deficiencies in Web page designs.

The GOMS model approach proposed by Card et al. (1983) is widely used among usability specialists for computer system designers because it provides quantitative and qualitative predictions about how people will interact with the system. It is composed of methods that are used to achieve specific goals. A user performs specific steps (goals), which are assigned a specific execution time. It consists of four constructs: goals, operators, methods, and selection-rules (Card et al., 1983; John et al., 1999, Rim et al., 2017). When there is more than one way to achieve a goal – i.e., alternative methods are available – a selection rule must be used to decide between them (Card et al., 1983). The GOMS is not only specified for human behavior but can be used to specify the behavior of animals or smart devices (Freed et al., 2000).

Many approaches seek to define how a smart environment should be designed and evaluated. The nature of interaction in intelligent environments shifts from explicit to implicit, encompasses new methods of interaction, and extends from one-to-one interactions to many-to-many interactions (Stephanidis et al., 2019).

Vegas-Barbas et al. (2017) defined a set of interaction patterns, which were validated by end users through an informal discussion and concluded that patterns were adequate to cover the needs of the design of intelligent environments. Interaction in intelligent environments also include thing-to-thing interactions, which introduce additional concerns regarding conflicts resolution, interoperability, and consistency of interactions (Andrade et al., 2017).

Pavlovic et al. (2020) suggested using storytelling videos to communicate user values and design scenarios to stakeholders, and to generate proposals based on five factors (context of interaction, required system data, sensor input, user input, and desired output). De Carolis et al. (2012) propose a framework for recognizing user´s social attitudes in multimodal interaction in smart environments.

Ntoa et al. (2021) suggested a framework called UXIE which foresees the evaluation of seven fundamental attributes, namely intuitiveness, unobtrusiveness, adaptability and adaptivity, usability, appeal and emotions, safety and privacy, as well as technology acceptance and adoption.

User interfaces are available for different purposes and have different target groups. Every kind of UI should be designed according to the specific design conventions and knowledge of the users (Johnson, 2010). Pastushenko et al. (2019) wrote that the design guidelines might not be applicable in a general way, that UI elements should be adjusted according to the requirements of the chosen UI type and those of its users.

No existing evaluation method can serve every purpose and each has its own strengths and weaknesses (Hartson et al., 2012).

Materials and methods

Design of prototype of control panel

Before designing user interface, the following was considered:

Question	Recommendation
How will users interact with an intelligent environment when voice control doesn´t work?	Touch control via tablet.
What functionality user wants?	Easy to use, usable, understandable, accessible.
Which features and behaviors of the user interface will the user expect?	The user interface must respond promptly, without long animations or visual effects
What size is an adequate size for UI elements for interaction?	Size of icons and text should be changeable.
What fonts are easy to read in this UI?	Sans-serif fonts are recommended.
What uniform terminology will be used?	All titles of elements should be consistent across the whole application.
What information will be provided to let a user know what will happen before they perform an action?	The application must communicate clearly and intelligibly with the user and all important actions must be confirmed.
What feedback will get a user when an action is performed? And for how long?	All action must have a visual response on the screen.

Source: author

Table 1: Questions before designing UI.

A well-chosen arrangement of central control components should improve the user's rapid perception and processing of data (Vegas-Barbas et al., 2017).

Two prototypes of user interface designs for control panel of an intelligent environment applicable for a tablet were created (Figure 1, Figure 2). The layout, shape, order and text location of components in each UI is different. The background of prototype B is darker than prototype A. The design and placement of main control elements is different on each prototype. As a background for each prototype a neutral and positive background was selected.

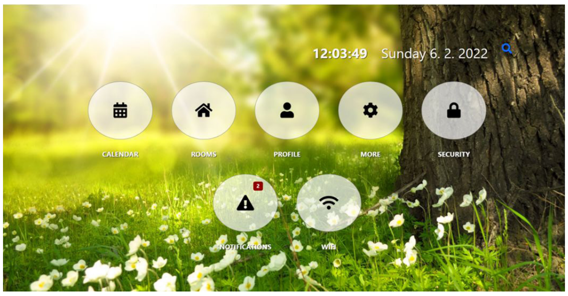

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Figure 1: Prototype A.

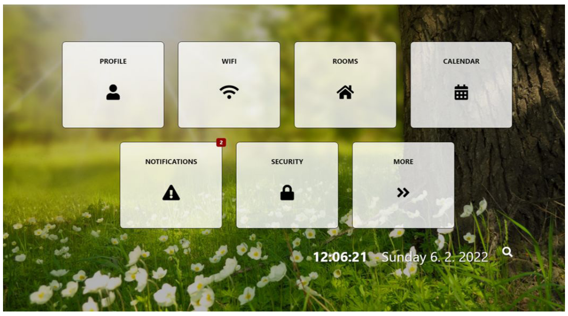

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Figure 2: Prototype B.

Participants

Fourteen participants were divided into two groups according to previous evaluation experience (Table 2). Seven of them have experience with evaluation. Therefore, both groups had seven participants. In each group was one woman. Age of participants was 26-48 years. Participants were testing the two designs of prototypes. All had good previous experience with information technology.

Evaluation used in prototype testing

A small-scale study was conducted to evaluate the prototypes of UI of a smart environment. The following methods were used to evaluate which layout is better: a) Eye-Tracking method with additional discussion about prototypes after testing. Testing was performed in the Usability laboratory in HUBRU (Human Behavior Research unit) at Czech University of Life Sciences in Prague; b) on-line questionnaire with twelve questions using the Likert scale which was evaluated by BeCoMe. The BeCoMe method has not been used for evaluating UX design by researchers yet.

Existing questionnaires were modified for this

Group	Experience with evaluation	Evaluation method
1	Possible users of systems - no	Eye-Tracking + discussion about prototypes
2	Experts for UX - yes	BeCoMe (questionnaire using of the Likert´s scale)

Source: author

Table 2: Division of groups.

evaluation (see Appendix 1). The questionnaire was inspired by SUS - System Usability Scale (Brooke, 1995) and QUIS - Questionnaire for User Interface Satisfaction (Shneiderman, 1987). Modified questionnaire with Likert´s scale was used in both methods.

Results and discussion

Our approach attempts to determine whether it is possible to use the decision-making method BeCoMe in the UX evaluation to support the choosing the best layout of components in the design of the control panel for an intelligent environment.

Each participant tested three scenarios. The results were evaluated by the Eye-Tracking method and the BeCoMe method.

Participants imagined a situation in which they came home and saw a red light, i.e., there is a problem with the control of intelligent system by speech. They had to control it through a control unit (in our case a tablet).

Results of Eye-Tracking testing

The participants had a goal to find out what happened to the system (find the error).

The participants easily found where the notification informing them about the system problem was in both prototypes (Figure 3 and Figure 4). Eye-Tracking results for prototype A show, that two participants first looked at a calendar, but they could not explain why.

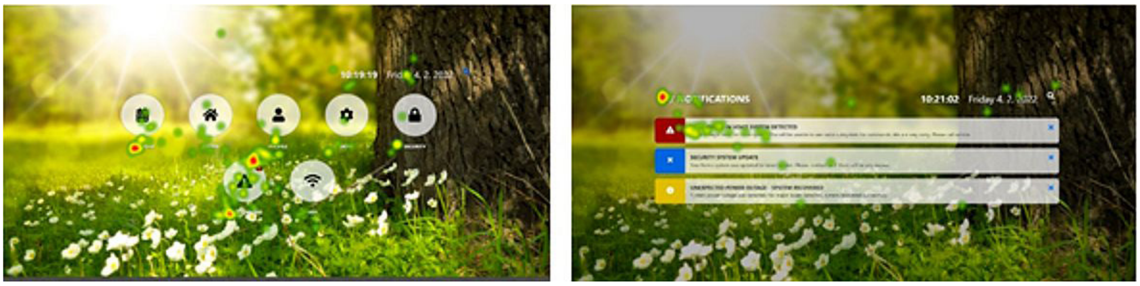
The participants were to look at the calendar and enter a new event.

Participants went through the scenario without any problems in both prototypes (Figure 5, Figure 6).

The participants were to set the temperature in room no. 2 to 22 °C

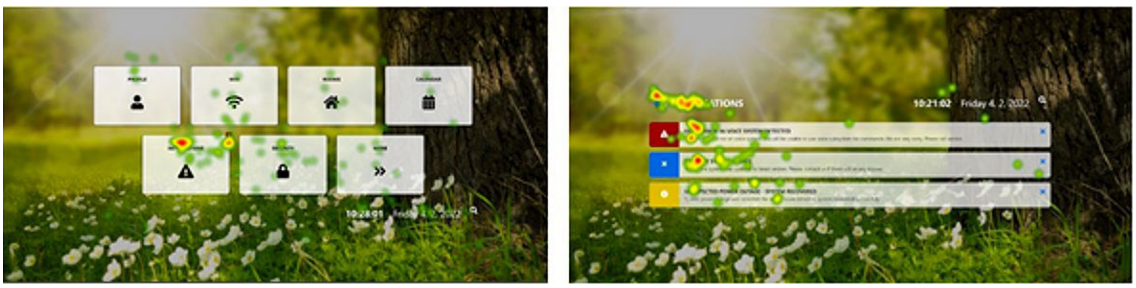
Participants managed the scenario without any problems (Figure 7, Figure 8). A participant did not immediately notice where the room selector was.

After Eye-Tracking testing, each participant discussed their experience with the prototypes. Both prototypes were easy to use by the participants, but they liked prototype A more. Also, seven out of seven participants expressed that the design of components in prototype A is more attractive. They confirmed Krug´s claim (2010) that they didn´t read, but only looked at the icons. They thought those were well chosen because they understood what the system would do. They didn´t have a problem either with the font size or with the terminology used or with the orientation of elements. All of them completed given scenarios.



Source: author

Figure 3: Test scenario no. 1, prototype A.



Source: author

Figure 4: Test scenario no. 1, prototype B.

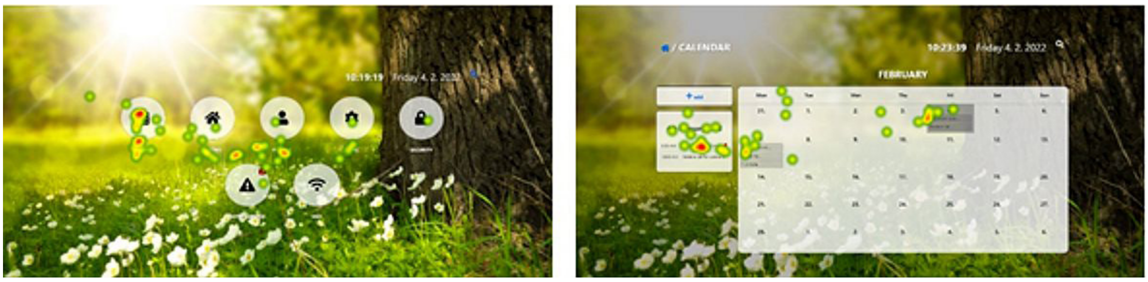


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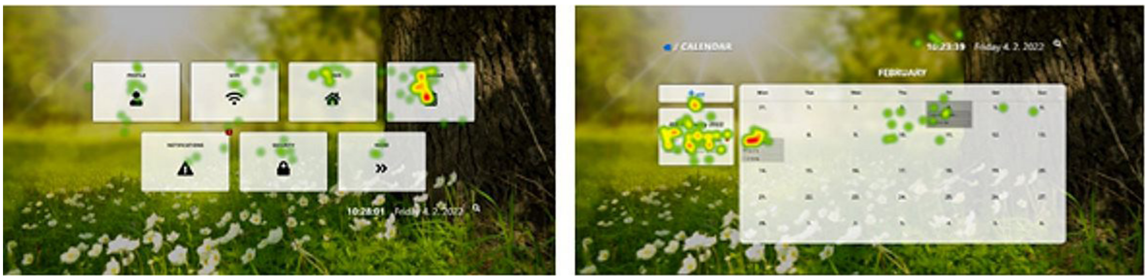
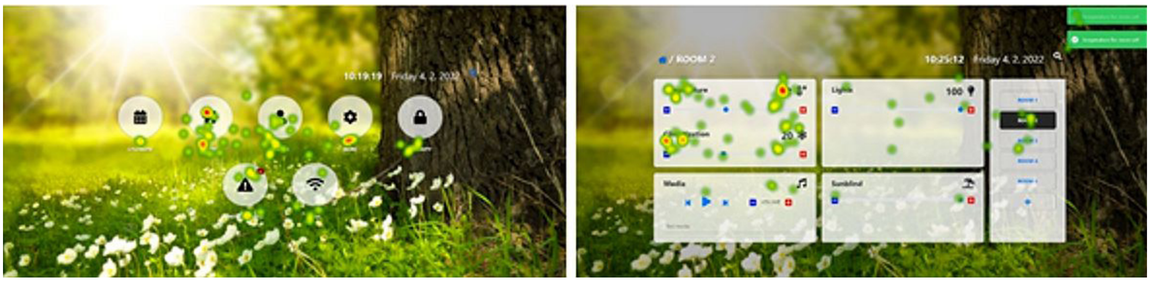
Figure 5: Test scenario no. 2, prototype A.



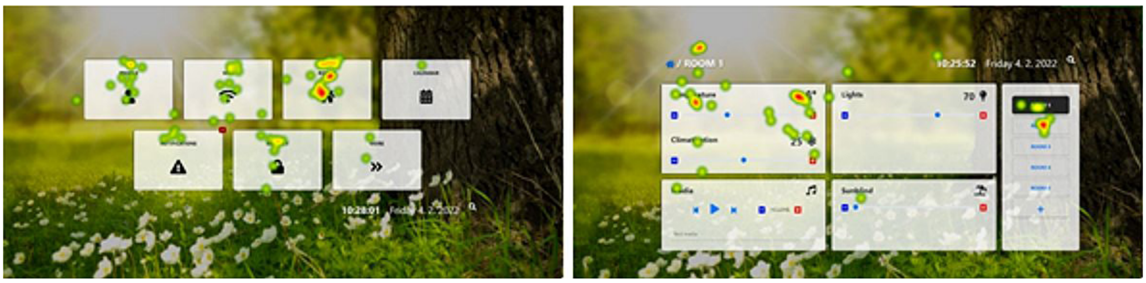
Source: author

Figure 6: Test scenario no. 2, prototype B.



Source: author

Figure 7: Test scenario no. 3, prototype A.



Source: author

Figure 8: Test scenario no. 3, prototype B.

Result of BeCoMe evaluation

Participants filled in questionnaires with twelve questions using the Likert scale for each prototype. For evaluation of questionnaires was used the BeCoMe method tool. Results of questionnaire for prototype A were better than for prototype B (Table 3). Both prototypes contained answers only in values not sure, rather yes, definitely yes. Negative values participants didn´t use.

The result of both methods Eye-Tracking and BeCoMe came out the same – prototype A is better. Therefore, it can be concluded that the using of the BeCoMe method in UX evaluation is possible. In the Table 4 we made a quick comparison of both methods.

Question	Prototype A		Prototype B	
1	76.79		98.21	1
2	94.64	1	71.43	
3	94.64	1	96.43	
4	76.79	1	73.21	
5	80.36	1	55.36	
6	92.86	1	78.57	
7	75.00		80.36	1
8	92.86	1	80.36	
9	92.86		94.64	1
10	100.00	1	94.64	
11	98.21	1	94.64	
12	98.21	1	78.57	
Sum of better result		9		3

Source: author

Table 3: Results of using the BeCoMe method tool.

	Eye-Tracking method with discussion	Questionnaires with Likert scale evaluated by **BeCoMe method**
When use?	In the planning phase. In the development phase. When redesign UI.	In the planning phase. In the development phase. When redesigning UI.When a decision is needed.
Place of evaluation	Lab with equipment for Eye-Tracking	Real environment – PC with Excel
Output data	Qualitative	Qualitative
Number of users/experts in our experiment	7 (6 men, 1 woman)	7 (6 men, 1 woman)

Source: author

Table 4: Comparison of both methods.

Conclusion

In the article, we presented if the BeCoMe method can be used to evaluate UX design. A common way of evaluating of an interface is to let users try out the interface and analyze how well they are able to perform selected scenarios. User testing can provide useful feedback, but mostly it is quite expensive in time and effort and financially if it is done in specialized laboratories. According to this small-scale study, it seems that the BeCoMe method can be used to evaluate UX design. In order to be able to state that the BeCoMe method can 100% replace the proven methods used to evaluate UX design, more extensive testing needs to be performed. Based on the information obtained within this study, we conclude that the BeCoMe method can be used as a complementary method to support the results of another evaluation method and can reduce costly laboratory testing.

Another finding which came from Eye-Tracking testing in the first scenario was that two participants looked at the calendar icon first instead of the notification icon. They couldn't explain why. We assume it could be because of the order of the icons on the screen of the prototype or it was just coincidence. Further testing is needed to verify why this occurred.

Although findings in this work are generally applicable the main goal was to prove that the BeCoMe method is usable as an effective method for UX evaluation in Agricultural Ambient Intelligence Environments. The main issue of those systems is the wide audience of users with different experience that can interact with those systems. Also, the main factor is a harsh agricultural environment which can limit commonly usable ways of communication. All those factors have impact on time and money spend to develop proper UX. Cost and time effective UX evaluation of those systems by experts with BeCoMe support is very promising.

Acknowledgements

This work was conducted within the project Smart environments - modeling and simulation of complex problems in intelligent systems (2022B0010) funded through the IGA foundation of the Faculty of Economics and Management, Czech University of Life Sciences in Prague.

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Appendix 1

QUESTIONAIRE USED IN BeCoMe METHOD

Evaluation criteria (Likert scales): 1 = definitely not, 2 = rather not, 3 = not sure, 4 = rather yes, 5 = definitely yes.

1. The system has a logical arrangement of components.
2. The system is consistent.
3. Overall, I am satisfied with how easy it is to use this system.
4. The visual design is attractive e.g., colors, shapes, layout.
5. I like the graphic elements of the system.
6. The font size is right for me.
7. I understand all the functions of the system.
8. Orientation in navigation is intuitive for me.
9. I simply find the required system functionality.
10. I am able to complete my tasks using the system.
11. It is easy to find the information I need.
12. Terminology is understandable.

Agris on-line Papers in Economics and Informatics

Volume XIV Number 2, 2022

Dynamics of Competition in the Hungarian Poultry Industry

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Abstract

This study examines the competitive nature of the Hungarian poultry sector between 2006 and 2016. The poultry population has stagnated over the period investigated, however the farm structure has changed significantly and the population of poultry held by individual farms has decreased. In this research, market competition was measured with the persistence of abnormal profits, while profit persistence was estimated using the Arellano-Bond GMM and Blundell-Bond dynamic panel regression. Based on the results, it can be said that the level of profit in the poultry sector is close to the equilibrium profit level. The farm size, technological development as well as the tax advantages of individual farms distort competition leading to higher profits. Taking long-term risk has a negative impact on abnormal profits. The results of the research suggests that the breakthrough points for the poultry sector are technological progress and population growth, as well as a reduction in labor intensity.

Keywords

Profit persistence, poultry, competition, agriculture.

Bareith, T. and Csonka, A. (2022) "Dynamics of Competition in the Hungarian Poultry Industry", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 2, pp. 15-29. ISSN 1804-1930. DOI 10.7160/aol.2022.140202.

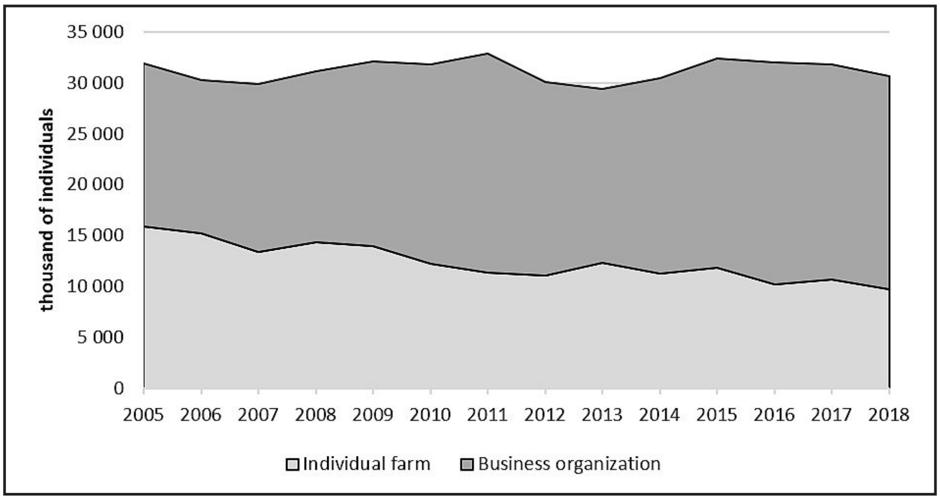
Introduction

Agricultural markets have undergone a significant transformation over the last 30-40 years and are very far from perfect competition. Usually, in agricultural sectors, due to corporate mergers and acquisitions, only a few agricultural players control 60-80% of the market leading to a high market concentration (Sexton, 2012). Horizontal integrations have a significant impact on the markets, and vertical integrations are also relevant actors in agri-food chains. In addition to vertical and horizontal concentration, the variety of products and quality differences all indicate that agricultural markets are not necessarily the best examples of perfect competition from a theoretical point of view (contrary to the foreign exchange markets, which are the closest to perfect competition due to the homogenous products, the high number of market players, and the immediate integration of information into prices).

Over the past 20 years the structure of the Hungarian poultry sector has been constantly changing, with a clear trend towards the decline of individual farms. There is a consensus in the Hungarian and international literature that the profitability, productivity and competitiveness of small-scale farms are very low, in general. The fragmented farm structure puts small-scale farms at a competitive disadvantage; the current structural transformation can therefore be seen as a natural market cleanup process.

The trend in the Hungarian poultry population is presented through the example of the most dominant poultry species (which is hen) in Figure 1. Domestic hen population has been fluctuating during the period investigated. Immediately after EU accession the total domestic population was close to 32 million heads. Following the accession, similarly to the majority of Hungarian animal husbandry sectors, the hen stock decreased. In the new EU-single market, the sector has recovered relatively quickly, with a ten percent increase between 2006 and 2016.

However, not the whole sector was affected by this expansion: the number of hens kept in individual farms continued to decrease during the whole period, the upward trend was limited to the corporate farms. The reason for this difference lies primarily in the differences in the size of farms and the size-related operational conditions. The average size difference between



Source: Own editing based on KSH (Hungarian Central Statistical Office) (2019) data

Figure 1: Development of the hen population in Hungary (2005-2018).

individual and corporate farms is well illustrated by the test farm data of the Research Institute of Agricultural Economics (hereinafter referred to as AKI - Agrárgazdasági Kutatóintézet) based on the standard production value per farm, the average farm size of corporate poultry farms in 2005 was about eighteen times higher than the average farm size of individual farms. The rate reached 20 in 2011, and was already well over 40 in 2015 (AKI, 2020). Popp (2014) emphasizes that modern technologies cannot be used economically in small-scale farms, while natural efficiency will be low in case of outdated farming technologies. Fragmented farm structure is also identified as a competitiveness problem by Varga et al. (2013), Nábrádi and Szőllősi (2008), and Udovecz et al. (2009).

As described above, it can be stated that after the initial downturn, a natural restructuring of the sector started in 2007, whereby the larger corporate farms using more advanced technology and being more competitive, were able to expand their production, at least until 2012.

Another reason for the sector problems lies in regulatory changes. In the European Union, burdens of market regulation have already led to significant competitive disadvantages vis-à-vis the competing countries in America and Asia in the early 2000s. During the second decade of the millennium, administrative, animal welfare and environmental standards for production and processing continued to tighten, for which poultry farms and slaughterhouses in less developed EU Member States were not fully prepared (Varga et al., 2013). One of the striking examples of tightening regulation is the 2012 regulation on expanding and replacing laying hens' cages. Increasing the minimum seating capacity and the obligatory number of sitting cows has not only increased production costs by 10-30 percent, but also raised the risk of injuries and mortality due to growing social stress and animal health problems (Aliczki, 2012).

The aim of the Paper is to examine the competitiveness and profitability of the Hungarian poultry sector through profit persistence. In addition to the examination of profit persistence, our further goal is to incorporate the factors influencing the profitability found in the literature into the competitive dynamics models and to estimate their impact on the abnormal profit level.

Our hypothesis is that a strong profit persistence exists in the Hungarian poultry sector and the poultry market is far from the perfect competition. The hypothesis is derived from the specific competitive characteristics of agricultural sectors and the structural transition of the Hungarian poultry farming mentioned above.

Research background – Profit persistence in agri-food sector

First, two similar studies, Hirsch and Gschwandtner (2013) and Gschwandtner and Hirsch (2013) dealing with profit persistence are presented here together. Both studies analyze the food industry in five European countries (Belgium, France, Germany, Italy and the United Kingdom) based on data from 1996 to 2008. What makes the two studies different is the methodology and the size of the sample. The study by Gschwandtner and Hirsch (2013) includes 4,676 companies, while

Hirsch and Gschwandtner (2013) includes 5,494.

In Gschwandtner and Hirsch (2013), short- and long-term profit persistence was estimated with AR1, and then the estimated coefficients were used as a dependent variable in an OLS model. Of the nine independent variables, five were company-related and four were industry-related indicators. Profit persistence and OLS models were estimated for each investigated country separately. According the results, the Belgian food industry market was the most competitive (profit persitence value is 0.06), while the United Kingdom (0.23) was the least competitive. However, the significant profit persistence values were between 38-42% for all countries, so less than a half of the companies deviates from the normal profit level. In the OLS model estimating short-term profit persistence, company size and growth were significant factors in four of five countries. In the long-term profit persistence model, there were also significant corporate effects (market share, company age, company growth), a single industry variable (number of companies operating in the industry) has become significant in at least three countries.

In Hirsch and Gschwandtner (2013) profit persistence was examined by dynamic panel GMM estimation. Similarly to the other study, Belgium had the lowest (0.11) and the United Kingdom had the highest (0.304) profit persistence. In the GMM model, short- and long-term profit persistence cannot be calculated as easily as in the case of autoregressive models. The authors solved this by relating the parameters of the independent variables to long-term profit persistence, and by relating the interaction between the dependent variable and its time lag to short-term profit persistence. Compared to their previous study, some new variables were included in the research, such as short-term risk and market concentration. For at least 3 countries, the following variables were significant for short-term profit persistence: firm size and growth, short-term risk and industry concentration (CR5). Three of this four effects were company-related effects, the result is very similar to the OLS estimation. Under the same criteria, short-term and long-term risk for long-term profit persistence was significant in at least three cases. Based on the results, high profit persistence was characteristic for young and large companies with a low risk rating. Another conclusion is that the food industry has lower profit persistence than the non-food sectors. In his doctoral dissertation, Hirsch (2014) reported only the results of the GMM estimation. In his meta-regression study, Hirsch (2018) highlights that many profit persistence research contains bias (citing some of his own studies as examples) because micro-sized firms are under-represented in the samples, which may result in profit persistence being overestimated. In the case of the two studies presented, a similar problem arises, so the real profit persistence values may be even lower.

The study by Tamirat et al. (2018) is most similar to our empirical research. The authors used the Dutch FADN database, the data were from 2001 to 2015 containing a total of 1796 companies. From the FADN database, dairy farms, field crop production, pig keepers and the category of mixed livestock farming were highlighted, with the largest number of pig keepers. To test the robustness of the results, two types of profit indicators (modified ROA and net profit margin) were also calculated. Three methodologies were used in the study, OLS, quantile OLS, and GMM. For the OLS and quantile OLS estimates, the authors do not incorporate the lagged profit rate into the model, so here will be presented only the results of the GMM models, focusing on the whole sample and the pig keepers. GMM models were filtered by year, region, and land type effect. Considering the modified ROA, the profit persistence was 0.075 for the total sample, and 0.071 for the pig keepers. These were very low values compared to the food industry (0.11-0.34). For both estimates (complete sample; pig keepers), long-term risk, firm age, size, and labor productivity were strong significant. In addition, working capital, capital intensity, and diversification were also significant variables in the overall sample. Considering the net profit margin, very similar results were obtained. Interestingly, the subsidy rate was not significant in either case, only for dairy farms.

Gschwandtner and Hirsch (2018) compared the profitability of the food processing industry in the European Union and the United States. Profit persistence analysis was performed with dynamic panel and GMM estimation, the comparability of samples was ensured by matching. In addition to the GMM estimation, the authors also performed a classical OLS estimation, with the aim of demonstrating the robustness of the estimation and quantifying the error of the OLS model (compared to GMM). The value of profit persistence became around 0.3 in both samples (GMM estimation), there were no significant differences between the EU and the US. This also means that profit persistence exists on both continents. The authors mentioned that a profit persistence of 0.3 is lower than those for other manufacturing industries. This finding was also made by Hirsch and Gschwandtner (2013), Hirsch and Hartmann (2014) and Goddard et al. (2005), among others, in their previous study. Among the company-related variables, the size of the company (logarithm of all assets), short-term risk (current liabilities / current assets) and long-term risk (long-term liabilities / equity) became significant. The size of the company and long-term risk show a positive relationship with the profit level, while short-term risk shows a negative relationship. Among the industry variables, a negative significant relationship was found for industry growth (industry revenue growth). In the EU sample, the coefficient was positive for the Herfindahl index. The authors tested the impact of the financial crisis in two ways: on the one hand, they marked the years of the crisis with dummy variables, and on the other hand, a second estimation was ran, excluding the years 2008 and 2009. In the case of the first method the crisis dummy variable did not become significant, in the case of the second method the profit persistence increased, however, the difference was not significant compared to the whole sample.

Figure 2 summarizes the significant variables found in the relevant profit persistence studies in the food industry. It can be seen that company-related factors are the most relevant.

Materials and methods

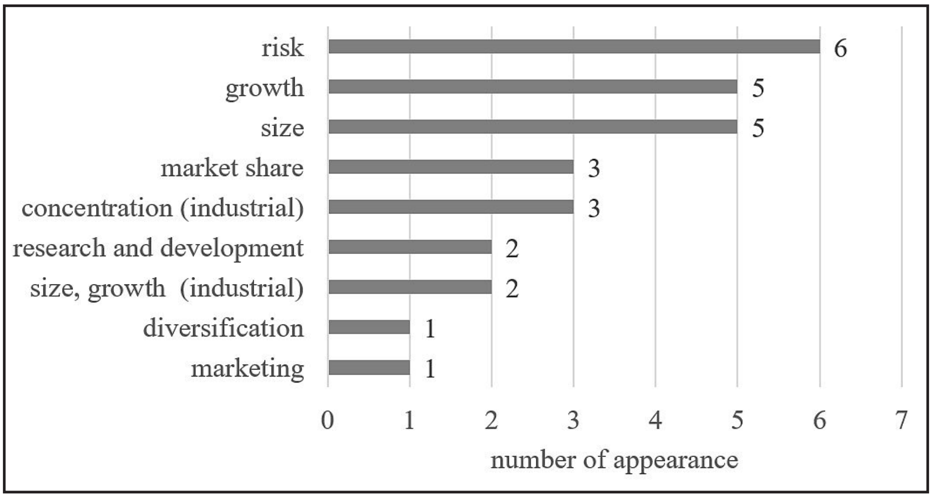
During the research, data were used from Farm Accountancy Data Network (FADN) provided by the National Agricultural Research and Innovation Centre (NAIK), Research Institute of Agricultural Economics (AKI). Every country in the European Union has the FADN system, which collects data about more than 80,000 farms. The EU-wide database represents a population of approximately 6.4 million farms (Keszthelyi, 2017). The database is representative of region, size and activity. Due to the form of data provision the data of individual and corporate farms becomes comparable. The Hungarian test farm system covers 2% of the Hungarian farm population; the monitored farms provide more than 5,000 data a year. The sample of this research includes data from 180 poultry farms between 2006 and 2016.

An abnormal profit test was used to examine the extent to which each company's annual ROA (profit before tax/total assets) deviates from the annual average industry profitability level. Thanks to normalization, the effects of macroeconomic cycles has been filtered out, and profit can be interpreted as a deviation from market norms (Maruyama and Odagiri, 2002; Gschwandtner, 2012).

$$\pi'_{i;t} = \frac{ROA_{i,t} - \underline{\underline{ROA_t}}}{\underline{\underline{ROA_t}}} \quad (1)$$

$\pi'_{i;t}$ denotes abnormal yield.

Initially, autoregressive processes were used to measure profit persistence, most often the AR (1) model. In number of lag 1 model, the profit rate at time t is explained by the profit rate one year earlier (t-1). In addition to autoregressive models, OLS models have appeared, most often using persistence values from AR (1) models as dependent variables.



Source: own editing based on related literature

Figure 2: Proxies for significant variables from the related literature.

The history of the measurement of profit persistence began with PCM models. Later, PCM method has been replaced by autoregressive models, primarily AR1. The next methodological development phase was to use the estimated AR1 parameter in an OLS model as a dependent variable and to use company-related and industry-related variables as independent variables. Roughly at the same time, fixed-effect (FE), pooled OLS, and in rare cases random effect (RE) models have been emerging. The primary use of panel OLS models was to estimate the AR1 parameter. After 2010 and nowadays, dynamic panel GMM models provide the most reliable estimate of profit persistence. GMM models usually deal with company-related, industry-related, and in some cases regional variables.

Hirsch and Gschwandtner (2013) found that due to the previously presented limitations of AR model estimation, the dynamic panel model with the Arellano-Bond Generalized Method of Moments (GMM) estimation is the most suitable for investigating profit persistence. According to Hirsch (2018), GMM is the proper technique for estimating profit persistence, OLS estimation biases upwards. The estimation can be applied well if there is a large number of observed companies (small T, large N type sample) for a short period of time.

$$\pi'_{i,t} = \sum_j \alpha_j (X_{j,i,t}) + \lambda \pi'_{i,t-1} + \varepsilon_{i,t} \quad (2)$$

Where $\varepsilon_{i,t} = \eta_i + v_{i,t}$. The Arellano-Bond GMM estimate is based on the first differences in the equation, which eliminates time-invariant firm specific (η_i) effects (Hirsch and Gschwandtner, 2013; Kozlenko, 2015). Firm and industry-specific variables (X_j) that may explain the persistence of corporate profits may be included in the model. The GMM estimate is considered consistent if there is no second order autocorrelation in the error terms (the first order cannot be due to the delayed explanatory variable) and the instruments are adequate. Second-order autocorrelation is easy to test, and instruments can be tested by Hansen and Sargan test. The lagged depended variable is endogenous; everything else is exogenous variables in the model (Hirsch and Gschwandtner, 2013). The Hansen test is robust to heteroscedasticity.

The 1st and the 99th percentiles of the distribution were identified as outliers and trimmed for each variable. The database is certainly distorted by human errors, it takes several steps to populate the database with data, and problems may arise during queries. For this reason, a "cut off" of two percents of the data is justified. The treatment was performed for all variables.

During the literature review, it happened only a few times that a different dynamic panel estimation procedure appeared in addition to the GMM model. In order to test the robustness of the results, a profit persistence estimation was performed using the Blundell-Bond (1998) method. The Arellano-Bond GMM estimation procedure gives more reliable results than the panel OLS estimates, but does not perform perfectly. The Arellano-Bond GMM performs very poorly if the auto-regressive parameter (λ) is too large or the ratio of the variance of the panel effect and the variance of the individual error terms is too large (Blundell and Bond, 1998). The Blundell-Bond model was developed to remedy this problem.

The Blundell-Bond estimator assumes that there is no autocorrelation among the individual error terms, and the panel effect is independent of the first difference of initial levels of dependent variable. Just like the Arellano-Bond estimator, Blundell-Bond works well when we have a lot of observations, but the number of time periods is limited. For profit persistence estimation, the Arellano-Bond method is considered the standard in the case of agricultural and food markets. In my opinion the reason for this is that although the Blundell-Bond estimator gives a more reliable estimation when the autoregressive parameter is high, but profit persistence is typically low in agriculture and food industry. For this reason, the Arellano-Bond estimator was used as preliminary compass, and the Blundell-Bond estimator was applied to check the robustness of the results.

The Markov chain analysis applied in this research was based on the study of Stephan and Tsapin (2008). The process of the analysis can be summarized as follows.

Denote the rate of profit by y_s^t. The Markov chain working with discrete values requires the following relationship:

$$P\{y_s^t = i\} = p_{ij} \quad (3)$$

It can be read from formula (3) that the profit rate in t+1 depends only on the state at time t. The transition between each group can be described as follows:

$$F_y^{t+1} = P * F_y^t \quad (4)$$

F_y denotes the distribution of corporate profitability in t and $t+1$. These equations can be used to estimate the transition probability matrix. The estimated probabilities will be unbiased if two conditions are met: 1) the data generating process is constant over time, so its variance is constant; 2) the number of observations is sufficiently large.

The variables included in the research were defined based on the literature focusing on the economic analysis of the poultry sector. One of the main drivers of the restructuring of the poultry sector is economies of scale. Szőllősi and Nábrádi (2008) found that the average farm size in the poultry sector is below the optimal level. Szőllősi and Molnár (2018) reached a similar conclusion in relation to profitability and size. Sipiczki et al. (2019) found that the average farm size was the lowest in the pig and poultry sector among the Hungarian agricultural sector. Accordingly, farm size was expected to have a positive impact on the profitability of poultry farms. In this study, two logarithmized variables were used to express the farm size: the number of poultry kept by the farm (number of animals) and the balance sheet total. The first serves to express the natural size of the farm, while the latter serves to express the size of the farm. The relationship between profit persistence and farm size (balance sheet total) is unclear. In the case of large size, the principle of economies of scale may work, although several studies have been written about less efficient large companies. Company size plays a significant role in the food industry (Hirsch and Gschwandtner, 2013; Hirsch and Hartmann, 2014). Consequently, a positive relationship between size and (abnormal) profitability is expected in this research.

Another important factor is the mechanization of farms. In addition to the indicator $\left(\frac{value\ of\ farm\ machinery}{all\ equipment}\right)$ generally used in the sector to measure mechanization, the machinery value per poultry was also measured as secondary indicator. To overcome the gap with advanced European competitors, the use of modern farm technology is required. Thanks to technological investments, natural efficiency indicators and thus profitability are significantly improved. One of the biggest problems of the poultry sector is the lack of technological development and innovation (Nábrádi and Szőllősi, 2008; Szőllősi, 2014; Szőllősi and Szűcs, 2014; Jankovics, 2017). In the Hungarian literature, technology is a recurring problem. Similar sentences can be found: "our professional knowledge is stagnant at the level of 1995-2000; our management knowledge is at the level of 15-20 years before" (Nábrádi and Szőllősi, 2008 cited by Bárány, 2007). According to the literature, the poultry sector is facing a major technology gap and there has been no significant progress at the sector level in the last 20 years. As a result, our poultry sector model includes two variables expressing the mechanization of the holdings.

In the lack of investment and innovation, the substitute for technology is farm labor, which, with few exceptions, is less efficient than machines. To express technological development, two mechanization index and one labor utilization index were included in the model. According to our preliminary expectations, mechanization may have a positive effect, while the latter may have a negative impact on profitability.

A long-standing dilemma for the Hungarian livestock industry is the question of whether to buy or grow feed. Furthermore, the optimal ratio of purchased feed is also a contentious issue. Jankovics (2017) states that cereal prices and broiler feed prices move closely together, but the actual problem is that the increase in grain prices is more pronounced increase costs by more than the increase in slaughter chicken prices. The most serious problem in the profitability of table egg producers besides size is the volatility of feed prices (Szőllősi and Molnár, 2018). According to Szőllősi's (2008) calculations, 60% of the costs of broiler chicken fattening is determined by the purchased feed. On this basis, profitability is very sensitive to changes in prices. The unfavorable development (opening) of the price scissors of industrial-agricultural products has a significant impact on the profitability of agricultural farms (Borszéki, 2003). Varga et al. (2017) found that price scissors have shown a favorable image in agriculture over the past 10 years, but the picture is improved by crop production and the situation for livestock farmers remains unfavorable. Taking all this into account, it should be assumed that the proportion of purchased feed within the total feed cost has a negative impact on profitability.

Realizing positive returns requires risk-taking, the risk is included in the definition of business. In line with profit persistence research, the concept of risk is approached from an accounting perspective, consequently, short-term and long-term risks are depending on the time horizon of indebtedness. High risk is expected to result in high expected returns (see CAPM model). Bowman (1980) found a negative correlation between risk and profit, which is supported by the practice of smoothing profits. Profit persistence research in the food industry has found a positive and negative relationship between risk and profitability. In most cases, long-term risk is positive or insignificant, and short-term risk has a negative impact on food companies. In his study, Borszéki (2008) estimated the cost of capital for the pig and poultry sectors. Based on his calculations, the optimal leverage ratio for both sectors is 35%, i.e. approximately two thirds of the liabilities side is equity and the remaining is debt. This is far below the optimal capital structure, one of the main reasons of which is the lack of own resources needed for foreign sources (Borszéki, 2003). The lack of technological development mentioned previously is rooted in the same place. This discrepancy and diversity characterizes well the relationship between risk and profitability, and consequently, we have no clear expectation of the relationship between any of the risk indicators. We measure long-term risk as the ratio of long-term liabilities to equity and short-term risk as the ratio of current assets to current liabilities.

The European Union and the prevailing domestic government policy have a special focus on agriculture. The level of subsidies in agriculture is outstanding compared to other industries (Sipiczki and Rajczi, 2018; Varga and Sipiczki, 2017a), and it is worth highlighting the favorable financing arrangements that are not effectively used by the farms. Subsidies received under the Common Agricultural Policy (CAP) also had a significant impact on the profitability of agricultural economies and the structure of production (Varga and Sipiczki, 2017b; Rajczi and Wickert, 2015). These factors mean a reduction in operational risks, so the subsidy ratio of total output were used as a control variable. Interestingly, except in one case, empirical studies processed in this paper do not include any form of support. The only exception is Tamirat et al. (2018), where the proportion of subsidies is not explanatory for the profitability of Dutch agriculture as a whole; the same is true for field crop production and pig holdings. There was a positive relationship only in dairy farms and a negative relationship in mixed livestock holdings between aid intensity and profitability. In our opinion, it is difficult to deny the subsidy dependence of the Hungarian agricultural economy although it is important to consider that the subsidy rate is much lower for livestock farmers than for crop producers. Moreover, according to Sipiczki et al. (2019), poultry and pig farming are the most profitable sectors within agriculture, but, if subsidies are taken into account, they become the least profitable. In the EU (and Hungary) there are only a few subsidies targeting the poultry sector. The most important year-to-year accessible subsidy is the so-called poultry animal welfare aid which partially compensates farmers for the increased production costs due to compliance with animal welfare rules. The other significant financial CAP-subsidy is the financial support for the modernization of poultry farms which provides a tender-based support for investments in production and manure management technology of farms. Several studies confirm that the profitability of poultry farms has deteriorated with the reduction of subsidies (Szőllősi and Nábrándi, 2008; Szőllősi, 2014). With these in mind, we expect the relationship between subsidy ratio and profitability to be positive or neutral. The subsidy ratio measured by the ratio

$$\left(\frac{subsidies\ without\ repayment\ obligations}{subsidies\ without\ repayment\ obligations + output}\right).$$

Non-repayable subsidies includes direct aid to producers, interest subsidies and aid for income compensation.

In case of the variable expressing the legal form of farming, it is assumed that the profitability of individual small-scale farmers and sole proprietors is higher than corporate farms and entrepreneur farmers. The reason for this is that the individual small-scale farmers' tax rules provide significant benefits and exemptions for families operating the farm. The poultry sector is characterized by a very small, sub-optimal (Szőllősi and Nábrádi, 2008) average farm size, which gives them tax advantages. As a result, the dummy variable for legal form (0 = individual farms, 1 = corporate farms) is assumed to have a negative relationship with profitability.

Variables	Expected impact	Mean	Median	Std. dev.
abnormal ROA.L1	0/low	0.096	-0.229	6.333
ln total assets	+	10.492	10.496	1.294
subsidy ratio	+/0	0.043	0.037	0.037
ln labor	-	0.713	0.647	0.820
purchased feed	-	4.064	3.283	2.920
ln number of poultry	+	8.848	8.985	1.412
long risk	+/-	0.444	0.000	1.288
short risk	+/-	5.577	1.634	14.435
mechanization _assets	+	0.048	0.008	0.087
mechanization_number	+	0.276	0.031	0.674
form of business	-	0.346	0.000	0.476

Source: own editing

Table 1: Expected impact and descriptive statistics of the variables used in the research.

Results and discussion

Table 2 shows the transition probabilities for the Hungarian poultry farms. While the ROA and aROA matrices are very similar for the poultry sector, the aROA probabilities are lower in most cases. So high ROA values do not automatically mean that abnormal profits are also high. The industry average profitability and the profitability of individual farms are rather likely to move together. The values in the diagonal are low. Values above 0.5 indicate strong profit persistence (Amidu and Harvey, 2016). Based on the values the competition is expected to be close to perfect competition.

Our results are in perfect agreement with the very similar study by Stabel et al. (2018) including 425 KFMA (Kansas Farm Management Associaton) farms: farm mobility between profit categories is generally high, but within this, the lowest and highest profit category farms are more likely to remain in their own quintiles. We agree with the findings of the cited authors that (i) this is most a problem for low-income farms, as they are less likely to be able to improve over time on their weaker profitability; (ii) for the highest-income farms, the same relative stability has a positive content, as it means more likely to maintain a favorable income position; (ii) the greater stability of the two extreme categories indicates the important role of farm management in profit stability.

The dynamic panel estimation will give a more accurate picture because 1) the conditions of the model are less strict (time invariance) than in the case of the Markov chain and 2) it provides an opportunity to control for different effects to get the most accurate value for the profit persistence coefficient. The Markov chain is appropriate as a starting point, and based on the results obtained, some expectations about the dynamics of competition can be derived.

The results of the Arellano-Bond dynamic panel estimation are shown in Table 3, Blundell-Bond results can be seen in Table 4. Hansen and Sargan test results are satisfactory. The profit persistence value is 0.108, but not significant. Considering the literature context, surprisingly rare is the study in which profit persistence is zero (e.g. Kozlenko (2015) for a few food sectors). On the other hand, on the basis of Hungarian literature, it has been emphasized on several occasions that the poultry farms are small, which is one of the barriers to profitability (Szőllősi and Nábrándi, 2008; Sipiczki et al., 2019).

In the case of farm size, the natural indicator ('ln number of poultry') is significant, so by increasing the average number of poultry per year the profitability of the farms also increases, this result supports the existence of economies of scale. There are examples in the international literature where the increase in size (from an accounting point of view) reduces profitability, but in the case of the Hungarian poultry sector this "critical size" seems to be far away. The results confirm the Hungarian and international theoretical and empirical research (Houedjofonon et al., 2020; Szőllősi et al., 2019; Khan and Afzal, 2018; Shorouei et al., 2017; Ymeri et al., 2017;

ROA	(1)	(2)	(3)	(4)	(5)	Pi
(1)	0.413	0.215	0.162	0.093	0.117	0.200
(2)	0.226	0.341	0.204	0.137	0.093	0.200
(3)	0.137	0.224	0.282	0.232	0.125	0.200
(4)	0.103	0.120	0.265	0.322	0.190	0.200
(5)	0.070	0.104	0.104	0.235	0.487	0.200
Pj	0.191	0.200	0.204	0.204	0.201	1.000

aROA	(1)	(2)	(3)	(4)	(5)	Pi
(1)	0.332	0.199	0.170	0.129	0.170	0.200
(2)	0.155	0.400	0.241	0.141	0.064	0.200
(3)	0.118	0.192	0.314	0.269	0.106	0.200
(4)	0.104	0.121	0.264	0.281	0.229	0.200
(5)	0.180	0.160	0.121	0.199	0.340	0.200
Pj	0.179	0.214	0.225	0.205	0.179	1.000

Source: own editing based on STATA output

Table 2: Transition Probability Matrices.

Arellano-Bond	Coefficient	Corrected Std. error	p-value
abnormal ROA.L1	0.108	0.109	0.325
ln total assets	-0.309	0.235	0.189
subsidy ratio	3.669	4.215	0.385
ln labor	-0.088	0.198	0.659
purchased feed	-0.022	0.064	0.737
ln number of poultry	0.478	0.277	0.087*
long risk	-0.424	0.136	0.002***
short risk	0.000	0.007	0.966
mechanization _assets	-6.475	3.190	0.044**
mechanization_number	0.574	0.323	0.077*
form of business	-0.822	0.436	0.061**
Tests			
AR(2)	z = -0.61		0.544
Sargan	Chi2(31) = 33.68		0.339
Hansen	Chi2(31) = 35.80		0.253

Note: ***, **, *Significant on 1, 5, 10 %
Source: own editing
Table 3: Results of dynamic panel estimation (Arellano-Bond).

		WC-Robost	
Arellano-Bond	Coefficient	Corrected Std. error	p-value
abnormal ROA.L1	0.001	0.021	0.955
ln total assets	-0.580	0.303	0.055**
subsidy ratio	1.705	7.673	0.824
ln labor	0.263	0.376	0.484
purchased feed	0.002	0.095	0.986
ln number of poultry	0.856	0.325	0.008***
long risk	-0.580	0.093	0.000***
short risk	0.002	0.013	0.882
mechanization _assets	-2.729	3.785	0.471
mechanization_number	1.101	0.436	0.012**
form of business	-1.860	0.947	0.049**
Test			
AR(2)	z = -0.89		0.375

Note: ***, **, *Significant on 1, 5, 10 %
Source: own editing
Table 4: Results of dynamic panel estimation (Blundell-Bond).

Szőllősi and Nábrádi, 2008) in the poultry sector.

Two variables were applied (‘mechanization_ assets’, ‘mechanization_number’) to get a more accurate picture of the depressing technological situation according to the literature. Both are significant, but with a different sign. In our opinion, the natural approach gives a more accurate picture, so with the growth of farm machinery per bird, efficiency increases and thus profitability. According to Szőllősi and Szűcs (2014), mechanisation is the only way to improve the profitability of the poultry sector; Jankovics (2017) also comes to a similar conclusion to escape forward. Recent international research (Rowe et al., 2019; Mancinelli et al., 2018; Hartung et al., 2017) also highlights the significant impact of mechanization. Based on these results, mechanization can be called one of the most important development areas of Hungarian poultry farming. In the case of mechanization ratio to the balance sheet total, accounting adjustments (the difference between real and calculated depreciation) and other items increasing or decreasing the balance sheet "move" this indicator. Although the logarithm of the balance sheet total is not significant, studies have treated declining farm size as a fact, so this effect also influences the mechanization index. A further reason for the negative impact is that investments are leveraged, as measured by long-term risk.

The variable for labor ('ln labor') has no explanatory power. The reason for this is on the one hand of technical origin, the effect of work intensity in the model is partly eliminated by the significant mechanization variable. On the other hand, it is a well-known fact that agricultural labor supply is declining in the region, as well as in the whole EU (Maucorps et al., 2019; Krajcsák and Kozár, 2018). According to the economic model of the labor market, insufficient labor supply moves wages upwards (Cassey et al., 2018; Zahniser et al., 2018). Thus, there were two contradictory effects during the period under review: firstly, the replacement of labor by mechanization had a reducing effect on costs (thereby improving profitability), and secondly, wage increases due to labor shortage had a reducing effect on profits. The two effects with opposite signs eventually extinguished each other.

Long-term risk (variable 'long risk') has a negative impact on profitability. The negative relationship is consistent with the findings of Lopez-Valeiras et al. (2016). Between 2006 and 2016 the average level of indebtedness fell by 80% on average (no significant difference by farm size), with the biggest drop after 2008, clearly a consequence of the global economic crisis. The debt has not recovered since the crisis, which also means that lack of investments. This is another sign of inefficiency and size problems. Improvements can be made primarily through the involvement of external capital, but with own funds, a farm is not indebted if the future expected profits yield the interest of the loan. On the other side, poultry farming, especially in the case of small-scale farms, is not an attractive target group for financial institutions providing loans. Because of high operational risks (e.g. animal epidemics, temporary restrictions on international trade, single costumer-dependence of farms), low transparency (unreliable accounting of individual small-scale farms), and the high volatility of input and output prices, loans to the poultry sector are risky, making them expensive and low in supply. In the current situation of the Hungarian poultry sector, this is a trap. In addition to low profitability, indebtedness in the short term is bound to worsen profitability, which owners are unlikely to undertake. Without improvements, profitability will also deteriorate, but in this case, it will be a slow process lasting several years, even decades, while in addition to indebtedness, there may be a sharp downturn and future returns are not guaranteed. In such a situation, it is difficult to choose the riskier way; especially if we consider the words of Bárány (2007) that management knowledge is 15-20 years behind.

The short-term risk is not significant according to the model. It is worth mentioning here the study of Borszéki (2008), who argues that the increase in trade payables does not mean an improvement in the market financing position, but rather the presence of the chains of debts, which is a sector problem.

Calling for grants and their rational use for development and risk reduction may be an appropriate "means". According to the model, the increase in the subsidy ratio within total output does not affect profitability. The reason for this is the low level of support compared to other agricultural sectors. According to Sipiczki et al. (2019), without subsidies, the poultry sector is one of the most profitable agricultural sectors. Considering the subsidies, the other sectors are improving to the extent that it becomes the least profitable. However, several studies (Szőllősi and Nábrádi, 2008; Borszéki, 2003) emphasize the minor and limited role of subsidies in the sector. For these reasons, the neutrality of the subsidies is not surprising.

The variable of purchased feeds is negative but not significant. In the model specification section has been mentioned the opening of the price scissors of industrial-agricultural products. Calculations have shown that the input price increase is higher than the output price increase, which clearly has a negative impact on profitability. The poultry sector has a high ratio of purchased feeds, as it is confirmed in Popp et al. (2018), according to which 50% of the nutrient mixes produced in Hungary in 2016 was poultry feeds, half of the feed mills produce poultry feeds. From this, two conclusions can be drawn: it is likely that poultry feed production is a profitable activity, and, on the other hand, poultry farms are not thinking about producing their own feed but buying. According to preliminary expectations, corporate farms will achieve lower abnormal profits and individual farms will be able to claim tax benefits.

Conclusion

The poultry sector has undergone a major transformation over the last two decades, and, according to a clear trend, most small-scale farms are unable to compete in the EU single market. Market competition was measured with abnormal profit (above-market-average portion of farm profit) persistence. The profit persistence of the poultry sector is not significant indicating, from a theoretical point of view, that the sector is close to perfect competition. Many small, sub-optimal farms justify the profit persistence value obtained.

In the case of the dynamic panel model, it can be stated that the increasing number of poultry (pcs) improves profitability and reduces competition, but the rate of financial (CAP-) supports does not affect the abnormal profit and thus has no distorting effect on the sector. Efficiency technology investments improves the abnormal profitability of farms, which is a breakout point for the poultry sector. Labor and purchased feed have no demonstrable effect on above-market yield. Among the risks, long-term indebtedness reduces abnormal profits, if the debt is invested in proper mechanization, companies can gain a competitive advantage in the long run. Individual farms have the potential to achieve higher returns in relative terms.

The results of the research, in comparison with the literature (theoretical and empirical), confirm the fact that the improvement of the international competitiveness of the sector within the Hungarian dual farm structure is clearly conceivable with large-scale, low-unit labor-intensive economies. Consequently, policy strategies and measures to maintain or possibly increase the Hungarian poultry population should be designed with this in mind, primarily focusing on the development of medium and large-scale livestock production.

The development of the competitiveness of individual and family farms can only be successful if future development programs and subsidies support the achievement of at least a medium-sized farm, the reduction of specific labor utilization, horizontal and vertical integration, and the provision of their own fodder base. An additional breakthrough point may be the expansion of one's own slaughtering and processing capacities, but this paper does not aim to support this statement.

Regarding the practical application of our results, authors consider the interaction between mechanization and indebtedness to be the most relevant. Mechanization as the most effective tool of increasing profits is of paramount importance for both producers and policy makers. If the technological heterogeneity of poultry farms will be not able to be reduced by the stakeholders, and the digitalization and precision technology transition does not take place in the next planning cycle, the Hungarian poultry sector will struggle with serious profitability and competitiveness problems. For successful technological developments and mechanization, however, it is essential to reduce the negative effects of long-term indebtedness. Therefore, we see the need to develop partially state-led loan schemes for the sector, enabling viable investments with a reduced / subsidized interest burden. With such schemes in place, farmers can start modernizing their farms with less risk and better profit prospects. We have not found any proposal in previous research to resolve the contradiction between the modernization constraint and the joint treatment of indebtedness as a hindering factor. In our opinion, the detailed elaboration of specific constructions and subsidies is another important area of future research.

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Agris on-line Papers in Economics and Informatics

Volume XIV Number 2, 2022

CAP After 2004: Policy to Promote Development or to Elimination Differences Between Regions? Non-parametric Approach Based on Farm Efficiency in the Old and New EU Regions

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Abstract

In the light of the Treaty establishing the European Economic Community (Treaty of Rome) of 25 March 1957, the primary aim of the Common Agricultural Policy is to provide European Economic Community citizens with adequate amounts of food at reasonable prices and to guarantee farmers a decent standard of living. That is more, the EU fund transfers were to eliminate differences between regions and promote development of individual regions. These aims proved to be particularly important following the EU enlargement in 2004. The indispensible effect of the integration process has been connected with changes in the directions of agricultural production and efficiency of utilisation of individual inputs. Nevertheless, it is difficult to evaluate the effects of the implemented policy based on univariate comparisons.

In view of the above, the aim of this paper is to assess the effects of the agricultural policy and the cohesion policy implemented in the EU, focusing on the valuation of the impact of the greatest EU enlargement on this relationship. This goal was achieved thanks to constructing multivariate rankings applying the DEA super-efficiency model for average farms specialising in plant, animal and mixed production in individual EU member countries for two period. The application of the DEA efficiency model makes it possible in the computation process to take into consideration the fact that in the course of agricultural production three groups of products are manufactured involving four basic types of inputs. The starting point for the analyses was provided by data published within the FADN agenda for average farms operating in the countries being the EU members.

The results showed that after the largest enlargement of the EU, in the case of plant and livestock production, a simultaneous increase in agricultural production and improvement in efficiency in the individual EU members was achieved, with a gradual reduction of disproportions in the efficiency of agricultural production between regions. The only area where such a relationship could not be observed was related to the production of mixed-type farms.

The novelty of the proposed in this article approach is that it allows for simultaneous analysing of changes in EU agriculture while taking into account several perspectives: changes in the assumptions of the common agricultural policy, the consequences of EU enlargement, and results of the implementation of the cohesion policy.

Keywords

EU cohesion policy, Common Agricultural Policy, supper-efficiency model, DEA.

Błażejczyk-Majka, L. (2022) "CAP After 2004: Policy to Promote Development or to Elimination Differences Between Regions? Non-parametric Approach Based on Farm Efficiency in the Old and New EU Regions", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 2, pp. 31-47. ISSN 1804-1930. DOI 10.7160/aol.2022.140203.

Introduction

The Common Agricultural Policy (CAP) is considered to be one of the most important EU policies supporting the functions of the European Single Market. It was developed in response to problems with food supply experienced in Europe after WWII (Balaceanu, 2013). The basic principles of the CAP were included already in the Treaty establishing the European Economic Community of 25 March 1957 (Treaty of Rome, 1957, Article 39). According to this document the primary aim of the CAP is to provide EU citizens with adequate amounts of food at reasonable prices and to guarantee a satisfactory standard of living to farmers. The wide scope of tasks allocated to the CAP has been realised in practice starting from 1962, when the European Agricultural Guidance and Guarantee Fund was founded (Ackrill, 2000).

Actions aiming at the assurance of food security in Europe obviously absorbed a high share of expenditure from the EC budget. As a result the agricultural policy has been this aspect of the European economic policy raising the greatest controversies among the populations of the member countries. In turn, due to the changing economic conditions from the very beginning the CAP has been one of the most frequently reformed policies. Particularly significant changes in its assumptions were introduced at the turn of the 21st century. In January 2003 the European Commission following the Mid-Term Review proposed the Luxembourg Common Agricultural Policy Reform (also referred to as the Fischler reform; Buckwell, 2003). The primary aims of this reform were connected first of all with the perspective of the greatest enlargement in the EU and the need to strengthen the bargaining position of the European Union within the WTO.

Assumptions of the CAP within the Luxembourg CAP Reform became an important element in the process aiming at the improvement of efficiency and competitiveness of the entire EU economy. In literature on the subject the Luxembourg CAP Reform is considered to be the most radical reform since the introduction of the CAP (Fischer Boel, 2005; Olper, 2008, 83-97; Swinnen, 2008). It is stated that it has led to greater simplicity and flexibility of the agricultural policy in the EU, making it more market-oriented. In the opinion of F. Fischler, the author of the reform, as well as other researchers of the EU agricultural policy, thanks to this reform the CAP is better adapted to the increasing social expectations in Europe and to the situation found on the international agricultural markets. The attempts within the CAP to attain greater marketability and competitiveness of European food products in relation to food produced in other parts of the world are to guarantee food security for the inhabitants of the EU member countries. Thus the re-defined model of the Common Agricultural Policy promotes solutions which do not disturb the directions, structure and character of the world agricultural trade (Walkowski, 2007).

However, in accordance with the concept of the European Model of Agriculture an equally essential role for the realisation of multi-functional rural development in Europe is played both by the instruments of the Common Agricultural Policy and the policy of economic, social and regional cohesion within the EU, as manifested in the Structural Funds (Barroso, 2005; Walkowski, 2007) aiming at the environmental protection and since 2013 also protection of local communities, creation of new jobs and reduction of greenhouse gas emissions (The CAP…, 2012). It needs to be stressed here that the primary aim of the cohesion policy is to ensure a higher level of regional cohesion within the EU thanks to the gradual elimination of disparity in the standard of living and living conditions for inhabitants of its individual regions.

In the case of agriculture the discrepancy between the idea of an efficient, market-oriented agriculture, sustainable, environmentally friendly development and territorial cohesion is particularly striking. The relationship between the aims of improving production efficiency and aims of the structural policy reflects dependencies between economic growth leading to disparity and the aspiration to attain territorial cohesion (Ryszkiewicz, 2013; Thematic Evaluation…, 2005; Bachtler et al., 2016). On the one hand, the EU transfers are to eliminate differences between regions in terms of their agricultural production efficiency, while on the other hand they should contribute to an accelerated development of regions in this area. Studies concerning entire economies have provided a general conclusion that a rapid economic growth of the whole country does not lead to a uniform level of development between its regions. Additionally, convergence between European regions does not progress at a rate adequate to the volume of EU funds allocated to that purpose (Pronobis, 2011).

In view of the above a question arises concerning the effect of the agricultural policy and the cohesion policy implemented in the first years after the greatest EU enlargement on the improvement of efficiency of agriculture in individual EU member countries, changes in the structure of this production as well as limitation of disparities in this respect. A particularly interesting hypothesis states that in agriculture, similarly as in the entire economies, production growth and improved efficiency in individual EU member countries do not coincide with the elimination of differences between regions. In view of the above the aim of this paper is to assess the effects of the agricultural policy and the cohesion policy implemented in the EU, focusing on the valuation of the impact of the greatest EU enlargement on this relationship.

The starting point for the analyses was provided by data published within the FADN agenda for average farms operating in individual EU member countries. Date of research should be connected not only with the availability of statistical data but also it should show the direction of changes in agriculture in the first dozen or so years after the admission of new members to the group of EU countries. In result data of research concerned 2004 and 2016. Realisation of this aim requires the application of multivariate quantitative methods, thanks to which the discussed problem may be considered in a comprehensive manner. Among the many possibilities it was decided to apply the DEA super-efficiency model, facilitating the construction of multivariate rankings for average farms in individual EU member countries. Thus this method provides a comparison of technical efficiency, which by definition to a lesser extent is burdened by the impact of various types of financial support. In this way the obtained assessments are closer to the free market principles, postulated in the assumptions of the Luxembourg CAP Reform. Additionally, the DEA methods make it possible to include several groups of agricultural products in the process of agricultural production involving many production inputs, which in turn facilitates evaluation of changes which have taken place in the structure of agricultural production over the investigated period.

The literature on the efficiency of agriculture is quite rich. It has been more detailed described in terms of the topics discussed and the methods used in the following chapters. However, it is worth emphasizing in this place, that in other publications the agriculture of individual EU countries was usually analysed from the perspective of only one a selected economic policy. From that point of view, the approach proposed in this article is really innovative because it proposes to use one numerical tool that allows analyzing EU agriculture both in terms of improving its effectiveness and the implementation of assumption of the cohesion policy.

The EU agricultural policy in view of assumptions of the cohesion policy

Already the Preamble to the Treaty of Rome contained references underlining the importance of economic cohesion in the European Community (Treaty of Rome, 1957). The primary instrument facilitating the realisation of the cohesion policy in the EU member countries was created in 1975 in the form of the European Regional Development Fund (ERDF). In the 1980s actions were undertaken to combine the cohesion policy with other economic areas. These concepts were confirmed when entering in the Article 23 of Single European Act the EC resolution on the strengthening of cohesion of its territory both in the economic and social aspects (Single European Act, 1987). Moreover, the formulation of the assumptions and implementation of the other EC policies (including the agricultural policy) had to be adapted to the conditions of economic and social cohesion. This meant that advantages resulting from the execution of other policies were considered positive on condition that their implementation does not increase regional disparities and does not lead to a deterioration of the position of poorer EU regions (Single European Act, 1987, Article 130). Such a position has been repeatedly underlined in successive years (see e.g. EU, 2004). At that time new principles were also specified for the EU cohesion policy for the years 1989-1993. The priorities for this policy included a reform of the CAP, modernisation and adaptation of the agricultural production structure as well as assistance in the development and structural changes in rural areas.

The key importance of the social and economic cohesion was also stated when the European Community decided to implement the Economic and Monetary Union, thus stressing that these actions concern also rural areas: “the community shall aim at reducing disparities between the levels of development of the various regions and the backwardness of the least favoured regions, including rural areas (Treaty in European…, 1992, Title XIV). Nevertheless, it needs to be stressed that the European structural policy only complements the efforts made by the Member States, who carry the main responsibility for smoothing out regional differences. In this way, the European structural policy helps to ensure that competitiveness can be established or re-established and that there is a lasting improvement in economic development. At the turn of the new century one of the challenges for the EU cohesion policy again included actions aiming at a reduction of differences in the conservation and care of rural areas (EU, Opinion of the Committee.., 1998, 1.1.3 and 2.1.5).

The evaluation of the impact of the other EU policies on cohesion became particularly essential in relation to the EU enlargement, which took place in 2004. It was known that this change, due to its scale, would result in a decrease of mean GDP per capita in the entire European Union. As a result, this meant the exclusion from assistance for some regions, which had been receiving it before (Ryszkiewicz, 2013). In the case of the European Union particularly evident disparities were observed in terms of the level of economic development between the countries, which had formed and for many years had been operating within the EU structures and those, which became new EU members in 2004. The EU enlargement to include the 10 new members produced new challenges for the cohesion policy (European Commission, 2004).

The EU cohesion policy concerned all the economic areas. Nevertheless it was known that disparities in the efficiency of agricultural production were particularly high immediately before the greatest EU enlargement (Henning, 2008). For this reason in Agenda 2000 a significant position was assigned to problems of rural areas and agriculture (Agenda 2000…, 1997). On this basis since mid-1999 the countries of Central and Eastern Europe (CEECs) as well as Malta and Cyprus initiated the period of preparations to full EU membership. In order to reduce development disparities EU funds were allocated to actions in the candidate countries related to structural adaptations. They were executed within the framework of preaccession programmes. The most important role for agriculture was played by the Special Accession Programme for Agriculture and Rural Development (SAPARD). Its objectives, next to facilitation of integration of the agricultural sector with the EU, included also improvement of structures for processing agricultural and fishery products, and financing of integrated rural development projects aiming at improved efficiency of farms (Commission Regulation…, 2000).

In March 2000 the European Commission adopted the principles of the Lisbon strategy, aiming primarily at the establishment of possibly the most competitive and knowledge-oriented economy worldwide. Objectives of the Lisbon strategy within the CAP were finally confirmed in Luxembourg on 26 June 2003 (European Parliament, 2020). The Luxembourg CAP Reform was based on several principles. The first - the decoupling principle – assumed partial decoupling of direct payments from the volume of agricultural production, which was to weaken incentives to continuously increase its production, thus leading to a rapid increase in the EU expenditure on agriculture. In turn, the principle of cross-compliance assumed a dependence of payments to farms on their meeting specific standards, including those connected with environmental protection. In turn, the modulation principle allowed for a gradual increase in expenditure for the 2nd pillar of the CAP, i.e. the multifunctional rural development. Resolutions of the Luxembourg CAP Reform were also to eliminate the negative effects of payments in the allocation of resources. In turn, the allocation of additional funds to rural development was to contribute to an improvement of the condition of the natural environment and economic growth in structurally weaker regions.

The greatest EU enlargement to date resulted in the cohesion policy playing a key role in support for the economic regeneration of rural areas, complementing the action supported by the new rural development fund (European Agricultural Fund for Rural Development – EAFRD). In the years 2004-2006 the CAP objectives were supplemented to include further support for environmental protection and strengthening of the European Model of Agriculture (Wojtaszak, 2012). This complementary approach should seek to support the restructuring and diversification of the economy in Europe's rural areas. The synergy between structural, employment and rural development policies needs to be encouraged. In this context, the member states should ensure synergy and consistency between actions to be financed by the ERDR, Cohesion Fund, ESF, European Fishery Fund (EFF) and EAFRD on a given territory and in a given field of activity (EU, 2006; European Parliament, 2007).

Assumptions of the Luxembourg CAP Reform were implemented gradually. Nevertheless, as a result of a review of the CAP with the 2009 'Health Check': consolidation of the 2003 reform framework the effects of the CAP reform were found to be positive, particularly in the area of the complete decoupling of assistance from the volume of production, coupling of payments with actions addressing environmental protection, food safety and animal welfare, as well as making the intervention actions on the agricultural market more flexible so that they would not limit the farmers' capacity to respond to market signals (Wojtaszak, 2012). It was also stressed that the agricultural policy has to satisfy the growing world demand and to promote the model of agriculture sustainably using inputs and creating new jobs. It also has to allow for agriculture as a producer of renewable energy and biomaterials to combat climate change (European Parliament, 2009). The principles of the Common Agricultural Policy for the years 2014-2020 were finally adopted in December 2013 (EU, 2013).

The Reform of 2013 constituted the final stage in the still on-going process leading to the realisation of the Luxembourg CAP Reform assumptions. As a result of the latest step of the CAP reform was expanded to include new economic, environmental and territorial objectives. The new economic aims comprised the aspiration of the EU member countries to ensure food security thanks to sustainable agricultural production as well as increased competitiveness and better distribution of value in the food supply chain. (EU, 2013). Thanks to the realisation of these objectives, in the opinion of the European Commission the EU agriculture became more efficient, more competitive and sustainable (Overview of CAP…, 2013).

However, already in 2005 the European Council decided that the realisation of the Lisbon priorities concerning economic growth turned out to lack consistency in individual EC countries. What is more, previous challenges in the beginnings of the 21st century became even more pressing and urgent in view of the observed economic and social transformations related to globalisation and increasing competition, restructurisation processes and growing unemployment, economic migration and ageing of the populations (Barroso, 2005). On the other hand, despite the long-term actions undertaken to attain European cohesion the main aim of this policy, i.e. reduction of economic and social differences in the level of development in the European regions, might hardly be considered achieved. The European Parliament generally accepted the opinion that the cohesion policy needs to cover not only the regions requiring the support. Politicians put forward a claim that the cohesion policy is not solely a simple mechanism of solidarity, but its role is also to stimulate the internal development potential of the European regions (European Commission, 2008). Thus a question arises whether despite the actual links between the instruments adopted in the realisation of aims of the cohesion policy and the Common Agricultural Policy it is possible to simultaneously attain objectives related to improved efficiency and competitiveness of agriculture and reduce the disparity in the development levels between individual regions or member states.

As shown above in this paragraph, there are many sources and studies describing changes in the EU policy concerning the common agricultural policy or the cohesion policy. The literature on research into the efficiency of EU agriculture is also rich. Previous studies in this area are interesting due to the perspective of time taken into account (Coelli & Rao, 2005), the methods used (Baráth and Fertő, 2020; Prokopchuk et al., 2020), or the topics considered (Kusz, 2014).

The first of them (Coelly & Rao, 2005) gives us a comprehensive view of changes in productivity in the world. But they are based on data containing a substantial amount of aggregation, which relies upon the availability of comparable price information across countries, where data quality and definitions can vary substantially from one country to the next. As a result, this type of study produces fairly approximate country-level information. Baráth and Fertő (2020) also note the problem of using comparable data in cross-country analyzes, especially those relating to agricultural prices. In their research, they try to estimate a Total Factor Productivity (TFP) index for global agriculture and global agricultural regions. They show that TFP growth has accelerated in world agriculture, largely due to better performance in transition countries. What is more, Baráth & Fertő (2020) proved that TFP growth in the EU has increased, but at a slower rate in recent years. In the old EU members, the growth rate has decreased, whereas in the old EU members it has increased. In turn, Prokopchuk et al. (2020), in their research on the grain maize yield only, presented a completely different approach to determining changes in agricultural productivity. In their opinion, due to the specificity of agriculture production, it should also take into account whether factors. Thanks to the use of parametric methods, they defined the combined weather index, that can be used to estimate a weather risks at the regional level. The last one Kusz (2014) the correlation between the need to modernise agriculture and sustainable development. In his paper, he proves that in the near future, the agriculture –environment relation will be subject to the change taking into account, on the one hand, concern about the natural environment, and, on the other, pressure on increasing the efficiency of production. In his opinion, the above challenges will be addressed by the need to implement efficient and, at the same time, environmentally-friendly production technologies and relevant legal instruments which oblige agricultural producers to protect the natural environment.

However, it should be emphasized that, these researches usually analyse the efficiency of agriculture only from one or two of the above-mentioned perspectives: they concern either the analysis of changes in the assumptions of the common agricultural policy (European Parliament, 2020; Heyl et al., 2021), or the consequences of EU enlargement (Kavcic and Erjavec, 2003; Kroupová et al., 2020), the implementation of the cohesion policy (Ferry and McMaster, 2013; Mohl, 2016). The approach described in this article allows for the simultaneous consideration of the three above-mentioned perspectives.

Materials and methods

Data

Introduction of changes within the CAP, in view of their social character and the ideas promoted by the EU, requires a detailed analysis of the economic situation of farms in each of the EU member countries. For this purpose the European Commission established a system of accountancy data collection from farms: Farm Accounting Data Network (FADN, 2020), which makes it possible to determine the actual economic situation of farms. These data also constitute the basis for the evaluation of efficiency of invested EU funds and for the identification of the directions in systemic changes (Table 1).

Countries	Direction of agricultural production 2004				Direction of agricultural production 2016			
	plant	animal	mixed	total	plant	animal	mixed	total
(ITA) Italy	80%	14%	6%	854140	77%	18%	5%	532030
(FRA) France	43%	44%	13%	313920	50%	37%	13%	296620
(DEU) Germany	28%	54%	18%	210340	32%	53%	15%	186190
(NED) Netherlands	41%	54%	5%	51710	38%	60%	1%	43310
(BEL) Belgium	25%	56%	19%	32520	33%	54%	13%	25650
(LUX) Luxembourg		95%	5%	1280	5%	89%	6%	1270
(IRE) Ireland	1%	97%	2%	105730	0%	100%		77100
(UKI) United Kingdom	27%	64%	9%	100240	29%	63%	7%	95670
(DAN) Denmark	43%	41%	16%	31600	58%	34%	8%	24010
(ELL) Greece	81%	9%	10%	384250	79%	16%	5%	327620
(ESP) Spain	74%	22%	4%	577730	71%	24%	5%	421940
(POR) Portugal	49%	32%	19%	108900	54%	32%	14%	94490
(OST) Austria	21%	71%	8%	85140	24%	67%	9%	85690
(SUO) Finland	45%	54%	1%	35670	64%	36%		33080
(SVE) Sweden	24%	70%	6%	29720	37%	58%	5%	22540
(POL) Poland	27%	20%	53%	727620	45%	20%	36%	724360
(HUN) Hungary	62%	16%	22%	77860	67%	9%	24%	95390
(SVN) Slovenia		67%	33%	33470	21%	53%	26%	39300
(LTU) Lithuania	31%	33%	36%	31760	30%	43%	27%	59810
(LVA) Latvia	15%	35%	50%	21090	26%	41%	33%	21580
(CZE) Czech Republic	41%	26%	33%	13820	45%	30%	25%	15530
(CYP) Cyprus	88%	12%		9100	86%	7%	7%	7170
(EST) Estonia	39%	40%	21%	3820	47%	37%	16%	6030
(SVK) Slovakia	71%	10%	19%	2710	62%	24%	13%	2980
(MLT) Malta	76%	24%		1230	80%	20%		2260
OLD members mean	61%	31%	8%	2922890	59%	33%	7%	2267210
NEW members mean	30%	22%	48%	922480	45%	22%	33%	974410

Source: the author's study based on data published by FADN (2020)

Table 1: The number and structure of farms in 2004 and 2016 depending on the direction of agricultural production.

The starting point for the historical analysis of the effects of the CAP after 2004 was provided by the data concerning average farms in individual EU member countries in 2004 and in 2016. The selection of data, particularly for inputs, typically is problematic for researchers. In this study the selected set of variables was to reflect the participation of the four basic production factors (inputs) involved in the production process, i.e. land, labour, fixed capital and operating capital, along with three outcome variables, such as the values of plant, animal and other production.

Inputs of labour (in the FADN methodology designated as SE010) were expressed by the number of employees working full-time on the farm. The next input, land, was described in ha of utilised agricultural area UAA (SE025). The other variable used in the analysis are monetary and they are expressed in thousands of Euro (1000 €). In this way the value of operating capital involved in agricultural production was expressed (the value of SE270 less depreciation SE360) and the value of fixed capital (the total values of buildings SE450, machines SE455 and foundation stock SE460). The outcome variables were also expressed in terms of values: the volume of plant production (SE135), the volume of animal production (SE206) and the other agricultural production (SE256).

It also needs to be stressed that the example below refers to a historical assessment of changes in productivity of farms depending on the direction of agricultural production in individual EU member countries. Thus volumes of production referred to involved inputs are compared. In contrast, the profitability of production is not considered, which at the system of direct payments and subsidies provided within the Common Agricultural Policy is not a measure identical or close to the approach proposed in this study (Zhu et al., 2012). Nevertheless, it seems that such a comparison, in view of the assumptions of the Luxembourg CAP Reform presented above, would more reliably reflect changes in the efficiency of utilisation of material inputs in EU farms, resulting from the changing market situation.

The FADN agenda makes available the data concerning average EU farms at varying levels of generalisation. Among the many options in the presented study the data used were collected for eight types of farming: 1) fieldcrops, 2) horticulture, 3) wine, 4) other permanent crops, 5) milk, 6) other grazing livestock, 7) granivores, and 8) mixed. In order to distinguish the three directions of production the values of respective types of farms were totalled using the weighted means. In this aggregation, similarly as it is done within the FADN, the number of farms representing a given type of production was used, as listed in the Table 1. In this way in order to obtain the values of variables for plant production the values corresponding to the first four types of farms were aggregated. In turn, the value of animal production comprised values characterising types of dairy farms, those rearing other grazing livestock and granivores. A separate group was composed of mixed type farms. Empty fields mean that in a given year in the agriculture of a given country there were no farms specialising in a given type of production. Additionally, in order to realise the aims of this study in the same manner – using weighted means – the average values of investigated indexes were established for the countries, which until 2004 formed the EU (EU-15, or old EU members) as well as those, which within the greatest to date EU enlargement in that year joined the EU (EU-10, or new EU members).

Rankings of efficiency

One of the quantitative tools used to assess the effects of an economic policy pursued in a given period is to construct rankings of territorial units comprising a given region. A particularly important role in the case of economic problems is played by rankings taking into consideration economic efficiency of the investigated entities. On the one hand, a comparison of rankings constructed for different time points makes it possible to determine the scope of divergence between the entities, which may be a measure of economic cohesion. On the other hand, a comparison of rankings indicates changes in the position of individual entities within the ranking, thus showing improvement or deterioration of their relative efficiency. Rankings may be univariate, i.e. based on a single product and one factor of production. However, the area of the comparison is typically multivariate.

In order to objectively assess within a given timeframe the effect of the agricultural policy and the cohesion policy implemented in the first years of the greatest EU enlargement on the structure of agricultural production, it is necessary to simultaneously consider many outcomes generated in that process (or their groups) in relation to inputs. A ranking of efficiency assuming the simultaneous generation of many products in the production process based on the multiple inputs involved may be prepared thanks to the application of non-parametric methods (see e.g. Charnes et al., 1978; Farrell 1957), particularly the Data Envelopment Analysis (DEA), a method well-established in the world and Polish literature on the subject (see e.g.: Førsund and Sarafoglou, 2002; Guzik, 2009a, Kocisova et al., 2018; Scippacercola and Sepe, 2014). This method also facilitates incorporation of variable effects of scale for specific production. As any method it has numerous advantages and certain drawbacks. A review of ranking methods based on DEA was presented by Adler et al. (2002). One of the approaches discussed in that publication was the application of the super-efficiency DEA model (SE-CCR), which makes it possible to construct a ranking both for reference units and for inefficient ones. This model was described in detail e.g. by Guzik (2009a). It needs to be stressed that this approach is popular in literature on the subject (Jahanshahloo et al. 2011; Li et al., 2007; Mosbah et al., 2020). It was also presented in a study by Błażejczyk-Majka (2016).

The super-efficiency DEA model

It needs to be stressed that the Data Envelopment Analysis (DEA) is typically used to asses efficiency of entities making independent economic decisions (decision-making units, DMUs) rather than sets of entities. Nevertheless, in the case of the EU agriculture decisions concerning the volume or directions of support for farms, or the level of convergence are made at the national level. In this sense averaged farms at the national level may be treated as decision-making units. A comparison of efficiency based on DEA for aggregate units, such as average farms at the regional or national level may be found in many publications (Błażejczyk-Majka et al., 2012; Coelli and Rao 2005; Galluzzo 2016; Zhu et al., 2012). The application of non-parametric methods to compare productivity at the international level was described in detail by Coelli et al. (2005).

The DEA consists in the solution of a series of linear equations, based on which maximum technical efficiency may be determined (Debreu 1951; Koopmans 1951). This is done by comparing vectors of results - outputs q and inputs x in all investigated decision-making units (DMU_i) (i = 1, 2, …, I). A necessary conditions to be met in this analysis is to indicate the type of technology. It may be based on the constant return to scale (CRS) or variable return to scale (VRS). In this analysis it is also necessary to define the orientation of the production run by the entities, which may consist in maximisation of production (outputs maximisation) or minimisation of inputs used in the production process (inputs minimisation). A detailed description of this method may be found in publications by Coelli et al. (2005) and Thanassoulis et al. (2008).

In the case of an assumption that production generates constant effects of scale and is oriented to minimise used inputs x_n (n = 1, 2, …, N) required to generate outputs q_r (r = 1, 2, …, R), the DEA method makes it possible to determine technical efficiency by solving I linear programmes, one for each DMU (Charnes et al., 1978; Coelli et al., 2005). Efficiency of each unit is thus assessed compared to all the objects in the group:

Objective function: $\text{Min}_{\theta\lambda}\, \theta_i$ (1)

subject to:
$$\boldsymbol{Q\lambda} \geq q_i,\quad \theta_i x_i \geq \boldsymbol{X\lambda},\quad \boldsymbol{\lambda} \geq 0,\quad \theta_i \leq 1$$

where θ_i is a scalar referred to as the multiplier of input levels (Guzik 2009b). In turn, λ is the vector of constans. A single component of this vector, reflecting the relationship between the o-th DMU, for which the programme of linear equations is solved with any j-th DMU from the tested group, will be denoted by scalar λ_{oj}. For each analysed unit its values are estimated in relation to the other units. Matrices X and Q correspond to inputs and outputs of all DMUs participating in the analysis. In turn, vectors x_i and q_i refer to incurred inputs and produced outputs in the i-th DMU. Such a formulated programme of linear equations is named after the authors of this approach Charnes et. al. (1978) and it referred to in literature on the subject as the CCR model (Førsund and Sarafoglou 2002). It should be mentioned here that this approach presents one of the methods to improve efficiency in an enterprise, such as lean management through reduction of inputs.

The multiplier of the level of inputs θi may assume values from the range of [0; 1], which define technical efficiency of the i-th DMU, also called θ-efficiency sensu Farrell (Coelli et al., 2005). All DMUs, for which $\theta_i < 1$ are considered inefficient. In turn, if $\theta_i = 1$, it means that the i-th DMU is characterised by the highest efficiency in the entire group – it is the leader, a reference unit. Typically in the course of the analysis it turns out that there are several such units, which hinders the application of this model to construct a ranking (Fried, et al., 2008).

The super-efficiency SE-CCR model is an extension of the CCR model (Andersen and Petersen, 1993). The programme of linear equations (1) is supplemented with an additional limiting condition: for the *o*-th DMU it is assumed that $\lambda_o = 0$. In order to distinguish the results of both methods the multiplier of the level of inputs, denoted in CCR as θ_i, in SE-CCR is described as ρ_o. Moreover, in SE-CCR the assumption that the multiplier of the level of inputs $\rho_o \leq 1$ is rejected. Thanks to such changes, efficiency of the *o*-th DMU is considered in relation to the group of the other DMUs excluding the *o*-th DMU and values of ρ-technical efficiency provided by the solution of the system of linear equations may assume values greater than 1. The value of $\rho_o \geq 1$ indicates a relative advantage of the *o*-th unit over the other units in the investigated group. The greater the multiplier ρ_o, the more efficient a given object is, since a smaller input provides assumed outputs (Guzik 2009a). In turn, if $\rho_o < 1$ then its value is equal to values θ_i determined by the CCR model. Such a situation means that competitors of the *o*-th DMU would have reached the same level of production at a smaller input. Thus the object is not efficient.

In the case of DEA it is assumed that the set of objects has to be homogeneous. This results from the postulate that the reference for an inefficient unit needs to be a technology feasibly attainable for this unit. Results provided by DEA are dependent on the number of analysed DMUs and the number of analysed variables. When the super-efficiency model is used then multivariate comparative analysis methods may be applied. In turn, Guzik (2009a) proposed testing of homogeneity of the set of units based on subjective adopted limits of homogeneity. In this study an intermediate solution is proposed: those units will be considered as failing to meet the condition of homogeneity, which may be considered as exhibiting insufficient or excessive efficiency in relation to the typical transformation of inputs into outcomes, i.e. those found outside the limits of homogeneity. The univariate quartile criterion (Tukey 1977) was adopted as the definition for limits of homogeneity, with the lower (ρ_D) and upper limits of homogeneity (ρ_U) assuming the form:

$$\rho_D = Q_1 - 3(Q_3 - Q_1),\ \rho_U = Q_3 + 3(Q_3 - Q_1). \qquad (2)$$

where Q_1 and Q_3 are the first and third quartile of values of ranking indicators ρ_o of all DMUs participating in the test. An identical solution is applied to determine extreme values in box-plots. Due to the fact that the values of estimated ranking indicators may change depending on the number of units in the analysed group (Guzik 2009b), the testing procedure for the homogeneity of the set of objects will consist in (stage 1) the determination of ranking indexes for all the units and the elimination of these units, which proved to be excessively or insufficiently effective. In stage 2 ranking indexes are determined for units from the already reduced set and again the homogeneity of the results is tested. The procedure is repeated until a homogeneous set is obtained, when all the units are found within the limits of homogeneity.

It also needs to be mentioned here that the DEA analysis is made available in many commercial statistical programmes. An open-source version of the DEAP programme developed specially for this method may be downloaded from the website of the Centre for Efficiency and Productivity Analysis (CEPA; 2020). Apart from the software an extensive description and a user's manual are also provided. In this study for the SE-CCR model the options of the Solver function of Excel were applied.

Results and discussion

The construction of a ranking for efficiency of average farms specialising in agricultural production within individual EU member countries, at the involvement of the four basic inputs and taking into consideration three groups of products, is made possible by the application of the super-efficiency SE-CCR model. In the proposed approach in this manner six rankings were constructed, separately for each of the investigated types of agricultural production, in both analysed years. Table 2 gives values of ranking indexes ρ_0 obtained at the application of this method, focused on input savings. The table comprises only the effect of the final calculations, which were preceded by several stages related with the identification of excessively efficient units (cf. formulas (2)). All the testing stages for the homogeneity of the set of investigated objects may be followed based on a publication by Błażejczyk-Majka (2016). What is more, the Table 2 shows in bold the results of these DMUs, which in the understanding of the SE-CCR model proved to be efficient, while the last two rows contain weighted mean values of ranking indexes ρ_0, determined for the EU15 and the EU-10 (i.e., the countries, which became full members in 2004). Similarly as above, the weights in the aggregation were the numbers of farms representing a given type of production, as listed in Table 1.

As a result of testing of the homogeneity in the set of investigated units, among the average farms in individual EU countries in 2004 farms specialising in plant production in Denmark and the Netherlands were considered excessively efficient. After over a decade this group was joined by Belgian agriculture, while Dutch farms showed the highest plant production, although this technology was already available for the other EU countries. In turn, in 2016 the technology of mixed agricultural production of average Dutch farms was considered to be excessively efficient. In the case of animal production the excessively efficient technology, feasibly unattainable for the other countries was found for the average Maltese farms in both years of the study.

When analysing the research results concerning plant production it may be observed that the lowest technical efficiency in the group of the EU-15 countries in 2004 was recorded for the Portuguese and Finnish agriculture. In 2016 this group was joined by Greek agriculture. However, it needs to be stressed that in the case of Portuguese agriculture an increase in average productivity through a reduction of inputs involved in the production process by 10% in 2004 and by 7% in 2016 would

Country	Crop production		Animal production		Mixed production	
	2004	2016	2004	2016	2004	2016
(ITA)	(12) **1.125**	(10) **1.214**	(7) 1.662	(7) 1.395	(8) 1.326	(8) 1.319
(FRA)	(13) **1.111**	(13) **1.094**	(22) 0.827	(21) 0.828	(21) 0.847	(17) 0.950
(DEU)	(3) **1.842**	(14) **1.063**	(14) 1.057	(15) 0.976	(10) 1.298	(9) 1.254
(NED)	*	(1) **1.952**	(1) 2.263	(2) 2.173	(2) 2.126	*
(BEL)	(1) **2.609**	*	(11) 1.116	(13) 1.012	(3) 1.519	(2) 1.981
(LUX)		(6) **1.483**	(9) 1.231	(10) 1.095	(12) 1.184	(16) 0.971
(IRE)	(9) **1.277**		(20) 0.882	(22) 0.810	(22) 0.847	
(UKI)	(6) **1.462**	(7) **1.377**	(16) 1.030	(19) 0.884	(13) 1.170	(12) 1.109
(DAN)	*	*	(3) 1.885	(4) 1.714	(16) 1.095	(1) 2.001
(ELL)	(7) **1.427**	(19) 0.860	(10) 1.217	(16) 0.974	(5) 1.388	(11) 1.151
(ESP)	(8) **1.419**	(8) **1.293**	(12) 1.085	(14) 1.004	(9) 1.299	(10) 1.233
(POR)	(17) **0.900**	(18) 0.934	(21) 0.846	(20) 0.838	(20) 0.889	(6) 1.416
(OST)	(10) **1.273**	(3) **1.675**	(2) 2.152	(3) 1.715	(1) 2.204	(4) 1.542
(SUO)	(21) 0.660	(21) 0.761	(24) 0.714	(24) 0.783	(23) 0.646	
(SVE)	(2) **1.912**	(2) **1.696**	(8) 1.477	(6) 1.478	(4) 1.435	(7) 1.330
(POL)	(18) 0.835	(17) 0.970	(19) 0.906	(18) 0.891	(17) 1.037	(20) 0.712
(HUN)	(16) 0.909	(12) **1.130**	(4) 1.713	(8) 1.200	(6) 1.382	(14) 1.011
(SVN)		(11) **1.171**	(17) 0.969	(5) 1.596	(15) 1.097	(13) 1.047
(LTU)	(15) 0.911	(20) 0.806	(6) 1.670	(9) 1.190	(11) 1.239	(18) 0.832
(LVA)	(14) **1.026**	(22) 0.733	(5) 1.697	(11) 1.044	(14) 1.101	(19) 0.822
(CZE)	(4) **1.542**	(15) **1.004**	(13) 1.076	(17) 0.891	(18) 0.959	(15) 0.987
(CYP)	(20) 0.695	(9) **1.262**	(18) 0.967	(23) 0.801		(5) 1.531
(EST)	(19) 0.750	(16) 0.979	(15) 1.044	(12) 1.013	(7) 1.346	(21) 0.698
(SVK)	(11) **1.142**	(5) **1.487**	(23) 0.753	(1) 2.447	(19) 0.910	(3) 1.606
(MLT)	(5) **1.466**	(4) **1.631**	*	*		
OLD members mean	(9.9) 1.254	(12.0) 1.121	(13.6) 1.049	(14.5) 1.261	(11.2) 1.215	(10.4) 1.221
NEW members mean	(17.2) 0.867	(16.1) 0.966	(16.5) 0.988	(14.8) 1.080	(16.3) 0.979	(19.1) 0.758

Note: * excessively efficient production technology, considerably exceeding the capabilities of the other countries. Source: the author's calculations based on FADN data.

Source: The author's calculations based on FADN data.

Table 2: Positions in ranking and ranking indexes ρ_0 obtained using SE-CCR of average farms in individual EU countries in 2004 and 2016.

have made it possible for that country to join the group of leaders. Analysis of efficiency of farms specialising in plant production in the countries, which accessed the EU in 2004 indicates that the position of leaders was only attained by the Czech and Maltese, Slovak and Latvian agriculture. However, it needs to be stressed that the most efficient among the new EU member countries, i.e. farms specialising in plant production in the Czech Republic – turned out to be over 1.5-fold less efficient than Belgian farms specialising in plant production, belonging to the group of "old" EU member countries (EU-15). In turn, in 2016 a considerable deterioration in the ranking of efficiency was recorded for plant production in average German, Greek and Czech farms. Generally it may be stated that in 2016 diversification in terms of plant production efficiency between both groups of countries was markedly reduced. This is manifested both in the average efficiencies and positions in the ranking presented in the last rows of Table 2 as well as the differences between efficiencies of the best average farms in both analysed groups.

In contrast, a different situation was observed for animal production. In 2004 among the fifteen average farms specialising in animal production in the EU-15 only four were characterised by an inefficient production technology. These included Finnish, Portuguese, Irish and French agriculture. In 2016 this group was composed of as many as seven countries. The above-mentioned were joined by Greek and British agriculture. Particularly in the case of Greek agriculture the reduction in efficiency of farms specialising in animal production in the investigated period was considerable. In turn, among the countries, which became full EU members in 2004, a situation was observed, which may be interpreted as almost opposite: only in relation to four countries – Slovakia, Cyprus, Slovenia and Poland – animal production may have been run more efficiently (cf. Kocisova et al., 2018). These results correspond to studies carried out separately for the production of pigs or milk (Błażejczyk-Majka and Kala, 2015b; Havlíček et al., 2020; Kroupová et al., 2020). Nevertheless, it needs to be stressed that except for Slovakian agriculture reaching full efficiency of farms specialising in animal production was connected with the limitation of the consumption of inputs by max. 10%. A comparison of the results concerning efficiency of plant and animal production in 2004 indicates that the gap between efficiency of animal production in the "old" and "new" EU member countries was much smaller than in the case of plant production. This result can be a voice in the discussion to the conclusions of Kusz (2014) or Heyl et al. (2021) who argued that modernization in modern agriculture is limited by environmental requirements, finiteness of natural resources, alongside the "rights" of farm animals as well as the social and cultural consequences, such as those related to the viability of rural areas. What is more, after over a decade of operation with the CAP and the realisation of the Luxembourg CAP Reform assumptions the gap between the "old" and "new" EU member countries in terms of animal production was greatly reduced. In the case of animal production we may even talk about its elimination. Of course, it is difficult to decide at this stage of the research to what extent this situation had been determined by the EU and national funding of EU cohesion policy (Ferry & McMaster, 2013).

As was shown in the analysis concerning farm structure in the EU (cf. Table 1) since the greatest to date EU enlargement in 2016 the number of farms specialising in mixed production was markedly reduced. This trend was particularly evident in the countries, which became full EU members in 2004 and was observed in another research too (Lucyna Błażejczyk-Majka and Kala, 2015a). In turn, based on the results of the SE-CCR model (cf. Table 2) it may be stated that efficiency of this type of farms in the "new" EU countries deteriorated. In 2004 six new EU countries ran agricultural production efficiently. In the next investigated year this number decreased to four. Only mixed farms in Slovakia (similarly as in the case of plant and animal production) recorded a considerable increase in efficiency. In turn, in the case of the EU-15 as many as six countries showed an increase in the ranking position, while in the case of Danish agriculture it was an extreme improvement of agricultural production efficiency.

Conclusion

The agricultural policy of the European Communities, and later the European Union has always aimed at reaching food self-sufficiency for its population. In turn, the beginning of the 21st century has marked the need for free agricultural markets and face strong external competition, which has been connected with an almost complete rejection of the Common Agricultural Policy instruments related with direct support for agricultural production. In such a situation the aim connected with the maintenance of food self-sufficiency of the EU member countries has become practically equivalent to the need for improvement of production efficiency in individual EU countries. On the other hand, since the very beginning the European Community has been striving to reduce the differences existing between the various regions and the backwardness of the less favoured regions (Treaty of Rome 1957). At the turn of the 20th and the 21st century the cohesion policy became a priority in relation to the other policies. Agriculture and rural areas are currently supported indirectly by eliminating barriers for convergence processes, particularly by strengthening the economic, social and cultural as well as the institutional and business environments (Kudełko et al., 2011). An especially interesting aspect is connected with the coupling of this trend with the CAP assumptions, which was manifested in the Luxembourg CAP Reform introduced in 2003.

The conducted analyses show that agricultural production in the EU is characterised by certain diversification, although in most cases efficiency of farms is comparable. In the case of the EU agriculture in 2004 only three countries ran agricultural production in technologies, which efficiency may not have been attainable for agriculture of any other EU country investigated in this study. In this respect the technology of plant production applied in the Netherlands and Denmark as well as the technology of animal production used in specialist farms in Malta. In 2016, the group of these countries was joined by Belgium (plant production). In the case of Dutch agriculture after over a decade of the CAP operation the plant production technology in that country became attainable, but it was the most efficient among all those used in the EU. In turn, efficiency of mixed farms in the Netherlands in the last investigated year was considerably different from the potential of farms in the other EU member countries.

In the first months of the realisation of the Luxembourg CAP Reform assumptions and in the year of the greatest EU enlargement it was shown that the "old" EU countries while far from homogeneous in terms of the outcomes, nevertheless showed on average higher efficiency in each of the three types of agricultural production. The most evident disparities were recorded in the case of plant production, while they were smallest in mixed production. Analysis of the outcomes conducted analogously for the year 2016 indicated that the gap between the "old" and the "new" member countries has narrowed, although these changes were not uniform. these results can be considered as complementary and detailed to the conclusions of (Baráth and Fertő, 2020).

Study results confirmed the necessity to conduct such comparisons taking into consideration the type of agricultural production. The most evident improvement was recorded in the case of animal production. In that area even a gradual unification may be observed in the level of agricultural production efficiency. This situation may have been influenced by the high environmental standards in animal production, common and equal for all the EU member countries, which have to be met by agricultural producers, and which in accordance with the Luxembourg CAP Reform assumptions are an indispensable element of support for agriculture.

A particularly important aspect is related with changes in farms specialising in mixed production. Firstly, the quantitative analysis for the structure of the EU farms indicated that the Luxembourg CAP Reform in the area of agriculture led to changes in farm structure. Especially marked changes may have been observed in the case of the "new" EU countries, with a marked farm specialisation. It was manifested in the reduced share of mixed farms at an increase in the number of farms specialising in plant production. Changes in that direction seem simpler and cheaper to implement than those towards the more input-intensive animal production.

Based on these conclusions the preliminary research hypothesis presented in the Introduction may be partly rejected. It turned out that in the EU agriculture in the case of plant and animal production, in contrast to the situation observed in the other branches of the economy in the years 2004 – 2015, a simultaneous growth of production and improvement of efficiency could be attained in individual EU member countries, along with a gradual reduction of disparities in the efficiency of agricultural production between the regions. However, this process was not uniform and it is necessary to distinguish the differences in the rate of changes in individual types of farms. The only area, in which no such dependence could be observed, is connected with production of mixed-type farms.

The presented approach allows for a comprehensive and multidimensional evaluation of changes in agricultural productivity in agriculture of individual EU members, and, consequently, for a macroeconomic assessment of the effects of the constantly implemented reforms of the CAP and the cohesion policy. However, the presented results have been established for selected years. To establish the trend of changes in this area, analyses should be made for each year of the period under examination. This is the direction of further research.

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Do Subsidies Decrease the Farm Income Inequality in Hungary?

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Abstract

The paper investigates the impact of different sources of income on farm household income inequality in Hungary using Farm Accountancy Data Network dataset for the period 2007-2015. The decomposition of the Gini coefficients by income sources is applied to focus on the impact of the policy shift from market to government support on farm household income inequality. Off-farm income are rather stable with a slight increase impact on farm household income inequality. Pillar 1 for direct income support subsidies have remained more important than Pillar 2 for rural development subsidies for farm income due to the importance of direct payments or single area payments for crop production. A slight increase in the importance of subsidies from Pillar 2 can be linked to a policy shift towards targeting farms in less favoured areas, and a greater role of agri-environmental and other rural development payments. The most striking finding is regarding instabilities, declining pattern, and for a large majority of farms negative market income. Subsidies from Pillar 1 reduced, while market income increased farm household income inequality.

Keywords

Income inequality, off-farm income, Gini decomposition.

JEL code: Q12; Q18; D31; H23

Fertö, I., Bojnec, Š. and Podruzsik, S. (2022) "Do Subsidies Decrease the Farm Income Inequality in Hungary?", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 2, pp. 49-56. ISSN 1804-1930. DOI 10.7160/aol.2022.140204.

Introduction

Reduction in income inequalities for farmers is one of the policy challenges. The available public financial resources, and the restructuring of budgetary expenditure patterns generate additional issues for farm income inequality to be resolved. Outside the European Union (EU), attempts have been made to address the situation by amending the regulatory and institutional frameworks, and strengthening market orientations, meanwhile, the goal is to eliminate income inequality between farmers (Mirsha et al., 2009). The impact of the policy measures applied may vary depending on whether the payments are decoupled from production (Espinosa et al., 2021), on the share of market income and direct payments within the total farm income (Nitta, 2020) as well as the size of farms and their market positions (Moreddu, 2011). The effect of market income remains significant while its share in total farm income decreases (Allanson, 2005; Bojnec & Fertő, 2019a). In addition to subsidies, the role of social factors such as education can eliminate or increase farm income inequalities (Gardner, 1969). Due to agricultural policy regulations, the concentration of direct payments on a smaller number of larger farms is observed in several countries. Small number of larger farms can receive most of the direct payments while a large number of small farms share the remaining part of subsidies (Witzke and Noleppa, 2007; Beluhova-Uzunova et al., 2017, 2020). Regional differences in economic and agri-environmental conditions and the regional needs can also influence the effects of reducing income inequality by direct payments (El Benni and Finger, 2013; Tantari et al., 2019). The level and distribution of farm incomes and their potential inequality have been topics of the highest political and economic importance (e.g., Aristei and Perugini, 2010; Fragoso et al., 2011).

Earlier literature has developed and empirically applied the concept and the context of the decomposition of the Gini Coefficient to the structure and evolution of farm income and agricultural household income (Keeney, 2000;

Mishra et al., 2009; El Benni and Finger, 2013; Severini and Tantari, 2013a, 2013b, 2015). These papers focus on the impact of Common Agricultural Policy (CAP) reform on farm income and farm household income inequality. While there may be heterogeneity in results across EU member states and their regions, most studies report that subsidies have reduced income concentration and thus also farm household income inequality. Keeney (2000) finds that direct payment policies have reduced farm income concentration in Ireland – particularly, the compensatory allowances awarded to farmers in areas faced with natural production handicaps – which are at the greatest risk of having low farm income. Allanson (2006) and Allanson et al. (2017) for Scotland, Allanson and Rocchi (2008) in a comparative study of Scotland and Tuscany (Italy), El Benni et al. (2012) and El Benni and Finger (2013) for Switzerland and Severeni and Tantari (2013a, 2013b, 2015) and Cilierti and Frascarelli (2018) for Italy have reported that agricultural support, especially direct payments (within the EU's CAP Pillar 1) have reduced income concentration and thus reduced farm income inequality within the agricultural sector. Hanson (2021) carried out a panel-level assessment for the redistributive impact of the 2013 CAP reform. The negative impact of direct payments has been shown for the largest beneficiaries while the redistributive effect on small farms is significant. Bojnec and Fertő (2019b) find that subsidies from Pillars 1 and 2 reduce farm income inequality in Slovenia especially for less-favoured area (LFA) farms. In short, empirical evidence suggests that farm subsidies may reduce the farm income inequalities in investigated European countries.

This paper contributes to the analysis of the impact of CAP reform on farm household income inequality. While the effects of agricultural policy on farm income inequality is well documented for the Western European countries and for other developed countries there have been limited similar studies for Central and Eastern European countries (except Bojnec and Fertő 2019b for Slovenia). Hungary with a dual farm structure is an interesting example to investigate the farm income inequality issues.

The remainder of this paper is structured as follows. In Sections 2 and 3, the methods and data used are presented. Section 4 presents and explains our results on the effects of CAP reforms on the income distribution of farm households. Section 5 discusses the results and derives policy implications focusing on the effects of subsidies from Pillars 1 and 2 on farm household income inequality. Finally, Section 6 summarises main findings and concludes with study limitations and directions for research in future.

Material and methods

The chosen method is based on the approaches employed in earlier literature (Keeney, 2000; Mishra et al., 2009; El Benni et al., 2012; El Benni and Finger, 2013; Severini and Tantari, 2013a, 2013b, 2015), in which income is generated by k components, and the decomposition of the Gini (G) coefficients by income sources is undertaken in the following way:

$$G = \sum_{k=1}^{K} R_k * G_k * S_k \quad (1)$$

where R_k is the 'Gini correlation' between income component k and the rank of total income, G_k is the Gini coefficient for the k^{th} income component, and S_k is income share of the k^{th} income source.

The concentration of coefficients of the kth income source (C_k) is defined as:

$$C_k = R_k * G_k \quad (2)$$

The 'proportional contribution to inequality' of the k^{th} income source (P_k) is defined as:

$$P_k = R_k * G_k * S_k/G \quad (3)$$

and the Gini coefficient rate of change with respect to the mean of the k^{th} income component is defined as:

$$\frac{dG}{d\mu_k} = \frac{1}{\mu} * (C_k - G) \quad (4)$$

Data

The Hungarian Farm Accountancy Data Network (FADN) for the period 2007-2015 is used as a data source to evaluate the impact of CAP reform and economic recession on farm income inequality in Hungary. In addition, price indices as deflators obtained from the Hungarian Statistical Office are used to transform current forint values into constant forint values using 2010 as the base-year. Total farm income is comprised of two potential components: 1) income components, which can contain market income and off-farm income, and; 2) subsidy components, which can contain subsidies from Pillars 1 and 2. Pillar 2 support includes subsidies related to agri-environmental measures, LFAs and other rural development measures.

Table 1 presents summary statistics of variables used from the Hungarian FADN datasets at a farm level. A large variation between negative minimum

Variables	Obs	Mean	Std. Dev.	Min	Max
total income	17553	144,691.80	438,488.9	-630,617.5	10,500,000
off-farm income	17553	29,419.96	211,300.4	-8,788.5	8,132,372
market income	17553	50,281.12	232,651.6	-6,355,737.0	6,058,521
total subsidy	17553	64,990.67	203,350.5	0	5,088.339
Pillar 1 subsidy	17553	53,239.47	157,633.4	0	3,786,887
Pillar 2 subsidy	17553	11,751.20	56,867.9	0	1,749,941

Source: Authors' calculations

Table 1: Summary statistics of variables (Euro).

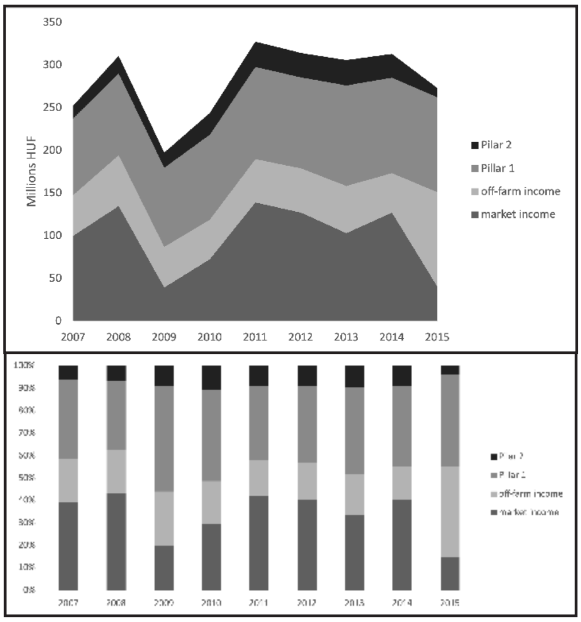
values and positive maximum values can be seen for total income, off-farm income and market income. As a remarkable is the negative minimum value for market income. Pillar 1 subsidies are more important than Pillar 2 subsidies in total CAP subsidies.

Results and discussion

The empirical results are presented in four steps. First, we present the evolution of farm household income structures in constant value terms and as relative shares. Second, we present total farm income inequality distribution by sources of income and total CAP subsidy distribution. Third, the farm household income inequalities rising the applied Gini coefficient decompositions. Finally, inequalities in total farm household income and total CAP subsidies distribution are presented by the Lorenz curves.

The evolution of total farm income and its components

Figure 1 illustrates the evolution in total farm income for total sample of FADN farms in Hungary (Figure 1 upper part). Total farm income tends to increase but undergoes considerable cyclical oscillation and a rapid decline in 2009 as well as in 2015 largely due to the considerable decline in market income. Due to this drop in market income, which is determined by farm output sales and output prices, its relative importance in total farm household income also declined (Figure 1 lower part). Off-farm income, except for an increase in 2015, remained rather stable both in terms of value and in the structure of total farm income. Subsidies from Pillar 1 remained more important than subsidies from Pillar 2. The share of subsidies from Pillars 1 and 2 in total farm household incomes tends to a slightly increase over time. The most remarkable is a substantial decline of market income and its role in total farm household income.



Source: Authors' calculations

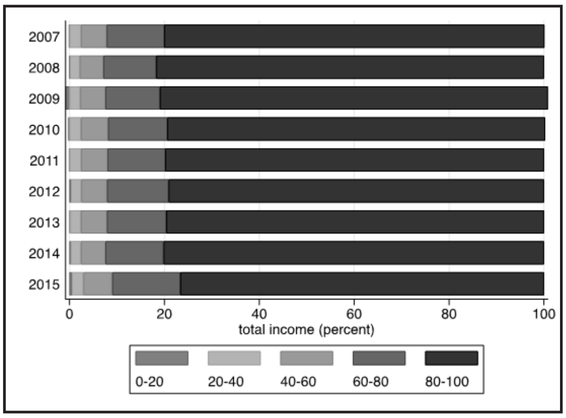
Figure 1: Income and income composition for total farms, 2007–2015.

Farm income inequality and CAP subsidy distribution

Figure 2 presents rather unequal distribution of total farm income that remained rather stable over the years 2007-2015: 20% of the largest farms according to total farm income contributed around 80% of total farm income. The second largest group of farms contributed additional around 10% of total farm income. Finally, all other 60% of smaller sized farms according to total farm income contributed less than 10% of total farm income.

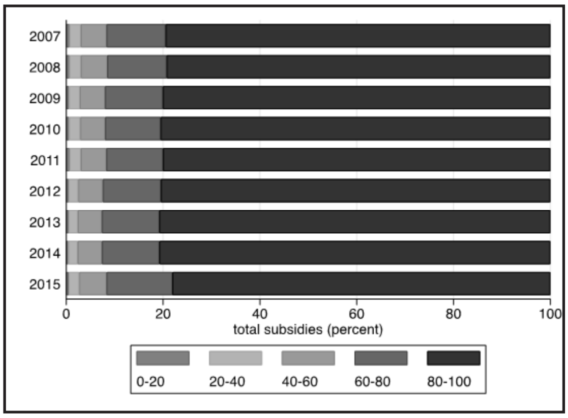
A strong concentration of income source on a smaller percentage of largest farms is also confirmed for distribution of total subsidy payments. The comparison of Figure 2 and 3 confirmed rather similar distribution of total farm income with distribution of total subsidies according to the farm size: 20% of the largest farms according to total subsidy payments received around 80% of total CAP subsidies; the second largest group of farms received additional around 10% of CAP subsidies, and all other 60% of smaller sized farms according to total subsidy payments received less than 10% of CAP subsidies.

The unequal distribution of total farm income and CAP subsidies strongly revealed dual structure of Hungarian farms where a smaller number of largest commercial farms dominates in the structure of total farm incomes and total CAP subsidies received by farms over a larger number of smaller, mostly individual farms.



Note: Cumulative percentage of total income by the quintiles of farm size.
Source: Authors' calculations

Figure 2: Distribution of total farm income between 2007 and 2015.



Note: Cumulative percentage of total income by the quintiles of farm size.
Source: Authors' calculations

Figure 3: Distribution of total CAP subsidy payments between 2007 and 2015.

Gini coefficient decompositions

The Gini (G_k) coefficients decomposition according to the different farm income sources ranged between 0 and 1, except for market income (Table 2), which overshoots 1 due to a negative farm income caused by losses from farm market activities (Manero, 2017; Bojnec and Fertő, 2019). Market income, off-farm income, and Pillar 2 subsidies (LFA payments, agri-environmental measures, and other rural development programs) are much more unequally distributed than subsidies from Pillar 1 (direct payments). Market income depends on quantity of sales and farm prices as well as possible relative farm output price changes between farm production specializations. Not all farms are engaged in off-farm income activities. LFA payments depends on a farm location in a specific, for farm less favourable production conditions. Agri-environmental payments are based on a voluntary farm participation in implementation of these farming practices. While other rural development payments largely depend on specific farm project investment and on-farm diversification activities supporting by rural development program.

Between 2007 and 2015, the Gk coefficients suggest substantial overshoots 1 for market income, a slight increase in income inequality from off-farm income, and Pillar II subsidies, while the G_k coefficient remains at similar level for Pillar 1 subsidies. Pillar 1 direct payment subsidies are often paid for use of farm-inputs such as cultivation per a hectare of utilized agricultural areas with certain crops and per a head of livestock payments.

The proportional contribution (S_k) to farm income inequality by income sources changed between 2007 and 2015. While in 2007, market income, Pillar 1, and off-farm income play a crucial role in terms of their proportional contribution to farm income inequality, this changed in 2015 with a substantial decline of market income and increased of off-farm income and Pillar 1 subsidies. Interestingly, unlike for Slovenia (Bojnec and Fertő, 2019), the proportional contribution of subsidies from Pillar 2 in Hungary is less important than from Pillar 1 for farm income inequality. The S_k for off-farm income remains at relatively low value but makes a relatively stable proportional contribution to farm income inequality. The most remarkable is the substitution effect of market income with off-farm income and further increase of Pillar 1 subsidies to the proportional contribution to farm income inequality. As can be seen from Table 1, there is also a strong correlation between the columns S_k and the Share suggesting that they capture similar structures.

The Pseudo-Gini correlation (R_k) coefficients of the different farm income sources are greater than 0, suggesting that income from the specific income sources is mainly distributed to farms in the upper tail of farm income distribution (El Benni and Finger, 2013). Except for market income in 2015, all other sources of income are strongly correlated with total farm income. The highest Pseudo-Gini coefficients are found for off-farm income and subsidies from Pillar 1. Unlike for Slovenia (Bojnec and Fertő, 2019), the Pseudo-Gini coefficients suggest that subsidies from Pillar 2 in Hungary are a slightly less important than subsidies from Pillar I. This can be explained by a greater role of direct payments from Pillar 1 for crops as an important source of income for Hungarian farms.

The estimated changes in the Gini Elasticities for the different income sources relating to farm income distribution, which is presented in the last column in Table 2, they range between less than zero (negative values) and more than zero (positive values). Values above 0 for market income and off-farm income in 2005 and off-farm income and Pillar 2 subsidies show that an increase in the income source under consideration of 1 per cent increased total farm income inequality (as measured using the Gini coefficient) by the defined percentage, ceteris paribus. While values below 0 for an increase in Pillars 1 and 2 subsidies in 2007 and an increase in market income and Pillar I subsidies in 2015 decreased the inequality of total farm income.

The values for the Gini elasticity of market income and off-farm income are positive in 2007. A 1% increase in market income and off-farm income could increase the Gini coefficient of total income by 0.0114% and 0.024%, respectively. The Gini elasticities of Pillar 1 and Pillar 2 subsidies present an equalizing effect in 2007, 1% increase in Pillar 1 and Pillar 2 subsidies reduce the Gini coefficients of total income by 0.0315% and 0.0039%.

The Gini elasticities show different impacts in 2015 by income sources. The market income and Pillar 1 subsidies reduce the Gini coefficient of total income by 0.0642% and 0.0223%. The off-farm income and Pillar 2 subsidies increase the Gini coefficient of total income by 0.0864% and 0.0001%.

Lorenz curves of total farm income and CAP subsidies distribution

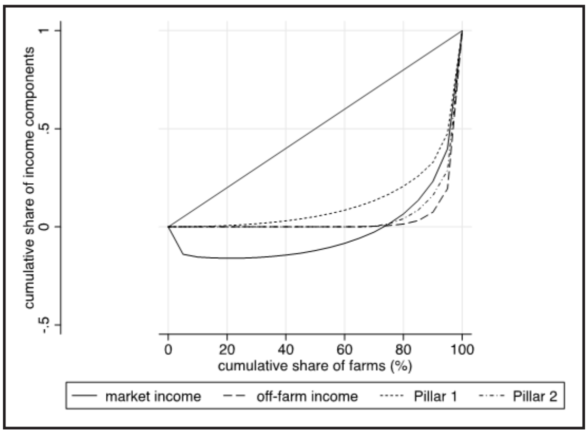
The Lorenz curves reinforce the striking finding on unequal distribution in farm income components according to their farm size. Almost 80% of Pillar 2 subsidies and particularly off-farm income were received by the largest 20% of farms, and these patterns were further strengthened between 2007 and 2015. Interestingly, Pillar 1 subsidies were a slightly less concentrated, but their inequality a slightly increased between the analysed years. The most striking finding is the negative market income for a large majority of the Hungarian FADN farms. In 2007, more than 70% of smaller farms experienced negative market income (Figure 4). Up to 2015, the percentage of farms with negative market income further increased and the negative market income became of larger size for a greater percentage of farms: around 95% of farms experienced negative market income (Figure 5). We can conclude that subsidies from Pillars 1 and 2 and off-farm income for a large majority of Hungarian farms were spent to cover losses or negative farm market income, and except for the largest farms according to total farm income, to reduce farm income inequality.

In their study, Enjoras et al. (2014) point out that public policy income redistribution poses a significant challenge to farm management and policy-making due to fluctuations in agricultural incomes. The framework for income redistribution in the EU is provided by the CAP, which has been undergoing reforms since the 1990s (Sinabell, 2013). One of the tools for this is direct payments or single area payments within Pillar 1, which are for several EU countries, including for Hungarian

Source	Sk	Gk	Rk	Share	Elasticity
	2007				
market income	0.3947	1.0594	0.7504	0.4061	0.0114
off-farm income	0.1895	0.9396	0.9265	0.2135	0.024
Pillar 1	0.3553	0.7589	0.9279	0.3238	-0.0315
Pillar 2	0.0604	0.9089	0.7958	0.0566	-0.0039
	2015				
market income	0.1468	3.3743	0.1228	0.0826	-0.0642
off-farm income	0.4065	0.9584	0.9314	0.493	0.0864
Pillar 1	0.4068	0.7532	0.9237	0.3845	-0.0223
Pillar 2	0.0398	0.938	0.7868	0.0399	0.0001

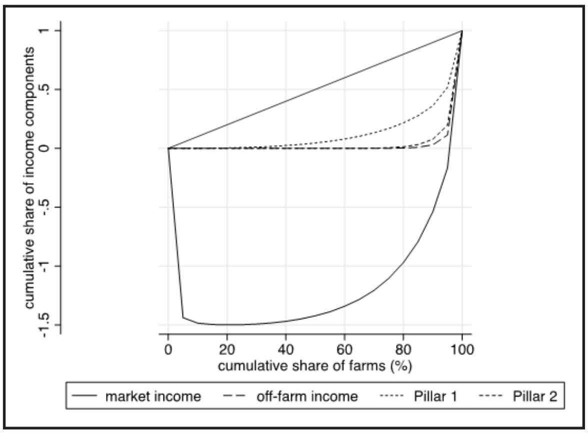
Source: Authors' calculations

Table 2: Gini decomposition of farm income in 2007 and 2015.



Source: Authors' calculations

Figure 4: Lorenz curves of farm income components in 2007.



Source: Authors' calculations

Figure 5: Lorenz curves of farm income components in 2015.

farms, the most important expenditure within CAP. The decoupling of direct payments from the level of farm production is intended to reduce income inequalities. The impact of it has been investigated in several studies (Ciliberti and Frascarelli, 2018). Based on the previous literatures, it becomes clear that the concentration of direct payments towards larger input-based farms is rather heterogeneous, with a high concentration in some EU Member States (Severini and Tantari, 2014). With the single payment scheme, differences in concentration cannot be clearly explained. The impact may vary not only from region to region but also from country to country. However, previous studies agree that CAP payments should be decoupled from the level of farm production and it is necessary to limit the amount of direct payments that can be paid to the largest beneficiaries (Nitta et al., 2020). Previous studies (El Benni and Finger, 2013; Tantari et al., 2019; Bojnec and Fertő, 2019b) used FADN data to show how income inequalities in the different regions or farming sectors with different production conditions evolved as a result of direct and other CAP payments.

The effect of farm market incomes, off-farm income, and CAP subsidies from Pillars 1 and 2 on farm income distribution is examined using the Gini coefficient decomposition. The Gini coefficient is a greater than 1 and increased between the years 2007 and 2015 due to a negative value for farm market income. The negative market income for a large majority of Hungarian FADN farms suggests that without CAP subsidies and off-farm income most of farms would more likely not be able to cover their operation costs and be able to survive.

A large dependence of farms on CAP subsidies and non-farming activities can be a treat for future development as they not only largely reduce the farm income inequality among Hungarian farms and rural areas, but they are also keeping them a live to maintain farming, particularly the restructuring and exit of less efficient and competitive farms. It might be also that several farms can be indebted, what has not been investigated and can be an issue for research in future.

There is less clear pattern regarding the convergence processes toward a reduction in concentration of CAP subsidies that would allow for a more equal distribution of support for lower income farms. Direct payments from Pillar 1 correlate to the level of farm income for Hungarian farms still more than the source of market-driven income that is rather volatile with a declining pattern. Therefore, direct payments from Pillar 1 represent a significant proportion of total farm income and have an impact on income equality (Ciliberti and Frascarelli, 2018). However, the system of CAP payments needs to be reformed to eliminate inequalities in the distribution of payments between the farms and regions of the EU. To improve the efficiency and equity of CAP measures, income support needs to be better defined and information provided on the farm income and wealth situation of the agricultural population.

Conclusion

The paper investigated the development of income inequality in Hungarian agriculture over the period 2007–2015 using FADN data. A shift in CAP policy and related measures, off-farm income, and particularly volatile and declining farm market income have determined the evolution and structure of farm incomes. While CAP subsidies can distort production activities and agri-food markets and postpone farm restructuring, they can also reduce farm household income inequality.

Our calculations highlight the importance of CAP subsidies in Hungarian farms and indicate that the role of CAP subsidies in farm incomes increased during the period of analysis. This can be explained by the existence of large-scale commercial and other crop farms in association to Pillar 1 direct payments, the small-sized farms and poor natural conditions for agricultural production in association to Pillar 2 rural development payments. CAP reform in rural development policy during the period 2007-2015 contributed towards the stabilization of farm incomes, which were volatile, declining and even negative for a large majority of Hungarian farms for market income.

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Agris on-line Papers in Economics and Informatics

Volume XIV Number 2, 2022

Are There the Impacts of Environmental Regulations on Manufacturing Export? Empirical Evidence from Chinese Manufacturing

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Abstract

Environmental regulation is an effective tool to control environmental problems caused by foreign trade. Research conclusions are inconsistent on the relationship between environmental regulations and exports. Based on the Heckscher-Ohlin-Vanek model, this paper provides an empirical analysis for examination the effect of environmental regulations on manufacturing exports, adopting panel data of 16 sectors from China's manufacturing during 2005-2015. Material capital, human capital, technology input and foreign direct investment are simultaneously selected as independent variables to explore the export impact of corresponding changes in these endowments. The pollution intensity index was introduced to categorise different manufacturing sectors. Results indicated that China's environmental regulations intensity play different roles in the manufacturing sectors with different pollution levels. Stricter environmental regulation improves the export of intensive pollution manufacturing sectors but hinders exports in light pollution sectors. Meanwhile, other endowment factors also exert varying effects in the light, moderate and intensive pollution manufacturing sectors.

Keywords

Environmental regulation, Heckscher-Ohlin-Vanek model, manufacturing export, China, pollution index.

Liu, Ch. and Rumánková, L. (2022) "Are There the Impacts of Environmental Regulations on Manufacturing Export? Empirical Evidence from Chinese Manufacturing", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 2, pp. 57-72. ISSN 1804-1930. DOI 10.7160/aol.2022.140205.

Introduction

The massive expansion of economic activity has changed the global environment more drastically and extensively than ever before, threatening sustainable economic development (Cai and Ye, 2020). As an essential driving force of rapid modern economic growth, international trade and environmental issues are inseparable. International trade is not only the exchange of goods and services between two countries or regions but also the exchange of natural resources and the ecological environment (Xiong and Wu, 2021). Awareness of regulating the environmental problems caused by international trade has been growing in recent decades, intensifying the global trend of increasingly stringent environmental regulations. An advanced understanding of the relationship between environmental regulations and international trade has become a significant topic for current and future research on human well-being and sustainable economic development (United Nations, 2015).

Since entering the WTO in 2001, the export trade has experienced an explosive expansion in China. The gross trade volume of Chinese exports grew from 0.27 USD trillion in 2001 to 2.50 USD trillion in 2019, equalling about 4.3% and 13.2% of gross world exports, respectively (NBSC, 2020). China's manufacturing actively participates in the global value chain (GVC) to assume the "world factory" role in the international community, capitalising on cheap labour, abundant raw materials, and a relatively complete industrial system. As of 2019, China's export of manufactured goods exceeded 2.37 USD trillion, making it a mainstay of China's export growth. However, China's manufacturing sectors mainly engage in middle and lower value-added production activities in the GVC and lack a say in regulation-making. Most heavy polluted industrials have been relocated from developed countries to developing countries due to low-cost advantages and loose environmental regulation, which means a transfer occurred in ecological resources consumption and environmental pollution (Copeland and Taylor, 2004). As the world's greatest carbon emitter, approximately 22% of China's total annual carbon dioxide emissions are generated from net exports (Qi et al., 2014). Thus, there are substantial environmental risks hidden behind the prosperity of China's manufacturing export. In a new normal of China's economy, the development of manufacturing export has shifted to a more quality-oriented, heralding the growing importance of environmental regulation.

Environmental regulation stems from environmental externalities, property rights theory and welfare economics (Zhu et al., 2019). Generally, the environmental resource is taken as freely accessible public goods (non-rival and non-excludable), resulting in the ineffectiveness of conventional market mechanisms to manage them. To this end, environmental regulation is an indispensable policy measure for regulators to control ecological problems and regulate economic activities to achieve economic and ecological coordination and sustainable development (Pigou, 1924). In economic globalisation, environmental regulation has been a conventional and effective tool for a country to deal with environmental issues caused by foreign trade. Generally, environmental regulation is defined as a set of environmental measures imposed by governments or economic organisations to protect the environment that impacts international trade, either mandatory or voluntary (Jiang et al., 2018). Policy discussions regarding industrial upgrading and greening manufacturing in China recently focused on the alleged trade-off between economic development versus environmental protection. This complex trade-off is especially evident in disputes about the effect of environmental regulations on the export scale in China's manufacturing. As China's environmental regulation became increasingly mature, there is an emerging concern regarding its impacts on manufacturing export trade (Wang et al., 2016).

Neoclassical economics model, stressing upon the "cost increase" effects, assumed that stricter environmental regulations increase production constraints and compliance costs of the regulated enterprises, and ultimately weaken the comparative advantage (Palmer et al., 1995; Cole et al., 2010). The additional economic burden will cause difficulties in the production, operation and sales of enterprises (Hering and Poncet, 2014), thereby reducing the product competitiveness and ultimately resulting in a cut down in the export possibilities and export volumes (Shi and Xu, 2018; Zhang, Cui and Lu, 2020). The pollution heaven hypothesis holds that compliance costs tend to prompt intensively polluted industries to transfer from countries with stricter environmental regulations to less environmentally regulated countries, reducing the corresponding industrial's export (Walter and Ugelow, 1979; Levinson,2010; Brunel, 2017; Cai et al.,2018). Contrarily, many scholars hold another view that environmental regulations would play a positive role in developing export trade (Rubashkina et al., 2015; Millimet and Roy, 2016). The most representative of theses, the Porter hypothesis (Porter, 1991), postulates that the well-designed environmental regulations could effectively reduce contamination, accelerate enterprise technology innovation, thus stimulating innovation compensation effects. This positive effect ultimately offset compliance costs and improve enterprise competitiveness and economic performance. Growing environmental compliance would affect export development patterns to enhance productivity and product competitiveness through innovative compensation effects, then achieving a win-win situation in alleviating environmental pressures and export growth (Porter and Van der Linde, 1995). Extensive empirical analyses have validated the Porter hypothesis that environmental regulations could be a critical driving force for increasing green export (Brandi et al., 2019; Zhu et al., 2019). There are also many theoretical and empirical studies that neither supports harmful effects nor beneficial effects. These findings have shown that changes in environmental regulation have uncertain or non-linear impacts on trade (Cole et al., 2005; Arouri et al., 2012; Ouyang et al., 2020; Song et al., 2020). Quantitatively estimating the effects of Environmental regulation is thus of great practical significance for accelerating the green development of China's manufacturing and enhancing promoting sustainable development of its export.

Given the above research background, this paper adopts the industrial panel data covering 2005-2015 to quantitatively explore how environmental regulation influences China's manufacturing export and how the effect differs across manufacturing sectors with various pollution intensities. First, this study introduces a pollution index to classify China's manufacturing sectors according to the degree of pollution. Second, this research measures the intensity of China's environmental regulation by using pollution discharge and pollution control expenditures as the evaluation method. In addition, environmental regulation is incorporated into the analysis framework of trade's influencing factors based on the Heckscher-Ohlin-Vanek (HOV) model. In the end, this paper to uncover the effect of selected factor endowments (environmental regulation, material capital, human capital, technology input, foreign direct investment) on China's exports of different manufacturing sectors.

Materials and methods

Classification of manufacturing sectors

In the case of the data availability, this research was conducted based on the sector-level data. As the classification system of the manufacturing sector in the National Economic Industry Classification Code (GB/T4754-2002) is inconsistent with ISIC Rev.4, this research has integrated and matched the sector code following the industry consolidation in the existing literature, to achieve consistency among sector codes.

To distinguish the pollution intensity of different manufacturing sectors, there needs to be an industrial pollution emission index. Existing kinds of the literature showed that the method of measuring industrial pollution intensity mainly include Pollution abatement and control expenditures (PACE), the ratio of the emissions in the industrial added value, standardized emissions data and pollution emission index (Fu and Li, 2010). Due to the Chinese government not having statistics on the cost of pollution reduction by sector, this study used the last quantitative method of Fu and Li (2010) to evaluate the pollution intensity. Manufacturing pollution is mainly manifested in the discharge of wastewater, waste gas and some toxic solid wastes. Using a method of Kheder and Zugravu (2012), this research standardized three pollutant emission indexes for various sectors, then calculated the pollution intensity index.

Based on the following formulations (Table 1), the pollution intensity of different sectors in China's manufacturing industry from 2005 to 2015 was calculated. The higher the pollution intensity index, the greater the sector's pollutant emission intensity, and the heavier the burden on the environment. After ranking the 16 industries by the size of the pollution intensity index, the pollution degree of sector is categorised according to its comparison with the cut-off point 0,05 and 1: intensive, moderate, and light (Copeland and Taylor 2004; Fu and Li, 2010) (Table 2).

Measurement of environmental regulation intensity

Various measurement methods have been used in the existing literature to quantify the stringency of environmental regulation, including qualitative indicators based on questionnaire research, the number of environmental regulations, the density of pollutant emissions, PACE, GDP per capita and Comprehensive indicators.

Measuring the level of environmental regulations

Step	Calculation	Explanation
Pollution emission index (Fu and Li, 2010)	$PE_{ij}=P_{ij}/TV_i$	PE_{ij}: pollution emission index of pollutant j in sector i
		P_{ij}: emission volume of pollutant j in sector i
		TV_i : total output value of sector i
Standardize (Kheder and Zugravu, 2012)	$\overline{PE}_{ij} = \frac{PE_{ij} - Min(PE_j)}{Max(PE_j) - Min(PE_j)}$	$\overline{PE}_{ij}$: normalized pollutant emission index
		$Max\ (PE_j)$: entire industrial maximum pollutant emission index of pollutant j
		$Min\ (PE_j)$: entire industrial minimum pollutant emission index of pollutant j
Pollution intensity index (Fu and Li, 2010)	$PI_i=\sum_j^3 \overline{PE}_{ij}$	PI_i : pollution intensity of sector i

Source: Own processing

Table 1: Pollution intensity index calculation steps.

Class	Code	Section description	PI
Intensive pollution sector PI>1	11	Manufacture of basic metals	1.6975
	4	Manufacture of paper and paper products	1.6011
	10	Manufacture of non-metallic mineral products	1.3512
	7	Manufacture of chemicals and chemical products	0.9887
Moderate pollution setctors 0.05<PI<1	6	Manufacture of coke and refined petroleum products	0.4593
	1	Manufacture of food, beverages and tobacco	0.2455
	8	Manufacture of medicinal and pharmaceutical products	0.1947
	2	Manufacture of textiles, wearing apparel and leather	0.1801
	3	Manufacture of cork and wood products (except furniture)	0.1601
	12	Manufacture of favricated metal products	0.1169
Light pollution sectors PI<0.05	9	Manufacture of rubber and plastics products	0.0562
	14	Manufacture of transport and related equipment	0.0425
	15	Manufacture of electronic and optical products	0.0275
	16	Manufacture of furniture	0.0184
	13	Manufacture of machinery and equipment	0.0140
	5	Printing and reproduction of recorder media	0.0106

Source: Own computation, the China Environmental Yearbook 2005-2016

Table 2: Ranking of the mean value of the sector's pollution intensity index (PI).

at the industrial level mainly depends on the response and compliance of economic entities in the industry. For the manufacturing industry, environmental regulation intensity could be quantified by controlling pollution emissions. Thus, this paper thereby integrated pollution control costs and pollution emissions when constructing indicators. By referring to previous literature method (Li and Li, 2017), the pollution control investment per unit of pollution discharge is employed as an indicator to measure the stringency of environmental regulation. In general, the higher the indicator, suggesting the more pollution control investment per unit of pollution emission, and the stricter the environmental regulation. The concrete calculation process of environmental regulation (ER) intensity is shown in the Table 3.

Data sources and processing

Panel data model have been adopted in numerous literatures to observe economic entities' behaviour (e.g., countries, regions, industries, et al.) over the entire time range (Torres Reyna, 2007). This paper adopted a balanced panel, covering 16 sectors of China's manufacturing from 2005 to 2015. The utilised data for measuring the environmental regulation intensity is sourced from the China Environmental Statistical Yearbook, which only counts all the data related to the three types of waste pollutants in various sectors from 2005 to 2015. Because of data availability, the period of 2005-2015 was selected to truly capture environmental regulation's impact on manufacturing export in China. The variables (Table 4) employed by the research include environmental regulation intensity (ER), export trade volume (EX), material capital endowment (K), human capital endowment (H), technology input endowment (T), and foreign direct investment (FDI). To eliminate the unit inconsistency with other indicators, this paper uses the annual average exchange rate of CNY against the US dollar for transforming the export trade volume uniformly. In addition, using the price index (2005=100) to eliminate price fluctuations and obtain the actual export trade value. Eviews rev.10. was used as the primary calculation software.

Empirical test of econometric model

- Stationarity Test: Panel data is also called cross-sectional time-series data. This study performs a unit root test on panel data stationarity before regression analysis to avoid spurious regression. Common root test and Individual root test are two mainly used methods for panel data stationarity testing in Eviews rev.10. Generally, Levin–Lin–Chu test (LLC test) and PP-Fisher tests are used to examine whether each series contains a unit root. Probabilities for Fisher test are computed using an asymptotic

Step	Calculation	Explanation
Unit pollution control investment	$ER_{ij} = PC_{ij}/P_{ij}$	ER_{ij}: Envorinment regulation (ER) intensity of pollutant j in sector i
		P_{ij}: emission volume of pollutant j in sector i
		PC_{ij}: pollution control investment of pollutant j in sector i
Standardize	$\overline{ER_{ij}} = \frac{ER_{ij}}{\sum_i^{16} ER_{ij}}$	$\overline{ER_{ij}}$: normalized ER intensity of pollutant j in sector i
		$\sum_i^{16} ER_{ij}$: sum of the ER intensity of pollutant j per unit output value of all sectors
ER intensity index	$ER_i = \sum_j^3 \overline{ER_{ij}}$	ER_i: ER intensity of sector i

Source: Own processing based on Li and Li (2017)

Table 3: ER intensity index calculation steps.

Variables	Description	Operationalization	Unit	Data source
EX	sector's export trade	the export trade volume of each sector	CNY	UN Comtrade the China Statistical Yearbook (2006-2016)
ER	environmental regulations' intensity	sector's pollution control and treatment investment/ sector's pollution discharge *100 (Li and Li, 2007)	%	the China Environmental Statistical Yearbook (2006–2016)
K	material capital	sector's fixed assets-net value / number of sector's employees (Cole et al., 2005)	CNY per capita	the China Statistical Yearbook the China Industry Statistical Yearbook (2006–2016)
H	human capital	sector's science and technology personnel/ the total sector's employment *100 (Teixeira and Teixeira, 2014)	%	the China Statistical Yearbook on Science and Technology (2006–2016)
T	technology input	sector's enterprise R&D expenditure (Zhai and An, 2020)	CNY	the China Statistical Yearbook on Science and Technology (2006–2016)
FDI	foreign direct investment	assets of sector's foreign-funded industrial enterprises / total assets of sector's industrial enterprises * 100	%	The China Trade and External Economic Statistical Yearbook (2006–2016)

Source: Own processing

Table 4: Variable description and data source.

Chi-square distribution, and LLC tests are computed assuming asymptotic normality. If P-value > 0.05, the panel data do not reject the null hypothesis of containing unit-roots, and the data are not stationary; otherwise, the panel data are stationary.

- Panel Equation Testing: Panel data models consist of two groups: the fixed effects model and the random effect model. The Redundant Fixed Effects-Likelihood Ratio Test and the Correlated Random Effect-Hausman Test are required to determine whether the empirical model uses a mixed effect model, a fixed effect model or a random effect model. First, the Redundant Fixed Effects-Likelihood Ratio Test: if the P-value of F statistic < 0.05, meaning that the null hypothesis is rejected, choose an individual fixed effect model; otherwise, establish the mixed effects model. Secondly, the Correlated Random Effect-Hausman Test: If the P-value of Chi-square statistic < 0.05, null hypothesis is rejected, an individual fixed effect model is selected; otherwise, choose the random effect model.

Model establishment

Heckscher-Ohlin (H-O) model has become a popular option for analysing environmental regulation and international trade relations. Trade specialisation usually depends on the composition of factor endowments, according to the setting of the H-O model and Ricardo's comparative advantage theory. Under a traditional H-O model framework, the production factor input of each sector mainly consists of capital, labour, and technological endowment. In conjunction with this, production activity will also produce pollution emissions and affect the environment. Environmental regulation could be treated as a kind of economic factor endowment invested by the enterprise during their production procession, thereby establishing an extended environmental Heckscher-Ohlin-Vanek (H-O-V) model (Tobey, 1990; Cole and Elliott, 2003; Cole and Elliott, 2010). It is a model of multiple countries, multiple commodities and multiple elements. The H-O-V model emphasises that a country becomes a net exporter of relatively abundant factors under free-trade conditions, export is expressed as a function of factor endowments. The traditional H-O-V model has the following form:

$$EX_{i,t} = \sum_{k=1}^{k} \beta_k F_{i,t,k} = \beta_0 + \beta_1 F_{i,t,1} + \\ + \beta_2 F_{i,t,2} + \ldots + \beta_k F_{i,t,k} + \varepsilon \quad (1)$$

where the subscripts i, t and k denote the sector, year and factors respectively. ε is a random error, and β_k is the estimated coefficient of each explanatory variable. $EX_{i,t}$ indicates the export trade scale of sector i in year t, $F_{i,t,k}$ is the k factor endowment of sector i in year t.

Export (EX) trade in this study is expressed as a function of environmental regulation intensity (ER), material capital endowment (K), human capital intensity (H), technology input element (T) and foreign direct investment (FDI). In this study, all variables are processed in logarithm (ln) to alleviate the multicollinearity and heteroscedasticity. The specific regression model is established as Equation 2

$$\ln EX_{it} = \beta_0 + \beta_1 \ln ER_{it} + \\ + \beta_2 \ln K_{it} + \beta_3 \ln H_{it} + \\ + \beta_4 \ln T_{it} + \beta_5 \ln FDI_{it} + \varepsilon \quad (2)$$

where the subscripts i and t denote the industry and year, respectively. β_0 is a constant term, ε is a random error, and β_{1-5} is the regression coefficient of each explanatory variable. EX_{it} indicates the export trade volume of each i in year t; ER_{it} is the environmental regulations intensity of sector i in year t; H_{it} is the human capital intensity of sector i in year t; K_{it} is the material capital intensity of sector i in year t; T_{it} is the research and development investment of sector i in year t; and FDI_{it} is the foreign investment of sector i in year t.

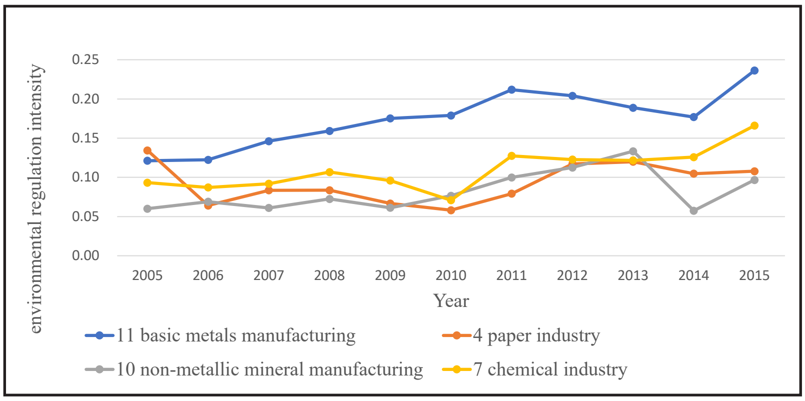
Results and discussion

Measurement results of environmental regulation intensity

As shown in Figure 1, 2 and 3, there are differences in the stringency of the environmental regulation between manufacturing sectors with different pollution intensities. The highest environmental regulation intensity is shown in the moderate pollution sectors. The intensity of environmental regulations in the intensive and light pollution sectors is in the same range. Due to this heterogeneity between industries, changes in the intensity of environmental regulations may affect manufacturing export.

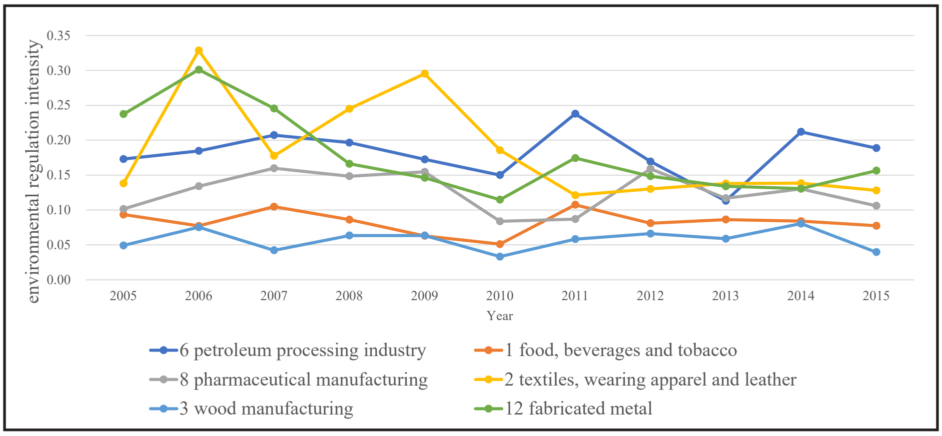
Figure 1 depicts that environmental regulation in the intensive pollution sectors has been continuously strengthened, showing a steady upward trend from 2005 to 2015. At the beginning of international trade development, China's heavy industry traded at the expense of the environment in exchange for economic expansion. Although the operating cost of pollution control continues to increase, it cannot keep up with the increase in production pollution emissions. Therefore, the intensity of environmental regulations has been in a relatively weak position compared with other sectors. However, as the world's awareness of environmental issues continues to increase, various countries' environmental regulations are simultaneously upgrading standards, leading to China's suffering from green trade barriers in its export trade. After that, China's heavy industry is gradually regaining its attention to the environment, and the intensity of environmental regulation in the intensive pollution sector has been increasing in recent years.

From a numerical point of view, the environmental regulation intensity has always been relatively high in moderate pollution sectors (Figure 2). Especially, resource-intensive and labour-intensive industries, such as the petroleum processing industry, textile and apparel industry, and fabricated metal



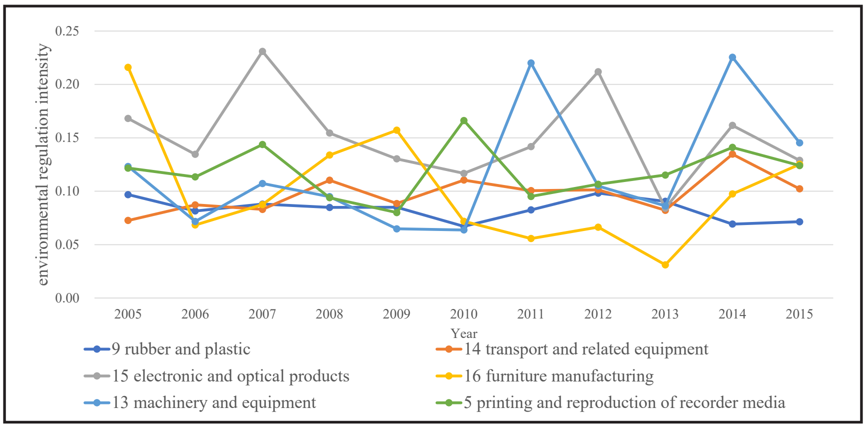
Source: Own computation

Figure 1: Environmental regulation intensity in intensive pollution sectors, 2005 – 2015.



Source: Own computation

Figure 2: Environmental regulation intensity in moderate pollution sectors, 2005 - 2015.



Source: Own computation

Figure 3: Environmental regulation intensity in lightly pollution sectors, 2005 – 2015.

manufacturing industries, have always highlighted China's pollution control, emission reduction and energy conservation.

Nevertheless, the wood processing industry, also energy-intensive and polluting, has not received sufficient attention. Furthermore, Figure 3 indicated that the stringency of environmental regulation of other light pollution sectors remains relatively low level, except the machinery and equipment manufacturing, electronic equipment, and optical product manufacturing industries. Meanwhile, the environmental regulation intensity of light pollution sectors has been fluctuating, and most sectors have undergone several changes in the process of falling first and then rising. The reason behind this phenomenon might be that: influenced by China's "11^{th}, 12^{th}, and 13^{th} Five-Year Plan", the environmental regulation intensity of these sectors fluctuates with economic development and new environmental policy orientation. Therefore, China should increase its attention to light pollution sectors and stabilize its environmental regulation at a certain level instead of reducing monitoring measures since weak pollution emissions.

The results of Stationarity Test

As Table 5 shows the unit root test results, the P-value of all series in the sector's model of different pollution levels is less than 0.05. Thereby, all series reject the null hypothesis of "contain unit roots" at the 5% significance level. Hence, all variables in this model belong to the stationary series of the same order, suggesting that the model's regression analysis is feasible in this paper.

The results of Fixed/Random Effects Test

The results of the Redundant Fixed Effects-Likelihood Ratio Test for three different pollution intensity sectors are shown in Table 6. All the P-values of all sample models is less than 0.05, which rejects the null hypothesis at the significance level of 5%, indicating that the fixed effects model is better than the mixed effects model. As shown in the Hausman test results in Table 7, the fixed-effects model is selected. Therefore, individual fixed effects models should be established for these three sets of sample data based on the above two test results.

	Variables	Statistical method	LLC	PP-Fisher	Results
Panel I: Intensive pollution sector's model					
	lnEX	(I,T,1)	0.0000	0.0000	stable
	lnER	(N,N,1)	0.0000	0.0000	stable
	lnK	(I,N,1)	0.0001	0.0026	stable
	lnH	(I,T,1)	0.0000	0.0008	stable
	lnT	(I,T,1)	0.0000	0.0000	stable
	lnFDI	(I,N,1)	0.0116	0.0002	stable
Panel II: Moderate pollution sector's model					
	lnEX	(I,T,0)	0.0000	0.0000	stable
	lnER	(I,T,0)	0.0000	0.0000	stable
	lnK	(I,T,0)	0.0000	0.0000	stable
	lnH	(I,T,0)	0.0000	0.0000	stable
	lnT	(I,T,0)	0.0000	0.0000	stable
	lnFDI	(I,T,0)	0.0000	0.0014	stable
Panel III: Light pollution sector's model					
	lnEX	(I,T,1)	0.0001	0.0007	stable
	lnER	(I,T,1)	0.0000	0.0028	stable
	lnK	(I,T,1)	0.0000	0.0036	stable
	lnH	(I,T,1)	0.0000	0.0000	stable
	lnT	(I,T,1)	0.0000	0.0001	stable
	lnFDI	(N,N,1)	0.0000	0.0000	stable

Note: "I" means that individual intercept is included in test equation; "T" means that individual linear trend is included in test equation; "N" means not including intercept/trend item; "0" or "1" means to test for unit root in level or in 1^{st} difference.
Source: Own computation of Eviews 10. result

Table 5: Result of stationary test.

Effect test	Statistic	Prob.
Panel I: Intensive pollution sector's model		
Cross-section F	97.4239	0.0000
Cross-section Chi-square	111.7988	0.0000
Period F	3.8983	0.0028
Period Chi-square	41.3488	0.0000
Cross-section/Period F	64.1656	0.0000
Cross-section/Period Chi-square	155.6311	0.0000
Panel II: Moderate pollution sector's model		
Cross-section F	263.088	0.0000
Cross-section Chi-square	224.9875	0.0000
Period F	5.7175	0.0000
Period Chi-square	54.1215	0.0000
Cross-section/Period F	133.7995	0.0000
Cross-section/Period Chi-square	252.1137	0.0000
Panel III: Light pollution sector's model		
Cross-section F	584.6469	0.0000
Cross-section Chi-square	263.4557	0.0000
Period F	14.1297	0.0000
Period Chi-square	93.7649	0.0000
Cross-section/Period F	669.5290	0.0000
Cross-section/Period Chi-square	357.2206	0.0000

Source: Own computation of Eviews rev.10. results

Table 6: The experimental results of the Redundant Fixed Effects-Likelihood Ratio Test.

Panel Model	Chi-Sq.Statistic	Prob.
Intensive pollution sector's model	27.5066	0.0000
Moderate pollution sector's model	45.9447	0.0000
Lightly pollution sector's model	38.1566	0.0000

Source: Own computation of Eviews rev.10. results

Table 7: The experimental results of the Correlated Random Effect-Hausman Test.

The estimation results

Table 8 provides the empirical results of three different pollution intensity sectors' panel models to demonstrate how the selected factors affect China's manufacturing export trade volume. As for model verification, the coefficient of determination R^2 and adjusted R^2 verified the regression predictions fit the data with relatively high accuracy. The statistically significant regression in these models can be found from the high value of the F-statistic. The concrete analysis is as follows in the Table 8.

Environmental regulation intensity

As empirical results are shown in Table 8, the environmental regulation variable's regression coefficient in the intensive pollution sector's model is negative and statistically significant at the 5% significance level. This result shows that environmental regulation has not positively impacted the export in intensive pollution sectors. The moderate pollution sector's estimation result indicates that environmental regulations harm exports, but this adjustment effect is not significant. The regression coefficient of the environmental regulation variables in the light pollution sector's model is positive and significant at the 5% significance level, which means a significant positive correlation between environmental regulation and exports in the light pollution sector. According to the construction of environmental regulation intensity indicators in the previous chapter, the higher the pollution control operation cost per unit of pollution discharge, the more stringent

Variables	Panel I	Panel II	Panel III
Constant	16.7162***	9.2312***	3.7412***
	(8.6890)	(4.5928)	(6.8620)
lnER	-0.0932**	-0.0782	0.0856**
	(-1.1708)	(-1.0149)	(2.4490)
lnK	0.6072***	-1.0147**	0.2871**
	(2.9879)	(-2.5111)	(2.4692)
lnH	0.3630	-0.0549***	-0.0266
	(0.7115)	(-0.7226)	(-0.9913)
lnT	0.5751**	0.3490**	0.4857***
	(2.6783)	(2.0984)	(4.1095)
lnFDI	0.1629	0.1278	0.3663*
	(0.7319)	(2.0310)	(1.7190)
Total pool observations	44	66	66
R-squared	0.9235	0.9931	0.9942
Adjusted R-squared	0.8825	0.9885	0.9932
F-statistic	22.5254	281.3833	945.8201

Notes: The numbers above brackets are regression coefficients. The t-value of T is in parentheses. * = significant at 10%; ** = significant at 5%; *** = significant at 1%.

Panel I: Intensive pollution sector's model; Panel II: Moderate pollution sector's model; Panel III: Light pollution sector's model.

Source: Own computation of Eviews rev.10. results

Table 8: The empirical results of Panel Least Squares.

the environmental regulation. The estimated regression coefficients imply that for each one percent increase in the environmental regulation intensity, export in light and intensive pollution sector will gain 0.0932 percent reduction and 0.0856 percent increase respectively. Therefore, to a certain extent, the rigorous intensity of the environmental regulation is conducive to export trade's growth of light pollution sector in China's manufacturing industry but hinder exports in intensive pollution sectors. Since no statistically significant results have been achieved, the impact is uncertain for the moderate pollution sectors.

As discussed in the existing literature, environmental regulations can show different effect results based on theoretical economic models (Ouyang et al., 2020). Under the pollution paradise hypothesis, the cost effects of strict environmental regulations will increase compliance costs of highly polluting enterprises and weaken export competitiveness, resulting in a decline in trade exports (Palmer et al., 1995; Walter and Ugelow, 1979). However, the Porter hypothesis holds that well-organized environmental regulations can effectively encourage enterprises to increase the export competitiveness of manufactured goods through technological innovation and green transformation (Porter, 1991). These firms can break through the green trade barriers set by developed countries and further expand the export scale. That is the so-called "innovation compensation effects" (Porter and Van der Linde, 1995). Therefore, the influencing results of environmental regulations on export primarily depend on the trade-off between cost and innovation compensation effects. In this study, there is no obvious empirical evidence that, driven by cost effects, stricter environmental regulation can improve export trade growth in intensive pollution sectors to refute Porter's hypothesis.

China started relatively late in environmental regulation of the light pollution manufacturing, especially the mechanical and electrical industries. China's pollution reduction-oriented regulatory tools currently have limited effect on the environment controlling these relatively clean industries. Generally, manufacturing sectors with light pollution degrees in China mainly are labour-intensive industries or high-tech industries. The proportion of fixed assets in these sectors' firms is typically low, suggesting that the cost of technological innovation is not a heavy economic burden. Therefore, these sectors can quickly incur innovation compensation effects with the implementation of environmental regulation. With the increasingly strict environmental regulation, the light pollution sectors have accelerated their industrial upgrading and further moved towards green transformation. This empirical study shows that the more stringent environmental regulations exert greater "innovation compensation effects" than the "cost effect" on lightly pollution sectors, thus benefiting export volume.

Overall, this study confirmed the heterogeneous impact of environmental regulations on manufacturing exports in China. It also found that the effect of environmental regulation on exports is not apparent compared to the other independent variables from the perspective of the coefficient value. This result indicates that traditional comparative advantages and factor endowments show more decisive than environmental regulation when analysing the influencing factors of China's manufacturing exports. Therefore, China's manufacturing exports are still highly likely to depend on accumulating the industry's material capital and its technological development.

Material capital endowment

There is a significant negative correlation between the material capital endowment and the export of moderate pollution sectors. Table 8 reveals that the regression coefficient of the material capital endowment variable in panel II is negative and statistically significant, implying the export of moderate pollution sector will reduce 1.0149 percent with a one percent increase in material capital endowment. The regression coefficient of the material capital endowment is positive and statistically significant in the intensive and light pollution sectors, which is consistent with the traditional economic viewpoint. The estimated percent increase in the export of light and intensive pollution sector are 0.6072 and 0.2871with a one percent increase in material capital endowment.

In this research, the material capital endowment variable is measured by material capital per capita. This variable shows a significant adverse effect in the moderate pollution sector, indicating that the rise of per capita capital negatively affects the export of the moderate pollution manufacturing sector. The reason behind this result is that labour-intensive industries are still play-dominated roles in the endowment factor structure. As the largest developing country, China's abundant factor endowment lies in its labour force. China's manufacturing exports have benefited from the demographic dividend for a long time, leading to export competitiveness concentratedly shown in labour-intensive industries (Wang and Zhang, 2019). With capital accumulation increasing, the demographic dividend gradually disappears, and the surplus labour supply tends to be tight (Yu and Wang, 2021). Under this circumstance, the optimal resource allocation of capital and labour cannot be achieved, and exports fall instead of rising with capital accumulation. Currently, China's foreign trade structure is in a critical transition from labour-intensive to capital-intensive. Thus, the material capital factor is impossible to be ignored in China's manufacturing development.

Human capital intensity

As reported in Table 8, the positive effect of human capital intensity on the light pollution sector's export is not statistically significant. However, the negative correlation between the human capital intensity and the moderate pollution sector's export is significant at a 1% significance level. The percentage change in the moderate pollution sector's export is -0.0549 resulting from a one percent change in human capital intensity. In the intensive pollution sector's model, the regression coefficient of human capital intensity is negative but not significant. Contrary to traditional views, the moderate and intensive pollution sector's export would decrease with the increasing intensiveness of human capital.

This paper uses the proportion of high-tech personnel to the industry's number to measure human capital intensity. The higher the human capital intensity, the higher the amount of scientific and technological (S&T) personnel in the industry with solid adaptability, adjustment, and innovation (Ouyang et al., 2020). Enterprises with rich human capital are more capable of adapting and responding to environmental regulations. Human capital positively promotes China's light pollution manufacturing sector's export, which means the increase in the proportion of high-tech personnel can significantly enhance the industry's technological innovation and progress, thereby enhancing export competitiveness. On the contrary, human capital intensity plays a negative role in China's moderate and intensive pollution manufacturing sector's export. The fact behind this result is that the distribution of scientific and technical personnel in different sectors in China's manufacturing is unreasonable, some human capital is in a rigid state, and the overall human capital utilization efficiency is not high (Song et al., 2020). Although the ratio of S&T personnel in the manufacturing industry increases, there is a lack of patents focusing on pollution control, emission reduction, and energy saving in terms of innovation output. Therefore, increasing human capital investment in moderate and intensive pollution manufacturing sector negatively influences the exports within the industry.

Technology input element

Table 8 demonstrates a significant positive correlation between the technical factor input and the export of various sector manufacturing, consistent with the Porter hypothesis. A one percent increase in technology input element leads to a 0.5751, 0.3490 and 0.4857 percent increase in the export of light, moderate and intensive pollution sector. The positive regression coefficient of the technology input variable is statistically significant in the light, moderate and intensive pollution sector at 5%, 5% and 1% significance levels separately. These coefficients are relatively high among other dependent variables in the three models, proving that technology input is an essential factor affecting China's manufacturing exports.

Relying on low-cost advantages, China made compelling achievements in its manufacturing export. However, accompanied by many environmental costs, it cannot maintain ongoing competitiveness in fierce international trade. For achieving sustainable development, increasing R&D investment to carry out technological innovation is conducive to updating production equipment, improving product innovation, winning high added value, and ultimately gaining export competitiveness. This paper measures the technology input element variable by research and development (R&D) investment in the industry. For the various pollution sector of manufacturing, technology input exerts a positive impact on China's manufacturing sector. As such, the consensus that "science and technology are the primary productive forces" has been verified in the field of manufacturing export trade.

Foreign direct investment

There is a positive correlation between foreign direct investment and the export of various manufacturing sectors. Nevertheless, this positive effect of foreign direct investment is not statistically significant in the light and moderate pollution sector's export. In the intensive pollution sector model, the promotion effect of foreign direct investment variables on exports is statistically significant, and the export will increase 0.3663 percent with a one percent increase in foreign direct investment.

It shows that foreign direct investment has failed to play significant positive impact on the light and moderate pollution manufacturing industries. That result can be attributed to the time lag, foreign direct investment's spillover effect has not been fully exerted, and domestic-funded enterprises have not yet benefited from it. Still, foreign direct investment plays a significant positive role in promoting the export of relatively heavy pollution industries, that is introducing FDI to provide necessary financial support for industrial development in case of lacking domestic capital. Besides, foreign direct investment is often accompanied by advanced science and technology, which promote the absorption of advanced technology by the invested country. Simultaneously, it facilitates the connection with the investor's home country market, thereby indirectly promoting the growth of exports. Therefore, except for intensive pollution sectors, FDI has not exerted a significantly impact on the growth in manufacturing export trade.

Conclusion

With environmental problems becoming increasingly prominent, many countries have gradually designed and implemented various environmental regulations to control pollutant discharge and solve environmental issues. However, China's environmental regulation has been a late start and is still at an early stage, meaning its intensity is far weaker than in developed countries. This research investigated the environmental regulation's impact on China's manufacturing export. Considering industry heterogeneity, this paper divides the manufacturing industry into intensive pollution, moderate pollution and light pollution sectors according to the varied pollution degrees. Besides, adopting the environmental regulation intensity indicator constructed by Li and Li (2017) to proxy the environmental regulation variables. Using a balanced panel that spans over a period from 2005 to 2015 and includes 16 of China's manufacturing sectors, this research provided an empirical analysis based on the H–O–V model. The main research conclusions obtained are as follows:

The empirical result confirmed that changes in China's environmental regulations intensity play different roles in manufacturing sectors with varying pollution levels. The environmental regulation is conducive to export trade's growth of intensive pollution sectors in China's manufacturing industry but hinder exports in light pollution sectors. In the case of the moderate pollution manufacturing sectors, there is no statistically significant evidence to confirm that environmental regulations play a role in these sectors' export.

Compared to other endowments of production factors, environmental regulation is a weak significant factor in China's manufacturing export trade. The material capital has a statistically significant positive impact on export in light and intensive pollution sectors but has a statistically significant adverse impact on export in moderate pollution sector. The human capital plays a statistically significant negative role in moderate pollution sector's export. For various pollution sector's export, the technological input human capital shows a statistically significant positive effect. In the intensive pollution sector's export, foreign direct investment plays a statistically significant positive role.

With the accumulation of material capital elements, manufacturing can effectively improve the infrastructure, upgrade the equipment and expand the production scale, ultimately increasing exports. The input of technological capital and human capital can magnify this effect at the same time. Therefore, the manufacturing industry in China can increase products competitiveness by raising capital and technology input. However, it is worth noting that improving the utilisation efficiency of each endowment is necessary by adjusting and optimising the product factor's input ratio.

The above conclusions reveal several implications for policymaking: First, the main component of China's manufacturing exports is generally processing and manufacturing industrial products. Most of them are high energy consumption, high pollution, high emission industries, and low-end manufacturing. It's necessary to optimize the export structure, develop green trade, and promote it to transform to high added value and low resource consumption. Furthermore, formulate industry-differentiated environmental policies rather than blindly strengthen the intensity of environmental regulations. Based on the characteristics of different pollution types in the manufacturing industry and China's current economic and social production development needs, differentiated environmental policies and methods should be adopted to manage problem issues. Second, the innovation compensation impact of environmental regulation depends on the cooperation of labour and capital. In the fierce international competition, the manufacturing industry in China should pay attention to the expansion of capital scale and pay attention to the efficiency of capital utilization and the integration of capital, labour, and technology.

Due to the data availability, there are several limitations of this study that should be considered. There would be a certain underestimation of the intensity of manufacturing environmental regulations since the lack of data on the treatment cost of industrial solid waste by sector. The potential endogenous problems in environmental regulations will have a certain impact on the empirical test results. Because of the data limitations, this paper only considers China's domestic environmental regulation. Future research can analyze the export impact of differences in domestic and foreign environmental regulations.

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Agris on-line Papers in Economics and Informatics

Volume XIV Number 2, 2022

Preferences of Small-Scale Farmers for Innovative Farming Techniques in Volcanic Highlands in Rwanda

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Abstract

This paper attempted to identify the determinant factors of innovative technologies preferences by small-scale farmers in the Volcanic Highlands in Rwanda. Data used were collected from a random sample of 401 small-scale crop producers using a structured questionnaire in the study area. A logit regression model was specified, whereby a binary maximum likelihood estimation method was used to identify the factors affecting of the adoption of chemical fertilizers, the determinants of the combined use of chemical and organic fertilizers, the determinants of the adoption of improved seeds, as well as the determinant factors of appropriate use of pesticides. The results showed that farmer's education level, farming experience, membership to farm cooperative, the number of extension visits, and crop farming are the factors that affect positively the probability of adopting one or other of the four innovative farming techniques. From these results, we suggest the enhancement of extension services and other needed support to small-scale farmers (grants and subsidies, access to finance for example), the spread of professional trainings to farmers, and the increased farmers' access to high-yielding seed varieties if farming professionalization and innovative farming techniques are still among the development goals.

Keywords

Innovative farming techniques, sustainability, adoption of technology, volcanic highlands, Rwanda.

JEL Classification codes: O33, Q12, Q16, R11.

Maniriho, A., Musabanganji, E., Mulumeoderhwa, F., Manirakiza, D. and Lebailly, P. (2022) "Preferences of Small-Scale Farmers for Innovative Farming Techniques in Volcanic Highlands in Rwanda", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 2, pp. 73-83. ISSN 1804-1930. DOI 10.7160/aol.2022.140206.

Introduction

The adoption of innovative technology among farmers remains central to the completion of agricultural policy objectives (Ruto and Garrod, 2009). Asrat et al. (2010) underlined that both socioeconomic characteristics of individuals and/or households such as land size, livestock possession, farmer's years of experience, and institutional factors like the number of extension visits affected the farmers' adoption decision about the farming techniques. The adoption decisions of farmers for farming innovative techniques depend highly on the farmers' perceptions of the technology characteristics (Adesina and Baidu-Forson, 1995) and it appeals reasonable interventions of public institutions (BID, 2019). In this line, Wauters and Mathijs (2013) recognized the role of spillover and learning effects on the adoption of innovative technologies by farmers. The reason behind the adoption of innovative technology is just its role on farmers' welfare improvement (Yirga and Alemu, 2016) and in poverty reduction specifically in developing countries (Mwangi and Kariuki, 2015). The adoption of new and innovative farming techniques increase the productivity and efficiency in production than the rudimentary ones (Onubuogu et al., 2014; Mabe et al., 2018) even though this can be constrained by the agricultural risks such as financial risks, price risks, professional risks, natural risks and other risks (Mulumeoderhwa et al, 2019).

The farmer's access to information plays a crucial role in technological adoption (Uaiene et al., 2009) since it reduces the uncertainty about the performance of a specific technology; clear information moves individual's mindset from subjectivity to objectivity (Bonabana-Wabbi 2002). This means that the existence of new technologies is not enough for itself. It allows the farmers to learn about the existence and the effective use of innovative farming practices. The farmers adopt the new technologies only when they are aware of their existence, and their potential impact on the farmers' welfare (Mwangi and Kariuki, 2015) through the increase in farm income. Other factors that may influence the adoption of new farming technologies are the farmer's level of education, the access to extension services, and the access to credit (Namwata et al., 2010), and professional training (Jerop et al., 2018).

The technology areas that contribute substantially to the increase in farm income include high yielding crop varieties, weed and pest management techniques, irrigation and water management schemes (Loevinsohn et al., 2013) as well as the new farm management methods, especially those aiming at raising the output and reducing the average cost of production (Challa, 2013). It can also enable the adopter to perform the work more easily than before and hence lead to time and labour saving (Bonabana-Wabbi, 2002). The consequence of innovative farm technologies and thus improved farm productivity includes responding to increasing demand, which is the basis of salient assessment of the performance of the technologies (Challa, 2013). Under such circumstances, the adoption of farm innovative technologies may also lead to sustainable food security and development through the dynamic adoption of innovative technologies, which is expected to sustain food and fiber supply (Loevinsohn et al., 2013). Hardaker and Lien (2010) have also considered profit as one of the most influential factors for famers to adopt a new technology or a new crop.

There has been the impact of new farming innovations on the improvement of the majority of the population in developing countries via the increase in farm production and farm income stability (Feder et al., 1985), but the adoption of new farm technologies by small-scale farmers in Sub-Saharan Africa "seems to be slow" (Meijer et al., 2015). This paper aims to identify the factors affecting the adoption of selected innovative farming techniques (use of organic fertilizers, use of chemicals, adoption of improved seeds, and use of pesticides) by small-scale farmers in the Volcanic Highlands in Rwanda. The rest of this paper is organised as follow. Section 2 describes the conceptual framework of technology adoption. Section 3 presents the materials and methods, while section 4 summarises empirical results and their discussion. The paper ends with conclusions and policy recommendations.

Conceptual framework of technology adoption

The concept of technology adoption is well explained by the diffusion of innovation theory that was developed by Rogers in 1962, which is one of the oldest theories of the social science (Rogers, 1983). It was suggested that the diffusion of innovations is significantly influenced by the adopter's perception and situation (Rogers, 2003) as well as own characteristics of innovations (Robertson and Gatignon, 1986). This theory is rooted from the area of communication and aims to explain how a new innovative technology gains interest and spreads in a social system (Rogers, 1962). In terms of Schumpeter (1934), innovation can be simply defined as "the changes in the methods of production and transportation, production of a new product, change in the industrial organization, opening up of a new market, and new sources of energy".

Seven sources of innovations were identified, from which first four are rooted within a market or industry while other three are originated outside. Sources of innovation within a business, an industry or a market are as follows (Drucker, 1986):

- The unexpected: as a source of innovation, it is hereby considered the unexpected success, the unexpected failure, or the unexpected outside event.
- The incongruity: this is a gap between "what is" and "what ought to be". It is "a symptom for an opportunity to innovate".
- process need; here, there is a process need in the organization and everybody is aware of it. Even though nothing is done to find a solution, any innovation that will appear will be obviously accepted.
- industry and market structure: this may seem completely stable, but it is "quite brittle because it can disintegrate very fast following a small scratch". It was also remarked that a structure change requires entrepreneurial skills from every member to enable innovation process within an industry.

Beside the internal sources of innovation, there are also sources of innovation that are instigated outside a business, an industry or a market. These are changes prevailing in the social, philosophical, political, and intellectual environment (Drucker, 1986). They include:

- Demographics: this is concerned with changes in population, its size, age structure, composition, employment, educational status, and income, as well as their most predictable consequences.
- Changes in perception: this is taken as a source of innovation because it has created considerable opportunities to innovate.
- New knowledge: in knowledge-based economy, new knowledge (scientific, technical, or social) is normally referred to as innovation. But it is to note that all knowledge-based innovations are not important, as some of them are trivial.

Rogers (1962) identified also five characteristics of innovative technologies. The first is the relative advantage which is defined as the cost-effectiveness and the set of benefits of new technologies to adopters compared to preceding technologies (Chang, 2001; Sanson-Fisher, 2004). Compatibility, which is the second factor, means that a new technology should be compatible with the adopter's norms, values, past experiences as well as their needs (Rogers, 1962; Sanson-Fisher, 2004). It comes then the complexity (Rogers, 1962) that measures the extent at which a new technology is difficult to understand and use (Sanson-Fisher, 2004). For trialability, Rogers (1962) defined it as the way a technology can be tested while piloting its use, assess its acceptability by the users, and examine its potential outcomes. The last element is thus the visibility of a new technology (Rogers, 1962), which implies the visibility or advocation of that technology. Bero et al. (1998) argued that there is an increasing chance for a new technology to be adopted if it is discussed and advocated by role-models, respected and influential practitioners.

Rogers (1962, 1983, 2003) argued that the process of the spread of innovations depends deeply on human capital, and stressed that it is built mainly on four elements, namely the innovation itself, communication channels, time, and a social system. According to Rogers (1983) and Starmann et al. (2018), the process for the diffusion of innovation goes through five steps: knowledge, persuasion, decision, implementation, and confirmation. It was highlighted that researchers are firstly aware and acquire knowledge of the proposed technological change; secondly, individual practitioner or user (the adopter) is convinced with the advantages of innovations; thirdly, the user decides to adopt or reject the innovation; fourthly, the innovation is integrated in everyday activity; finally, the users seek to confirm the adoption of innovation as per their abilities to tolerate high degrees of risk and uncertainty (see also Sanson-Fisher, 2004). In consideration of the rate at which an innovation is adopted, Rogers (1962) identified five adopter categories from fastest to lowest adopters, namely innovators, early adopters, early majority, late majority, and laggards, bearing on their readiness to own innovative technologies. It is also worth important to note that adoption of a new technology is voluntary (Hightower and Brightman, 1994).

An innovator is referred to as the first fastest innovation adopter who is venturesome, young, and wealthy with high social status, characterized by the willing to accept risks and the closest contact with scientists as well as with other innovators (Rogers, 1962). Chamorro-Premuzic (2013) described a successful innovator as someone with such characteristics as creativity, opportunistic mindset, formal education or training, proactivity and high degree of persistence, a healthy dose of prudence, and social capital. An early adopter is the second fastest adopter of new technologies, who is the role model to the surrounding community, respectable, with high social status, with strong contact with local change agents (Rogers, 1962; Ali and Miraz, 2015). Early majority is composed of people who are willing to accept and use new technologies only after the peers have already adopted. Deliberate, such people are in considerable contact with change agents and early adopters (Rogers, 1962; Ali and Miraz, 2015). Late majority is a category of people who are skeptical, able to resist to the pressure of peers before adoption occurs, in relation with peers who are mainly late majority or early majority. Such people hardly use mass media (Rogers, 1962). Laggards, the slowest adopters of new technologies, are attached to the tradition and oriented to the past. Conservative and suspicious of change agents, they get information from neighbours, friends, and relatives with similar level of mindset (Rogers, 1962; Ali and Miraz, 2015).

Materials and methods

Data used for this study were collected through a farmer survey in October to December 2019. The questionnaire used to collect data included the socioeconomic factors characterizing the farmers and their households as well as the preferred farming techniques practiced on the farms. For details, data were collected on demographic characteristics of the farmer, access to productive assets (land, credit, livestock), crop production and farm supplies (crops grown, use of fertilizers and their costs, crop output, farm income, membership of farm cooperative), access to extension services, and the innovative farming techniques practiced. The study considered a sample of 401 small-scale farmers randomly selected from the Volcanic Highlands of Rwanda (also known as "*Birunga*" region). This region is extended on four districts and 101 farmers were surveyed Burera District, 101 in Musanze District, 100 in Nyabihu District and 99 in Rubavu District. The "*Birunga*" region is one of the 12 agro-ecological zones in Rwanda besides Imbo, Impala, Kivu Lake Borders, Congo Nile Crest, Eastern Plateau, Central Plateau, Buberuka Highlands, Mayaga, Bugesera, and Eastern Savannah (Verdoodt and van Ranst, 2003; Rushemuka et al., 2014). The Birunga agricultural region is well known for its essentially agricultural soil (altitude of 1600 to 2500 metres, highly permeable black volcanic soils with excellent agricultural value) (Ndindabahizi and Ngwabije, 1991), the main crops being the Irish potato, vegetables (red onion, white onion, etc.), corn, beans, wheat, etc. (MINAGRI, 2012). Delepierre (1982) and MINAGRI (1989) presented in details the specific characteristics of the agro-ecological zone of Birunga: regular rains; fairly shallow soil, hence the simple agricultural equipment and generalization of cropping; reduced risk of erosion thanks to bedding cultivation, soil permeability and often little uneven terrain; soils rich in humus (andosols or andepts) of black color with a good fertility, suitable for crops of temperate climate, but whose acidity is variable (from little acids to acids) throughout the region.

Farmers should choose the farming techniques that will enable them to take delight from the agricultural potentials of the region. Four farming techniques have been selected for this analysis, namely the adoption of chemical fertilizers (1=yes), the appropriate combination of chemicals and organic fertilizers (1=yes), the adoption of improved (or high yielding varieties of) seeds (1=yes), as well as the best practice of pesticides (1=yes). The descriptive statistics of all study variables are summarized in Table 1.

Variable	Variable definition	Mean	SD
	Dependent variables		
Chemicals	Appropriate use of chemical fertilizers (1=yes)	.26	.44
Combination	Appropriate combination of chemicals and org. fertilizers	.31	.46
Improved seeds	Appropriate use of improved seeds (1=yes)	.72	.45
Pesticides	Appropriate use of pesticides (1=yes)	.55	.49
	Independent variables		
Age	Age of the farm producer (in years)	40.57	9.04
Sex	Sex of the farm producers (1=female, 0 if otherwise)	1.48	.50
Marital status	Marital status of the farm producer (categorical)	2.17	1.93
Education	Education level of the farm producer (categorical)	3.26	1.67
Household size	Number of the household's members	4.96	2.03
Experience	The farmer's experience (in years)	17.76	8.75
Agriculture	If the farmer has agriculture as the sole activity (1=yes)	1.24	.43
Cooperative	If the farmer is a member of a farm cooperative (1=yes)	1.09	.29
Extension	The number of extension visits	1.22	1.03
Land size	The farm size (in square meters)	3,220.96	1,604.27
Farm income	Net farm income in Rwandan francs	870,000.00	1,130,000.00
TLU	Tropical livestock units held by a household	1.66	1.43
Credit	The loan amount in Rwandan francs	186,000.00	405,000.00
Crop	The crop grown (1=if onion, 0=otherwise)	.23	.42
Seed costs	The seed costs in Rwandan francs	83,309.82	68,323.87
Organic fertilizer costs	The cost of organic fertilizers in Rwandan francs	20,712.97	14,617.77
Chemical costs	The cost of chemical fertilizers in Rwandan francs	61,710.35	97,184.02
Pesticide costs	The cost of pesticides in Rwandan francs	45,056.73	46,219.27

Source: own processing

Table 1: Descriptive statistics of variables used in this study.

For data analysis, we specified a logit regression model for which we used a maximum likelihood estimation (MLE) method to identify the factors influencing the farmer's preference for an innovative farming technique. The results are represented in the Table 2. With the aim of identifying the factors affecting farmer's preference for a farming technique, with a dichotomous dependent variable Y_i with two values, 1 (when a farmer has practiced a technique) or 0 (otherwise), a binomial logistic regression model (Agresti, 2018; Breen et al., 2018). The set X of p explanatory variables (made of both push and pull characteristics) is made by continuous and categorical/dichotomous variables. The probability that a farmer i has practiced a farming technique is given by the function:

$$\pi_i(X) = \frac{e^{\beta_0+\beta_1 X_{i1}+\beta_2 X_{i2}+\ldots+\beta_p X_{ip}}}{1+e^{\beta_0+\beta_1 X_{i1}+\beta_2 X_{i2}+\ldots+\beta_p X_{ip}}} \quad (1)$$

and then $\frac{\pi_i}{1-\pi_i}$ is the odd in favor of the famer's preference for a technique. Hence, by applying the natural logarithm on both sides of (1), the logit model is then written as:

$$Y_i = \ln\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_p X_{ip} \quad (2)$$

The equation (2) is estimated by the maximum likelihood estimation method and the basic assumptions of normality, linearity, and homogeneity of variance for the independent variables are not a requirement. The results from econometric estimation of the equation (2) are presented in the Table 2. The coefficients of the estimated models are the odd rations: if the coefficient is greater than 1, it implies that the factor affects positively the probability of adopting innovative farming techniques; otherwise, there is no or negative effect of the factor concerned.

Variable	Burera District	Musanze District	Nyabihu District	Rubavu District	Whole region of Volcanic Highlands
Age	41.17	39.58	39.72	41.81	40.57
Sex					
Male	45	53	58	52	208
Female	56	48	42	47	193
Crop selected					
Potato	33	82	11	6	132
Bean	31	8	0	0	39
Maize	15	9	0	0	24
Wheat	0	1	0	0	1
Pyrethrum	0	1	0	0	1
Sorghum	14	0	0	0	14
Onion	0	0	50	44	94
Carrots	1	0	19	26	46
cabbage	7	0	20	23	50
Education level of the respondents					
No formal education	9	17	23	15	64
Primary	60	50	41	41	
Secondary	22	18	23	31	
Technical and vocational	7	13	13	9	42
University	2	3	0	0	5
Farming techniques					
Use of chemicals	33	14	35	24	106
Use of organic fertilizers	77	89	54	78	298
Combination of fertilizers[a]	26	43	16	40	125
Use of pesticides	50	65	44	61	220

Note: [a] Chemical and organic fertilizers
Source: own processing

Table 2: Socioeconomic characteristics and distribution of the respondents by crops, level of education and farming techniques.

Results and discussion

The socioeconomic characteristics of the respondents and their distribution by crops, levels of education and farming techniques are presented in the Table 2. Alongside this study, we identified separately the determinant factors of the adoption of the use of chemical fertilizers, the appropriate combination of organic and chemical fertilizers, the adoption of improved (or high yielding) seeds, and the appropriate use of pesticides (Table 3) where the odd ratios are provided as coefficients. The results from econometric analysis of the determinants

Variables	Model 1. Use of chemical fertilizers	Model 2. Combination of chem. and org.	Model 3. Use of improved seeds	Model 4. Use of pesticides
	Coefficients¤ (Stand. Dev.)	Coefficients¤ (Stand. Dev.)	Coefficients¤ (Stand. Dev.)	Coefficients¤ (Stand. Dev.)
Age (X_1)	0.993 (0.027)	0.972 (0.024)	0.928** (0.027)	0.937** (0.024)
Sex (X_2)	0.850 (0.219)	1.034 (0.250)	1.103 (0.289)	1.102 (0.256)
Marital status (X_3)	0.921 (0.070)	0.941 (0.061)	0.978 (0.072)	0.964 (0.063)
Education (X_4)	1.070 (0.095)	1.142 (0.093)	0.911 (0.084)	1.152* (0.093)
Household size (X_5)	0.903 (0.093)	---	1.121 (0.118)	1.057 (0.100)
Experience (years) (X_6)	1.020 (0.027)	1.046* (0.027)	1.017 (0.027)	1.053** (0.026)
Agriculture (1=yes) (X_7)	0.526* (0.176)	0.590* (0.185)	1.301 (0.427)	1.033 (0.294)
Cooperative (X_8)	2.545** (1.114)	3.919*** (1.656)	1.479 (0.694)	1.362 (0.569)
Extension visits (X_9)	1.092 (0.141)	1.092 (0.133)	0.922 (0.121)	0.838 (0.099)
Land size (X_{10})	1.000*** (0.000)	1.000 (0.000)	1.001*** (0.000)	1.000*** (0.000)
Net farm income (X_{11})	1.000** (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)
TLU (X_{12})	1.159 (0.146)	1.001 (0.119)	1.000(0.139)	0.875 (0.103)
Credit (FRW) (X_{13})	1.000 (0.000)	1.000 (0.000)	1.000(0.000)	1.000* (0.000)
Crop (1=if onion, 0=otherwise) (X_{14})	4.391*** (2.065)	1.961 (0.894)	5.214*** (2.851)	2.211* (0.980)
Seed costs (X_{15})	1.000 (0.000)	1.000 (0.000)	1.000* (0.000)	1.000 (0.000)
Org. fertilizer costs (X_{16})	--	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)
Chemical fertilizer costs (X_{17})	1.000** (0.000)	1.000*** (0.000)	1.000 (0.000)	1.000 (0.000)
Pesticide costs (X_{18})	1.000 (0.000)	1.000* (0.000)	1.000*** (0.000)	1.000*** (0.000)
Constant	0.202 (0.233)	0.100** (0.110)	2.410 (2.847)	1.045 (1.097)
Observations	377	377	377	377
Chi-square	33.673	42.552	55.456	39.773
Prob > chi^2	0.009	0.001	0	0.002

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$; Coefficients are the odds ratios
Source: own processing

Table 2: Socioeconomic characteristics and distribution of the respondents by crops, level of education and farming techniques.

of the use of chemical fertilizers (Model 1) reveal that the probability of adopting the use of chemicals is positively affected by the farmer's level of education, the farming experience, the cooperative membership, the number of extension visits, the number of domestic animals held, and if the farmer grows onion, where cooperative membership and onion farming are the most influential factors.

For the determinant factors of the combination of chemical and organic fertilizers (Model 2 on the Table 3), the results show that the sex of the farmer (being female), the farmer's education level, the farmer's experience, the cooperative membership, the number of extension visits, and the number of domestic animals held are the primary factors affecting the farmer's decision, farmer's experience and cooperative membership being the most significant ones. The analysis also shows that the adoption of improved (or high yielding varieties of seeds is positively affected by the sex of the farmer (being female), the number of household members, the farmer's experience, the farming practice as a sole economic activity, cooperative membership, the land size, and the onion farming (Model 3 on the Table 3). These results also indicate that land size and onion farming are the most significant determinants of the use of improved seeds.

As for the use of pesticides, the results (Model 4 on the Table 3) point to the sex of the farmer (being female), the farmer's education level, the number of household members, the farmer's experience, the farming practice as a sole economic activity, cooperative membership, and the onion farming as the determinants with positive effect on the farmer's decision to use pesticides, whereby the level of education, farmer's experience, and the onion farming are the statistically significant factors.

Previous studies proved that the adoption of new innovative farming technologies results in increasing production and reducing average cost of production (Challa, 2013), making easy the farming work, which consequently results in saving time and labor (Bonabana-Wabbi, 2002) in improving agricultural productivity (Challa, 2013), as well as in stabilizing farm income (Feder al., 1985). The results from econometric estimations show that the sex of the farmer (being female) leads to the increase in the probability of farmers to combine in appropriate proportions organic and chemical fertilizers, that of adopting improved seeds, and that of appropriate use of pesticides, which emphasizes the role of socioeconomic characteristics of farmers in their decisions to adopt new technologies (Asrat et al., 2010).

The results point specifically to the positive and significant effect of farmer's education and experience on different crop farming techniques (use of chemicals, adoption of improved seeds, and appropriate use of pesticides), which highlights the role of education as a measure of human capital in the adoption of agricultural technologies (Namwata et al., 2010). We have also found out that the cooperative membership and the number of extension visits affect positively the adoption of some innovative farming techniques, and this is aligned with the role of institutional factors (Asrat et al., 2010). It is important to note that cooperatives and extension services can also serve as information channels that may influence farmers to adopt new technologies (Bonabana-Wabbi 2002; Uaiene et al., 2009). For the crop grown, its positive effect shows that the farming techniques should be adapted to different crops through different localities during different periods of time (Shiferaw et al., 2009; Asrat et al., 2010; Lybbert and Summer, 2010). In contrast with the existing literature on the importance of credit (Sain and Martinez, 1999; Quddus, 2012 for example), this study showed that the access to credit has no effect on the adoption of innovative farming technologies. In line with Inter-American Development Bank, the adoption of innovative techniques enable farmers to shift from ineffective farming practices and consequently improve the fertility and the productivity of arable land, which is leveraged by significant intervention of Governments (BID, 2019).

Conclusion

This study aimed to identify the determinant factors of the adoption of innovative farming techniques by small-scale farmers in Rwanda. Data used were collected through the administration of a questionnaire to a sample of 401 crop farmers randomly selected in the Volcanic Highlands in Rwanda. This region is one of the most fertile zones, but it is important for farmers to practice innovative farming techniques if they want to take delight of all its potentials. The results from binary maximum likelihood estimates of a logit regression model show that the probability of adopting the use of chemical fertilizers is positively and significantly influenced by the membership to farm cooperative and the selection of onion as the primary crop. For the combined use of chemicals and organic fertilizers in appropriate rates, farmer's experience and cooperative membership have been identified as the most significant determinants of the adoption of this farming technique. The same results also reveal that the adoption of high-yielding varieties of seeds is positively but significantly influenced by the farm size and the onion exploitation as the primary crop. As for the appropriate use of pesticides, the level of education, farmer's experience, and the onion farming are the statistically significant factors have been identified as the most influential determinants of the farmers' decision. Based on these findings, we recommend that the government and the development partners should enhance farm technology subsidy and farmer's access to finance, enhance the farmers' professional trainings, align the extension services to farmers' needs and environment, and avail high-yielding varieties of seeds. For farmers, they should own the agriculture development policy and follow all advice and support from the government and the institutions partnering for agriculture development.

Acknowledgements

The authors acknowledge the funding of ARES-CCD, as well as the surveyed farmers for providing the required information for the successful completion of this research. They recognize also the efforts of anonymous reviewers to improve the quality of the work.

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Volume XIV Number 2, 2022

Agricultural Cooperatives and Their Impact on Economic Performance of Farms in Slovakia

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Abstract

Effects of membership in cooperative organizations was investigated in many studies, and their results were sometimes controversial. Presented paper contributes to discussion related to cooperative membership by comparing members and non-members, with elimination of self-selection bias, to identify motivation to become member and main effects coming from membership in producer organization. Panel data used in the presented analysis are from Ministry of Agriculture of Slovak Republic at farm level for period of years 2009-2016, which was the most recent available data. Propensity score matching approach was applied to eliminate self-selection bias and to create sample of members and corresponding non-member farms in each year. Difference between these two groups were evaluated by methods of statistical inference. In general, it can be concluded, that in presented period were members of producer organizations more profitable than non-members. Also difference in total revenue was significant in period of year 2010-2013, which means probably successful using of advantage from better bargaining position of producer organization, compared to non-members. Significant difference in profit disappeared in last three years 2014-2016, this could suggest, that membership in producer organization was less attractive to many farms which led to decrease in number of members. Membership in producer organization probably improved economic performance of farms in Slovakia in period 2009-2013, but this advantage disappeared in last years. This could be probably linked to support for producer organizations from European Union in period 2007-2013.

Keywords

Cooperative membership, producer organizations, propensity score matching, economic effects.

Palkovič, J., Matejková, E. and Richterová, E. (2022) "Agricultural Cooperatives and Their Impact on Economic Performance of Farms in Slovakia", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 2, pp. 85-95. ISSN 1804-1930. DOI 10.7160/aol.2022.140207.

Introduction

Cooperative organizations play important role in agriculture in many countries. Contemporary agricultural market created demand for various method of cooperation, usually in horizontal or vertical way. Many authors claim that current development on the agricultural markets creates demand for more vertically coordinated organizations (Höhler and Kühl, 2014). In European Union cooperatives represent over 50% of market share in agricultural production. This situation is characteristic especially for dairy products, or hog meat market in some European countries (Bijman, 2012; Liang and Wang, 2020). In the milk market in USA (83%) and New Zealand (99%) have cooperative organizations even higher market share (Cakir and Balagtas, 2012; Iliopoulos, Cook et. al., 2012). Motivation of producer to join cooperative organizations can be various. Usually, farmers join producer organizations if they have some benefits coming from their membership. This also influences their loyalty to their organization and lasting of their membership. According to Gray and Kraenzle (1998) are larger farm units more involved in producer organizations membership than smaller farms, which are less satisfied by membership and have less time available to participate. Main benefits coming from participation in agricultural cooperatives are aggregation, marketing of larger production and advantage of scale economies to inputs. It allows farmers to improve their bargaining position and negotiate better prices. (Bijman and Wijers 2019). Cooperation also helps farmers to disseminate their knowledge, service and technologies, and marketing of their products (Ortmann and King 2007). Vertical cooperation allows farmer to participate in value-adding process and increase their bargaining power even more. It is also way how farmers can increase their credibility and visibility for potential buyers. On the other hand, for their clients is easier to negotiate a single contract with farmers organized in producer organization. Cooperation therefore plays an important role in the long-run sustainability of the agri-food value chain helping farmers to reach financial viability and solvency (Wang, Cheng, et. al., 2019). Grashuis and Su (2019) suggest, that main channel how cooperative membership helps farmers to increase their profit involves minimizing information asymmetries. In many countries it also includes adoption of food safety labels and certifications amongst farmers. Recent studies focused on the on the effectiveness and inclusion as the outcome of cooperation in agricultural industry. Authors tried to quantify impact of membership on income of cooperatives (World Bank report, 2008; Verhofstadt and Maertens, 2015). According to results of Ma and Abdulai (2016) cooperation increased yields, net returns, and income of farmers. Their results suggest differences between agricultural cooperatives, dependent on commodity, business sector, and geography. Duvaleix-Treguer and Gaigne (2015) suggest, that different producer organization types can impact differently on farmers´ performance. According to results of research conducted by Michalek Ciaian and Pokrivcak (2018) in Slovakia, membership in producer organization improves economic performance of farms. Same result was in Slovakia concluded also by Fandel and Bartová (2019) who used metafrontier approach. Similar result was confirmed also by research conducted in China by Ito, Bao and Su (2012) who suggest that cooperative membership contributes substantially to an increase in farm income of farmers. According to these authors is especially in China effect of agricultural cooperatives dependent on commodity, business sector, and geography. In conclusion, cooperative system is important way how to improve economic status of farmers. Cooperative membership also reduces market risks in relation to greater capacity to diversify markets and products and strengthen downstream and upstream integration (Alho, 2015; Cook and Plunkett, 2006; Kyriakopoulos et al., 2004, Valentinov, 2007). On the other hand, Nilsson (1998) states, that current cooperative business models are efficient only under specific economic conditions. This could be either continually declining cost curve with size, or situation when price is not affected by individual firm´s sales volume. In general, empirical results investigating the effect of producer organizations on its members performance are limited and mixed in conclusions. Mostly, because it is necessary to distinguish between motivation of producer organizations in developed and developing countries. In developed countries is motivation of producer organizations focused on bargaining position of farmers and better response to changing market conditions. In developing countries is the aim of cooperative organizations to address rural poverty and reduce market barriers. (e.g., Abebaw and Haile, 2013; Bernard et al., 2008; Duvaleix-Treguer and Gaigne, 2015; Chagwiza et al., 2016; Ito et al., 2012; Latynskiy and Berger, 2016; Markelova et al., 2009; Vandeplas et al., 2013; Verhofstadt and Maertens, 2015; Michalek Ciaian and Pokrivcak, 2018, Fandel and Bartova, 2019). Studies are not only mixed in their conclusions, but also failing in describing the mechanism behind the estimated effects. This paper extents the knowledge about impact of membership in cooperative organizations on economic performance of farms in Slovakia and continues further in contrafactual analysis based on results of researchers mentioned above. Analysis includes major determinants of membership in cooperative organizations, but also compares economic performance of members and non-members. Study is focused not only on profit and revenues of farms, but also on structure of their costs. For this purpose, was used data from Ministry of Agriculture of Slovak republic with economic indicators of farms covering period of years 2009-2016. This was currently the most recent available data coming from the last statistical investigation of Slovak farms. Data was anal and matched pairs were compared by procedures of statistical inference. This allowed us to identify main differences in economic performance between members and non-members of agricultural cooperative organizations with elimination of selection bias.

Materials and methods

The main objective of proposed paper is identification of major difference between members of cooperative organizations and non-members. The analysis includes following procedures:

1. Estimation of panel logit model which predict membership of farm in cooperative organization – this model identifies main determinants of membership in cooperative organizations.

2. Panel logit model was used to generate propensity score for each farm, which was used in next step to match similar farms.
3. Members and non-member farms within each year were matched using propensity score matching to create comparable pairs of farms with similar properties – this procedure was conducted to eliminate self-selection bias. Each cooperative member was matched 1:1 to nearest non-member neighbour.

Groups were compared using paired t-test to identify significant differences between members and non-members within each year and overall difference for analysed period. Source of the data is the Slovak Ministry of Agriculture and covers economic indicators of farms for period of years 2009-2016 (currently the most recent data). Every year includes 431 variables for 735 farms in Slovakia, which is 5880 observations in total. Variables covers information about revenue, sales, cost, production, and property structure of farms. Dataset includes variables which are cumulated into aggregated categories. In the first step were selected relevant variables which characterize major proportion of analysed farms and dropped observations with prevalence of missing values. These data were used for estimation of panel logit model with random effects. Parameters of panel logit model were estimated using 5722 observation from dataset. In the next step was conducted propensity score matching. Based on this procedure were created in total 1794 matched pairs of farms which were compared by paired t-test. Aggregated values were calculated into euro per ha, to allow comparison of farms with different size. Only wage category was analysed in total and in euro per ha. The only variable, which was not expressed in euro was number of employees.

Propensity Score Matching

Farms who are members of cooperative organizations are not selected randomly, which can cause the self-selection bias problem. Propensity score matching is method used often in contrafactual studies used to eliminate selection bias and was employed also in this study. Propensity score matching matches farms which are members of cooperative organizations with non-member farms that have similar likelihood of being member based on observed characteristic (Rahman et al., 2018; Gautam et al., 2017; Schreinemachers et al., 2016; Gitonga et al., 2013; Khan et al., 2012; Abebaw et al., 2010). The propensity score was generated by following panel logit model with random effects.

$$Ln\left(\frac{P\left(Y_{ij}=1\middle|x_{ij},u_j\right)}{P\left(Y_{ij}=0\middle|x_{ij},u_j\right)}\right)=a_1+\sum_{k=1}^{K}\beta_k x_{kij}+u_j, \quad (1)$$

Where u_j is normally distributed with mean = 0 and variance σ^2, and $j = 1, 2, 3, \ldots, J;$ $i = 1, 2, 3, \ldots, n_j$.

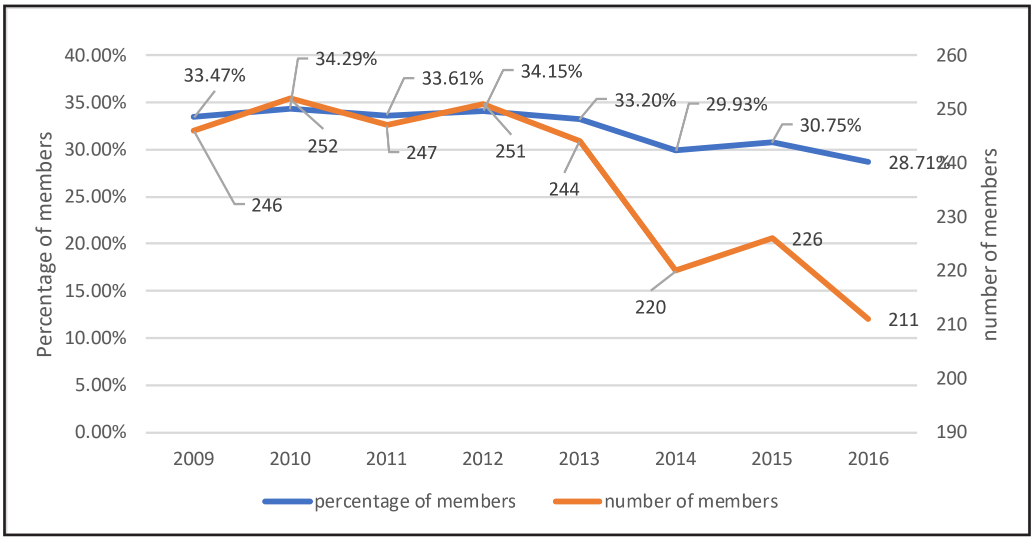
With Y_{ij} is dichotomic variable equal 1, if farm participate in agricultural cooperative organization, 0 if farm is not a member, of the ith subject in the jth center, X_{ij} represent covariates, a_1 is the intercept and β_k is the k^{th} regression coefficient, u_j is the random effect representing the effect of the j^{th} center. Here X_{ij} represents explanatory variables number of employees, value added tax (proxy of added value), revenues (measures economic performance), and cost of electric energy (measures energetic intensity of farm production). These explanatory variables are result of model selection process, from the original set of all 431 variables included in the database. Selection process considered explanatory ability of each variable, multicollinearity between variables, quality of the model together with his simplicity and previously published results by other authors mentioned in the introduction. Coefficient β_k measures the effect of increasing X_{ij} by one unit on the log odds ratio. (Li, B. et al., 2011). In the next step was conducted matching of cooperative organization members with non-members by estimated propensity score. Each member was matched with non-member with the same, or the nearest value of their propensity score. The average difference between these groups was considered as the effect of membership in cooperative organization. Significance of this difference was evaluated by paired t-test. This was suggested by Austin (2011) as the more efficient method in relation to propensity score matching compared to test for independent samples. Analysis included evaluation of differences between variables: value added tax (VAT), cost of electric energy, wage per year, wage per ha., cost of fuel, sum of overdue receivables, number of employees, consumption, total cost, received support, saps (single area payment scheme), plants and animal production, sales, revenue, and profit.

Results and discussion

Proportion of cooperative members was slightly decreasing for this period, from initial 33.47% of members (246 farms) in 2009 to 28.71% of members (211 farms) in 2016. Decrease is even more significant in absolute numbers of members in period 2012 to 2016, where number of members declined by 40 farms in the last four years. Number of members and their proportion on total number of farms is shown in the Figure 1. This decreasing tendency in number of cooperative organization members may suggest, that membership in last years ceased to be an advantage for some farms. Period between 2009 and 2012 was number of members of agricultural cooperative organizations in Slovakia stable in absolute and in relative numbers. We can expect that after this period situation in some member farms changed. Some farms were not motivated enough, to be member of cooperative organization in next years. This could be related to support for producer organizations and producer groups, which are included in group of analysed cooperative organisations from European Union in period 2007-2013. End of this support could also influence decrease in number of cooperatives in Slovak Republic.

Initial dataset of 735 farms for period 2009-2016 was used to estimate panel logit model. This model (Table 1) predicted membership in cooperative organization (dependent variable membership, 1 for members 0 for non-members). From estimation were excluded variables with prevalence of missing values, and it was necessary also to consider strong correlation between some considered explanatory factors. In the variables selection process was considered significance of the variables entering the model using backward elimination, and previous results of other authors. Michalek, Ciaian and Pokrivcak (2018) used in their work panel logit model with following explanatory variables: farm gross value added, farm profit, farm employment, and labour productivity (gross value added/annual work unit). Considering all the factors mentioned above was conducted modelling procedure with various variables and model types. In final, was selected logit model in the Table 1. estimated with robust standard errors. Likelihood ratio chi-square equals to 64.2 with p-value = 0.0000 which suggest strong significance of the model. Compared to results of authors mentioned above, same variable employees are included in both models. Our model includes variable VAT (value added tax) as proxy of gross value added created by farm. As the measure of economic performance in this model was used revenue, instead of profit in the model mentioned above. Both variables were significantly correlated, and revenue was in this case considered as the variable better predicting membership in cooperative organization in our dataset (according to difference between members and non-members). Intensity of productivity in this case was measured by cost spent on electric energy instead of labour productivity, because this information was not available for major proportion of farms in our dataset. Also, other variables available in our dataset were considered as explanatory, but according to significance and explanatory ability was selected as the best following panel logit model with random effects (parameters shown in table 1). The Table 1 includes estimated coefficients of the model, together with odds ratios and their significance.

According to results of estimated model, subjects with higher use of electric energy, higher number of employees and higher amount of paid value



Source: Author´s work based on data from Ministry of Agriculture of SR

Figure 1: Relative proportion and number of cooperative members in dataset.

Cooperative membership = 1	Coefficient	Std. Error	z	P>z	Odds Ratio	Odds ratio 95% confidence interval	
el. energy	0.01	0.003	2.95	0.003	1.010313	1.003451	1.017222
revenues	0.00	0.00	-3.09	0.002	0.999815	0.9996976	0.9999324
VAT	0.001	0.00	2.62	0.009	1.001045	1.000264	1.001826
employees	0.033	0.008	4.11	<0.001	1.033097	1.017194	1.049249
constant	-4.44	0.478	-9.29	<0.001			

Source: Author´s work, based on data from Ministry of Agriculture of SR

Table 1: Panel random effect logit model, dependent variable: membership in cooperative organizations.

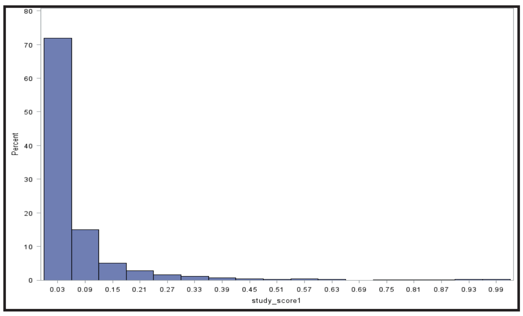
Matching score	Group	Mean	Median	Variance	Std. Dev	Coeff. of Variation	Kurtosis	Skewness
before matching	nonmembers	0.06	0.02	0.02	0.12	212.82	27.11	4.94
	members	0.10	0.04	0.03	0.18	174.76	12.33	3.44
after matching	control- nonmembers	0.07	0.04	0.01	0.11	157.66	27.98	4.64
	study - members	0.07	0.04	0.01	0.11	154.68	28.48	4.69

Source: Author´s work, based on data from Ministry of Agriculture of SR

Table 2: Score before and after matching.

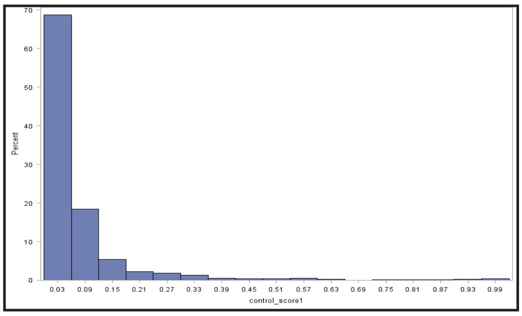
added tax tend to be more likely members of agricultural cooperative organizations. On the other side, with increasing revenues are odds in favour of being member decreasing. This could suggest that motivation of farms to be a member is decreasing with higher revenues. In such case is also decreasing advantage from being part of cooperative organization. On the other side, with increasing cost are farms more likely looking for ways how to use economics of scale in their favour. This result is in line with expectations and confirms results of other researchers. According to results of the model was the most significant factor influencing membership in cooperative organizations number of employees. With increasing number of employees are also increasing odds in favour of being a member. Panel model was used for generation of score (probability of being member) for each farm. Based on this score was conducted propensity score matching. Each member farm was matched to non-member with the same or very similar value of propensity score within each year (accuracy 0,01). As the result was constructed database including 1794 pairs of matched observations in total. Table 2 compares distribution of score (predicted probability of being member in cooperative organization) before and after matching. Dataset before matching included 5880 observations. After matching was created 1794 of member and non-member pairs which is in total 3588 farms observations, which were used for further comparison (1:1 matching). Efficiency of matching is shown in the Table 2.

Before matching was significant difference in score between members and non-members, with higher variability in non-members group. This suggests higher variability in data, a larger difference between farms caused by self-selection bias. This means, that samples are not selected randomly, but each farm can decide to be a cooperative member by itself. After matching was average score in both groups equal to 0,07 with variability measured by standard deviation equal to 0,109. Also, the shape of distribution measured by kurtosis and skewness in both distributions was similar. Matching procedure found for each cooperative farm, non-member farm with similar score generated by the panel logit model within the same year. Distribution of score in both groups is shown in the Figure 2 and 3 below. After matching procedure should both samples include farms with similar character, which makes them comparable.



Source: Author´s work, based on data from Ministry of Agriculture of SR

Figure 2: Distribution of score for members.



Source: Author´s work, based on data from Ministry of Agriculture of SR

Figure 3: Distribution of score for non-members.

Both distributions are significantly right-skewed, with most of values on the left side. Similar shape of distribution suggests proper conducted matching procedure. In further analysis will be these two groups treated as matched samples. It means, that analysis will be focused more on average difference between mean values in each matched pair than on average difference between groups. It also means that compared will be farms within the same year. From the initial data set, which included 431 variables, were selected main categories of costs and revenues (15 variables) which are compared in Table 3 shown below. It is necessary to remind, that most of the variables are in euro per ha. Names of the cost categories variables are in bold. Bold notation of mean values denotes statistically significant difference according to test results. All variables are characterized by high variability in both groups. In overall comparison were most of significant differences recorded in cost categories, particularly in value added tax, wage, fuel, overdue receivables, and number of employees. In most cases, were significantly smaller costs

Variable	Mean	Median	Variance	Std Dev	Coeff. of Variation	Kurtosis	Skewness
members_VAT	19.26	0.43	307632.49	554.65	2879.74	1653.00	39.86
non-members_VAT	56.84	1.00	77617.21	278.60	490.15	57.02	7.02
members_el. energy	45.63	26.58	132532.01	364.05	797.91	1636.88	39.77
non-members_el. energy	40.34	30.63	2253.04	47.47	117.67	42.11	4.72
members_wage per year	329964.11	279540.00	81134352921.00	284840.93	86.32	6.22	1.98
non-members_wage per year	**337978.13**	257347.00	80654042860.00	283996.55	84.03	5.51	1.71
members_wage per ha	254.15	201.68	833885.71	913.17	359.30	1609.65	39.16
non-members_wage per ha	**367.89**	227.19	591187.28	768.89	209.00	72.23	7.89
members_fuel	106.50	91.65	17829.48	133.53	125.37	860.85	25.20
non-members_fuel	**132.49**	81.17	20376.10	142.74	107.74	47.09	5.51
members_ overdue receivables	113.34	41.99	56507.81	237.71	209.74	68.75	4.57
non-members_overdue receivables	**135.40**	31.94	154548.06	393.13	290.33	124.51	9.59
members_employees	**39.48**	33.00	936.53	30.60	77.52	4.89	1.73
non-members_employees	38.08	34.00	933.35	30.55	80.23	9.93	2.25
members_ consumption	791.18	517.91	38875563.89	6235.03	788.07	1732.88	41.33
non-members_consumption	622.13	444.33	375367.14	612.67	98.48	62.87	4.96
members_total cost	1920.21	1308.38	84419005.22	9187.98	478.49	1657.79	40.01
non-members_ total cost	2369.20	1464.44	17600405.02	4195.28	177.08	81.74	8.39
members_recieved support	322.65	298.19	69326.23	263.30	81.60	465.11	18.01
non-members_recieved support	**370.14**	369.70	22120.29	148.73	40.18	1.61	-0.05
members_saps	151.59	155.14	1843.94	42.94	28.33	4.23	-1.17
non-members_saps	153.52	155.36	1603.23	40.04	26.08	2.38	-1.20
members_revenue plants and animal production	1136.85	729.81	94321346.19	9711.92	854.29	1744.60	41.53
non-members_revenue plants and animal production	952.44	559.70	1248083.42	1117.18	117.30	32.47	3.51
members_sales	1381.06	828.16	106696579.00	10329.40	747.94	1380.65	35.99
non-members_sales	1511.89	868.26	16319067.48	4039.69	267.19	95.24	9.33
members_revenue	1926.88	1292.05	90605459.04	9518.69	493.99	1645.65	39.81
non-members_revenue	2313.09	1466.50	18543511.86	4306.22	186.17	84.92	8.62
members_profit	**6.74**	8.38	381661.58	617.79	9166.20	422.61	17.90
non-members_profit	-64.36	-4.59	140527.21	374.87	-582.45	18.84	-0.71

Source: Author´s work, based on data from Ministry of Agriculture of SR

Table 3: Descriptive statistics in matched groups.

in category of cooperative organization members. Only number of employees was significantly higher in this category, compared to non-members category. This is in contrast with higher amount of wage in members group. In other cost variables was not identified significant differences, no matter what the difference between mean values was. On the other side, in category of revenues was significant difference between amount of support which was higher in non-members category. Significant differences in costs and insignificant difference in revenues was reflected in significantly higher profit in group of cooperative member farms. Members of cooperative organizations take advantage from their membership, and economics of scale coming from cooperation, allows them to lower their cost, compared to non-members. On revenues side was not confirmed significant differences between members and non-members. This overall comparison led to conclusion, that for the period of years 2009-2016 member farms took advantage in more efficient using of cost to reach significantly higher profit compared to non-members.

Results in the Table 4 are aggregated average values for whole analysed period and can lead to general conclusion. This means, that also significance of difference between member and non-members was based on the average difference over the whole period 2009-2016. On the other side, condition in the market changed over years, which may lead also to different impact of membership in cooperative organization. This can be expected especially from the development of chart in the Figure 1, where number of cooperative members started to decrease in 2013. How the significance of these differences developed over years is shown in table 4. Last two columns include information about significance of overall comparison and in case of significant result is in last column comparison of member a non-member group. For example, in case of value added tax was between members and non-members significant difference only in years 2010, 2011, 2012 and then in 2015 and 2016. In other years, this difference was not significant. In overall comparison for the whole period of years can be concluded, that members and non-members paid significantly different amount of value added tax, with higher value on the side of non-members. As can be seen in the table, differences between members and non-members significantly changed over period 2009-2016. Only in case of revenues from animal and plant production was not recorded significant difference between members and non-members in any year from analysed period. In case of other variables was identified significant difference at least in one year.

At the beginning of analysed period, in 2009 was identified significant difference between members and non-members only in case of wage per year, overdue receivables and profit. At the end of analysed period was identified significant difference between members and non-members in all variables except energy cost, consumption, revenue from plant and animal production, sales, and total revenue. Difference in total cost and saps was significant at 0,1 level of significance. Year, when the results of cooperative organization members and non-members were the most similar was 2014.

Difference pvalues	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Overall comparison**	**Overall difference**
VAT	0.91	0.00***	0.00***	0.00***	0.38	0.83	0.02**	0.00***	0.01**	non-memb.>members
energy	0.26	0.62	0.00***	0.19	0.01**	0.66	0.8	0.01**	0.54	-
wage per year	0.01**	0.32	0.68	0.07*	0.00***	0.00***	0.53	0.05*	0.04**	non-memb.>members
wage per ha	0.63	0.00***	<0.0001***	0.03**	0.18	0.01**	0.45	0.00***	<0.0001***	non-memb.>members
overdue recievables	0.00***	0.00***	0.02**	0.8	0.00***	0.49	0.01***	0.38	0.03**	non-memb.>members
employees	0.12	0.77	<0.0001***	0.34	0.62	0.22	0.99	<0.0001***	0.01**	non-memb.<members
consumption	0.3	0.15	0.46	0.34	0.22	0.43	0.01***	0.54	0.25	-
total cost	0.63	0.09*	<0.0001***	0.00***	<0.0001***	0.4	0.37	0.00***	0.06*	non-memb.>members
recieved support	0.92	<0.0001***	0.00***	0.01**	<0.0001***	<0.0001***	<0.0001***	<0.0001***	<0.0001***	non-memb.>members
SAPS	0.97	0.00***	0.00***	0.21	<0.0001***	0.54	<0.0001***	0.00***	0.09*	non-memb.>members
plant and animal production revenue	0.31	0.61	0.1	0.54	0.09*	0.32	0.38	0.35	0.43	-
sales	0.52	0.39	0.03**	0.13	0.61	0.42	0.42	0.00***	0.61	-
total revenues	0.58	0.04**	0.00***	0.03**	<0.0001***	0.52	0.12	0.01**	0.11	-
profit	0.02**	0.00***	<0.0001***	<0.0001***	<0.0001***	0.36	0.87	0.08*	<0.0001***	non-memb.<members

Note: *** significance at α=0,01 ** significance at α = 0.05 * significance at α = 0.1
Source: Author´s work based on data from Ministry of Agriculture of SR

Table 4: Significance of differences between members and non-members over the years.

In this year was not significant difference even in profit of these two groups. In case of profit is interesting, that significant differences were recorded in period 2009-2013. This could be linked with significant support of producer organizations, which ended in 2013. There was recorded significant difference in received support between members and non-members, but significant difference in revenues and profit corresponds with supporting period. In period 2014-2016 was not significant difference in profit between cooperative members and non-members. Similarity between members and non-members could lead to continuously decreasing number of members in this period. In 2014 and 2015 the differences in cost variables were not so common which resulted in similar profit. In 2016 were differences in cost variables more frequent, but there were also recorded more differences in revenues compared to other years. Difference in profit in 2016 was only significant at $\alpha = 0.1$. It is interesting, that almost in whole period was significant difference between non-members and members in amount of received support. In non-members group are probably farms, which can easier receive support without membership in cooperative organization. On the other hand, decrease in total cost seems to be important motivation for membership in agricultural cooperative organization. At the beginning of analysed period were farms motivated to cooperate also by European support for producer groups and producer organizations, which finished in 2013 and probably significantly affected revenues and profit of cooperatives in this period.

Conclusion

Objective of this paper was analysis of membership in cooperative organizations on economic performance of farms. This was investigated using propensity score matching approach. Analysis was conducted on the panel of farms covering period of years 2009-2016. In general, it can be concluded, that in presented period was members of cooperative organizations more profitable than non-members. This was caused especially by difference in cost structure between members and non-members. The Reason was probably fact, that members successfully used advantages of scale economics, when joined together in cooperative organization. Also difference in total revenue was significant in period of years 2010-2013, which means probably successful using of advantage from better bargaining position of cooperative organizations, compared to non-members, and which was influenced also by European support for producer organizations in period 2007-2013. Significant difference in profit disappeared in last three years 2014-2016, when there was not significant difference in profit between members and non-members. Membership in cooperative organization probably improved economic performance of farms in Slovakia in period 2009-2013, but this advantage disappeared in 2014-2016. This result corresponds to period of support for producer organizations from EU, which finished in 2013 and which was motivation for farms to cooperate. This loss of advantage from membership in cooperative organizations reflected also into decreasing number of members in these years. Interesting fact was, that non-member group had significantly larger amount of received support in whole analysed period of years. Farms with high amount of received support are probably not motivated to join cooperative organization. Another interesting result was that non-members had significantly higher wage cost compared to members in most of analysed years. Similar result was found also in case of total cost. On the other side, number of employees was significantly different only in two years and was higher in members group. In general, it can be concluded that economic conditions in analysed period changed over time and members of agricultural cooperative organizations in 2014 and 2015 had problem to achieve full advantage from their membership compared to economic performance of non-members, as it was in previous years. This was also influenced by the end of European support for producer organizations in 2013, which led to disappearance of significant economic advantage from membership in cooperative organisation. Agricultural producer organizations significantly benefited from this support, which confirms also results of Bijman, Iliopoulos et. al. (2012). If membership does not bring farms significant economic advantage, it will be probably reflected in decreasing number of cooperative farms. Slightly improvement in position of members was in 2016, which could indicate better future for agricultural cooperative organizations. This could be confirmed by more actual data, which will be available in 2020.

Acknowledgements

Research was supported by the Scientific Grant Agency grant no. 1/0845/17 and Grant Agency FEM SPU project No 01/2021/GA FEM SPU.

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Agris on-line Papers in Economics and Informatics

Volume XIV Number 2, 2022

Agricultural Aid and Growth in Sub Saharan Africa: a Review of Empirical Evidence

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Abstract

There are interesting debates on the influence of foreign aid to agriculture on economic growth in Africa. Some scholars have argued that, despite the inflows, majority of rural smallholder farmers in the continent are extremely poor. The precise channels through which foreign aid is to promote sectoral growth has been inadequately understood from the literature. This paper is a systematic literature review on the empirical evidence of the relationship between agricultural aid and growth in Sub Saharan African countries. The Generalized Methods of Moments and the Granger causality test are the main methodological approaches of papers reviewed and the relationship between agricultural aid and productivity growth is positive and quite significant. However, the results demonstrate a weak synergy between the various forms of agricultural aid and growth. The main recommendation is to have a broader conceptual, theoretical or analytical frameworks that clearly define how agricultural aid influences productivity when measured against other influencing factors. Aid is only a catalyst to growth so, governments must invest and provide the necessary infrastructure and a conducive policy environment for increased productivity and growth.

Keywords

Agricultural aid, productivity, growth, Generalised Methods of Methods.

Shaibu, A.-F. and Shaibu, M. H. (2022) "Agricultural Aid and Growth in Sub Saharan Africa: a Review of Empirical Evidence", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 2, pp. 97-109. ISSN 1804-1930. DOI 10.7160/aol.2022.140208.

Introduction

The causes of low agricultural production and its consequences in Sub-Saharan Africa (SSA) has attracted a lot of discussions in recent times. The populations of Africa are mostly farmers who are unable to feed themselves. This coupled with increased number of under-nourished people and persistent food imports, has exacerbated the phenomenon of low agricultural productivity and growth in the region (African Union, 2006). Although many factors have been attributed to this, the decline in agricultural investment is thought to be a major contributing factor (Shafiail and Moi, 2015). Foreign agricultural aid and public domestic investment are two critical agricultural investment sources that can provide the necessary support to farmers to increase productivity. foreign aids or grants come in different forms; improved inputs, innovation technology, capacity building, rehabilitation and construction of roads that will connect farming communities to markets, credit to agribusinesses and private sector investments. All of these are necessary to spur growth in the agricultural sector. However agricultural growth in Africa largely depends on a combination of several factors including homegrown policies and reliable donor support and none of these factors is sufficient on their own to generate the desired growth in the sector (Kosta and Zezza, 2003 and Binswanger-Mkhize, 2009).

In an effort to use home grown policies to deal with the challenges of growth in the agricultural sector, African governments have begun to mobilize local resources to increase public spending on agriculture. A classical example is the Comprehensive Africa Agriculture Development Programme (CAADP) which is a strong initiative to support smallholder farmers. One of the strong pillars of the CAADP framework is ‘improving rural infrastructure and trade related capacities for market access where African nations have pledged to devote 10% of their national budgets to agriculture (African Union and NEPAD, 2003) with some countries surpassing this threshold (Shenggen et al., 2009). This agreement is critical to encourage governments to respond to important opportunities for African agriculture such as increasing domestic demand and rising world food prices among others.

Despite huge foreign agricultural inflows, majority of people in Africa who are extremely poor still live in rural areas and as smallholder subsistence farmers. These farmers are characterised by low average agricultural value added output and yield, soil nutrient deficiency, and low levels of modern input use and irrigation systems (Gollin et al., 2014 and McArthur, 2019). In the same vain, there is considerable evidence to show that agricultural growth has important aggregate effects in reducing global extreme poverty. The sector has been particularly fundamental in promoting growth in non-agricultural sectors, through channels of structural transformation from low level rural sector productivity to higher productivity in urban sectors (McArthur and McCord, 2017).

The interesting point is that, the precise channels through which foreign aid is to promote sectoral growth has been inadequately understood from the literature. Empirical studies have grappled with how to specify the conditions and pathways through which aid, as a source of public finance, might support agricultural growth (Werker et al, 2009; Arndt et al., 2016 and Galiani et al., 2016). Though these debates remain important, their common emphasis on cross-country empirical relationships only provide limited insight regarding the actual channels through which aid might support productivity and growth in the agricultural sector.

The main purpose of this paper therefore, is to review relevant literature on foreign agricultural aid and agricultural growth from the perspective of Development Assistance (DA). It seeks to identify and synthesize methodological approaches and the relationships between foreign agricultural aid and growth in Sub-Saharan Africa. The first objective provides an overview of the conceptual, theoretical or analytical frameworks guiding the discourse in foreign aid and growth. The second objective examines the empirical evidence of the relation between agricultural aid and growth. The third objective assesses the methodological approaches used to measure these relationships.

Development aid

All the funding or financing provided by public actors from the most well-off countries to improve living conditions in the least well-off countries is often regarded as Development aid. They are usually in the form of grants or loans at favourable rates, whose purpose is to finance programmes to improve living conditions in recipient countries. Official Development Assistance ODA in particular plays an essential role. It helps start up projects in sectors or areas that have been left behind. It initiates processes of “virtuous development” and creates dynamics that can help bring all the other stakeholders, especially businesses, into the picture. It creates a leverage effect that multiplies impacts. Development aid since 1960 has proven to be effective. It is a powerful factor of change for the most vulnerable populations as it been premised on an agenda to help poor developing nations grow out of poverty.

Nevertheless, aid has come with its own challenges for developing countries. Two prominent areas of concern in recent economic development literature are the effectiveness of foreign aid and the impact of different types of aid on poverty in developing countries. From the literature, there is a very limited number of studies which attempt to address the relationship between foreign agricultural aid and agricultural growth even though there is a vast literature on the effect of foreign aid in general on economic growth (Debre et al., 2007 and Ssozi et al., 2018). Although some studies have established positive correlation between development assistance and agricultural productivity but when analyzing its impact on major agricultural recipient sectors, there is a substitution effect between food crop production and industrial crop production (Ssozi et al., 2018; Norton et al., 1992)

Agricultural productivity and growth in sub-Saharan Africa

Agricultural growth is thought of as a measure of output, input utilization and total factor productivity. The Agriculture sector plays a critical role in the development of the Sub-Saharan Africa (SSA), serving as the major source of livelihood of about 53 percent of the region’s workforce (OECD and FAO, 2016). It is a key strategy to poverty reduction in developing countries. Available data show that over 60 percent of rural population of Africa rely on agriculture for their livelihoods (African Development Bank, 2016) and women make up almost half of the agricultural labour force (Dao, 2009). It has also been reported that growth in agriculture has a larger spillover effect in reducing poverty than growth in non-agricultural sectors, especially on extreme poverty (Christiaensen et al., 2010). Some papers even suggest that GDP growth have had less impact on poverty reduction than growth in the agricultural sector due to the high level of poverty in rural areas of developing countries although the sectors contributions to total GDP in SSA on average, is about 15 percent (OECD and FAO, 2016).

Using agriculture as a poverty reduction strategy is therefore critical. The African model of agricultural growth differs significantly from the rest of the continents in the world especially Asia and South America. In the two continents, growth is largely driven by intensification and labour productivity whereas in Africa, farm area expansion and intensification of cropping systems are significant drivers of agricultural growth (Badiane and Collins, 2016). Experts have projected an annual growth rate of 2.5 percent to eradicate hunger by the end of 2025 (African Union, 2014; OECD and FAO, 2016) and such productivity gains could be attributed to multiple influencing factors including faster technology adoption and improved smallholder integration into the value chain. However, despite this positive outlook, yields gabs and the importation of primary food products are among the greatest challenges of agricultural growth in SSA. Other key challenges are uncertain policy environment and poor infrastructural development that limit market access, increase post-harvest losses and raise the cost of trade (OECD and FAO 2016). How then does foreign development aid to agricultural addresses these challenges? Does it play a critical role in agricultural productivity and growth?

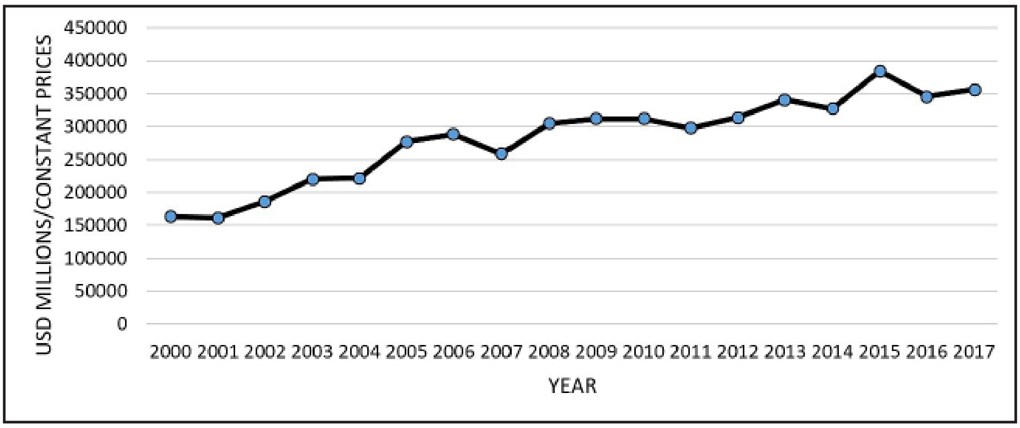
Investment in agriculture

All though agriculture is diversified in Africa, its investment remains weak despite efforts made by public authorities, the private sector and international development partners. As a result of this and other factors such as climate change, market crises and food security issues, heads of states and international organisations have regained interest in the global discussions of agriculture. Following this move is the commitment by African governments of 10 percent of their annual budgetary allocations to the agricultural sector over a period of 5 years with a 6 percent annual sector growth rate at the national level (NEPAD, 2015). This noble agreement which has been supported by Multi-Donor Trust Fund (MDTF) goes beyond the objective of increasing agricultural productivity to include, the creation of wealth and economic opportunities, food and nutrition security, and resilience and sustainability of households in the African region. The importance of agricultural finance in Africa is also highlighted in the Kampala "principle" where African leaders have not only recognised agricultural finance as a part of the overall financial system of a country, but also the need to give special attention to financial services required by agriculture sectors Gerrard et al., 2016).

As a result of the problem of low income and access to credit, Foreign Direct Investments are also critical in offsetting the investment and technological gaps in Africa (Awunyo-Vitor and Sackey, 2018). In 2017, the share of FDI inflows to agriculture in the continent was 22 percent compared with other regions of North America (43 percent), Asia (29 percent) and Europe (4 percent) (World Bank, 2020). Analysis of AID-Monitor from FAO[1] presented in Figure 1 indicate that Foreign Direct Investments inflows to agriculture, forestry and fishery in Africa, have increased from \$1.2 billion to \$1.7 billion between 1997 to 2011. There is also a significant increase in Official Development Assistance for Agriculture development in the region between 2000 and 2017 from 157,697.4 USD Million to 342,801.97 USD Million representing over 100 percent increase inflows within the period.

Despite these substantial foreign inflows to the agricultural sector, sustainable productivity and growth continue to be a major challenge in most countries. In Ghana for example, the rapid economic growth experienced between 2007 and 2010 (7.3 percent) was largely driven by the service sector. Its acceleration to 10.3 percent by end of 2013 was also on the back of oil exploration (Ghana Statistical Service, 2019). Although agricultural growth has increased from 0.9 percent in 2014 to 4.8 percent in 2018, it contribution to GDP continue to decline (Ghana Statistical Service, 2019). Other countries in the continent of Africa such as Nigeria, Senegal, Mali and Sudan experienced similar trend in growth between 2002 and 2019. In Nigeria for example the agricultural share of GDP dropped from 36.9 percent in 2002 to 21.9 percent in 2019 (World Bank 2020). In fact, in Sub Saharan African countries in general, agricultural GDP had significantly dropped from 21.1 percent in 1994 to about 15.3 percent by the year 2019 (World Bank, 2020). The distribution of agricultural GDP on sub

[1] See: http://www.fao.org/aid-monitor/analyse/sector/en/



Source: Extract from FAO AID monitor (2020)

Figure 1: Total ODA Commitment to agricultural development in Africa (2000-2017).

regional basis is even skewed. Whereas West and East Africa have 30 and 29 percent respectively, Central and South African sub regions have 19 and 7 percent respectively (Alabi, 2014).

Bilateral and Multilateral aid

Bilateral aid has been described as transactions undertaken by a donor country directly with a developing country including those with NGOs active in development and other, internal development related transactions on development awareness. A multilateral aid on the other hand, are transactions delivered only by an international institution conducting all or part of its activities in favour of development (Biscaye, Reynolds and Anderson, 2017).

There have been debates on the choice between multilateral and bilateral aid channels. Some have argued that aid disbursements by multilateral agencies looks quite similar to the disbursements of bilateral donors, with similar terms and conditions while others, have contended that there is quite a number of different considerations between the two (Annen and Knack, 2018). The stimulus to understand the benefits of the two channels is the need to justify and account for aid spending in donor countries. Overall, multilateral aid channel has been favoured in most aspects. There are evidences to suggest that bilateral channels are more politicized (Verdier, 2008 and Girod, 2012), aid recipient countries prefer multilateral channels because they deal with more legitimate and trustworthy partners (Andreopoulos et al., 2011 and OECD, 2007). Multilateral aid is more selective in targeting countries with democracy and good governance and the rule of law (Dollar and Levin, 2006). The most striking characteristics are that multilateral channels of aid are better suppliers of global public goods and plays a vital role in responding to food security, climate change, and conflict challenges (Deaton, 2013 and Wickstead, 2015).

How do these channels respond to the challenges of agricultural growth in SSAs? From the literature review, there seem to be a little bit of disconnection between foreign aid and agricultural growth and productivity in Sub Saharan Africa despite the enormous global attention to use foreign aid as a catalyst to spur growth and poverty reduction in developing countries. There is also continuous and polarising debates on its effectiveness in delivering on the Sustainable Development Goals (SDGs) especially on sustained economic growth and poverty reduction (Gu et al., 2019; Meijaard and Sheil, 2019). Concerns are also raised about the fact that, donor agencies may not necessarily allocate aid flow to regions or countries that need them most but, are influenced in part by their political and strategic considerations including good governance, fiscal sustainability and accountability (Carothers and De Gramont, 2013 and Kosack, 2003).

Materials and methods

Conceptual framework

From the Development aid literature, the common hypotheses are that aid will lead to growth only in countries with sound macroeconomic environment. It is detriment to nations where there is political instability and high level corruption (Alabi, 2014 and Nahanga, 2017). However, foreign agricultural aid or Official Development Assistance influences productivity and growth in the sector, there are equally other significant influencing factors Chenery and Strout (1996) s two-gap model has been influential in explaining the effectiveness of foreign aid. In this model, savings and export revenue constrains in developing countries hamper investment and growth and foreign aid flows are necessary to fill this gab. On the other hand, public investment in productivity and growth generally in most developing countries, is low due to low revenue mobilisation.

Following the hypothesis that economic growth in developing countries especially in Africa is largely driven by the agricultural sector (Shimeles et al., 2018), the relationship between agricultural aid or official development assistance to agricultural is therefore critical to expand the literature on aid and economic growth. Agricultural aid in developing countries are generally in the form of research, input support programmes, technology transfers, climate change adaptation and capacity building among others. By categories some are bilateral while others are multilateral (Alabi, 2014). The phrase “agricultural aid” is used in this study to reflect bilateral and multilateral Official Development Assistance to agriculture excluding private flows such as contributions by NGOs to agricultural development. This has been excluded in the assessment because mapping of private sector financing flow for agricultural development has proven difficult (McNellis, 2009)

How do these influence productivity and growth in the agricultural sector? Although productivity have been interpreted differently in the literature, agricultural productivity is thought of as a measure of efficiency in an agricultural production system which employs land, labour, capital and other related resources. Precisely, it is the measurement of the quantity of agricultural output produced for a given quantity of input or a set of inputs (Mozumdar, 2012). Sources of productivity may include mechanization, high yielding seed variety, fertilizer, irrigation, pesticides, genetic engineering and education among others (Nin et al., 2003 and Fischer et al., 2009). On the other hand, agricultural growth may be measured by the increase in agricultural production or productivity over time which could be influenced essentially by institutional, infrastructural and technological factors. For cross-country analysis the most common measure of growth is agricultural GDP (van Arendonk, 2015), but other measures are levels of crop and animal production over time. Some literature also suggest that agricultural productivity will automatically lead to growth. For analytical purposes therefore, productivity and growth have been conceptualized to mean to same thing in this paper.

Data collection procedure

Following the work of Ansah et al. (2019) and Gough et al. (2012), a systematic literature search was conducted using CAB Abstracts, Web of Science, Scopus, and PubMed as data bases. These were supplemented with in-document reference selection using a 'snowball' algorithm to identify relevant articles cited in published papers. Three main key words were created and used to find relevant papers. Among these are agricultural productivity or growth as dependent variables, Development Assistance for Agriculture or Official Development Assistance for Agriculture as the intervention variable, and agricultural output or share of GDP as the unit of analysis. The retrievals were centered on disciplines such as economics, agricultural economics and policy, and development economics, and the literature search was based on title, abstract, and key terms. The study relied on databases that allowed connections to export retrieved documents to the Endnote program to separate databases that did not correspond to the topic area or did not focus on basic scientific studies in order to remove databases that did not correspond to the subject of interest.

The papers acquired from the databases were first vetted by reviewing the titles, abstracts, and key words to see if they were appropriate for the study's objectives. The paper's major goal is to look at the empirical evidence on the link between agricultural aid and agricultural productivity and growth. Papers that met the selection criteria were kept for additional examination, while those that did not were discarded. Table 1 shows a summary of the literature searches and screening criteria.

Scope	Database				
	Web of Science	Scopus	Cab Abstract	PubMed	Total
Keyword 1 Development aid	1 072	2 516	3 868	1792	
Synonyms: Development assistance, Official Development, Assistance, Economic assistance, International aid, Overseas aid, Foreign aid					
Keyword 2: Agricultural aid	30 328	33 061	50 231	4230	
Synonyms: agricultural support, agricultural subsidies, agricultural subsidy, aid to agriculture, support for agricultural, agricultural assistance					
Keyword 3: Agricultural productivity/growth	61 239	105 986	167 018	87 432	
Synonyms: Agricultural output, agricultural production, Agricultural GDP, Agricultural yield, Average agricultural output					
Combined search for all key words (1,2 & 3)	45	32	145	69	291
Further screening by titles, abstract, keywords	10	14	28	12	64
Retained after removing duplicates					50
Further screening with inclusion / exclusion criteria					22
Snowball "in-document" referrals					4
Retained for final review					18

Source: author's compilation from search results September 2020

Table 1: Literature search results and articles screened and selected.

Results and discussion

The paper is mainly a methodological review of literature on the relationship between agricultural aid and growth in sub Saharan African countries. Specifically, it focuses on the conceptual and analytical framework in the discourse of foreign aid and economic growth, the relationship between foreign agricultural aid and growth and the methodologies used by scientific papers and journal articles. A systematic review was conducted to achieve the stated objectives.

Characteristics of reviewed papers

Out of the 18 reviewed papers, 10 are mainly analytical and empirical, 3 are both conceptual and analytical, while 2 are conceptual, analytical and empirical in scope. Of the empirical papers, only a few examine the conceptual, analytical or theoretical framework of agricultural and growth. All the empirical studies used panel or time series data. None of the studies used cross sectional data and a few were gray literature. A summary of the characteristics of the studies reviewed are presented in Table 2 Overall time series data were used for analysis involving up to 98 Developing countries which 47 are Sub Saharan African countries. The Generalized Methods of Moments (GMM), OLS, the Correlations Coefficients (Pearson (r) and Spearman) were the main methods of analysis.

The historical overview of defining and conceptualising foreign aid and growth is not straight forward. Some writers believe that development aid will lead to growth only in countries with sound macroeconomic environment and that aid is detriment to nations where there is political instability and high level corruption (Alabi, 2014 and Andreopoulos et al., 2011). Foreign aid enhances economic growth as long as fiscal policies are effective (Durbarry et al., 1998). The evidence adduced by Boone (1995), suggest that aid-intensive African Greenaway countries had experienced no growth in per capita income for over a decade between 1970 and 1980 despite the fact that GDP share of foreign aid had increased over the period. This analysis is supported by Omoruyi et al. (2016) and raises important questions as to the actual effectiveness of monetary assistance to developing countries by developed nations and multinational institutions. Quite a sizeable number of papers have underscored the relevance of foreign agricultural aid in particular as a poverty reduction strategy in developing countries. The framework of Nahanga (2017) suggest that underdeveloped economies, substantially rely on foreign resources to boost their per capita income. Other scholars have identified multilateral aid, input support programmes, sectoral growth time lag, aid volatility and country specific fixed effects as the main drivers of the relationship between foreign agricultural

SN	Author (s)	Type of study	Methodology	Data Used/Sample
1	Alabi (2014)	Empirical, Conceptual & Analytical	Generalised Methods of Moments (GMM) Granger Causality Test	Time series (2002-2010), 46 SSA Countries
2	Arndt et al (2015)	Empirical, analytical	Structural Causal Model (SCM); OLS, LIMH and IPWLS	Time Series (1970–2007) 78 Developing Countries
3	Awunyo-Vitor and Sackey (2018)	Empirical, analytical	Descriptive statistic, unit root test, Granger causality test and error correction model	Time Series (1975-2017) Ghana
4	Barkat and Alsamara (2019)	Empirical	Augmented Mean Group Common Correlated Effects-2SLS Dumitrescu-Hurlin Panel Causality test	Panel Data (1975 - 2013) 29 African countries
5	Blížkovský and Emelin (2020)	Empirical	Pearson correlation coefficient (r), Spearman correlation coefficient	Times series (2002- 2016), 3 SSA Countries (Ghana, Cameroon & Mali
6	Chenery and Strout (1966)	Theoretical	The two-gab Growth Model	Time series (1960-1970) 50 Developing Countries
7	Durbarry et al. (1998)	Empirical	Augmented Fischer-Easterly type model	cross-section and panel data techniques (1970-93)
8	Galiani et al. (2014)	Experimental	Quasi-Experiment Two-Stage least squares (2SLS)	panel data (1987 and 2010) 35 Developinig countries
9	Gunasekera et al. (2015).	Global economy-wide modelling framework	The General-Equilibrium Model (GEM)- Global Trade Analysis Project model (Gdyn)	African countries
10	Kumi et al. (2017)	Empirical, Analytical	System GMM	Panel dataset (1983–2014) 37 SSA Countries
11	Mahembe and Odhiambo (2019)	Empirical, theoretical	Vector Error-Correction model (VECM), Granger causality test	Time series (1981–2013) 82 developing countries
12	McArthur and Sachs (2019)	Stimulation/ Modelling	Simulation, Modelling (Production Function)	Time series (10 year period) Uganda
13	Nahanga Verter (2017)	Empirical, theoretical	OLS, Granger Causality Test and VDA	Time series (1981 - 2014) Nigeria
14	Norton Ortiz and Pardey (1992)		Aggregate Production-OLS (log-linear)	Times series (1970-85) 98 Developing countries
15	Shenggen et al. (2009)	Policy Brief	Case study approach	Time series 16 African Countries
16	Ssozi et al. (2018)	Empiral, Conptual Analytical	System two-step GMM;	Panel dataset (1983–2014) 36 SSA Countries
17	Werker et al.(2009)	Empirical, Experimental	Instrumental Variable Approach, two stage least squares (2SLS)	Time series 54 Developing countries
18	Wickstead, M. (2015)	Analytical	Trend Analysis	Time series (1980 -2007)

Source authors' elaboration from reviewed papers 2020

Table 2: Characteristics of reviewed papers.

aid and growth in African countries (Kumi et al., 2017; Duflo et al., 2011). In fact, low agricultural productivity experienced by the African continent largely is the result of poor institutions, inadequate human capital development, inappropriate or poor agricultural policies and natural factors (Ajao and Salami, 2012).

Relation between development aid and agricultural productivity and growth

A significant number of papers reviewed, have established quite positive relationship between agriculture aid and agricultural sector growth but with a substitution effect between food and industrial crop production. Average output for cash or industrial crops for countries receiving Agricultural ODA have increased relative to food crops (Ssozi et al., 2018) though some studies have observed a positive correlation between cereal crop production and multilateral aid especially in Ghana and Mali (Blížkovský and Emelin, 2020). In general, the empirical review revealed an important link between foreign agricultural aid, growth and poverty reduction in sub Saharan African countries. What is actually missing is the causality of the relationships even though very few of the papers run the Granger Causality Test to find out whether lagged information provides any statistical information about agricultural productivity. Overall, these papers were not inherently controlled studies to have focused so much on establishing causality between the variables. Nonetheless, the strong drivers of agricultural productivity and growth in African countries are soil productivity, public investment policies, climate change, the availability and nature of arable land which are mostly country-specific factors (Nahanga, 2017; McArthur and Sachs, 2019 and Kumi et al., 2017). In general, there are still many different statistical studies with widely differing results regarding the correlation between aid and economic growth.

Methodological approaches

In the publications evaluated, the Generalized Methods of Moments, OLS, the Correlations Coefficients (Pearson and Spearman), and the Granger Causality Test were all employed to evaluate the link between agricultural aid and growth. This is to be expected, because the system GMM, as a widely used estimate method, outperforms other methods in estimating the parameters in a dynamic panel data model (Bun and Windmeijer, 2009). The superiority of OLS over other models was not well justified in the papers that employed it. Agricultural growth, as defined by production or output, and productivity, as measured by cereal yield (kg/ha), agricultural share of GDP, Average agricultural value added per worker are the dependent variables in the majority of the publications. while the independent variables are total Official Development Assistance (ODA) for agriculture, ODA for rural development, arable land, agricultural imports and exports and country-specific effects such as governance index, and corruption. Papers that used correlation methods added a dimension to the investigations by looking at how bilateral and multilateral agricultural aid correlates with productivity and growth. All the 18 papers reviewed used panel data mostly covering between 16 and 47 Sub Saharan African countries within the period 1985 to 2017.

Strengths, weaknesses and biases of reviewed papers

One of the key strengths of the papers is the use of multiple methodological approaches and time series data. For example, about 10 out of the 18 papers each used a combination of Granger Causality test, the GMM and Variance Decomposition methods. This is good because when numerous approaches are used to investigate a phenomenon, the results are more robust and persuasive than when only one approach is used (Davis et al, 2011). Another critical component is the emphasis on cereal productivity growth, as it is a critical crop for many smallholder farmers in SSA. (Nyiawung et al., 2019). In Analyzing Food Security in Africa, Dzanku and Sarpong (2010) emphasized the importance of cereal food staples.

However, each study on average used about 12 countries as case studies which represents just about 4.4% of the population of countries in the SSA and the inclusion and exclusion criteria was not also explained. The political economy of foreign aid is largely missing in the empirical studies. In development literature, some papers suggest that the impact of foreign aid on economic growth is conditional on good institutions and policy environment (Akramov, 2012; Bräutigam and Knack, 2004).

Conclusions

The paper reviewed relevant literature on foreign agricultural aid and growth in SSA from the perspective of Development Assistance (DA) by identifying and synthesising, methodological approaches and relationships. Using a systematic approach, it provides an overview of the conceptual and analytical frameworks of foreign aid and growth. It also examines the empirical evidence of the relation between Agricultural aid and productivity growth and assesses the methodological approaches of relevant studies reviewed.

The conceptual, theoretical or analytical framework reviewed presents some important scenarios which support a growing interest in understanding the interactions of foreign assistance with agricultural productivity and growth in Sub Saharan African countries. First, a larger share of government expenditures in many developing countries are from foreign aid. Secondly, agricultural sector development plays a critical role in the overall economic development of these countries especially in the early stages of development where government plays a critical role by investing in agricultural research and physical infrasture. Finally, foreign agricultural aid does not only consist of cash or material transfers but also involves transfer of ideas through policy advice and skills in the form of technical assistance.

Empirically, there is a significant relationship between foreign agricultural aid and agricultural productivity and growth in Suh Saharan African counties but when compared with other independent factors such soil productivity, public investment policies, climate change, the availability of arable land and other country specific factors the relationship is weak. However, multilateral agricultural aid is reported to have been stronger than other forms of aid. The results suggest that aid is only acting as a catalyst in agriculture-led growth in Africa. So much responsibility and commitment is required of governments. They have huge responsibilities to create and main rural infrastructure, invest in agricultural research and facilitate small holder farmers access to credit. In general, there are still many different statistical studies with varying results regarding the correlation between aid and economic growth

The Generalised Method of Moments (GMM) is a widely used approach to examine the relationship between aid and growth in Developing countries. This is quite expected given the nature of data sets and sample size of the investigations; (time series and between 29 - 47 SSAs involving several indicators). The GMM allows for most flexible identification of estimates. Alternatively, the MLE could provide a better statistical significance for parameter estimates, but it requires strong distributional assumptions. The Data Generation Process must be completely specified. However, some studies have shown that GMM estimators of dynamic panel models are unstable and potentially biased in finite samples (Roodman, 2009a and 2009b in Galiani et al., 2017).

For future research on foreign aid and economic growth in Africa, there should a broader conceptual, theoretical and analytical framework that clearly define how agricultural aid influences productivity when measured against other influencing factors. This is particularly important when issues of political or ideological underpinnings in foreign aid flows have not been adequately captured.

The problem of a weak relationship between agricultural productivity growth and aid in Africa

can be reversed if governments are able to provide sound political environment and physical infrastructure to promote investment in agricultural. It will therefore be interesting if further studies incorporate Foreign Direct Investment in the models of analysis even though these are largely not aid related

For proper analysis, foreign aid must be segmented in the equation model to determine its strength more appropriately. We could have bilateral aid, multilateral aid, financial and non-financial aid variables in the equation as separate independent variables.

To establish causality and capture key concepts, future investigations should consider the Structural Equation Models (SEMs). This can be used to test and evaluate multivariate causal relationships, the direct and indirect effects on pre-assumed causal relationships and to accurately measure key concepts such as governance index, political and ideological pathways of foreign aid.

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Agris on-line Papers in Economics and Informatics

Volume XIV Number 2, 2022

Fair Label versus Blockchain Technology from the Consumer Perspective: Towards a Comprehensive Research Agenda

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Abstract

Many small farmers and workers on plantations in poorer countries constantly live on the poverty threshold. Those people suffer from rising commodity prices and trade structures that pass price pressure to the weakest link. Farmers are at the mercy of these structures and must comply as they have no other choice. On the consumers' side of the supply chain, it is often hard to recognize agricultural products' fairness and originality, especially in processed food. Many organizations – through food labelling - partially inform consumers about products' provenance and fairness. Whereas several studies confirm that food labels positively influence the consumers' intention to buy food, the vast number of organizations and labels are hard to evaluate and distinguish. A technology that could be a gamechanger in sustainable and fair global agriculture could be Blockchain Technology (BCT). With the help of BCT, the need for a central authority like a "fair label" agency may become obsolete, with the same or even better results. This conceptual article surveys subject matter literature and concludes that there is a noticeable research gap in the possibility of BCT replacing or enhancing fair food labels. Thus, the paper shows the potential of BCT to improve fairer agricultural supply chains and make them transparent for customers. By doing so, some research areas and research questions will be derived. Furthermore, specific directions for future research will be shown.

Keywords

Fair agriculture, blockchain, supply chain management, fairtrade, food labelling

Sodamin, D., Vaněk, J., Ulman, M. and Šimek, P. (2022) "Fair Label versus Blockchain Technology from the Consumer Perspective: Towards a Comprehensive Research Agenda", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 2, pp. 111-119. ISSN 1804-1930. DOI 10.7160/aol.2022.140209.

Introduction

There are many unsolved economic and ethical issues within the supply chain of agricultural products and food. Many small farmers and workers on plantations in poorer countries constantly live on the poverty threshold. Those people suffer from rising commodity prices and trade structures that pass price pressure to the weakest link. Farmers are at the mercy of these structures and must comply to make a living. Therefore, many organizations evolved to eliminate inequalities amongst global agricultural supply chains and diminish sustainability issues. For example, the Fairtrade Label guarantees smallholder farmers a minimum price for their product, intended to cover the average costs of sustainable production and improve their living conditions (Jefford, 2021).

Consequently, fair label organizations certify the fairness of products with labels visible on agricultural products and food. Further, also food consumers want the assurance that their food is safe and that the accompanying information is accurate (Rupprecht et al., 2020). It seems that those fair food label organizations excel in alleviating inequalities and are sustainable; however, the variety of organizations is hard to comprehend and distinguish for consumers. Consequently, consumers are faced with an increasing number of sustainable food labels, deprived of the possibility to prove which is the right one. According to Sirieix et al. (2013), these different labels add to the competition of product information in consumers' minds, even though it is not transparent for consumers if the whole product is traded fair or just parts of it.

Studies (Wang et al., 2020) found that the perceived quality of food labels positively influences the consumers' intention to buy food. That means food producers strive to put trusted labels on their products to increase sales. Also, "Made-in" labels are used by customers to judge a product's quality ex-ante (Haucap et al., 1997). However, customers hold different levels of trust in different labels, which depend on the food certifying body. Consequently, consumers need to trust organizations or labels on products to know the provenance of agricultural products (Wang et al., 2020). For example, there is no real transparency between farmers' and government administrations' exchanged data, especially in poorer regions. Consequently, governments could alter information for their advantage, and the development of the agricultural industry will be hindered (Sowmya et al., 2020).

This issue imposes some room for improvement through new technologies. One technology that could be a gamechanger in sustainable and fair global agriculture is Blockchain Technology (BCT). With the help of BCT, the need for a central authority like a "fair label" agency may become obsolete, with the same or even better results. This technology is not just a significant improvement for customers, but it is also a gamechanger for farmers in poorer regions – as BCT can democratize the information in supply chains. In addition, the technology could inform farmers more about their products' journey and better manage customer relationships and risks (Fairtrade Foundation, 2019).

The agricultural supply chain

The recent supply chain issues, which span over many worldwide industries and products, do not stop at the agricultural industry. Ironically, the issue with agricultural supply chains is that there is a shortage of food on the one hand, and on the other, there is rotten food in containers around the world. The reasons for that are various: labour shortages due to COVID-19, shortages of raw materials to repair equipment and the lack of herbicides which make crops growing more expensive (Sönmez, 2021).

Generally, modern supply chains are a complex endeavour across different industries with multiple functions, potentially conflicting objectives, and numerous dependencies between material and information flows. The agricultural supply chain (ASC) is more complex, with many inbound and outbound networks (Denis et al., 2020). The complexity in the ASC is enhanced by the fact that most agricultural products are perishable. Therefore the opportunity to use inventory as a buffer against demand and transportation variability is limited (Ahumada and Villalobos, 2009). Moreover, ASC are more complex to manage than other supply chains, mainly due to the importance of factors like food safety and quality, limited shelf life, demand, and price variability. An efficient and fair agricultural supply chain results from stable networks and common relations between input suppliers, producers, processors, traders and retailers (Bhagat and Dhar, 2011). In addition, recent studies (Eluubek kyzy et al., 2021) found that current agricultural supply chains have a hard time helping impoverished farmers because agricultural supply chains focus mainly on the processes between farmers and consumers and omit smallholder farmers. That is because the agricultural industry prefers to work with large scale farmers that use modern technology, and small farmers do not have any possibility to negotiate from the same level. Hence agencies can bargain prices down. Summarized, the main issues of ASC are food loss, safety, insecurity, accessibility, increased demand, diminishing resources, and the global food crisis (Despoudi et al., 2021).

Blockchain technology

Since the ground-breaking invention of the peer to peer electronic cash system (Bitcoin) in 2008 (Nakamoto, 2008), Blockchain Technology (BCT) has seen an enormous rise in academic and practical significance for various applications. This interest might be fuelled by vast and valuable applications paired with the fairytale-like rise of Bitcoin and other cryptocurrencies (Coinmarketcap.com, 2021).

Initially, the BCT was used as a decentralized platform to validate transactions in financial applications without the need for any third party. Gradually, applications in non-financial industries are on the rise and impose many opportunities (Nofer et al., 2017). BCT is applicable for every business which relies on an intermediary between two parties. Therefore the BCT can challenge existing business models in almost every industry (Morkunas et al., 2019).

Without technical detail, a blockchain can be described as a distributed data database in encrypted so-called "blocks" (Rymarczik, 2020). These data blocks are cryptographically linked together and can be verified by all parties at any time (Antonucci et al., 2019; Nakamoto, 2008). To be able to do so, the data is stored with reference to the previous data block, forming an indefinite ever-growing chain of blocks. The blocks are created by parties who maintain the whole network and are called miners and get rewarded for their contribution (Chitchyan and Murkin, 2018).

By doing so, the data on the Blockchain is for everybody viewable and due to the connection of the blocks not amendable. This opens many possibilities for applications where trust is a crucial issue.

Blockchain technology in the agricultural supply chain

The agricultural sector is still one of the most minuscule digitalized industries, with many unused possibilities and inefficiencies (Gandhi et al., 2016). It brakes the development of modern business models based on IT tools implementation despite their steep spread in business activity (Hu et al., 2019; Roshchyk et al., 2022). Furthermore, the food supply chain has become a worldwide, multi-actor, distributed supply chain, where many stakeholders, like farmers, shipping companies, wholesalers, retailers, and end customers, are included (Kamilaris et al., 2019). Through BCT, there is a reliable approach for tracing all transactions and managing all stakeholders. This reduces the space for fraud and malfunctions along the supply chain and quicker detection of inefficiencies. Hence, BCT technology can provide solutions to food-quality and food-safety issues, which are concerns of both customers and governments (Xiong et al., 2020). Furthermore, considering the current backlogs and issues along global supply chains, a transparent supply chain optimizes operations, guarantees the quality of outputs and ensures the sustainability of processes (Montecchi et al., 2021; Křenková et al., 2021). These consequences are valuable due to increasing challenges for agriculture development in an international environment (Przekota et al., 2020).

Although the Blockchain had its primary usage in the financial industry and is also known mainly because of digital currencies like Bitcoin, Ether and many other financial usages, the Blockchain in agriculture has its justification. The fields of applications are vast but can be categorized mainly around the supply chain of food (Kamilaris et al., 2019). Like many other industries, supply chains in the agricultural industry have never undergone a digital transformation.

The main challenges that need to be tackled in the future are the rising food demand, changing consumer preferences, environmental issues and sustainability, costs, food safety, and fair trade (Schmidhuber, 2018). Lately, the BCT in agriculture has become a growing trend, and Blockchain led innovations in the agricultural market have been rapidly gaining traction (Jefford, 2021). As an example, BCT could improve food labelling: Studies show that BCT could be far superior to a food label organization, as customers must trust the organization in guaranteeing the quality of the product. However, BCT is not based on trust but on knowledge that cannot be manipulated (Uhlich and Lux, 2021).

Furthermore, consumers are increasingly demanding high quality as well as safe food, paired with a wish for a smaller environmental footprint of agricultural products, which is also fostering the need for new innovative technology to trace food along the supply chain in an effective manner (Rana et al., 2021). In fact, farm-to-shelf traceability can be an essential factor in establishing a benchmark for food quality and safety ([x]cube LABS, 2020). Therefore, more and more companies are starting to use BCT along the supply chain: Coca Cola has been exploring multiple blockchain projects for years to tackle different issues. One latest project was created to find a secure registry for sugar cane workers to tackle forced labour worldwide (Chavez-Dreyfuss, 2018). Also, a Norwegian salmon producer made it possible to monitor every aspect of the salmon supply chain with the use of digital twins of the salmons on the Blockchain and make it, therefore, completely comprehensible (Ultsch, 2021). Nestle has been trying to ensure that its used palm oil is not linked to any deforestation of the rainforest. Therefore, with the help of BCT, Nestle can track the provenance and the correct shipment of palm fruits (Chandrasekhar, 2020). Most of the companies, both mentioned above and in general, are using BCT based on the IBM Food trust – a modular solution based on BCT that enables a more sustainable food ecosystem (IBM-Foodtrust, 2021). The IBM Food Trust Blockchain benefits are based on increased efficiency, fresher, safer food and sustainable food, less fraud, and reduced waste. Moreover, companies can build up a better reputation and can therefore increase the customer's confidence in the company's product. For example, IBM is working with start-ups on fairer conditions for coffee farmers. Customers can track the coffee beans back to the farmers and directly donate money to them (Stede, 2020).

Materials and methods

This article's main objective is to find research opportunities and define a research agenda for the possibility of BCT improving or replacing fair food labels. The research gap was identified by literature research. A combination of the keywords "Fair Label" and "Blockchain" was chosen to evaluate the available research on this matter. For this article searches were performed over Emerald, Web of Sciences and Google Scholar. No restrictions concerning the date were selected. Although the vast amount of literature on BCT and ASC, there is an apparent lack of papers investigating the consumer perception of BCT and the possibility of the technology to improve or replace fair trade food labels or, in general, food labels. In fact, the author could not find any literature which is dedicating itself to the topic. Therefore, adequate research questions based on well-grounded theory must be formulated to create a comprehensive research agenda. Nevertheless, given the novelty of blockchain technology in the agricultural sector, there are many promising research possibilities for the future.

Results and discussion

BCT could transform the food industry in many ways: more food safety, less fraud and faster and fairer payments (Charlebois et al., 2017). According to Katsikouli et al. (2021), food fraud causes problems from several perspectives. Not only causes it the loss of trust from consumers in food products, but also can it lead to unfair competition and is a threat to brand reputation. This could have massive long term economic consequences for the affected company or even the country. Information of the foods supply chain as a whole and the environmental responsibility of each food producer are essential components of the consumer's trust (Sengupta and Kim, 2021). BCT could make supply chains more transparent and enables the agricultural industry to produce high-quality food with low social and environmental impacts (Rana et al., 2021).

Further, BCT could enable consumers to make more informed decisions about the products they are buying. According to Asioli et al. (2020), there is no denying that the agricultural production systems are facing unprecedented challenges and that due to sustainability concerns, there has been a proliferation of sustainable related food labels. However, the question remains: how could those sustainable related food labels be more informative so that consumers can distinguish those and grasp the value. Many of the advantages which a food label brings a consumer, like transparency, fairness, and information, could also be delivered by a transparent supply chain on a blockchain. Moreover, while using food labels, consumers need to trust companies or organizations responsible for the labels; there is no need by the use of BCT to trust any intermediating party. Due to the possible advantages of a BCT approach, the following research question can be derived:

RQ1: Blockchain technology improves the trust of consumers in fair agricultural products

It is almost impossible for consumers to understand the difference between various fair trade labels, and apart from some serious initiatives, it can be seen that the implementation of fair trade strategies is still very immature (Katsikouli et al., 2021). Consumers are bombarded with many claims on products on how the food is processed, produced and regulated, although consumers mainly cannot distinguish products just because of labelling and therefore are left confused (Abrams et al., 2010).

Almost all traditional food labels are intended to provide consumers with additional information. Studies like Banterle et al. (2013) state that with the use of sustainable food labels, the vertical coordination of supply chains increases and the product uncertainty is reduced. However, several studies indicate that consumers lack an understanding of their meaning (Hamilton and Raison, 2019). What is more, consumers could also struggle with trust in the source of the food label. Hence, Rupprecht et al. (2020) investigated the consumer's perception of five sources of label information: Producers, Governments, Producer Associations, Experts and Consumers. They found that, whereas labels of experts were the least legible, they were found to be the most trustworthy across all the examined countries and food types. So, the emergence of a widely used expert label, where scientific testing of food product is in the foreground as a trustworthy source of information, is proposed. They argue that this development aligns with the trend of greater supply chain transparency. However, what they are not even considering is a solution based on BCT.

On the contrary, Garaus and Treiblmaier (2021) found that blockchain traceability systems positively impact the retailer choices of customers. They argue that with the use of product labels, it can be shown that a traceable and immutable database has been used, which is increasing consumers' trust. Also, others like Behnke and Janssen (2020) describe BCT as a possible technological solution for a food traceability framework – amongst some boundaries which needed to be solved first. In addition, Uhlich and Lux (2021) state that consumers should demand documentation of supply chains via Blockchain, as they argue that BCT is far superior to any sustainable food label. By doing so, companies would be forced to implement the technology and give it a preference over classical food labels (Upadhyay et al., 2021).

Hence, future studies could test whether BCT excels in using food labels. Based on that, a survey design similar to the survey conducted by Rupprecht et al. (2020) is proposed; however, extended with the sources of label information for each food type with a solution using BCT (Table 1).

Researchers could investigate and let BCT compete with the other label information sources. This leads to RQ2:

RQ2: Blockchain Technology is superior to fair labels in the perception of consumers

The issue with fair and sustainable food is linked to many sustainable development goals of the UN. Based on the arguments stated in the previous chapters, the author reckons that a BCT based fair label could improve many issues which are currently not or just partially solved. A way to show that foods provenance could be tracked in a tamper-proof manner would be a gamechanger for the customers and the industry. This can be achieved by a transparent blockchain delivered by BCT. By doing so, small farmers could see amongst others for how much their products will be sold, and big food companies could organize better business calculations by having more accurate and unalerted information on the provenance of its raw materials. BCT could also help companies to reach their Environmental Social Governance (ESG) goals, as BCT could allow for a credible sustainability assessment (Joseph, 2022). Finally, also consumers could profit, as they would undeniably see from where the product is from and whether farmers were treated fair.

This article aimed to show a research possibility about improving fair food labels using blockchain technology. Although most of the investigated articles were about classic food labels, describing the contents of the food, the author assumes that fair food labels can be seen analogously to food labels, as both are basically requiring the same trust for the issuing institution. It is immanent that ASCs are complex for many reasons (Ahumada and Villalobos, 2009; Denis et al., 2020; Kamilaris et al., 2019). So, it is not easy for the customer to understand and track food contents. Using a BCT fair food label, the customer could easily track food components back to the farmer and confirm theproduct'ss sustainability and fairness. The author suggests that the research questions could be answered by a survey similarly to Rupprecht et al. (2020) but extended with a BCT based information source. Research should pay attention to the fact that customers might not be able to grasp the technology initially and therefore might not see the advantages it could bring. Therefore, the survey authors may need to distinguish between people who are aware of the technology and people who are not. Another possibility would be to inform the respondents about the technology before taking the survey; however, this could result in a biased result. Furthermore, with BCT, some issues may remain; for instance, who assures that the data entered on the Blockchain is accurate (Jiang, 2019)? Consequently, someone could argue that BCT does not bring any value to supply chain tracking. However, some companies like Circularise evolved to develop solutions for these issues.

One limitation of this research agenda is that solely the customers' perspective is reviewed. However, the producers' and suppliers' perspective also bear interesting research possibilities that future research could also investigate. Another promising possibility would be to look at the perspective of fair food label organizations. For example, BCT might be a competitive product of fair food labels: A potential customer could make sure whether the product was traded fairly or not by having a completely transparent supply chain. Hence, there is no need for a fair label organization anymore. Contrary to that, someone could argue that a BCT

Label information source	Description of label information source
Blockchain based trust model	Crop to finished food trackability solution
Producers	People who produce the food
Governments	Departments in governments responsible for food
Experts	Independent, neutral researchers
Consumers	Customers who evaluate the food

Source: Rupprecht et al. (2020)

Table 1: Six types of sources of label information and their definition.

fair food label could also be a complimentary product to food labels organizations where the fair food label organization certifies that all data on the Blockchain is valid. Nonetheless, it needs to be researched if such an approach improves the current business-standard.

Conclusion

In this article, the possibility of BCT to improve and or replace classic fair food labelling is discussed. After a description of the ASC and BCT itself, research questions for further research on this topic are derived based on current literature. The question remains: Who is responsible for making the ASC more transparent and, therefore, fairer. What are current barriers to the adoption, and who, with which means, can implement the technology? According to the literature, industry leaders should embrace the technology and make it business-standard. By doing so, the entire food industry could be enhanced (Charlebois et al., 2017). Also, currently, governments are playing an essential role in ensuring that information provided on food is accurately and understood by consumers (Sengupta and Kim, 2021). Studies are also reasoning that the customers should start to demand more transparent ASC (Uhlich and Lux, 2021), which would ultimately lead to a fairer and probably more sustainable ASC. Future studies could also look at companies dedicated to changing current systems by implementing BCT and investigating the adoption. Future research can work on those thoughts, extend or refine them and adapt the stated research questions or answer them.

Acknowledgements

This research has received funding from the Faculty of Economics and Management CZU Prague under the grant no. 2022B0006.

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Agris on-line Papers in Economics and Informatics

Volume XIV Number 2, 2022

Assessing the Digital Transformation in Two Banks: Case Study in Hungary

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Abstract

The influence of Industry 4.0 and the trend of economic globalization has led to growing competition among enterprises in all business sectors, then compelled them to seek new ways to create competitive advantages and sustainable development. Presently, digital transformation plays a critical role across many countries and in all sectors including the agriculture and the rural development. New players have been increasing in the banking sector in which incumbent banks are competing with other traditional banks, fintech, and big tech. Nevertheless, not all banks are successful in digital transformation. By analyzing the practices of two banks in Hungary, this study aims to highlight the digital transformation process which happens at the leading banks and compare and contrast in all dimensions at these transformations. The study results confirm that digitalization in incumbent banks is still at a low and medium level. Moreover, the study outcomes suggest that strategic planning and human resource play key roles in implementing Digital transformation. In addition, digital transformation at traditional banks is not only related to internal; external stakeholders can be drivers or barriers to this process. Government policy and support are important factors to improve the digitalization process in Hungary related to financial services for the agriculture. Based on the results obtained, the authors aim to supplement the lack of research on digital transformation in Hungary.

Keywords

Digital transformation, bank, Hungary, case study.

Tran, L. Q. T., Phan, D. T., Herdon, M. and Kovacs, L. (2022) "Assessing the Digital Transformation in Two Banks: Case Study in Hungary", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 2, pp. 121-134. ISSN 1804-1930. DOI 10.7160/aol.2022.140210.

Introduction

With the convergence of digital-physical-biological technologies, the fourth industrial revolution completely changed how people live, work, and run society. This revolution greatly impacts the competitive advantages of countries. Currently, digital transformation and the digital economy are becoming a remarkable feature and an inevitable trend in the world; many governments, organizations, industrial, agricultural and rural development associations have worked on strategic-foresight studies to ground their associated long-term policies (Ebert and Duarte, 2018). Digital financial services (DFS) can give a direct link to increasing farmer income and decreasing malnutrition. The great benefits of digital transformation spread across various aspects of the business (Phornlaphatrachakorn and Kalasindhu, 2021). The value of DFS is apparent in 1. Reducing loss; 2. Increasing social protection and 3. Extending saving, insurance, and credit services and creating new market opportunities (for new business models, products, and services in every sector). One of many credit vehicles used to finance agricultural transactions, including loans, notes, drafts, and bankers' acceptances. These types of grants are tailored to the specific financial needs of farmers, as determined by planting, harvesting, and marketing cycles (USAID, 2018). Digital transformation is a continuous process with no end, so learning from practical success always brings valuable lessons to all enterprises (Chanias et al., 2019). Significantly under the consequence of the Covid-19 pandemic, the digital transformation would be not only an approach but a mandatory requirement for each country and enterprise. However, despite its importance, it remains an open question of implementing a successful digital transformation. According to a global survey from McKinsey (2018), only 16% of managers confirmed that their companies could perform better after implementing their digital transformation.

Going digital inevitably brings benefits and challenges to all enterprises, and the banking industry is not out of this trend. Digital transformation requires incumbent banks to understand and accept the increasing challenges to survive (Vasiljeva and Lukanova, 2016) and offers new opportunities for the development process (Omarini, 2017). In light of industrialization 4.0, the banking industry has witnessed fundamental changes. On the demand side, the global transition to digital technology, which has changed the customers' behaviors, requires banks to find new technologies to develop their digital services and competencies (Cuesta et al., 2015). On the supply side, financial services would no longer be the game among traditional banks but witness the entry of big-tech (such as Apple, Amazon, Alibaba, Google) and full digital banks (such as N26, Revolut), making this marketplace more competitive (Cuesta et al., 2015; Phan, 2020). The challenges in the digital age force traditional banks to look for new business models that are not relying heavily on transaction costs (Breidbach et al., 2020). The noticeable approach in the business model of traditional banks is to use digital technologies such as open APIs (Application Programming Interfaces), Big Data, and AI (Artificial Intelligence) to create its ecosystem with highly customer personalization, combining non-financial services and financial services, and using a solely digital platform (Pantielieieva et al., 2019). In addition to that, the business environment is becoming more volatile and disruptive. More than ten years since the effects of the 2007-2008 financial crisis, the world economy has gone into a new state of uncertainty due to the Covid-19 pandemic, which has caused some unprecedented business operations in the banking sector. The challenges faced by incumbent banks come from outside factors and the bank's operations. For instance, the changing role of brick-and-mortar bank branches, managing non-branch channels more secure, and the lack of transparency associated with executing regulations issued by banks (Feher and Varga, 2019). Faced with such challenges in the highly dynamic environment, it is clear that a digital transformation is an approach with many potential benefits, frankly speaking, digital transformation in the banking sector would be an irreversible trend. Financial institutions in developed and developing countries have rapidly caught up and embraced this trend. However, it may be that incumbent banks with large assets are more reluctant to adopt digital technologies (Zhou et al., 2021). In many countries, the level of digitization of the banking sector is still not high compared to the comparative advantage they have. For example, the level of digitalization of Hungarian domestic incumbent banks is low and medium (Magyar Nemzeti Bank, 2019, 2021). It means that there is much space for banks to accelerate their digital transformation process during the next few years. Therefore, it is important to deeply understand digital transformation in the banking sector. Despite the importance of digital transformation, there remains a paucity of evidence on the Hungarian banking sector. In order to fulfill this shortage, the current study aims to bring the best practices from analyzing case studies and give a more holistic view of the digital transformation taking place in banking sectors in Hungary.

By comparing the latest implementation of digitalization between two leading banks, the study would highlight the best practice and differences and analyze how these banks develop their digital capabilities in improving their performance. The current study is composed of five parts. The first part will be the introduction; the second part will briefly present the literature review. The third part will present the methodology used for this study. Part four analyses the digital transformation of two banks. The remaining part of this paper is the discussion and conclusion part.

Theoretical aspect

Digital transformation is a holistic approach to renovate strategy and business model through digital technology (Besson and Rowe, 2012). Some associated terms such as digitization and digitalization should not be misunderstood and often have many different understandings among academicians. Therefore, it is necessary to clarify what these words mean. The term ‘digitization’ has been used to define the transformation from analog to digital (Bloomberg, 2018). More broadly, digitization is considered the process of changing analog information into digitized information and is associated with the ultimate goal of creating new value for the stakeholders (Schallmo and Williams, 2018). While digitization is related to changing at the information level, the term digitalization has been used to describe the transformation happening at the business process level (Schallmo and Williams, 2018). Meanwhile, digital transformation occurs at the strategic level, emphasizing the changes to the new/ innovative business model toward customers based on digital technology (Bloomberg, 2018; Schallmo and Williams, 2018). Nonetheless, widely varying definitions of digital transformation have emerged. For Nwankpa and Roumani (2016), digital transformation means changes based on a foundation of digital technologies. Meanwhile, Libert et al. (2016) and Stief et al. (2016) argue that digital transformation is based on the implementation and application of digital technology, ICTs in order to transform the existing business operation into a new process, products/ service, or new business model, sometimes new digital products. In a broader definition, Janssens (2019) defines that digital transformation as the shifting to a new management model and a different philosophy which encourages innovation and new business models and uplifts the use of digital technologies to enhance the experience of internal and external customers. As Kane et al. (2015) mention, digital transformation does not lie in digital technology but in how enterprises organize and implement the transform. In endeavors to provide an overview of digital transformation at the enterprise level, digital maturity models and digital frameworks have been proposed by many researchers (Table 1). For instance, Cuesta et al. (2015) reveal that the digital transformation in the banking sector is divided into three stages. At the first stage, as a response to the change in the competitive circumstances, banks create new channels which focus on mobile devices and new digital products, which predominantly happen in retail payment activities. The second stage strongly emphasizes innovative technological adaptation to transform banks' technology platforms, upgrade the current IT infrastructure. The last stage is the organization-wide transformation from large digital technology investments to organizational culture. Meanwhile, Backbase (2020) introduces the digital-first framework, which explains how incumbent banks compete successfully with digital newcomers. The framework includes four pillars: omnichannel banking, smart banking, modular banking, and open banking. Matt et al. (2015) propose a digital transformation framework that combines four primary dimensions: Use of technologies, changes in value creation, structural changes, and financial aspects. Accordingly, the use of technologies is considered a strategic priority in digital transformation, thereby helping banks add new products and services to their current offerings or introducing new business models and opportunities. Not only that, the emergence of new technologies and new value chains requires changes in structural operations to ensure effective digital transformation. Matt et al. (2015) argue that financial aspects are the foundation for implementing the remaining three dimensions. Erjavec et al. (2018) show that innovation is mainly derived from the business. While current information technology architectures are dropping behind, somewhat hindering digital transformation, organizational factors such as culture shift or change management contribute greatly to digital transformation success. In Hungary, Kő et al. (2019), through a survey on digital transformation with 167 organizations, shows that enhancing operating efficiency and improving client experiences are the most popular digital transformation goals. However, many companies have paid too little attention to preconditions for successful transformation. Similarly, Endrődi-Kovács and Stukovszky (2022) conclude that the level of digitalization in Hungary is far below the average level in Europe.

Authors	Journal/ Source	Proposed framework	Main idea
Backbase (2020)	*Backbase*	Four pilar framework	It is suggested that banks should build four pillars: omnichannel banking, open banking, modular banking, and smart banking.
Cuesta et al. (2015)	*BBVA research*	The three successive stages	The study identifies three important stages to going digital for traditional banks: developing new channels and products, adapting the technological infrastructure, positioning in the digital environment.
Sia et al. (2021)	*California Management Review*	Design a future-ready framework	The study presents a framework based on the digital transformation journey of DBS Bank.
Krasonikolakis et al. (2020)	*Journal of General Management*	Multiple polar frameworks	The study proposes multiple polar frameworks that present the five most important factors: customer value, system and process; culture; business model, and institutional context.

Source: Authors' elaboration

Table 1: Some digital transformation frameworks in the banking sector.

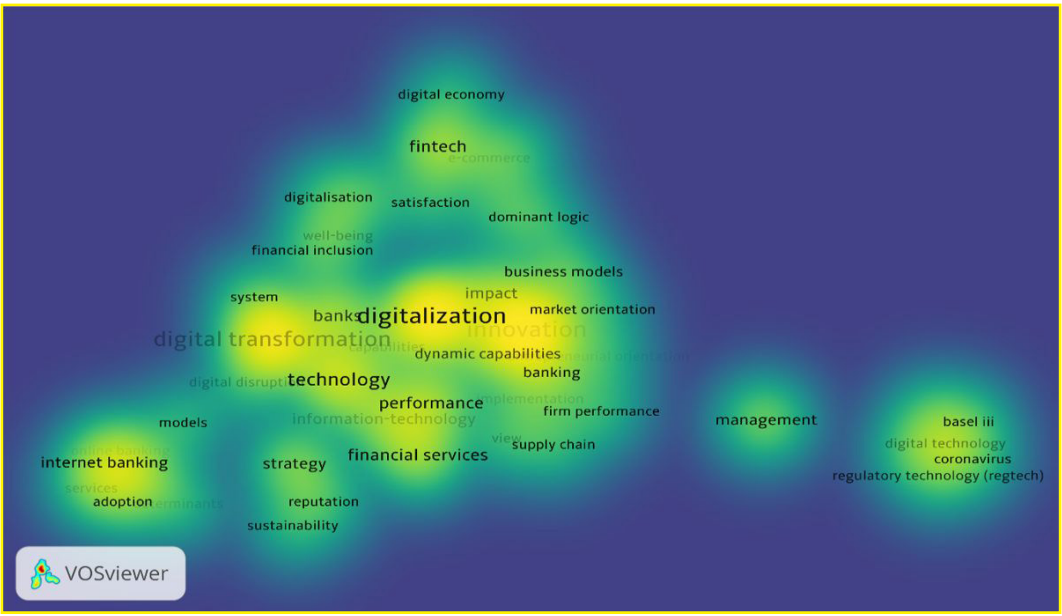
Figure 1 shows interesting topics in digital transformation research related to the financial service industry. The most noticeable research trends focus on many aspects, such as the impact of digitalization on bank performance (Zhou et al., 2021), bank reputation (Bernini et al., 2021), the digital transformation framework and approach (Backbase, 2020; Cuesta et al., 2015; Krasonikolakis et al., 2020; Sia et al., 2021), workplace and human resources (Selimović et al., 2021), customers' behaviors (Abdulquadri et al., 2021; Filotto et al., 2021), financial inclusion (Kanungo and Gupta, 2021). Especially, some new research directions associated with the Covid-19 era, regulatory technology (Regtech), or smart treasury have been conducted.

As the most suggested approach, assessing digital transformation at the organizational level should be conducted in a holistic approach that can cover many aspects of firms, such as strategy, technology, human resource, organizational cultures, and customers. This study adopts the (Evans, 2017) model as a research framework following this way of thinking. This framework encompasses four dimensions that ensure a holistic view on strategy and vision, people and culture, process and governance, technology and capabilities (Evans, 2017). However, one of the shortages of Evans' framework (2017) is neglecting the role of external players in the digital transformation. Therefore, the current research adds one more dimension which considers the role of customers and outside players in banks' digital transformation. Particularly, increasing banking services to agribusinesses can play a larger role in improving overall corporate profitability while also facilitating cash circulation among farmers who are members of the agriculture enterprise. Agribusinesses of different sizes, which need more efficient and modern digital financial services, are increasingly becoming important external partners in all countries, including Hungary. Banks providing DFS services are involved at different stages of the agricultural production life cycle, from land preparation and delivery of seeds or livestock to harvesting, trading, and distributing products to domestic or international markets (IFC, 2017).

Materials and methods

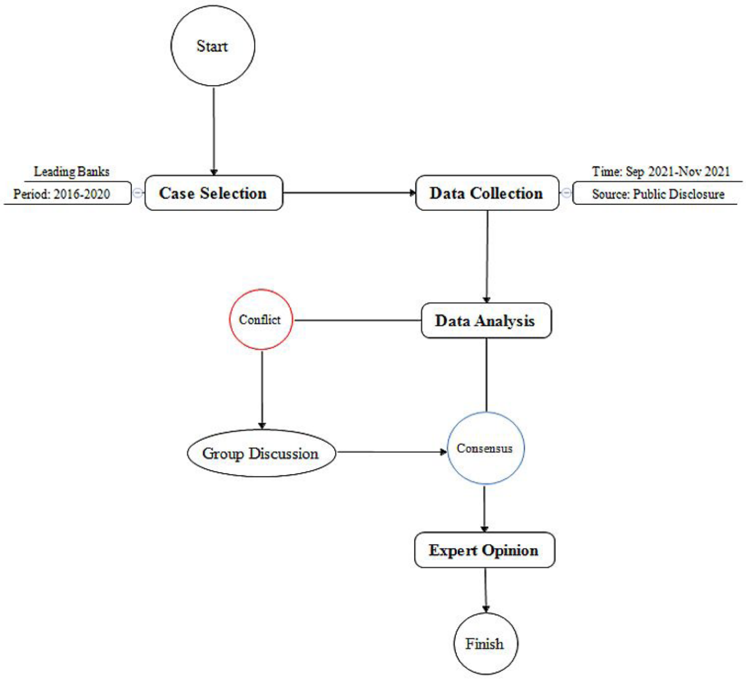
Qualitative case studies are a well-established approach in analyzing the new social context. This method can be more useful for identifying a holistic view of a contemporary phenomenon in a real-life context (Yin, 1994). Hess et al. (2016) point out that it is possible to base on case studies to assess digitalization, thereby building a pattern. As a result, analyzing each case study could build a common framework for digital transformation best practices.

- The first step in analyzing case studies was to select cases (Figure 2). This research adopted the multiple case approach in order to improve the validity



Source: Data collected from the Web of Science database and processed by VOSviewer

Figure 1: The most popular keywords related to the digital transformation in financial service providers.



Source: Authors' elaboration

Figure 2: Workflow for analyzing the case studies.

and reduce observer bias. Moreover, selecting two cases allows researchers to compare and contrast cases (Meyer, 2001). Due to mergers and acquisitions, the number of banks varies yearly. Until the end of 2020, there were 21 commercial banks and 3 three specialized banks in Hungary, some of which provided financial services to the agricultural sector (EBF, 2021). Our research selected two banks with a wide range of customers and activities and have already achieved some results in the development of digitization in the bank's operations and services. Then, we defined the period for assessing the digital transformation implementation at these two banks from 2016 to 2020. The period from 2016 to 2020 was chosen because of some reasons. Firstly, a period of 5 years is enough to analyze the change in digital transformation at the bank and evaluate its results. Secondly, the period from 2016 onwards is considered a period of stability and development in Hungary's banking system after the financial crisis (Kovács, 2019). Finally, we conducted this research in 2021; therefore, most bank reports could have been completed about 2020.

- The second step in our research was to collect data. Table 2 describes the various sources utilized in this study. This study highlighted the context of the Covid-19 pandemic. For research on the new topic as such digitalization, utilizing reliable sources such as public disclosure from banks, the Central Bank, and the Banking Association is considered an effective method that can be applied (Zhou et al., 2021). Finally, 26 documents with a length of 3034 pages were collected.
- The third step of the research was to analyze data. The two authors searched separately for digitalization keywords (described in the following paragraphs). Then, the sentences in the vicinity of the keyword will be coded manually in Excel files. This process is quite time-consuming but ensures high accuracy. After that, these two authors grouped these codes into each theme: strategy and vision, people, and culture; process and governance; technology and capabilities; and external dimensions. These two authors are then compared against each other based on the encrypted file. If items can be linked to two themes, the four authors will discuss choosing an appropriate theme.

Sources	The type of documents	The number of documents	The number of pages
Two cases	Annual reports & sustainability reports	21	2785
The Hungarian Banking Association	Reports	3	145
The Central Bank of Hungary	Fintech and digitalization reports	2	104
Total		26	3034

Source: Authors' elaboration

Table 2: Sources for data collection.

- The fourth step was used to check for better accuracy and reliability of data analyses. When all information received the authors' consent, it was sent to a professional expert with a great understanding of the digital transformation process in the Hungarian banking sector. As a result, one item was suggested to be re-checked, then all authors would work on this item before finding the agreement. The analyzed dimensions were:
  - Strategy and vision
  - People and culture
  - Process and governance
  - Technology and capabilities
  - External dimension

Furthermore, this study adopts a method to measure digitalization from Martín-Peña et al. (2020) and Zhou et al. (2021), who assessed the level of digitalization as the combination of digital technologies. In this study, the level of digitalization of two case studies was examined in the following step. We first listed the six following digital technologies suggested by OECD (2017) and Zhou et al. (2021): multi-channel banking (mobile banking; online banking; internet banking); data management (big data analysis); platforms (crowdlending); artificial intelligence (Robo financial advisors), blockchain (cryptocurrencies), and other digital infrastructures (5G; machine learning; cloud computing). By scanning the sustainability reports and annual reports from these banks during the studied period, if one item was mentioned, then indicated as 1, if not indicated as 0. Then total numbers were used to indicate the level of digitalization. It means six indicated the highest level of digitalization, 0 indicated the lowest level.

Results and discussion

Case study 1: Bank A

Bank A is among the leading financial service provider groups in Hungary. Currently, this bank has more than 200 bank branches in Hungary with around 10000 employees. The agriculture sector and SMEs customers are its priority. The bank provides many financial services to agricultural farms. Some important ones: AgroDevelopment, Restart Investment, Crisis Loan; Agricultural Direct Payments Pre-Financing; Agricultural Investment Loan with interest rate subsidy; Agro-Enterpreneur Overdraft Facility. In addition to these services, professional online help is Land subsidy calculator, Management calculator, Agricultural machinery financing calculator, Farmland calculator.

1. Strategy and vision

The digital transformation strategy was implemented from 2016-2018, emphasizing four goals: (1) Develop online product application processes; (2) Renew digital platforms and improve customer experiences; (3) Go beyond banking services through the internet and mobile apps; (4) Switching paper-based to electronic processes. Digital transformation strategy is considered a priority strategy of the group; Bank's digital transformation object is to improve the customer experience and enhance our banking operations. Until 2018, this bank has completed 25 digital projects. This bank positions customers as the focus of the development process. In addition to shifting the provision of service to the internet and mobile channels to meet new demand, the bank continues to innovate the in-branch financial services to meet traditional customers who prefer to conduct banking transactions in the traditional ways. Consequently, the Bank determines the parallel transformation to serve all customers better.

2. People and culture

Along with digital transformation, Bank also innovates its corporate culture. During the digital transformation period, the bank's CEO has expressed the need to enhance the organizational culture to implement successful digital transformation. This bank has implemented many projects towards developing organizational culture and innovative skills during digital transformation. For example, in 2017, this bank established an innovation center to encourage an innovative culture and enhance the bank's competitiveness. This center becomes a place to gather innovative ideas with high applicability, supported by Bank for testing and wide application. These innovative ideas contribute to changing the mindset of employees, raising awareness of innovation in the bank. One of the ideas that have been successfully launched is the redesign of the bank's branches. Along with promoting the transformation of staff and managers thinking about digital transformation, Bank also adopts digital technology in training staff and managers. The whole training process was moved to digital environments in 2020 because of the Covid-19 pandemic. At the group level, to enhance digital skills in a new digital working environment, this bank provides a course in leadership skills in cyberspace for manager-levels. At the same time, in 2020, Bank has released internal standards for the communication process in the whole corporation. Accordingly, all information sources from this group, such as website, email, message system will be required to follow this legal document using plain language.

3. Process and governance

As for organizational changes, Bank implemented a change management program starting in 2018, first with the retail and IT department. This program aims towards internal workflow changes, in which teams are formed with ten members whose covering multiple functions work in a single space allowing for faster decision making, accelerating the product development process to market. The result of this program is shortening the time to launch new products/services and increasing customer satisfaction. This program's results initially show success when teams working under this new model can reduce a loan product delivery time by 30-90% and launch one new mobile payment service. The digital transformation process requires close support and supervision from top managers; for example, customer complaints will regularly be reported to top managers in Bank.

4. Technology and capabilities

New technologies such as big data analytics, artificial intelligent allow banks to create new business models and automate and robotize working processes in the banking sector (Werth et al., 2020). In 2014, Bank started to adopt the business intelligence system at customer service and call centers. The automated process reduced the waiting time from customer requests, so more quick answers and immediate resolution could be provided. Furthermore, this bank established a robot-process-automation competence center that could process high-volume workflow without staff present physically. This robotic process is applied to some loan packages. Robots could take over more and more internal processes in the future. This bank has also actively upgraded existing services, such as creating a new website to provide more useful agricultural market information and building a chatbot function on the bank's website. In addition, Bank has installed security software protecting ATMs against software attacks on all ATMs and established a cybersecurity center to ensure information security.

5. External dimension

For mobile services, to meet the increased demand for transactions via the internet and mobile, this bank promotes the shift of online banking services. Furthermore, there is Going beyond conventional banking services: Bank's Mobile application (in 2016, further shopping options were added: booking cinema, theater & concert ticket, paying for parking, motorway tolls, or calling a taxi). In 2016, services such as opening accounts and personal loan applications were carried out on the internet without physically visiting the bank, and this bank also opened a new service such as "meeting online with experts". By 2017, the service "meeting online with experts" was be deployed on more than 130 branches. By 2020, this service would be expanded to include experts in loan assessments and approvals. Being consulted by high-quality and highly experienced experts brings many benefits to customers, especially for services related to high-value investments.

For customer services in branches, in 2016, this bank focused on a customer-friendly approach, the continuous expansion of an available function, expanding our clients, financial knowledge. Therefore, Bank provided easy-to-understand information to customers, such as direct kiosks (2016) or Online video (2017). In 2017, the "Tudasbank" (knowledge banks) service launched many videos on the website and YouTube channel to explain the most important information regarding the building society saving products. A notable feature is the introduction of cashless branches, where smart ATMs carry out cash transactions; the main purpose of branches is to advise customers on complex products.

To grasp the advantages of financial technology and start-up companies, Bank decided to cooperate with them to add more features for customers. For example, customers can use consumer loans on some partner websites.

Bank's digital transformation implementation brings benefits to the community. The visible benefit of digital transformation the Bank is reducing paperwork and paper consumption. Meanwhile, the video conference model also helps reduce business travel and emissions. Moreover, some benefits from digitalization that Bank contributes to society can be mentioned, such as an online donation channel (in 2018) or using YouTube videos and digital training courses to improve financial literacy.

Case study 2: Bank B

Bank B is a member of Europe's leading banking and insurance business institution, headquartered in a Western European Country. According to an independent rating agency, the level of digitalization at the parent bank is in second place, only behind a fully digital bank in the Belgian market. That is a prove of the success that this Bank has achieved for its digital transformation. Hungary is one of six core markets alongside the other five markets.

1. Strategy and vision

Digital transformation in this Bank is closely related to the digital transformation from the parent Bank. In 2017, the parent bank decided to invest 1.5 billion EUR for its 3-year innovation and digital transformation strategy from 2017-2020. Bank's digital strategy uses an omnichannel approach which aims to optimize customer experiences and create more integrated and more seamless interactions between channels. From 2020, realizing the importance and necessity of digital technologies and innovations solutions in the coming up years, this Bank added these terms to its strategic objective.

2. People and culture

Organizational culture contributes significantly to the success of the parent bank which is implemented to the whole group. The Group's well-known acronym (implemented since 2012) has created a long-admired internal culture, working as a fundamental of successful implementation of the digital transformation strategy. From 2020, Bank added one more dimension to its organizational culture. This dimension expresses more cooperation, more supports to develop innovative ideas and solutions at the group-wide level. Furthermore, to build a strong culture, the parent bank creates a bank slogan used for all branches and their banks in 6 markets. This attempt aims to promote pride and solidarity within the group, regardless of which market country they serve.

3. Process and governance

In 2016, to execute the digital transformation plan in the entire group, the parent group appointed a Chief Innovation Manager and created an innovation board. Digital strategy implementation plans, and initiatives would be discussed at the Innovation Board of CIM and the CEOs at six core markets. The group understands that the digital transformation trend will expand and affect many areas, departments, and markets. Therefore, the parent group focuses on developing team building to promote learning and sharing new ideas and experiences. Team building groups would include members from many fields and markets to create diversity and group-wide commonality. In addition, under the impact of the Covid 19-pandemic, the Bank has invested more in equipment and IT infrastructure for work from home in the new condition. At the same time, training activities are also invested millions of forints for digital training.

4. Technology and capabilities

In digital transformation, Bank understands that it is necessary to respond quickly to requests to serve customers better, and simplifying all processes becomes the most important issue. Through the help of Artificial Intelligence and data analysis, the whole internal process is done faster. As a result, the decision-making is faster and more accurate based on data. The parent group had plans to launch many full digital assistants in each core market, and this mobilization service is the main trend to provide banking services in the future; many functions are expanded, aiming to synchronize all services. For example, customers can track their savings and investment portfolio with one click. At the same time, the infrastructure of this bank has also been upgraded to a new banking platform. Such as, this bank is implementing a new and modern open-core banking platform which would help

Bank be able to respond quickly to the dynamic Hungarian market.

5. External dimensions

For customers, Bank's digital transformation strategy defines digital-first channel development to meet customers' preferences and demands. For the digital-first channel, the bank will develop digital assistants through mobile apps. All services provided by the bank will be available in a digital manner. At the same time, combining the use of digital technology, the Bank focuses on human-human advice services, and expands cooperation with fintech companies to launch new services such as artificial intelligent-operated cash loan services. The Bank also cooperated with some Vloggers in providing finance and banking knowledge in an easy-to-understand form. It is among the first banks in Hungary to comply with the Payment Service Directive 2 (PSD2), which allows third parties access to the bank account for information and payment purposes. Before the Covid-19 pandemic, the Bank had built legal and infrastructure frameworks that allow its employees to work from home safely. That explains why this bank responded quickly to the Government requirements related to the covid-19 pandemic.

Discussion

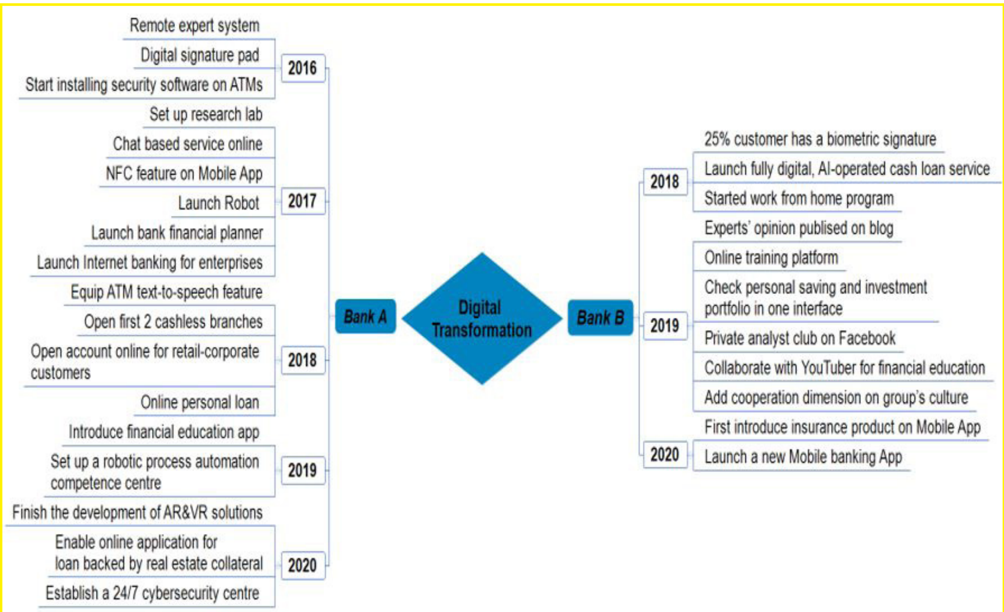
After analyzing 2 case studies, the article has synthesized features in the digital transformation process according to the schedule from 2016 to 2020 (Figure 3). Therefore, the research shows the improvement of technology application and the speediness of digital transformation of each case study.

1. Strategy and vision

Firstly, digital transformation plays an important role in the strategy of banks. In which digital transformation at banks is understood as a higher-level transformation than digitalization, positioned strategically in the long-term, not merely in internal process simplification, instead of towards creating new business model, new services, and products. It seems obvious that banking operations are highly secure, promoting safety and stability, which implies that banks must carefully test new changes and new technologies. The digital transformation in incumbent banks is happening in a parallel process in the new business and traditional models. This result is consistent with the conclusion from Sebastian et al. (2020). Second, the focus of the digital transformation strategy is to serve customers better. The benefits that digital transformation brings to banks are quite large, including new experiences to customers and allowing banks to provide more new types of services, expanding their customer base beyond traditional markets.

2. People and culture

Practices from two case studies show that digital transformation does not just change in technology, processes, or product services. More importantly, it must change the mindset of thinking, corporate



Source: Authors' elaboration

Figure 3: Some features in the digital transformation process from two case studies.

culture, and awareness of each employee in banks. For a successful digital transformation, the role of people and culture is crucial. Therefore, along with digital transformation activities in the operation process and the deployment of new technology, training activities for current and potential employees are necessary. At the same time, education activities occur not only for existing employees but also for bank customers. New training and retraining are necessary to employees due to the digital transformation.

3. Process and governance

Implementing digital transformation requires strong support and monitoring from top managers. In addition, digital transformation projects need to be practical, targeted towards solving specific problems, and done step by step before rolling out in all branches.

4. Technology and capabilities

The application of digital technology in the banking industry is inevitable. Banks set up digital transformation projects for each specific goal, according to which the effectiveness of each item can be assessed. It can be seen from the two banks that digital transformation projects are carried out in many stages carefully, evaluating effectiveness before being applied to the whole system. Currently, the trend of digital service, synchronization in connecting services, robotization of some internal processes is the mainstream trend to be seen. According to the digitalization measurement suggested by Martín-Peña et al. (2020) and Zhou et al. (2021), we found both two banks are still in a low and medium level of digitalization. It can be seen that the application of digital technologies in these banks is still limited and mainly focus on online channels such as mobile banking applications, internet platforms. The expansion has recently applied AI and robotics to a few new products. However, new technologies such as blockchain, cloud computing, crowdlending, or machine learning have not been mentioned. This result is in line with the recent findings from the Fintech report from the central bank of Hungary. This result is also consistent with the results from Zhou et al. (2021), who conclude that incumbent banks reluctantly adopt digital technologies and wait for the mature phase of digital technologies.

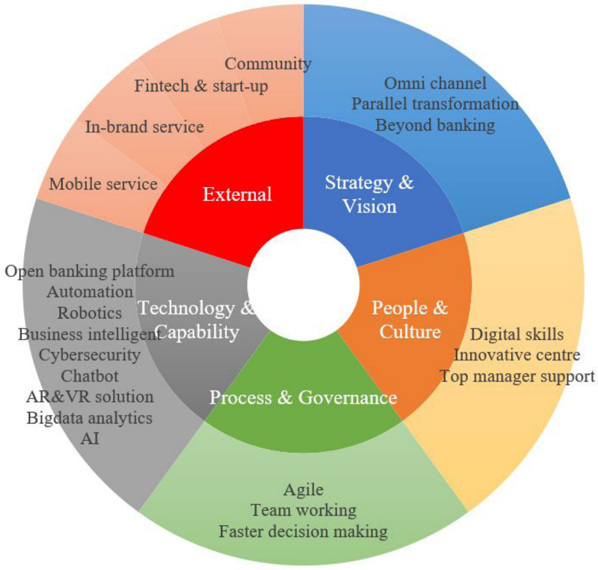
5. External dimensions

Banks promote digital transformation on online and offline channels regarding distributing products and services (Figure 3). Digital transformation strategy takes place in four identifiable directions. First, they are launching new mobile applications and internet solutions in providing and expanding their services beyond banking. Second, incumbent banks applied the latest digital technology for in-branch services to develop more financial consulting services at their branches. Third, cooperating with fintech and start-ups mainly focuses on financial information and stimulating innovative ideas. Fourth, for contributing to society, realizing the importance of financial inclusion in this digital era, banks organized many interactive channels to improve financial knowledge for young, elderly, and rural customers. Moreover, using digital technologies to support sustainable development is another identifiable trend from our case studies.

Conclusions

The current research was designed to access a holistic approach to the digital transformation in the two Hungarian banks. The findings from this study make some contributions to the current literature and shed new light on the digital transformation implementation. The present study has been one of the first attempts to thoroughly examine the digital transformation in Hungarian banks. Theoretically, the digital transformation process is happening in five dimensions: strategy and vision, people and culture, technology, governance, and external dimension (Figure 4). By highlighting and providing a new understanding of digital transformation in two leading banks in Hungary, this research may assist banks and bank managers. Our study confirms that incumbent banks in Hungary are still in the early adoption of digital technologies. Some important points could be highlighted in the digital transformation of our case studies.

- Strategic planning is an important factor in implementing Digital Transformation. Banks should prioritize the content of Digital Transformation's orientation in their development plan. This research suggests that banks should carefully implement and evaluate their digital projects before launching in the whole group.
- Human resource plays a key role in successfully implementing Digital Transformation. The human resource is shown in two aspects: managers' support and vision and staff skills. The leaders' strategic vision and close supervision



Source: Authors' elaboration

Figure 4: Digital transformation framework.

from the top management support will help the digitalization projects go on the right track. For example, Bank A requires a direct report on customer complaints to the board of directors. Bank B appointed a Chief of Data Officer position of the whole group, responsible for discussing directly with a Chief Executive Officer at each national market and bringing cohesion, sharing information and experience for innovative ideas and projects.

- Our study highlights that digital transformation at traditional banks is not only related to inside stakeholders; among them, customers is the center of digitalization process. From the perspective of agricultural customers, the study found that digital transformation toward this group of customers is relatively limited. For example, although the agricultural sector is Bank A's main customer, digitization mainly focuses on improving internal processes through faster lending methods or providing market information via the websites. Meanwhile, Bank B supports innovation development in the agricultural sector by providing grants for R&D activities.
- In terms of Governmental policy, a key policy priority should be to plan for the long-term care of digital skills for financial inclusions, such as small and medium enterprises, young people, older people, and rural residents in remote areas. Governments should also provide more support to develop innovative centers that could bridge banks and scientific research institutions to join and cooperate in researching and applying new innovative ideas.

Limitation and further research

The most important limitations lie that this study was carried out on two banks and based on reports and archives. Therefore, this weakness will limit the generalizability of these results. Furthermore, digital transformation is a continuous process. It is associated with the evolution of digital technologies and changes in customer needs, so more studies are needed to clarify how leading banks can maintain their sustainable digital transformation. Understanding the importance of digital technology is the center of digital transformation; meanwhile, each technology requests a different type of skills and supports. Therefore, we hope that future studies would extend our knowledge to answer how to diffuse the innovative technologies in the banking industry effectively and efficiently.

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Agris on-line Papers in Economics and Informatics

Volume XIV Number 2, 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.

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ISSN 1804-1930