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Analysis of eAGRI Web Portal Ergonomics And Presentation of Information in Terms of the General Public

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Abstract

The aim of the eAGRI portal is to inform not only professionals in the field of agriculture but also the general public about current events and news in the respective resort. Merit of the paper is to discover if the current level of eAGRI portal ergonomics is sufficient or not. Several usability analysis and studies were applied with unflattering results. The results of all applied analysis show that the overall ergonomics of the portal is not at a satisfactory level and that there is no significant improvement on the portal in the last year.

Keywords

Ergonomics, Usability Analysis, eAGRI portal, Human-Computer Interface, Five second test, Thirty second test, Heuristic evaluation, First click test.

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Introduction

The eagri.cz web portal is the central access point to the information sources of the Ministry of Agriculture and its deputy organizations (Ministry of Agriculture CR, 2015a). Therefore it is appropriate to analyze the ergonomics of the eAGRI portal in terms of the general public to which the community of agricultural professionals belongs.

The word "Ergonomics" is currently widely used among people. In terms of draft recommendations in ergonomics of an average web portal it is necessary to analyze current state of this portal first. This can be realized by using specific User Experience (UX) or Usability methods on which it is then possible to formulate appropriate recommendations. Terms like usability and UX are used mainly by computer science professionals and those are not well known to the general public. So, how Ergonomics is related to those terms?

The term Ergonomics came into use about 1950 when the priorities of developing industry were taking over from the priorities of the military. The development of research and application for the following thirty years is described in detail in Singleton (1982), where the Ergonomics is defined as the study or measurement of work. In this context, the term work signifies purposeful human function it extends beyond the more restricted concept of work as labor for monetary gain to incorporate all activities whereby a rational human operator systematically pursues an objective. Thus it includes sports and other leisure activities, domestic work such as child care and home maintenance, education and training, health and social service, and either controlling engineered systems or adapting to them, for example, as a passenger in a vehicle.

IEA (2017) and ISO 6385:2016 (2016) define the modern Ergonomics as the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. Ergonomics is a systems-oriented discipline which now extends across all aspects of human activity. Practicing ergonomists must have a broad understanding of the full scope of the discipline. That is, ergonomics promotes a holistic approach in which considerations of physical, cognitive, social, organizational, environmental and other relevant factors are taken into account.

In modern era, with the arrival of computers, Ergonomics also targets the Human-Computer Interaction (HCI). Until late 1970s, no one could interact with computers except for computer experts. This situation changed entirely

after personal computing, including both personal software and personal computer platforms, was developed, which turned everybody into a potential computer user (Carrol and Rosson, 2009). Rogers (2012) states that HCI at the beginning followed the scientific method borrowing theories from cognitive science to test theories about user performance at the interface. Carrol (2003) adds that Human-Computer Interaction combines several different disciplines, each of which focuses on a different aspect of creating user interfaces. These disciplines include information science, psychology, sociology, anthropology, design, linguistics, ergonomics, and all other disciplines that focus on the subject. Zhang and Li (2005) see that with the rapid growth of information systems and communication technology, information technology has come to play a central role in daily lives. Issues regarding the interaction between humans and computers have thus become important and fundamental.

The cooperation between designers, engineers and scientists in the Human–Computer Interaction (HCI) community is often difficult, and can only be explained by investigating the different paradigms by which they operate (Bartneck and Rauterberg, 2007). Rusu, et al. (2015) describe HCI from multiple perspectives, when HCI should be a basic part of the formative process of all Computer Science (CS) professionals. Usability and User Experience (UX) were (re)defined by many authors and well recognized standards. UX is usually considered as an extension of usability. To move from usability to UX seems to be a tendency lately. The lack of generally agreed formal definitions of HCI/usability/UX may have consequences on their development and recognition among Computer Science communities.

All those terms are met and described within the term Human-Centred Design (HCD) which has its roots in fields such ergonomics and computer science (Giacomin, 2014) and it is standardized by ISO 9241-210:2010 - Ergonomics of Human-system interaction — Part 210: Human-centred design for interactive systems. New important ISO document about “Usability: Definitions and concepts” is still under development (ISO/FDIS 9241-11, 2017).

Based on the presented information we can conclude that the concept of Ergonomics, which is often referred by the general public as a key element of interaction with the computer or e.g. the web portal, is too wide. For the purposes of this article, it is necessary to focus especially on the identified components of Ergonomics, such are UX and Usability.

According to ISO 9241-210:2010, the User Experience (UX) can be defined as the perception and reaction of persons resulting from the use or assumption of use of a given product, system or service. Usability is understood as a part of UX and subsequently as part of Human-Centred Design concept. The Usability itself is defined by ISO 9241-11:1998 that is used in subsequent related ergonomic standards as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. Expert on Website Design and Usability Steve Krug (2006) formulated three basic facts about user behavior:

- We do not read pages, but browse;
- We do not make optimal selections, but compromise;
- We do not worry about how things work, we simply "do somehow".

The website should be intuitive, understandable and navigable. In any case, the user should not think about where to start navigating the site, where he finds what he is looking for, or what's important on the page. The most visited pages are those that are simple, clear and intuitively manageable (Krug, 2006; Nielsen, 1993). Designers must understand the effects of their designs on users’ choices so they can choose whether to implement a design that nudges users deliberately or one that reduces the effects of the design on users’ choices in order to increase free will (Weinmann et al., 2016).

Materials and methods

Some usability studies of eAGRI portal, such are Benda, et al. (2016) and Ulman, et al. (2017) has been implemented already in 2016 and early 2017. This paper therefore uses the same usability methods to maintain comparability of results. However, the subject of investigation itself is slightly expanded. Specifically, these usability tests are: Five Second Test, Thirty Second Test and Heuristic evaluation. Currently performed test is a First Click test. An important data input and analysis was also performed by Google Analytics. Five Second Test and Thirty Second Test were, compared to the above-mentioned studies, slightly widened.

Five second test

Five second test can help increase website conversion and improve Return of Investments (ROI). Five seconds is a time for a website visitor to determine if there is enough quality in a website

to stay, or to leave and potentially never to return. Using a Five second test to optimize conversion is a powerful way to improve the ROI of a website. This is because the critical driver of website success is the ability of the home page, or any page for that matter, to deliver three pieces of critical information in five seconds or less. The first piece is delivering information about the website – What is it about. The second one describing the information what product or service the website provides. The third one informing user why to stay and continue the navigation thru the web, so – what user able to find and use on the website (Tomlin, 2014).

Lindgaard et al. (2006) conducted a study to determine how quickly people decide whether they like or dislike what they see, and whether such judgments may constitute a mere exposure effect. The data suggest that a reliable decision is going to be be made in 50 ms, which supports the contention that judgments of visual appeal could represent a mere exposure effect. The level of agreement between participants and between experiments was impressive and highly correlated even for the 50 ms condition.

Websites that are able to quickly and efficiently communicate these three critical elements within 5 seconds typically have much better conversion, and thus ROI than websites that do not (Tomlin, 2014). As well as Doncaster (2014) and Benda et al. (2016), we used this kind of test to ask users whether they know where they are and let them to simply describe what they saw and are able to find on the portal. So, to collect all three pieces of critical information for users described by Tomlin (2014).

Thirty second test

This method was used by Benda et al. (2016). The main goal of this method is to follow the Five second test and enable users to scroll and navigate the home page or landing page of the website briefly and get more detailed information about the portal. Then ask users the same questions like after the Five second test.

Heuristic evaluation

A heuristic evaluation is a usability inspection method for computer software that helps to identify usability problems in the user interface (UI) design. It specifically involves expert evaluators examining the interface and judging its compliance with recognized usability principles - the "heuristics" (Nielsen, 1993). A heuristic evaluation should not replace usability testing. Although the heuristics relate to criteria that affect usability of tested, the issues identified in a heuristic evaluation are different than those found in a usability test (Molich and Nielsen, 1990).

Usability principles and heuristics by Nielsen (1993):

- Visibility of system status - The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
- Match between system and the real world - The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
- User control and freedom - Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
- Consistency and standards - Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
- Error prevention - Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
- Recognition rather than recall - Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
- Flexibility and efficiency of use - Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
- Aesthetic and minimalist design - Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

- Help users recognize, diagnose, and recover from errors - Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
- Help and documentation - Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

First click Test

This type of test examines what a user would click on first on the interface in order to complete their intended task. It can be performed on a functioning website, a prototype or a wireframe. It is also important not only to find where user clicked, but also to ask the user “Why?” (Sauro, 2011; Geisen and Bergstrom, 2017). The results obtained in this way are also appropriate to compare with the real potential of the website and to find out whether the requested information can actually be found using the executed click.

Analysis of Google Analytics data

Google Analytics provide digital analytics tools to analyze data from all touchpoints in one place, for a deeper understanding of the user experience. It offers free and enterprise analytics tools to measure website, app, digital and offline data to gain customer insights (Google, 2017).

For the purposes of this study Ministry of Agriculture of the Czech Republic gave us an access to the online data provided by the Google Analytics service.

Results and discussion

Unlike the order described in the Materials and methods chapter we would like to begin with a results of the analysis, which delivers relevant data and results from the behavior of eAGRI portal users. Access to the Google Analytics data gave us a comprehensive view to facts about the use of eAGRI portal by the real users in the real time.

Analysis of Google Analytics data

Ministry of Agriculture of the Czech Republic allows us to analyze data provided by the Google Analytics service. We focused on data proposed by the account which collects data from the whole eAGRI portal. We provide only a comprehensive description for the purposes of this paper. The presented data are therefore only approximate. The reason for using this approximate data is to support the results of further analysis within the study also by the real qualitative data. All analyzed data refer to the period 1.1.2017 - 23.6.2017.

The average download speed of eAGRI is 1.92 seconds. Google understands this value as below average, especially it is given that the portal is not optimized for speed. This can be achieved by optimizing images, compressing source code, browser caching, and eliminating JavaScript scripts and CSS styles that block page rendering.

The average visit duration is about 3 minutes and on average, users visit 4 web pages per one visit. 50% of users use Internet Explorer as a web browser, almost 27% Chrome and almost 15% Firefox. All other results of browsers are beneath 4%. Just about 6% of users use mobile phone or tablet to browse the portal.

Within the measured time period more than 11 700 000 views of web pages were shown to the users on the eAGRI portal. Almost 11% of all views is dedicated for a home page. The second one with almost 7% is a web page which allows professional users of the portal to log in to the internal farming applications called "the Farmer's portal" - *eagri.cz/ssl/web/mze/farmar*. The third one with about 5% of all visits is a web page really close to the previous one. This web page provides information about internal farming applications and also contains a direct link to log in to such applications which was presented as an URL (Uniform Resource Locator) in previous sentence. We realized by the further research of data that user are not staying on this web page for long, just about a few seconds and then click mentioned link to log in the applications. The fourth web page - *eagri.cz/ssl/web-mze* with the result of almost 4% of all views was just another link to internal applications which allows users to sign in. The fact that the site contains more than one URL which refers to the same result is not only significant usability problem, but also problem of possible Search Engine Optimization (SEO).

The fifth web page viewed by user visits in about 2% is an internal Search tool provided by eAGRI portal. All other results are beneath 2%. It is obvious that the eAGRI portal is used by professional users which want to sign to the internal part of a portal in about 16%. The most views of user visits are dedicated to the home page of a portal in 11% and about 2% of views users spent on search tool.

The analysis of eAGRI portal landing page visits

shows very similar data. There were more than 3 million visits during the measured time period overall. Almost 33% represent a home page landing visits. Three other pages with almost 25% of visits together were dedicated to "the Farmer's portal":

- *eagri.cz/public/web/mze/farmar;*
- *eagri.cz/ssl/web/mze/farmar;*
- *eagri.cz/ssl/web/mze/.*

This number also represents a fact that almost 25% of users are looking for an internal applications directly for their first visit and thus the first use of a portal for their purposes. All other results are beneath 2% and moreover out of the top positions of those 2% are other direct URLs to other internal applications such are LPIS (Land Parcel Identification System) and UKZUZ (engl. - Central Institute for Supervising and Testing in Agriculture). It all means that nearly 30% of the first user visits of the portal target internal applications, thus almost 30% of landing pages refer to agrarian professionals and their needs.

Interesting results are also presented by the Acquisition Overview analysis. The Acquisition Overview provides a quick view of the top channels sending visitors to the portal, as well as the associated acquisition, behavior and conversions details for each channel. Slightly over 37% of visits come from Referral traffic source. It means that more than 37% of visits coming to the portal from another website by clicking on a link. Almost 32% of visits come from Organic Search channel, thus 1/3 of traffic refers to the results of search engines. Almost the same amount of users come Direct. Those are visitors who come to the portal without a traceable referral source, such as typing direct portal URL into their address bar or using a bookmark on their browser. Just about 1% of users come from Social Networks and less than a 0.02% of visits come from Email.

It follows from the above that the main source of eAGRI traffic is dedicated to the visits from other websites. Specifically, from about 84% this is ilogin.mze.cz. This means, amongst other, that these visits also come from sites provided by Ministry of Agriculture of the Czech Republic, but outside the structure of the eAGRI portal. And it means again, that the most traffic aims to the internal eAGRI application for professionals.

Deeper analyzes of Organic Search source show that almost 68% of Organic Search is not available in Google Analytics. The second most commonly used key word is with more than 9% "the Farmer's portal" and then with a little more than 1% the keyword "LPIS". Other analyzes show that about 665 thousand visits are attributed to the Google search engine and about 271 thousand the Seznam.cz Search Engine. The third search engine is Bing with about 37 thousand visits. Other search engines are only in the level of thousands.

Most often direct entry URL is with almost 78% the default eAGRI web page. The second page is “the Farmer's portal” but only with a little more than 1%.

Traffic from Social Networks, which generates only about 1% of all visits, falls to Facebook in almost 98%, when almost 49% of the traffic comes to a page *eagri.cz/public/web/mze/tiskovy-servis/aktualne/samosber-jahod-prehled-po-krajich-1.html*, at the same time it is the most widely used landing page of the eAGRI portal from Social Networks, the other is with 6% *eagri.cz/public/web/mze/ministerstvo-zemedelstvi/volna-pracovni-mista/*. The next is Twitter with only about 1%. Other social networks are about a tenth of a percent.

The lowest attendance is reported by the "Email" medium. According to the results, those visits targeted mainly at *http://eagri.cz/public/web/vinarsky-zakon/*. Most traffic then falls into the first week of March 2017.

Analysis of Google Analytics data - summary

The above-described analysis of Google Analytics data emphasizes several facts that should be at least perceived by portal provider. Only 7% of users use mobile devices to use the portal. Nowadays eAGRI portal does not offer any type of responsive design. Therefore, it is not entirely clear whether this percentage is so low, because the portal is very difficult to use on these devices, or if that percentage of users with this kind of device is really so low. StatCounter global stats (2017a) reports that average use of mobile device in the Czech Republic in last 12 month is 18.96%, tablet 2.95% and the desktop rules with 78.09%. How this data fits to Czech agrarian sector should be part of the further research. According to StatCounter global stats (2017b) a web browser use also differs. In the last 12 month the leading browser of the Czech Republic market is Chrome with 55.47%, in the contrary Internet Explorer has just 7.77% of the market. In case where the portal eAGRI will be modernized in terms of usability for mobile devices, it will also need to take potential problems with the implementation of modern methods and technologies into account.

Other analysis lead us to the result that about 1/3

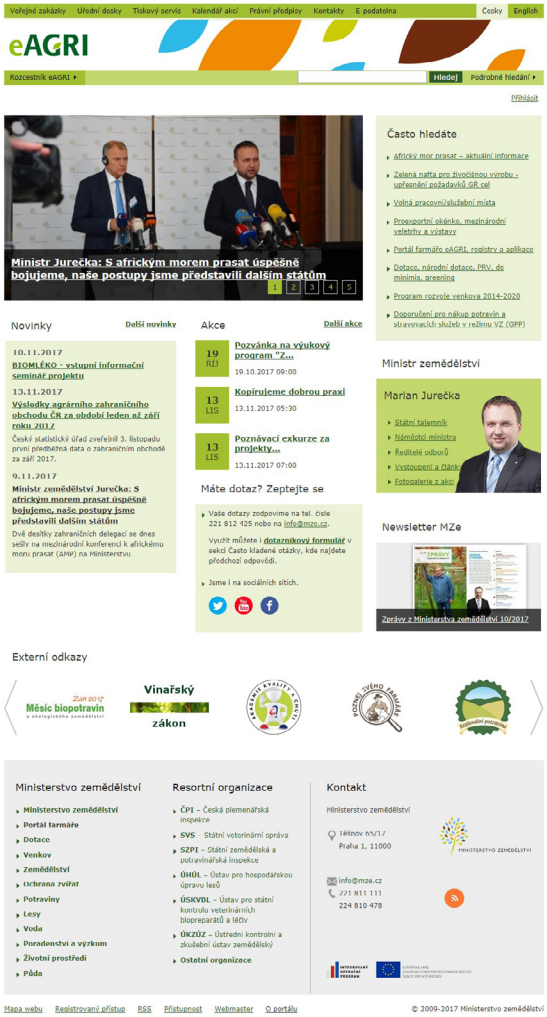
of all visits and views are focusing on internal applications of the portal. This information is not a problem at all, on the other hand, there is more than one website which leads users to the same result and this causing inconsistency in the structure of the portal, user navigation and their potential confusion. Another potential problem we see is a lack of eAGRI branding. Still quite a lot of users use search engine when they need to reach internal applications of the portal instead of the eAGRI home page or URL which lead to these application directly.

We are not clear about eAGRI strategy in Social Networks and Email marketing, but on the basis of the data obtained, it can be stated there is none or only random.

Five second test

None of testers knew what kind of website they will evaluate and each tester tested the objective web page independently. All tests were performed in the usability lab. We formed 2 groups of testers each containing 5 testers. Due to maintain comparability of results with studies conducted by Benda et al. (2016) and the first group of testers tested the home page of eAGRI portal - *eagri.cz/public/web/mze/*. After 5 second testers spent on this page we asked them to simply describe what they saw and what are they able to find on the page. We asked them if they are familiar with the eAGRI portal also.

1. Tester – identified eAGRI logo, Minister of Agriculture image and information about African swine fever, which is actual and leading information in the web page carrousel. The tester tagged this page as online information newsletter from agrarian sector. To the question whether this site has the tester visited previously tester responded negatively.
2. Tester - identified eAGRI logo, Minister of Agriculture image and information about African swine fever. The tester also noticed carousel with images about farming in the middle of the web page. The tester tagged this page as information page about farming. The tester was not familiar with eAGRI portal.
3. Tester - identified eAGRI logo, information about African swine fever and some of menu items. The tester tagged this page as a web page dedicated to hunters or farmers. The tester was not familiar with eAGRI portal.
4. Tester - identified eAGRI logo and Marian Jurečka as s Secretary of State, because this text information is presented on the website too close to the minister photo and the visual arrangements of this information is misleading. Tester also described some menu items and news. Tester tagged the web page as a service for information portal for farmers. The tester was not familiar with eAGRI portal.
5. Tester - identified eAGRI logo and described all the tested web page as a portal dedicated to inform farmers and wide audience about agriculture sector. He described himself as a brother of a farmer which is quite familiar with the content and also internal applications.



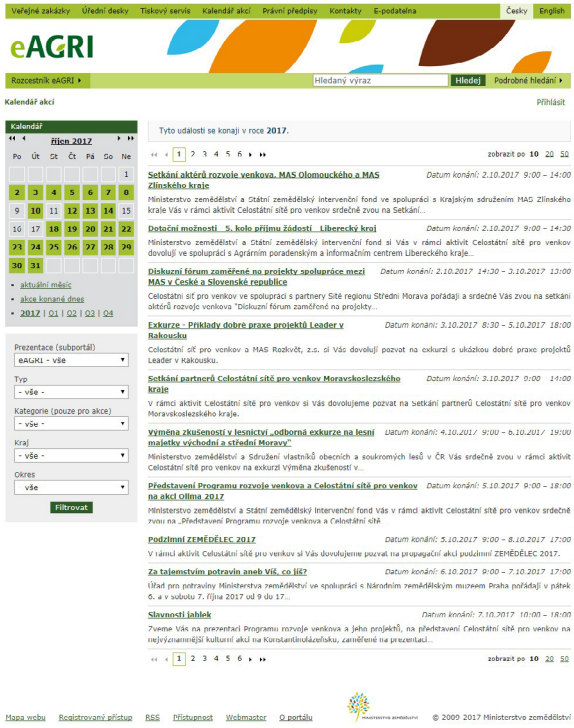
Source: http://eagri.cz/public/web/mze/

Figure 1: eAGRI portal home page (November 2017).

Overall, none of the testers except the fifth one were able to combine the eAGRI logo with the Ministry of Agriculture of the Czech

Republic and they also did not know the brand. Compared with the study from year 2016 conducted by Benda et al. (2016) the results are very similar. From this, it can be judged that there were no improvements in the eAGRI portal home page during the year 2017.

The second group of testers tested different web page of eAGRI portal. This page was an event calendar - *eagri.cz/public/web/mze/kalendar-akci/*. After 5 seconds on a web page all 5 users have to respond to the same questions like previous group.



Source: eagri.cz/public/web/mze/kalendar-akci/

Figure 2: eAGRI event calendar page (November 2017).

1. Tester - identified eAGRI logo and tagged the web page as an event calendar in year 2017.
2. Tester - identified eAGRI logo and described some events. The tester tagged the web page as informing channel about agricultural events.
3. Tester – was not able to perform results after only 5 seconds on the web page.
4. Tester - identified eAGRI logo. Tester was not able to tell what the web page is about.
5. Tester - identified eAGRI logo, some menu items and information about events in year 2017. Tester tagged the web page as an events calendar for workers in agriculture based on events information.

None of the testers mentioned the previous knowledge of the eAGRI portal. None of the testers were able to combine the eAGRI logo with the Ministry of Agriculture of the Czech Republic and they also did not know the brand. The results of the correct classification of a portal content in the overall context on this page are even worse than in previous group. The web page tested by this group is full of text, less clear, and does not contain any significant points that the tester's eyes could focus on.

Overall, on the basis of the tests made, the identification of the portal itself is insufficient. The incoming user is not informed about the web page visited and eAGRI brand should also describe its meaning more. Also the combination of information for professionals and general public does not seem appropriate. Both of those groups seeking different kind of information and if the portal should serve both, these information should be divided.

Thirty second test

For the purpose of this test we formed 2 groups of testers 5 users each again. These testers were different people than in groups that tested during Five second test. After the 30 second they spent on objective web pages we ask them the same question like after the Five second test. Like the first group in Five second test, the first group of tester tested the home page of eAGRI portal - *eagri.cz/public/web/mze*, this time for 30 seconds.

Again, the results are close to the results of a study done by Benda et al. (2016). After 30 seconds the testers spent on the web page, all of them were able to describe the purpose of the web page and its operator, the Ministry of Agriculture of the Czech Republic. All five testers found this information in the footer of the web page. Four testers tagged the web page as an information portal about the agriculture. One tester tagged the web page as a portal for farmers and workers in agriculture. This tester also mentioned his previous knowledge of the portal, because his job in the forestry area. But we can point out that description of the portal by this user is not so accurate.

The testing performed by the other group was more controversial. The second group tested the same page with the event calendar *eagri.cz/public/web/mze/kalendar-akci/* as well as the second group during the Five second test. One tester tagged the web page as an internal event calendar for employees of Ministry of Agriculture. The reason was the logo at the bottom of the web

page and events description. Two testers identified themselves as a farmer and employee of the Agro-holding company. Both identified web page based on logo as a part of the large portal which focusing on agrarian information for all the Czech people. Two last testers tagged the web page identically as a tool for sorting and displaying calendar and events in agro-business and agriculture from the Ministry of Agriculture of the Czech Republic. Those testers had no previous experience with the portal.

Despite the fact that the second tested web page is the part of the same web portal, it looks different and for example footer is also different than on the home page. This fact can again lead to confusion of the users. In 30 seconds all testers should identify the main and key purpose of the tested web page clearly. If they are not able to do so, than we can identify significant problems with usability.

Heuristic evaluation

All the complex Heuristic evaluation analysis goes beyond the scope of this article. We would like to provide information on whether or not the heuristics are met using the Table 1 and the comments below. For our analysis we used the list of heuristics created by Nielsen (1991). The study was performed by one usability expert. Heuristics and results are presented in Table 1.

The data in the table shows that the verified heuristics are not met. The reason is in particular the inconsistency of the portal, mixing of information for different types of users, confusing navigation, irrelevant search results which are not lead to content with the entered keywords and many others. Undo and redo functions are not provided by the portal itself and have to be supplied just by the browser. There is no special Error 404 web page on the portal and some of internal links end by this result. The user is not informed about, how to solve this problem. In terms of internal applications there is inconsistent help and documentation provided but not in a useful way and often for the older versions of those applications and mainly in the form of non-online help.

The results of the Heuristic evaluation study correspond to the conclusions of Benda et al. (2016). From this point of view, it can be said that the eAGRI portal has not made any noticeable improvements in this respect.

First click test

This testing was performed by the same group of 5 testers which tested the home page of eAGRI portal - *eagri.cz/public/web/mze* during the Five second test. The main purpose of this testing was to analyze whether testers are able to identify key navigation parts of a web page and use them to achieve their goals. Those goals were:

1. Find contacts to the Ministry of Agriculture of the Czech Republic;
2. Use internal Search tool;
3. Find the application “Portal of a farmer”;
4. Find information about Regional food.

All testers were able to meet the goals and click to the proper part of the document. Some of them needed a noticeable time to achieve the goal, but the time was not measured during this study.

No.	Description	Recommendation	Results
1.	Visibility of system status	provide a feedback of the system in reasonable time	N
2.	Match between system and the real world	use language familiar to the user, information in a natural and logical order	Y
3.	User control and freedom	help user to deal with mistakes and turns, support undo and redo	N
4.	Consistency and standards	follow the convention, use consistent styles and actions	N
5.	Error prevention	eliminate errors and prevent problems, ask for confirmation before complicated tasks	N
6.	Recognition rather than recall	make options visible, don’t force user to remember information about different parts of a dialogue	N
7.	Flexibility and efficiency of use	system with options for inexperienced and experienced user	N
8.	Aesthetic and minimalist design	only insert important and relevant information in dialogues	N
9.	Help users recognize, diagnose, and recover from errors	indicate the problem and suggest a solution	N
10.	Help and documentation	provide help and documentation with the easy access to information and logical structure	Y/N

Source: Nielsen (1991), adapted by authors

Table 1: List of Heuristics and results.

At the same time, some findings need to be emphasized. Two testers found Contacts – Goal no. 1 in the menu. Three others in the footer. None of the tester used the menu item "eAGRI Signpost" despite the fact this is the key navigation part of the portal and for example leads to the internal applications and other main parts of the eAGRI portal. All testers navigate during the goal no. 3 just by the link in the footer. The last goal took testers the largest amount of time. The most of them tried upper menu before they read the whole content of the web page, where is also a link to Regional food information external web site provided.

Discussion

All performed studies, tests and analysis focused on the general public. General public are all average users with average equipment and with their need to perform whatever they like on the eAGRI portal, navigate anywhere they want to, how they want to and, moreover, to land from outside on any web page of the portal structure. Results of the Analysis of Google Analytics data shows that almost 1/3 of all portal users seems to be professionals in agrarian sector. Taking this into account it is obvious that it would be appropriate to perform a study of ergonomics which will be focused mainly on this group of users. But this group of users is just the part of the mentioned general public. The age structure of the agricultural population is described by Ministry of Agriculture CR (2015b): In the 4th quarter of 2015, 45-59 years old employees (42.3%) were in the agrarian sector of the Czech Republic, followed by workers aged 30-44 (35.6%). Lower earning workers were 15-29 years old (11.2%) and older workers, i.e. aged 60 and over (10.9%). Studies conducted by for example Shamim et al. (2016) and Righi et al. (2017) show that there the age was found to be significant for visual appeal, comprehensiveness, intuitiveness, and pre-knowledge requirement but there is also no need to focus on design for older people but focus on the useful and also usable design for an average user. And not only in the way of ergonomics, usability and design, but also in the social role.

Conclusion

In this paper, we presented results of several usability methods applied on the eAGRI portal which report unflattering results. The main task was to find out if the ergonomic level of the portal is sufficient or not. A partial goal was to compare the findings from a previously conducted study by Benda et al. (2016). The results of all analyzes show that the overall ergonomics of the portal is not at a satisfactory level and that there is no significant improvement on the portal in the last year. The reason for poor results is in particular the inconsistency of the portal, mixing of information for different types of users, confusing navigation, irrelevant search results which are not lead to content with the entered keywords and many others. Users are not able to understand the purpose of the portal or namely the landing web page, because the portal does not offer this information easily in 5 or even in 30 seconds. Due to the portal structure it is not clear if the eAGRI portal truly knows its purpose goals and focus. This brings us to the same conclusion as Ulman et al. (2017) presented as a result of their research: "The provision and user experience of agricultural e-government services must be improved by the Ministry of Agriculture to improve the services quality". To find the purpose and focus of the eAGRI portal should be the very first step of the Ministry of Agriculture of the Czech Republic to improve the ergonomics quality of the portal and provide users with the convenience in using the portal.

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Price Volatility Modelling – Wheat: GARCH Model Application

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Abstract

This paper is focused on the modelling of volatility in the agricultural commodity market, specifically on wheat. The aim of this study is to develop an applicable and relevant model of conditional heteroscedasticity from the GARCH family for wheat futures prices. The GARCH (1,1) model has the ability to capture the main characteristics of the commodity market, specifically leptokurtic distribution and volatility clustering. The results show that the forecasted volatility of wheat has a tendency towards standard error reversion in the long-run and the position of price distribution is closed to the normal distribution. The wheat production can be hedged against the price variability with long-term contracts. The price of wheat was influenced during the years of 2005 to 2015 by different events, in particular; financial crisis, increasing grain demand and cross-sectional price variability. The results suggest that agricultural producers should focus on short-term structural events the wheat market, rather than long-term variability.

Keywords

Price volatility, forecasting, GARCH, wheat price, CME, futures contracts.

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Introduction

In today's market, commodities are frequently characterized by an increasing trend in the long term. There were significant fluctuations of commodity prices during the period of 2006 to 2009, followed by decreasing prices in the commodity markets due to the financial crisis (Bourdon-Huchet, 2011). In general, high volatility is now evident in every financial market, especially in the case of the commodities market. Examples of this can be found in the problems of storability, seasonality (agricultural products) and price shocks during periods of high volatility. These events are important in the modelling of the chosen commodity.

Volatility modelling is of great interest to many financial analysts and practitioners, in particular, Reider (2009), Zhang (2015), Huang Poon (2005). The origin of the evaluation of price fluctuation is based on price movements and dynamics. Markowitz (1952) firstly focuses on the concept of uncertainty of the asset price. The problem of price variability modelling is primarily due to the difficulties with visibility and the analysis of patterns or other structures of simulated data, see Zhang et al. (2015) The structure of price trajectory has changed over last decade because of the availability of high-frequency data (Maneesoonthorn, 2015). These movements are often brought on by news announcements or trading activity by institutions. Due to this price variability and volatility, there is an obvious effect on commodity market returns. The ability to accurately and unambiguously forecast and predict volatility in any market has multiple applications. Firstly, there is asset allocation in regards to risk management. There are other utilizations, however the most significant effect of volatility measurement for commodity and equities traders can be felt in the field of portfolio management consisting of assets and derivatives (Hull, 1987). According to a study by Fama (1965), the prices of commodities are characterized with volatile periods changing over time.

There are multiple reasons why to study the price volatility of agricultural commodities. Firstly, the variability of prices is influenced by external shocks or weather. Secondly, we can predict price fluctuation in regards to confidence levels. The volatility is also influenced by the supply of commodities.

The main approach of characteristics of financial time series exhibits the volatility clustering. The papers of Mandelbrot (1963) and Black (1973) documented this evidence in detail

about leptokurtosis and clustering among financial time series. In the last fifteen years, many economists and researchers have begun estimating time series variation by utilizing higher levels of lagged variables. The recent studies of Najand (2002) and Lee, Faff (2009) handle aspects of both volatility clustering and fat-tailed time series. The approach of modern financial volatility modelling was developed by Engle (1982). This paper deals with changing variance using the Autoregressive Conditional Heteroscedasticity (ARCH) model. Later, Bollerslev (1986) introduced the extended version of the ARCH model e.g. with the generalized version – GARCH model. The assumption of this model is that the returns have time-varying conditional variances. According to Val, Pinto and Klotze (2014) the family of GARCH models has significant predictive power when using intra-day data. We assume that the ARCH – family models have a tendency to capture the conditional variance using lags. The conclusion of modelling price volatility is based on the stochastic process. It assumes a financial time series can be defined as a result of a collection of random elements (Douc et al., 2014).

Wheat as a commodity belongs to the family of basic food commodities. The main reason for using wheat is directly connected with nutrition. Wheat has a large impact on mostly agricultural producers, but it influences processors as well.

This paper principally addresses modelling and forecasting the volatility of wheat prices using Generalized Autoregressive Conditional Heteroscedasticity (GARCH). For the purpose of this paper we have selected the time series of wheat futures prices traded on the Chicago Mercantile Exchange (CME). The primary objective of this study is to design an appropriate model of conditional heteroscedasticity from the GARCH family for wheat futures prices based on variance analysis and data. With that in mind, the paper specifically addresses the following research questions:

i. What are the prediction capabilities of GARCH (1,1) for the CME wheat market?

ii. Is it possible to use the output of the GARCH model application for the hedging of risks by wheat producers?

Literature review

Kroner, Kneafsey, Claessenes (1995) studied the long-term forecasting of commodity price volatility. They divided the commodities into different types of forecasts.

In the study by Yang, Haigh, Leatham (2010) there is a GARCH model application under conditions of agricultural liberalization policy. They discovered that the price liberalization caused an increase in the commodity price volatility in the case of several popular commodities – wheat, corn and soybeans. The results included an observation from the 1990s.

Authors Onour, Sergi (2012) employed the competing models with Student t- distribution in the period of 1984 – 2009. The forecast captured the existence of short-term memory behaviour. The paper from Musunuru (2014) focuses on the relationship between wheat and corn in modelling price volatility with the use of the multivariate GARCH model. The results of the paper show that agricultural commodity returns can change significantly over time. Franses, Van Dijk (1996) argue that there are some models, which are not recommended for forecasting such as the Glosten, Jagannathan, and Runkle (GJR) model. The model that is best suited for forecasting non-linear or seasonal time series comes from the GARCH model family. Also, authors such as Tulley and Lucey (2007) have estimated the predictive power of the GARCH model. Baur (2011) employed stochastic volatility models to predict the asymmetry of the volatility of gold. Chkili, Hammoudeh and Nguyen (2014) explored the determinants of change in volatility and forecasting in the example of gas, oil, gold and silver. In a book by Knight and Satchell (2007) there is an evaluation of crucial determinants of commodities, for instance the distribution of contracts, volatility clustering or leverage.

Hansen and Lunde (2005) compare ARCH – type models in the context of describing their conditional variance using exchange rates. According to the authors, the model GARCH (1,1) is unbiased. In addition, Chong (1999) works with modifications of the GARCH model in the stock exchange.

Authors Wei, Wang and Huang (2010) use the non-linear models of the GARCH family to forecast the price of crude oil with the capability to capture the long-term memory over long time periods. Olowe (2009) assumes and advises that the best model for forecasting and evaluating the volatility is GARCH (1,1).

The structure of the paper follows: The next chapter is focused on used methods and data basement. The chapter results and discussion describes results with discussed problems. The last chapter Conclusion summarizes the overall topic according to research questions.

Materials and methods

The data set consists of 2770 observations. The time series represents the period of 2005 to 2015. The frequency is daily and represents the closing prices of wheat CME Futures. The stationarity is tested using the ADF test (Dickey et al., 1979).

We address the problem of time-variant residual variance by using the ARCH and GARCH models, respectively. The GARCH model is an extended version of the ARCH model that allows for the inclusion of lags of conditional variance.

The ARCH model is extended with the possibility of using the lags of conditional variance. The volatility is dependent on previous observations. Thus the volatility model Generalized Autoregressive Conditional Heteroscedasticity (GARCH) is used (Bollerslev, 1986).

The general form of GARCH(p,q) is:

$$h_t = \alpha_0 + \alpha_1 Y^2_{t-1} + \alpha_2 Y^2_{t-2} + \ldots + \alpha_p Y^2_{t-p} + \beta_1 h_{t-1} + \beta_2 h_{t-2} + \ldots + \beta_q h_{t-q} + u_t \quad (1)$$

where $p > 0$; $q \geq 0$; $\alpha_0 > 0$; $\alpha_i \geq 0$ for i =1; 2 ... p; $\beta_y \geq 0$ for y = 1; 2 …. q (2)

and u_t is the an error term.

The value of "p" represents the lags of residual returns and "q" is a lag of variances.

In our application, the lag length choice is based on Akaike Information Criterion. The verification of the model includes the test data for heteroscedasticity and residual autocorrelation. Heteroscedasticity is tested using the ARCH model, i.e. Langrange multiplier for testing to assess the significance of ARCH effects.

ARCH LM test, can be specified as:

$$u_t^2 = \gamma_0 + \sum_{i=1}^{q} \gamma_1 u_{t-1}^2 + v_t \quad (3)$$

With the null hypothesis about the constant conditional variance, i. e. H_0: $\gamma_i = 0$ for i = 1.. q, and v_t is the error term.

The serial correlation is tested by using the Breusch-Godfrey test. This test is based on a null hypothesis there is no autocorrelation of order p.

The Breusch-Godfrey test is based on the following regression.

$$\hat{u}_t = \mu_0 + \mu X_{t,1} + \rho_1 \hat{u}_{t-1} + \cdots + \rho_p \hat{u}_{t-p} + \varepsilon_t \quad (4)$$

where X is a matrix of regressors, and ε_t is an error term.

Then the null hypothesis H_0 is $\rho_1 = \ldots. \rho_p = 0$

Results and discussion

Table 1 provides the results of the Augmented Dickey-Fuller test to detect the unit root in time series. The results suggest that the null hypothesis about the unit root in time series cannot be rejected with a 10% significance level. That is, the time series needs to be transformed.

Test statistic with constant	-2.5364`
Test statistic with constant and trend	-2.3395`

Note: ` Akaike Information Criterion was used for lag length selection

Source: Own calculation in EViews based on CME data, 2016

Table 1: Augmented Dickey-Fuller test statistic.

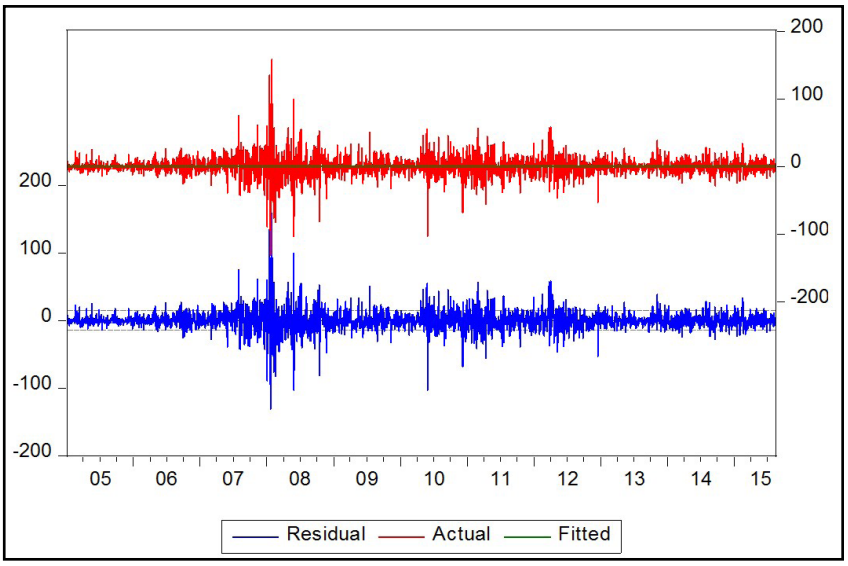
First, the daily closing prices of wheat traded at the CME were transformed using the first differences. Table 2 shows residuals from OLS regression. The table demonstrates that the intercept is not significant with a significance level of 0.05.

Figure 1 displays the residuals from OLS regression and the returns on wheat prices, both actual and fitted ones. The chart captures the volatility clustering and the period with high volatility in 2008 related to the shocks on financial markets. The volatility clustering can be captured by GARCH (p,q). The volatility clustering is based on the assumption

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.059567	0.279947	0.212779	0.8315
R-squared	0.000000	Mean dependent var		0.059567
Adjusted R-squared	0.000000	S.D. dependent var		14.73383
S.E. of regression	14.73383	Akaike info criterion		8.218530
Sum squared resid	601110.2	Schwarz criterion		8.220670
Log likelihood	-11381.66	Hannan-Quinn criter.		8.219303
Durbin-Watson stat	1.889717			

Source: Own calculation in STATA 13 based on CME data, 2016

Table 2: OLS regression.



Source: Own calculation in STATA 13 based on CME data, 2016

Figure 1: Residuals.

that the large values of conditional variance are followed by large values of volatility during the given period.

Figure 1 shows the period with higher volatility during the years from 2005 to 2015. The trend correction occurred at the beginning of 2005, but it did not affect the volatility of residuals. The correction was caused by the growth in grain production, which increased the supply in the market. The period of higher volatility started in 2006. In this case, the grain market paralleled increasing prices of stocks and crude oil (farmdoc, 2006). At the same time, the demand for bio-fuels was increasing as well (Babock and Fabiosa, 2011; Zilberman et al., 2013). The volatility reached its maximum height between 2007 and 2008. The period of 2008 to 2009 can be characterized by financial crisis in the markets and the period of high volatility continued during this time. In this case, the commodities shadowed the stock market with a delay of approximately half of year (CRB, 2013). The recovery of financial and commodity markets occurred in second half of 2009. We can observe the decrease in volatility during this period. At the same time, quantitative easing started in United States and other countries (FRED, 2016; Klotz et al., 2014). Financial markets and the crude-oil market were affected by the so called "Arab spring" in 2013, when the price of crude-oil suddenly increased (Krane, 2015). The other commodities including grains followed this trend, but with a moderate course, so there was not an obvious impact on volatility.

Table 3 and Table 4 contain the parameter estimates of GARCH (1,1) and GARCH (1,0) model, respectively. Both estimated models can be compared according to Akaike information criterion and Schwarz criterion. These criteria indicate how much information has been lost by using the given form of model. Both criteria prefer the use of the GARCH (1,1) model that will be used further.

Then the model is defined as:

$$h_t = 1.106458 + 0.066772 * Y^2_{t-1} + 0.928826 * h_{t-1} + u_t \quad (5)$$

The serial correlation in GARCH (1,1) model has been tested by using the Breusch-Godfrey Serial Correlation LM test. Table 4 shows that the null hypothesis about no autocorrelation in data can be rejected.

The ARCH LM test has been run to test for heteroscedasticity in the estimated GARCH (1,1) model. The results in Table 5 suggest that the hypothesis about homoscedasticity cannot be rejected, not even at the level of significance $\alpha = 0.01$.

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.081645	0.172681	-0.472808	0.6364
		Variance Equation		
C	1.106458	0.153129	7.225650	0.0000
RESID(-1)^2	0.066772	0.005021	13.29797	0.0000
GARCH(-1)	0.928826	0.00506	183.5767	0.0000
R-squared	-0.000092	Mean dependent var		0.059567
Adjusted R-squared	-0.000092	S.D. dependent var		14.73383
S.E. of regression	14.7345	Akaike info criterion		7.704837
Sum squared resid	601165.4	Schwarz criterion		7.713395
Log likelihood	-10667.2	Hannan-Quinn criter.		7.707928
Durbin-Watson stat	1.889544			

Source: Own calculation in STATA 13 based on CME data, 2016

Table 3: - GARCH (1,1).

F-statistic	8.423408	Prob. F(2,2767)		0.0002
Obs*R-squared	16.76302	Prob. Chi-Square(2)		0.0002
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.13E-05	0.279199	-0.00022	0.9998
RESID(-1)	0.058111	0.018983	3.061281	0.0022
R-squared	0.006052	Mean dependent var		-7.55E-15
Adjusted R-squared	0.005333	S.D. dependent var		14.73383
S.E. of regression	14.69449	Akaike info criterion		8.213904
Sum squared resid	597472.5	Schwarz criterion		8.220323
Log likelihood	-11373.26	Hannan-Quinn criter.		8.216222
F-statistic	8.423408	Durbin-Watson stat		2.001479
Prob(F-statistic)	0.000225			

Source: Own calculation in STATA 13 based on CME data, 2016

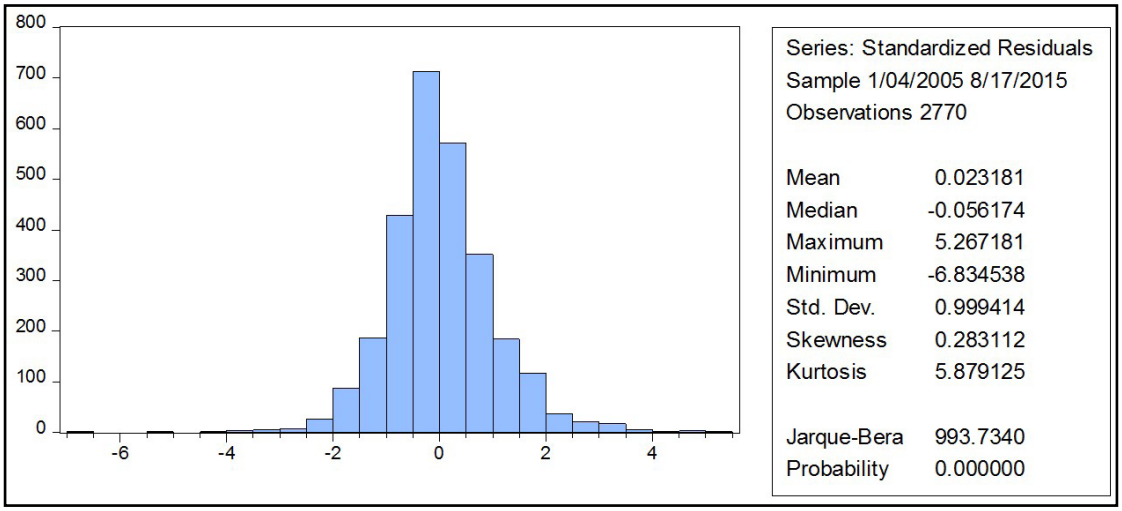
Table 4: Breusch-Godfrey Serial Correlation LM Test.

F-statistic	1.727948	Prob. F(2,2767)		0.1888
Obs*R-squared	1.728118	Prob. Chi-Square(2)		0.1887
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.973908	0.046132	21.11134	0
RESID(-1)	0.024982	0.019005	1.314514	0.1888
R-squared	0.000624	Mean dependent var		0.998866
Adjusted R-squared	0.000263	S.D. dependent var		2.212689
S.E. of regression	2.212399	Akaike info criterion		4.426754
Sum squared resid	13543.66	Schwarz criterion		4.431034
Log likelihood	-6126.84	Hannan-Quinn criter.		4.4283
F-statistic	1.727948	Durbin-Watson stat		2.000289
Prob(F-statistic)	0.188782			

Source: Own calculation in STATA 13 based on CME data, 2016

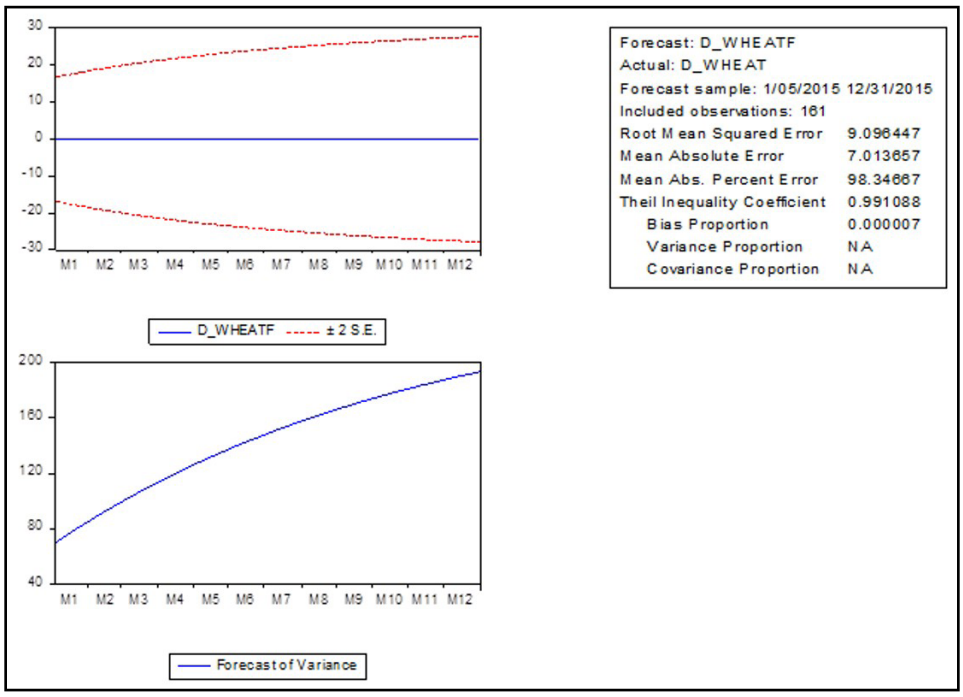
Table 5: - ARCH LM TEST.

Figure 2 provides the residuals distribution. It suggests that the residuals are not distributed normally. In particular, the visual representation of data shows that the residuals are skewed towards lower values. It can be seen that there is still no normality. The skewness of data is characterized by the value 0.28. Moreover, the data is characterized by fatter tails with a long peak in the mean. This evidence we can call leptokurtosis.



Source: Own calculation in STATA 13 based on CME data, 2016

Figure 2: Residuals Distribution.



Source: Own calculation in STATA 13 based on CME data, 2016

Figure 3: GARCH (1,1) 2016 static forecast.

Similar results were achieved by the work of Bai et al. (2003). The authors applied the GARCH model, which detected the leptokurtosis within commodity financial time series. On the other hand, there is a study of Zuppiroli, Giha (2015) showing the use of the GARCH model in application to wheat futures prices. The results support the time-varying process of time series similar to volatility behaviour in something like streamflow trajectory. Authors Alberg et al. (2008) recommend that the characteristics of the GARCH model in fat-tailed densities are evidence of forecasting utilization and accuracy. As a result of the research of the paper by Fang (2008), the GARCH model, which has leptokurtosis, disappeared after introducing the break into the variance equation. There are many studies working with conditional variance that ignore the problem of leptokurtosis and fat-tailed density.

After the verification of the estimated model the prediction for one year has been done. The results are represented in Figure 3. The forecast was made for the year 2016 and included 161 observations. There is a need to take into account that the forecast is based on daily data

for wheat futures contracts traded at the CME.

The results of the static forecast for 2016 suggest that the daily basis of data is more appropriate for short-term predictive purposes. For long-term forecasting, it would be better to use weekly or monthly data. These findings have an implication for agricultural producers in different fields. First, the producers of wheat can hedge their production with short-term futures contracts, due to the ability of a fitted model to predict price fluctuations in short run. Next, the wheat price has a trend to revert to its mean.

The economic implication of wheat volatility modelling has considerable influence on producers and processing decision making. That is, the production cycle is predominantly dependent on external factors. There are also financial participants for instance investors. They are holding large contracts in basic agricultural commodity, as it is case of wheat.

Conclusion

The aim of this paper was to determine and forecast the volatility of CME daily closing prices of wheat by using stochastic models of conditional heteroscedasticity. The observed data is characterized by the clustering of volatility. This fact is best demonstrated by Figure 1 which shows that the performance of wheat prices recorded the period with high volatility in year 2008. The tests of the fitted model for heteroscedasticity shows that the data's variance was changing over the observed period.

According to Hansen and Lunde (2005) the model GARCH is best utilized when implemented for the purpose of forecasting time series in the financial markets, which are specified by non-constant variance and volatility clustering. Based on that, the authors proposed a GARCH model in order to forecast short-term periods for the daily data of wheat commodity prices traded on the Chicago Mercantile Exchange.

The testing of the fitted model for heteroscedasticity shows that the data has non-constant variance. According to the verification, the GARCH (1,1) model can be used as an appropriate model for wheat futures prices volatility modelling. Based on this model and the static prediction of volatility, it is possible to see the convergence of predicted values to the conditional variance in long-term. Thus the GARCH (1,1) is more suitable for short-term predictions. Some other forms of GARCH family models can be considered for long-term volatility of wheat daily closing price prediction. For instance the non-linear models of GARCH family can be tested to predict the volatility with higher statistical significance.

The fitted GARCH model is suitable in the short-term as a tool for risk management when the prediction capability of the model can be used by wheat producers. In the beginning of 2005, there was a trend correction which didn't affect the observed volatility. After that, the increasing grain production on the supply side influenced the level of volatility. During the years 2008 to 2009, wheat prices reached a significant peak in volatility degree. The other reaction in higher wheat price variability was caused by quantitative easing in the United States.

From the economic point of view, the results have wide implications for wheat processing, especially for earnings and agricultural producers. First, the price fluctuation of wheat is more persistent in the short term. That means the fitted model used in this paper is accurate for predictions. The outputs in agriculture are variable all the time, such as natural shocks or weather. Second, there is a problem on the supply side. It means, that the producers cannot respond to the changes of the wheat price in the short term.

The paper also has implications for agricultural producers in hedging techniques. In particular, the wheat producers can sell contracts with longer maturity to protect the price of wheat. This concept can be extended by focusing on the Granger analysis of fundamental events.

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Economic Crisis And the Fragility of World Wine Export

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Abstract

The paper investigates the impacts of economic crisis on the duration of word wine exports for 40 leading wine exporter countries between 2000 and 2012. We analyze three attributes of wine exports embodied in exports relationships: the initial value of exports, the growth of exports within a spell, and the hazard of exports ceasing. Our results indicate that wine exports are rather short lived even for leading wine exporter countries. Our estimations imply that economic crisis has not significant impacts on initial value of wine export starting before crisis, whilst it has negative effects on spells beginning after crisis. However, economic crisis does not influence the export growth, and decrease the probability of failure of wine exports.

Keywords

Duration of world wine exports, economic crises, leading wine exporters.

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Introduction

During the last two decades, the world's wine market has experienced a rapid process of globalization. Growth in the wine trade boomed during the nineties both in wine consumption in Northern Europe and in North America and in exports of the so-called New World wine producers. Recently, the wine international trade has been boosted by increasing demand in countries (Anderson et al., 2004; Anderson and Nelgen, 2011; Mariani et al., 2012). There is a growing literature on various aspects of recent developments on world wine markets including the impacts tariff and tariff frictions (Mariani et al. 2014; Dal Bianco et al., 2016), dynamics of world wine trade (Castillo et al., 2016), characteristics of intra-EU markets (Fertő et al., 2016; Lombardi et al., 2016).

However, one question is not yet addressed in empirical wine trade literature: when do countries trade and how long do their trade relationships last? Our analysis of this latter issue is, among other things, motivated by the finding of recent research that many countries do not trade in any given year and for any given product (Haveman and Hummels, 2004, Feenstra and Rose, 2000, Schott, 2004). As a consequence of it, a new literature focusing on the duration of international trade has emerged. Based on the surprising finding in Besedeš and Prusa (2006a) that US import flows have a remarkably short duration, the question asked is: "which factors determine how long international trade relationships last?" From a policy-oriented point of view this is indeed an important question to ask. Trade will not grow very much if new products stop being exported after only a few years. Therefore, to better understand which factors may help countries increase their trade, and thereby potentially improve economic development, it is important to learn more about what determines the duration of trade flows. Recent studies provide evidence that trade relationships (e.g. Besedeš and Prusa, 2006b; Nitsch, 2009; Fertő and Soós, 2009; Brenton et al., 2010; Obashi, 2010; Cadot et al., 2013) are surprisingly short lived. Empirical studies usually confirm that exporter characteristics (such as GDP and language), product characteristics (such as unit values) and market characteristics (such as the import value, and market share) affect the duration of trade (Hess and Persson 2011, 2012). However all studies focus only manufacturing or all products except (Bojnec and Fertő, 2012).

In addition, being in or out of the market may be a particularly important issue when the market is affected by external shocks. The economic crisis in 2008 is good natural experiment. Our research focuses on the question how major wine exporter countries in the world market before and after the economic crisis. Specifically, we examine how economic crisis affect the value of wine export

at the start of a new wine export relationship, the length of wine export relationships, and how quickly wine export grows within a relationship.

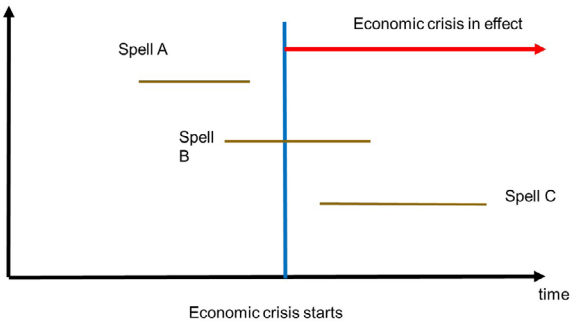
Materials and methods

There are two empirical strands in the international trade literature on the duration of trade. The first analyses the duration of bilateral trade relations at the product (category) level and the second analyses the trade behaviour of firms, in particular switching of export products and destinations. This paper builds upon on the first strand of the literature focusing on country-product relations.

Besedeš and Prusa (2006a) distinguish homogeneous and differentiated goods using the Rauch (1999) classification They find that homogeneous goods have higher hazard rates than differentiated goods and higher initial trade values increase survival. In addition their results indicate lower transportation costs, higher GDP, higher tariffs, and depreciation of the source country's currency all lead to longer durations. Nitsch (2009) applies also Cox proportional hazard models on the duration of German import relations between 1995 and 2005. He also concludes that GDP in the exporting country and a similar language lowers the hazard rate. This is also the case for the initial trade value and market share in the importing country. Brenton et al. (2009) analyse the duration of export flows at the 5-digit SITC level of about 80 exporting countries and 50 importing countries between 1985 and 2005. They also conclude that the initial trade value is important for survival. Hess and Persson (2011) focus on the imports of 15 EU-countries from 140 different exporting countries between 1962 and 2006 at the 4-digit SITC level. They conclude that the mean duration of import flows is only 1 year. Morover they show that export diversification, which - both in terms of the number of products exported and the number of markets served with the given product - substantially lowers the hazard of trade flows dying. Notice, that these studies suffers from the lack of theoretical background. Existing theories based on heterogenous firms does not explain the short lived export relationships (Hess and Persson 2011). More recently Besedeš et al. (2016) provide a theory to explain some empirical regularities of short lived trade relationships.

Following their model we test the following hypotheses. First, the probability of an export relationship ceasing is decreasing in its size and age (or duration). Second, the growth rate of exports is decreasing in size conditional on duration and decreasing in duration conditional on size. Third, larger initial volumes of exports are associated with longer lasting relationships and lower hazard rates. Beyond to theoretical considerations we focus on the impact of the economic crisis on the duration of wine exports. Uncertainties in demand side and cost conditions have important role in export decisions which cannot be resolved after entry of foreign markets. Nguyen (2012) argues that uncertainties may reconcile the high exit rates after first years. We can assume that economic crisis has increased the uncertainties especially on demand side, thus we can expect that crisis has negative impact on the duration of wine exports.

Figure 1 provides a schematic illustration of the types of trade spells a pair of countries can have as they relate to economic crisis, they enter into. The advent of crisis allows us to distinguish between three types of spells. There will be spells such as spell A, which begin and end before the crisis goes into effect. These spells are unaffected by the crisis. There are also spells such as spell B which start before the crisis, but do not end until after the crisis goes into effect. These spells will be directly affected by the crisis. Finally, there are also spells, such as spell C, which start after the crisis has been established.



Source: Own compilation

Figure 1: Effects of economic crisis on trade.

To properly identify the effects of economic crisis, we need to differentiate between spells active when the crisis begins and spells which begin after the crisis. In order to properly capture all effects of economic crisis we use two variables. One variable, labeled 'crisis in effect' (Spell B), identifies the years during which crisis is in force, thus identifying the differential effect of the crisis itself. Since model predicts that relationships or spells which start after the crisis are different from already active ones, we use a second dummy variable, 'Spell starts after crisis' (Spell C), which identifies all spells which started after the crisis is put in force. The 'crisis in effect' and 'Spell

starts after crisis variables in conjunction identify the effect on spells which begin after the crisis is in effect.

We are interested in the effect economic crisis have on three attributes of exports spells: the volume of exports in the first year, the growth of the volume of exports while the spell is active, and the conditional probability it will cease to be active or the hazard rate. We examine the effect on initial volumes and the growth of exports within an active spells by estimating two separate OLS regressions:

$$X(1)_{ikt} = \alpha_0 + \alpha_1 Crisis_t + \alpha_2 afterCrisis_{ikt} + \gamma_i + \mu_k + \eta_t + \varepsilon_{ikt} \quad (1)$$

$$Xgrowth_{ikt} = \alpha_0 + \alpha_1 Duration_{ikt} + \alpha_2 X_{ikt-1} + \alpha_3 Crisis_t + \alpha_4 afterCrisis_{ikt} + \gamma_i + \mu_k + \eta_t + \varepsilon_{ikt} \quad (2)$$

Where $X(1)_{ikt}$ denotes export values in initial period, $Xgrowth_{ikt}$ describes the export growth, X_{ikt-1} is lagged value of exports, *Crisis* is a dummy takes 1 before 2009, otherwise zero, *afterCrisis* is a variable reflecting how long the crisis has been in effect when a spell starts, *Duration* the age of spell k in year *t,* γ_i is exporter fixed effects, μ_k is importer fixed effects and η_t year fixed effects.

Next step we focus on the duration of world wine exports. Duration analysis of export (export > 0) is estimated by the survival function, S(t), using the nonparametric Kaplan-Meier product limit estimator (Cleves et al., 2004). We assume that a sample contains n independent observations denoted (t_i; c_i), where $i = 1, 2,\ldots, n$, t_i is the survival time, and c_i is the censoring indicator variable C taking a value of 1 if failure occurred, and 0 otherwise of observation i. It is assumed that there are $m < n$ recorded times of failure. The rank-ordered survival times are denoted as $t(_1) < t(_2) < \ldots < t(_m)$, while n_j denotes the number of subjects at risk of failing at $t(_j)$, and d_j denotes the number of observed failures. The Kaplan-Meier estimator of the survival function is then:

$$\hat{S}(t) = \prod_{t(i)<t} \frac{n_j - d_j}{n_j} \quad (3)$$

with the convention that $\hat{S}(t) = 1$ if $t < t(_1)$. Given that many observations are censored, it is then noted that the Kaplan-Meier estimator is robust to censoring and uses information from both censored and non-censored observations.

Beyond to descriptive analysis of duration of export, we are interested in the factors explaining the survival. Recent literature on the determinants of trade and comparative advantage duration uses Cox proportional hazards models (e.g. Besedeš and Prusa, 2006; Bojnec and Fertő, 2012; Cadot et al., 2013). However, recent papers point out three relevant problems inherent in the Cox model that reduce the efficiency of estimators (Hess and Persson, 2011, 2012). First, continuous-time models (such as the Cox model) may result in biased coefficients when the database refers to discrete-time intervals (years in our case) and especially in samples with a high number of ties (numerous short spell lengths). Second, Cox models do not control for unobserved heterogeneity (or frailty). Thus, results might not only be biased, but also spurious. The third issue is based on the proportional hazards assumption that implies similar effects at different moments of the duration spell. Following Hess and Persson (2011), we estimate discrete-time models, namely probit specifications, where exporter country random effects are incorporated to control for unobservable heterogeneity.

More specifically, we estimate the hazard of exports ceasing at time t by estimating a discrete hazard using random effects probit specification controlling to origin's and destination's GDP, a vector of bilateral time-invariant gravity variables (distance, common border, and common language)

$$XD_{ikt} = \alpha_0 + \alpha_1 Duration_{ikt} + \alpha_2 X_{ikt-1} + \alpha_3 Crisist + \alpha_4 afterCrisis_{ikt} + \alpha_5 GDP_{it} + \alpha_6 GDP_{kt} + \alpha_7 lndistance_{ik} + \alpha_8 border_{ik} + \alpha_9 language_{ik} + \varepsilon_{ikt} \quad (3)$$

Our empirical analysis is based on a panel data set includes bilateral trade data of 40 major wine exporter countries and 216 trading partners between 2000-2012, giving 54587 observations. Wine export data comes from the World Bank World Integrated Trade Solution (WITS) database in HS-6 level, product code 2204, in thousand US dollars (World Bank, 2016a). Data for the other explanatory variables are obtained from the following data sources: GDP from the World Bank (2016b) database, trade costs variables including distance, common border and common language are from the CEPII database (Mayer and Zignano, 2011).

Results and discission

In our aim to explore the duration of wine trade in leading wine exporters countries, we start by performing a thorough descriptive analysis. Table 1 offers some initial summary statistics as to the length of wine exports flows. Notice first that there is a large number of observed spells

(over 6700). Table 1 shows that the mean duration of a spell in our benchmark data is less than 5 years for the leading wine exporters countries within a relatively short time span (13 years). The mean length of spells starting and ending before crisis (A sample) is rather short less than two years. The average duration of spells surviving crisis (B sample) is relatively long 7.3 years, whilst the length of spells entering into market after crisis is already short (1.8 years). The short lived duration is in line with findings of previous studies (Besedeš and Prusa, 2006b; Besedeš et al., 2016, Bojnec and Fertő, 2012; Nitsch, 2009; Fertő and Soós, 2009; Brenton et al., 2010; Obashi, 2010).

sample	Obs	Mean	Std. Dev.	Min	Max
total sample	6706	4.9	4.8	1	13
A sample	2966	1.9	1.6	1	9
B sample	3740	7.3	5.2	1	13
C sample	1625	1.8	1.0	1	4

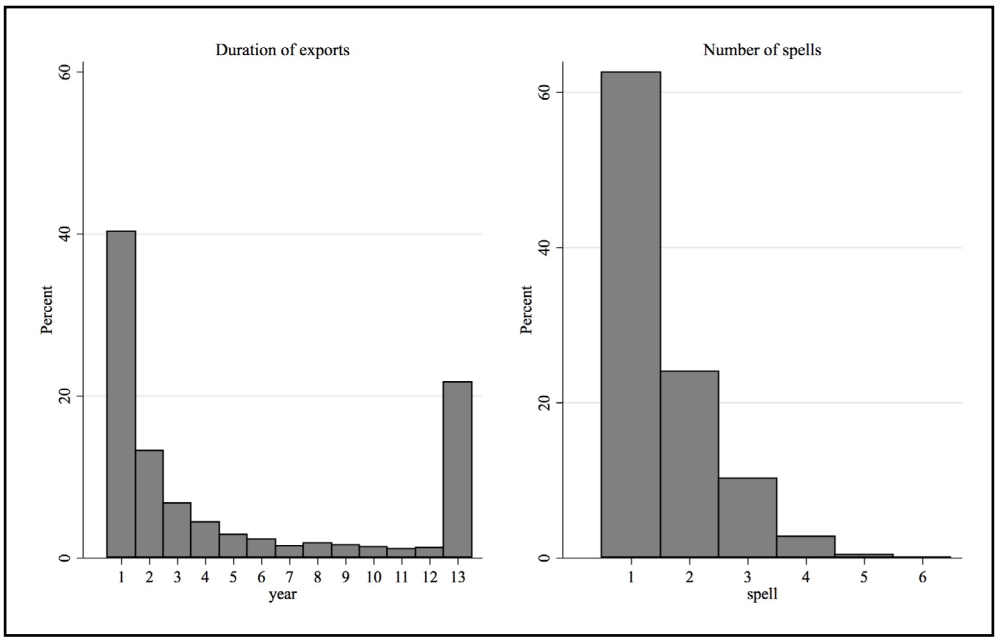
Source: Own calculations based on World Bank WITS database (2017)

Table 1: Summary statistics of spells.

The left histogram in Figure 1 presents the distribution of the duration density of the number countries with exports > 0 over the thirteen years analyzed, which is slightly more concentrated on the left side, indicating fewer years continuously being at exports>0, than on the right side of the same histogram, indicating more years being continuously at exports > 0. Around 22 percent of the wine products have a perfect continued survival rate in exports > 0 during the thirteen analyzed years.

The right histogram in Figure 2 presents the number of spells with exports > 0, focusing on the difference between single spells and multiple spells per a given wine product. First, the high share of a single spell with continuous exports > 0 indicates that most of the main wine exporter countries have a high percentage of wine products that survived a certain number of years in 2000-2012. During the analyzed 13-year period, the minimum length of a spell is one year, and the maximum length of a spell for a given wine exporter countries with continuous exports > 0 is 13 years. The average value of the length of spell is 4.9 years, while the median value of duration of the spell is only 2 years. Second, among the multiple spells with exports>0 per given wine product, two and three spells, and to a lesser extent four and five spells for a given wine product are identified.

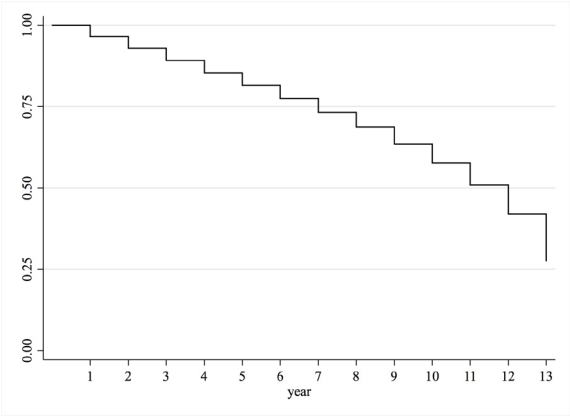
To be able to describe the trade flows with more information than a mere mean or standard deviation value will allow, we also plot a descriptive survivor function. Figure 3 depicts empirical survivor functions of wine exports spells. The x-axis plots the observed spell length, and the y-axis plots the fraction of observations whose observed spell of service exceeds a given length. The Kaplan-



Source: Own calculations based on World Bank WITS database (2017)

Figure 2: Histograms of the number of spells and duration of the exports.

Meier survival function indicate that in the first half of the period less than 25 per cent of spells have ceased, but this ratio has doubled in the second half of period. In other words more than 50% of all spells have ceased after economic crisis.



Source: Own calculations based on World Bank WITS database (2017)

Figure 3: Kaplan-Meier survival estimates.

Now we turn to determinants of duration of wine trade. First, we investigate the impact of economic crisis on the initial volume of wine export. Since we are examining a single value at the starting point of a spell, our ability to identify different effects of economic crisis is reduced. A spell either starts before or after the crisis. As a result, the impact of crisis taking effect only applies to spells starting after the crisis. We thus have two variables identifying the impacts of crisis: a dummy variable identifying the years when the agreement is in effect (crisis in effect) and a variable reflecting how long the crisis has been in effect when a spell starts.

The first and second columns of Table 2 collect the results from estimating equation (1). Using only the dummy variable identifying when the crisis is in effect we have not find significant impact. We then add the variable measuring how long the crisis was in effect when the spell started. The augmented model show that in a fixed (with respect to time) effect of the crisis decreasing initial volumes by 3,300 thousand dollars, as well as a time-dependent effect which decreases initial volumes by 894 thousand dollars for every year of the crisis being in force. In other words. The impacts of economic crisis was higher by 3.5 for pre-crisis initial values than for post-crisis initial values.

We now turn to examining the impact of economic crisis on the growth of wine exports embodied in active spells. In particular, we investigate the growth of wine exports conditional on spell survival. Our results imply that the rate of growth of wine exports within a spell decreases the longer the duration of the spell, just as Besedeš et al. (2016) model predicts (third and fourth columns). Larger spells grow faster. The impacts of economic crisis are insignificant for both crisis and post-crisis dummies.

We estimate the hazard of wine exports ceasing by estimating equation (3) using random effects probit, which allows us to take into account unobserved heterogeneity. To estimate the hazard we include the standard gravity variables, GDP

	Initial value	Initial value	growth	growth	duration	duration
$Crisis_t$	458.509	-3.3e+03***		-8.9e+04		-0.121***
$afterCrisis_{ikt}$		-893.583***		4.0e+04		-0.086***
$Duration_{ikt}$			-1.8e+05***	-1.9e+05***	-0.110***	-0.073***
X_{ikt-1}			2.8e+05***	2.7e+05***	-0.617***	-0.609***
$lnGDP_{it}$					-0.067***	-0.064***
$lnGDP_{kt}$					-0.080***	-0.076***
$lndistance_{ik}$					0.130***	0.125***
$border_{ik}$					-0.167**	-0.166**
$language_{ik}$					-0.079**	-0.072*
constant	-1.7e+06***	-485.560	-2.7e+05***	2.7e+05***	3.153***	3.083***
N	54587	50388	50388	50388	46865	46865
R^2	0.1436	0.0972	0.2350	0.1658		
Chi^2					4183.966	4426.496
Rho					0.154	0.149

Note: * p<0.1; ** p<0.05; *** p<0.01
Source: Authors' own calculations

Table 2: Estimation results.

of both the importer and the exporter, distance between the two, as well as a dummy indicating the existence of a common border and a common language that the two countries share. Our results indicate that the hazard are decreasing in duration, indicating that longer lived spells are less likely to cease and also grow less (fifth and sixth columns) confirming findings by Besedeš et al. (2016). The size of GDP for both exporter and importer sides decrease the probability of wine export ceasing. In addition, exports are less sensitive to the GDP of the exporting country than to the income of the importing countries. Similarly to earlier studies (Brenton et al., 2009; Hess and Persson, 2011, 2012; Besedeš et al., 2016) estimations suggest that the common border and common language decreases, whilst the distance increases the likelihood of failure in the wine export relationships in both specifications.

Conclusion

The paper analyses the impact of economic crisis on the duration of word wine exports for 40 leading wine exporter countries between 2000 and 2012. More specifically, we investigate three attributes of wine exports embodied in exports relationships: the initial value of exports, the growth of exports within a spell, and the hazard of exports ceasing. Trade relationships between the 40 leading wine exporters and their partners and are often dynamic, with numerous entry and exits and spells of service. During the 2000 to 2012 period, there were 6706 different exporter trade relationships for leading wine exporters. While two-third of these trade relationships had a single spell of service, one-third of all trade relationships have multiple spells of service. Approximately 40 per cent of all spells of service last for just a single year, and approximately 55 per cent of all spells of service last for three years or less. In line with the literature on the trade duration, we find that wine exports are rather short lived even for leading wine exporter countries. Compared with other duration studies, we find relatively longer spells of service for wine exports.

Our estimations imply that economic crisis has not significant impacts on initial value of wine export starting before crisis, whilst it has negative effects on spells beginning after crisis. Surprisingly, economic crisis does not influence the export growth, and decrease the probability of failure of wine exports. This puzzling results can be explained by quick recovery of world wine exports after economic crisis. The effects are usually smaller for spells starting after crisis. This suggests that we find two types of spells according to starting before and after crisis. Estimations indicate that longer lived spells are less likely to cease and also grow less. We find the standard ‘‘gravity’’ determinants of trade including market size and trade costs do affect on the export duration at the world wine market.

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Exploitation of Agricultural Land in the Czech Republic and EU Countries

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Abstract

The primary objective of the paper is to assess the extent and exploitation of agricultural land in the CR and EU countries based on selected macro-socioeconomic indicators in order to determine the position of the CR and future desirable exploitation, protection and stabilisation of agricultural land in the CR.

The following methods will be employed in order to meet the objective: (1) The Coefficient of Geographical Association (CGA) and my own modified coefficients of association reflecting the impact of exploitation of agricultural land on indicators of the country's economic level. (2) Comparison (shrinkage of agricultural land, workforce in agriculture and market price of agricultural land in selected countries). (3) The Coefficient of Ecological Stability to assess the extent of stable and unstable areas in EU-27 countries. The following data are used for calculations: Eurostat (2009, 2015), World Bank and FAOSTAT (1993-2014). The extent of agricultural land in the CR (2014/1993) has been decreasing more slowly than in the detailed comparison countries (5 countries with the lowest CGA). The price of the agricultural land (2014) is lower than in France, Germany and Poland; nevertheless, the actual price rates are not as contrasting against these countries if purchase parity is considered. The Coefficient of Ecological Stability ranks the Czech Republic in the second half of the list of EU-27 countries (22nd place). While the ecological stability of land has decreased slightly in Germany and France (2009-2015), an improvement has occurred in the CR.

Keywords

Agricultural land fund, the Coefficient of Geographical Association, agricultural land loss, the Coefficient of Ecological Stability, land price.

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Introduction

The primary objective of the paper is to assess the extent and exploitation of agricultural land in the CR and EU countries based on selected macro-socioeconomic indicators in order to determine the position of the CR and future desirable exploitation, protection and stabilisation of agricultural land in the CR.

Secondary objectives are to: (1) determine EU countries with natural conditions and macroeconomic results in the agricultural sector similar to those in the CR. (2) describe the development of extent and price of agricultural land with the five "most similar countries". (3) determine how ecologically stable the Czech Republic is within the EU.

According to the European Environment Agency (EEA), Europe is one of the most intensively exploited continents in the world. Its method of exploitation presents one of the fundamental causes of environmental change, which has a considerable impact on quality of life and ecosystems and on infrastructure management. However, the management of extent of agricultural land and its numerous functions – food production, nature protection, recreation and housing – is important (EEA, online 2013). The total area of agricultural land in the EU decreases in time in favour of construction and other areas, and partly even forest. In spite of the agricultural overproduction, this is a trend that different countries gradually try to prevent by means of various legislative measures, primarily because the knowledge and awareness of non-productive functions of soils have been increasing (MoA, 2015). The shrinkage of agricultural land in the Czech Republic as a consequence of climate change is studied by Lorencová et al. (2013).

Long-term shrinkage of agricultural land in selected areas of Poland is highlighted by Bucała-Hrabia (2017). Schwaab et al. (2017) study the rapid decrease in fertile soils in large urban areas and search for compromises that will not endanger urban development in Switzerland.

German authors (Steinhäußer et al., 2015) have found out: Within just a few years, land-use conflicts have become considerably more acute in Germany, mainly due to recent changes in the national energy policy. Land users have become much more aware that land is a limited resource, and this has led to competition among the following land-use sectors: settlements/transportation, agriculture, forestry and conservation.

Land use changes are the result of a complex interplay of drivers and processes operating at different spatial and temporal levels. Landowners play a crucial role in land use changes and are the target of many policy interventions and instruments. Yet, we lack a full understanding of the relationship between different drivers and how they influence landowners' decision-making processes and strategies.) Kristensen (2016). Agricultural landscapes safeguard ecosystem services (ES) and biodiversity upon which human well-being depends. However, only a fraction of these services are generally considered in land management decisions, resulting in trade-offs and societally inefficient solutions. The study indicate that the continued decrease of ES and biodiversity in Germany can be explained by implementation deficits within a well-established nature conservation system (Albert at al., 2017).

Agriculture is the largest type of land use in the UK, accounting for about 77 per cent of the total area, compared with an average 50 per cent for the EU27. It seems likely that over the next 50 years, the UK's land area will be required to deliver an increasingly diverse range of private and public goods to meet growing human needs and aspirations. This will require a balance of policy-driven goals and market forces. It will also need a much improved understanding of the trade-offs between food production and environmental goals and of the institutional arrangements required to achieve a balance of economic, social and environmental outcomes (Angus, 2009). Land use optimization is a prerequisite for sustainable development, regardless the characteristics of the zone before and after industrial intervention. The results show special need for developing artificial wetlands (42%), followed by Agriculture (23%) and Forestry (12%). The results for "Do Nothing" (23%) relate to the actual situation of the recovered zone after mining intervention with agriculture applications which had been proved to be successful in attaining Sustainable Development (Palencia-Aguilar, 2015). Agriculture is the primary land use across Europe, hence future European land use is largely a function of the activity chosen for this sector. The main driving factor that determines how agricultural land is managed is profitability (Rounsevell et al., 2003). A low profit can lead to land abandonment. Conversely a large profit can lead to forest and land that is otherwise unsuitable, being converted to agriculture. The changes in relative profit between enterprises (whether due to technology, subsidy or economics) can lead to large areas of single crops, landscapes of brightly coloured crops, and arable crops replacing permanent grassland on slopes. All these changes in agricultural land use have profound impacts on the quality of the landscape and the environment through, for example, nutrient dynamics, soil erosion, ecological diversity and food resources for birds and other wildlife. In the second half of the 20th century technology and socio-economic change have driven rapid changes in land use (Ewert et al., 2005).

The dynamic ability of ecosystems to constantly maintain and renew conditions for their existence with self-regulatory mechanisms is referred to as ecological stability of landscape. It is characterised by steadiness, resistance and flexibility to disrupting influences of both natural and anthropogenic origin. The ecological stability of a country can be regarded as a basis for assessment of all conditions and prerequisites for landscape exploitation. If a certain degree of land exploitation is exceeded, the stabilisation, recovery and production functions of soil are reduced or even halted completely. With inappropriate land management, this brings numerous risks in the form of degradation of landscape and its components (Zaušková and Midriak, 2007). Forman and Godron (1993) understand the stability of land and its resistance to disruption and its ability to recover after disruption. Vološčuk and Míchal (1991) refer to ecological stability as the ability of an ecosystem to restore its dynamic equilibrium or its "normal" development direction by means of its internal mechanisms. The faster an ecosystem recovers and the smaller deviations it shows, the more stable it is.

Materials and methods

The objective will be attained by using the following mathematical formulas, described procedure and data.

Materials

Information about production factors (soil, labour) will be taken from the FAOSTAT database and then I will use it for the calculation of economic level indicators (for 1993-2014). Information about the division of agricultural land for the EU-27 (data from Croatia absent) will be taken from the EUROSTAT database (Land cover overview by NUTS 2 regions) for 2009 and 2015. Addition economic indicators: "Agriculture, value added (% of GDP)" and "Employment in agriculture" will be taken from the World Bank database (2014, online 2017). Calculations will be made with data for 1993-2014 and 2015. The year 1993 corresponds to the Czech Republic's independence and the years 2014 and 2015 are the latest available years in the international databases at the time of writing.

Procedure nad formulas

The Coefficient of Geographical Association (*CGA)* (equation 1) will be used to determine the similarity in structure of agricultural land in EU countries. The calculation will include indicators comprising components of agricultural land (AL). The calculation consists in a sum of absolute differences of selected AL indicators between the selected country and the other compared countries. The lower the sum of differences, the greater the similarity between the countries examined. I intend to identify 5 countries with the most similar AL exploitation.

Coefficient of geographical association (*CGA*) by Bičík (1982):

$$CGA = |\Delta K_1| + |\Delta K_2| + |\Delta K_3| + \ldots |\Delta K_n| \quad (1)$$

Where:

$|\Delta K|$ = Absolute difference of indicators (percentage points): The Czech Republic (%) to the comparative country (%).

n = number of indicators

In addition, I intend to identify the socioeconomic consequences of AL exploitation. I will therefore modify the *CGA* (Bičík, 1982) in my own way (equations 2, 3). Inclusion of different variables will be purely individual; and I will use my own names of the modified coefficients.

Coefficient of Basic Association (*CBA*) will be calculated from the following indicators: Agricultural land (% of land area) (K_1) and Arable land (% of agricultural land area) (K_2).

$$CBA = |\Delta K_1| + |\Delta K_2| \quad (2)$$

Coefficient of extended association (CEA). The coefficient of basic association will be extended with additional qualitative economic indicators: Agricultural land per capita (K_3), Agriculture, value added (% of GDP) (K_4) and Employment in agriculture (K_5) in %.

$$CEA = |\Delta K_1| + |\Delta K_2| + |\Delta K_3| + |\Delta K_4| + |\Delta K_5| \quad (3)$$

Countries with the lowest results will be identified based on equations 1, 2, 3. These will be countries with similar geographical conditions, producing similar agricultural outputs based on a similar extent of production factors used (labour, soil). These countries will then be included in the detailed comparison. I will compare the annual decrease in AL, the share of AL in the country area, the tilled land percentage, employment in agriculture (period 1993-2014), and the market price of agricultural land (2014). If countries with similar natural conditions attain better economic results, then there is room for improvement in the CR (e.g. size of businesses, ownership relations, shrinkage of agricultural land, amount of investment in agriculture, labour productivity, amount of subsidies received, etc.).

Effective agricultural policy should work in connection with environmental sustainability. Attention will be paid to ecological stability of landscape in the assessment of agricultural land in the EU countries. Míchal (1985) has defined the procedure for calculating the *Coefficient of Ecological Stability* (*CES)* (equation 4) and made a classification of results (Table 1).

$$CES = \frac{forest\ land + water\ areas\ and\ watercourses + permanent\ grasslands + wetlands + sets + hop\ gardens}{arable\ land + vineyards + anthropogenic\ areas + others\ areas} \quad (4)$$

Note: The *CES* expresses the stable areas ratio to unstable landscaping elements.

0.1 < CES < 0.30	The area is used above the average, with the distinct disruption of natural structures. The basic environmental functions must be continually replaced by the technical interventions.
0.3 < CES < 1.00	The intensively used area - mostly by agricultural activities. The weakened self-regulation processes can cause an ecological lability in ecosystems.
1.00 < CES < 3.00	Enough balanced landscape. Technical objects are relatively in compliance with natural structures
CES > 3.00	Nature with the strong predominance of ecologically stable structures and low intensity of landscape use by humans.

Source: Míchal (1985)

Table 1: The coefficient of ecological stability - classification (in CR).

The international databases follow the structure of agricultural land differently from those in the CR. I will therefore modify equation 4 according to the landscape character (stable/ unstable) to yield the CES_{EU} (equation 5).

$$CES_{EU} \frac{(\text{Woodland} + \text{Shrubland}) + (\text{Water} + \text{Wetland}) + \text{Grassland} + \text{Bareland}}{\text{Cropland} + \text{Artificial land}} \quad (5)$$

Note: The limits of CES_{EU} for inclusion of countries in categories of results are identical to those of CES Míchal (Table 1).

Source: Author by: Míchal (1985), CSO (2006) and "Land Cover" EUROSTAT

The next phase of identification of ecologically important landscape will employ equations containing weighted coefficients for different types of areas (Miklós, 1986; Löw et al., 1987). The objective is to find out how the assigned importance of cultivation influences the ranking of EU countries in the ecological assessment of landscape.

$$CES(Miklós) = \frac{p_n * k_{pn}}{p} \quad (6)$$

Where p_n = area of individual cultures, p = total monitored area, k_{pn} = coefficient of ecological significance: field: 0.14, meadows: 0.62, pastures: 0.68, gardens: 0.5, fruit orchards: 0.3, forests and water: 1, other 0.1 (more in: Miklós, 1986).

$$CES\ (Löw) \frac{1.5A + B + 0.5C}{0.2D + 0.8E} \quad (7)$$

Where A = 5th grade area (best landscape: forest area, water area, wetlands, bare mountain), B = 4th grade area (scrub/bush), C = 3rd grade area (permanent grasslands), D = 2nd grade area (arable land), E = 1st grade area (worst land use: built up areas, anthropogenic areas). Units: % (more in: Löw, 1987).

The results will then be evaluated by means of comparison. I will identify the trends in agricultural land exploitation in EU countries as well as the detailed comparison countries. The comparison will indicate the economic valuation of agricultural land and how anthropogenic interventions affect AL exploitation. These conclusions will form the input information for the follow-up research in the area of efficiency of agricultural land exploitation.

Results and discussion

The initial comparison of EU countries based on quantitative and qualitative economic indicators that are explicitly related to AL exploitation. The Czech Republic's position within the EU-27 is derived from the data shown in Table 2 (WB, FAO, 2014). The CR has an above-average share of AL in the national territory (+11.27 p.p.) as well as the tilled area (+11.86 p.p.) in relation to the EU average. In terms of agricultural land per capita, the CR has an average value within the European Union. The macroeconomic indicators describe the CR as a country with a lower economic importance of agricultural production. Agriculture value addend (% of GDP) in the CR is 1.04 p.p. higher than the EU average, and Employment in agriculture is 1.95 p.p. lower than in the EU. The importance of agriculture in the Czech Republic is decreasing, its share in the GDP and employment are also decreasing (WB, 1993-2014). The technical equipment is better than in the other Central and Eastern European countries; however, the agricultural efficiency does not achieve EU-15 results (Pělucha, 2006).

The smaller EU countries of Northern and Western Europe, where the share of added value of agriculture in the GDP is below 2%, are oriented to exportation of agricultural products with a high added value (Denmark, Ireland, the Netherlands). Other countries in this area do not have significant export activities (Belgium, United Kingdom, Finland, Sweden) . In Finland and Sweden, the tilled land percentage is normally higher than 85%. In large EU countries (France and Spain), agriculture plays a significant role and is relatively efficient (share of agriculture in GDP is 1.73% and 2.50%, respectively, and the share of economically active is 2.82% and 4.24%). These countries too belong among major exporters of agricultural commodities (FAO, 2014). South European countries (Portugal, Italy and Greece) belong among areas where agriculture is important but not efficient. Agriculture is clearly important in economically important countries of Central Europe (Germany and Austria). It is based on small-scale farms. Austria belongs among countries with a high share of ecologically farmed soil. However, both countries are importers of agricultural products (FAO, 2014).

The Baltic states have a higher share of agriculture in GDP (approx. 4%), they have a problem with high employment in the sector (4-9%) and they struggle with obsolete technical equipment in agriculture (ČTK, 2003). Among Central and South-Eastern European countries, agriculture is of great importance particularly in Poland, Romania and Bulgaria with a share in GDP of 3-5%, while both Poland and Romania have a high employment in agriculture (11.47% and 28.35% of economically active). The share

of the agricultural sector in GDP of newly acceded EU countries decreased over the study years, although it is still above the 1.7% average for the EU-28 (WB, 2000-2014). More in Table 2.

Analysis of structure of agricultural land and associated macroeconomic indicators

Using the procedure of Bičík (1982) (equation 1), the analysis of structure of agricultural land found out that the agricultural land exploitation in the Czech Republic shows the greatest similarity with Poland (*CGA* = 4.03), Slovakia (5.83) and Germany (*CGA* = 8.32), as well as Bulgaria (*CGA* = 9.01) and Lithuania (*CGA* = 10.11). The countries least similar in terms of AL structure (reflection of natural conditions) are Ireland, Slovenia, Portugal, Greece and the UK. This is generally due to the higher share of permanent grassland in agricultural land (from 76.28% in Ireland to 49.04% in Portugal). In addition, Greece and Portugal have a higher share of permanent cultivation in AL (11.96 and 18.40%) than the CR.

As needed for the research, equation 1 has been modified to equations 2 and 3, in which the attention is not focused only on structure of agricultural land but on wider context derived from agricultural land exploitation.

The calculation of the *Coefficient of Basic Association (CBA)* (equation 2) indicates: the relative extent of agricultural land

Country	Agricultural land (% of land area)	Tilled land (% of agricultural land area)	Agricultural land per capita	Agriculture, value added (% of GDP)	Employment in agriculture
	%	%	hectare	%	%
Austria	32.36	49.80	0.32	1.40	4.80
Belgium	43.61	61.37	0.12	0.72	1.22
Bulgaria	44.84	70.04	0.69	5.26	7.01
Croatia	26.66	53.90	0.36	4.14	9.50
Cyprus	11.69	73.82	0.09	2.08	4.43
Czechia	53.46	74.55	0.40	2.74	2.75
Denmark	61.25	92.51	0.47	1.58	2.48
Estonia	21.54	66.52	0.74	3.58	3.85
Finland	6.70	98.40	0.42	2.79	4.24
France	52.39	63.73	0.43	1.73	2.82
Germany	46.80	70.98	0.21	0.78	1.43
Greece	61.95	31.80	0.75	3.72	13.57
Hungary	57.47	82.38	0.54	4.70	4.66
Ireland	63.55	23.69	0.97	1.46	5.69
Italy	43.68	51.12	0.22	2.16	3.64
Latvia	29.03	64.58	0.94	3.48	7.50
Lithuania	45.22	79.60	1.01	3.79	9.17
Luxembourg	50.58	47.80	0.24	0.29	1.40
Malta	31.97	87.68	0.02	1.29	1.34
Netherlands	44.27	56.82	0.11	1.84	2.11
Poland	46.13	75.76	0.38	2.95	11.47
Portugal	40.14	30.72	0.36	2.32	8.65
Romania	58.01	63.47	0.69	5.34	28.35
Slovakia	39.25	72.45	0.36	4.37	3.50
Slovenia	30.34	29.95	0.30	2.42	9.57
Spain	52.53	46.20	0.57	2.50	4.24
Sweden	6.78	85.34	0.31	1.34	1.96
United Kingdom	70.74	36.17	0.27	0.68	1.24
EU average	42.19	62.69	0.46	1.70	4.70

Sources: Own calculations based on FAOSTAT (2014) and WORLDBANK (2014)

Table 2: Selected economic indicators (EU, 2014).

Coefficient of Geographic Association CGA (Bičík, 1982)			Coefficient of the Basic Association CBA (2 indicators)			Coefficient of the Extended Association CEA (5 indicators)		
Differences of EU countries to the value of the Czech Republic: 4.03-105.28			Differences of EU countries to the value of the Czech Republic: 8.53-70.60			Differences of EU countries to the value of the Czech Republic: 12.99-74.95		
	Country			Country			Country	
1	Poland	4.03	1	Poland	8.54	1	France	12.99
2	Slovakia	5.83	2	Germany	10.23	2	Germany	13.70
3	Germany	8.32	3	Hungary	11.84	3	Hungary	15.85
4	Bulgaria	9.01	4	France	11.88	4	Poland	17.49
5	Lithuania	10.11	5	Bulgaria	13.12	5	Slovakia	18.73
23	United Kingdom	79.84	23	Portugal	57.15	23	Greece	63.39
24	Greece	85.49	24	Sweden	57.46	24	Portugal	63.51
25	Portugal	87.67	25	Ireland	60.95	25	Ireland	65.74
26	Slovenia	89.20	26	Slovenia	67.71	26	Finland	72.16
27	Ireland	105.28	27	Finland	70.60	27	Slovenia	74.95

Note: Malta - not evaluated (incomplete information in the FAOSTAT).
Source: Own calculations based on relation (2), (3) and FAOSTAT (2014)

Table 3: Values of Coefficient of Association (2014).

in the Czech Republic (with respect to share of AL in the country's soil and conversion to AL per capita) is similar to that in Poland, Germany, Hungary, France and Bulgaria. The greatest similarity was found with Poland (difference between the two selected indicators = 8.54).

The macroeconomic characteristics of agriculture, involved in the calculation of the *Coefficient of Extended Association (CEA)* (equation 3) confirmed the relationship between the CR and Germany, France, Hungary and Poland. The list of "similar" countries was extended by Slovakia (to the detriment of Bulgaria).

The highest *CEA* values were against identified for Slovenia, Portugal, Ireland, Greece and Finland. These are countries with natural conditions different from those in the CR. Moreover, Portugal has a 13.32 p.p. lower share of AL in the national territory. Except Finland and Ireland, they are countries with a higher share of people employed in agriculture (more than 8% of economically active). Finland has a very low share of AL in its national territory (6.7%) and thus the high tilled land percentage (98.4%) makes sense. Both the employment and share of the sector in GDP in Finland are low, attesting to its high economic level.

The next comparison focused on countries with which the CR has similar economic-geographical indicators, i.e., a similar base for development of agricultural primary production as indicated by the calculations of the *CEA* (Table 4, equation 3).

The share of agricultural land in the total national territory of selected countries in 1993 was from 48.05% (Germany) to 65.89% (Hungary). In 2014, the lower bound of the range (Germany) decreased to 46.80%, and a significant reduction occurred in Hungary (to 57.47%). The upper and lower bounds thus converged to a range of 10.67 percentage points (p.p.).

The tilled land percentage has been traditionally high in the new EU member states (Table 2): CR = 74.55%, Hungary = 82.38%, Poland = 75.76%, Slovakia = 72.45%.

The assessment of the time series (1993-2014) indicates the following. While the tilled land percentage decreased in the Czech Republic (-3.27 p.p.), it increased in France, Germany, Hungary and Slovakia. This is caused by the increasing arable land area (France, Germany) or a decrease in the arable land area lower than in the agricultural land (Hungary, Slovakia). In Slovakia the 10.63 p.p. decrease in the share of AL in its national territory (1993-2014) has been offset by the increased share of tilled land (+8.60 p.p.). It can be said that the countries in the detailed comparison show a tendency towards reduction in the tilled land percentage to around 70% (except Hungary, which has 82.3% in 2014).

Employment in agriculture (1993-2014) has been decreasing significantly in all the studied countries. The greatest decrease has been in the CR (-65% of agricultural employees) and Slovakia (-66%). Significant decreases are

	Agricultural land (% of land area)	Tilled land (% of agricultural land area)	Agricultural land per capita	Agricultural land area	Employment in agriculture
Czechia	0.98	0.96	0.96	0.98	0.35
France	0.94	1.07	0.82	0.94	0.51
Germany	0.97	1.04	0.98	0.97	0.40
Hungary	0.87	1.06	0.91	0.87	0.51
Poland	0.77	0.99	0.78	0.77	0.47
Slovakia	0.78	1.13	0.77	0.79	0.34

Source: Own calculations based on FAOSTAT (1993, 2014)

Table 4: Baseline indicies of selected economic indicators (1993 – 2014).

also registered in Germany (-60%) and Poland (53%). The reasons are reductions to agricultural production, decreasing farmed areas of AL (see below), and increasing automation of agricultural production.

The Czech Republic shows an average annual decrease in AL (-0.07% over the study period of 1993-2014). The stably low rates of decrease can easily be compared to the situation in Germany and France. Other countries included in the comparison show worse results (annual decrease in extent of AL from -0.68% to -1.28%). The information on average annual shrinkage of agricultural land is complemented with the baseline index (2014/1993). The 19-year time series indicates that the extent of AL in Poland and Slovakia has shrunk by a significant 23% and 21%, respectively (baseline index, Table 5).

Indicator	Average annual rate of loss (1993-2014) in %	Baseline index of loss (2014/1993)
Czechia	-0.07	0.98
France	-0.25	0.95
Germany	-0.12	0.97
Hungary	-0.68	0.87
Poland	-1.28	0.77
Slovakia	-1.21	0.79

Source: Own calculations based on FAOSTAT (1993, 2014)

Table 5: Loss of Agricultural Land (1993-2014).

The causes of the annual shrinkage of agricultural land (Poland, Slovakia, Hungary) are the following:

- Poland belongs to those EU countries with a high share of economically active people employed in agriculture (1994: 24%, 2011: 11.47%; WB 2014). The basis of Poland's agriculture is family farms, which are relatively "overstaffed" and, particularly during the economic crisis in 2009, rural inhabitants were willing to dissolve their farms, leave home and travel to work even to other EU countries.
- Slovakia does not have the conditions for intensive agricultural production. The country is characterised by mountainous areas with a higher share of pastures. People are leaving agriculture for other sectors of the national economy for economic reasons. Farming prefers agricultural land of better qualitative properties while other, less valuable soil is permanently afforested (VÚPOP, 2015).
- At the onset of the economic crisis, Hungary was forced by economic reasons to reduce both the rent per hectare and the extent of farmed agricultural land (1993: 65.89%, 2009: 62.16%, 2014: 57.47% , WB 2014, MoA 2015).
- Besides, a common factor of shrinkage of agricultural land is the preference to extensive infrastructure construction, primarily the construction of vast logistics centres in Central and Eastern European countries (EUROSTAT, 2009, 2015).

Agricultural land in the CR is losing both its quality and utility value (effects of water and wind erosion, floods, intensive droughts and farming methods). The reduced quality of soil is reflected in the reduced official price of soil in the CR's cadastral areas (MoA, 2015). The average market price of agricultural land grew by approx. 7% year-on-year in 2009-2014 (IQ Fund Management In: Daniel, 2015).

In comparison with the old EU-15 countries, the Central and Eastern European countries have lower agricultural land prices (MoA, 2015; Daniel, 2015). The international comparison is made based on marked prices of land in the national currency adjusted for the exchange rate (Sklenička et al., 2013; MoA, 2015). Table 6 shows the comparison of AL prices with respect to domestic population income (net income of selected economic category of population in EUR/year).

	Agricultural land price	Net income of selected group of inhabitants[1)]	Agricultural land price ratio between the selected EU countries and the Czech Republic	Annual income ratio of selected EU countries to the Czech Republic	Agricultural land price ratio of the selected country to the Czech Republic (by purchasing power)	Affordable agricultural land area according to the net income of residents
	EUR/ha	EUR/year				hectares
Czechia	5 070	8 675				1.71
Germany	18 099	27 662	3.57	3.19	1.12	1.53
France[2)]	5 910	26 578	1.17	3.06	0.38	4.50
Poland	5 706	7 994	1.13	0.92	1.22	1.40
Slovakia[3)]	4 100	8 034	0.81	0.93	0.87	1.96
Niederland	53 000	33 237	10.45	3.83	2.73	0.63

Note: [1)] Net income after taxes in EUR (Single person at 100% of average earnings, no child). Exchange rate for 2014: 1 EUR = 27.533 CZK. Source: OECD, Pepersonal income tax rate (2014). [2)] Source: MoA, 2015. [3)] The selected districts of the Slovakia, Source: Budaj, Š. et al. (2015).
Source: IQ fund management (2015), Kursy. CZ (2014), unless otherwise defined herein.

Table 6: Comparison of market prices of agricultural land in the Czech Republic and selected EU countries (2014).

The prices of agricultural land are 3.57 times higher in Germany than in the CR, 1.17 times in France, and 1.13 times in Poland (Table 6). The prices are 1.24 times lower in Slovakia than in the CR. For information, the AL price in the Netherlands is shown, which is 10.45 times higher than in the CR (2014). In terms of purchase parity of domestic population (selected category), the situation is as follows: With the exception of France and Slovakia, purchase of agricultural land is more financially demanding for the other domestic inhabitants in Germany, Poland and the Netherlands. For example, Land in Germany is more than 3 times as expensive as in the CR, but purchasing AL in Germany is only 1.12 more expensive for German citizens than it is for Czechs in the CR. In the CR (limited to selected population category), 1.73 ha can be purchased for the net annual income; it is 1.53 ha in Germany (Table 6). It cannot be supposed that it is necessary to equalise the prices of AL in the CR to, e.g. the German level without the countries' income levels equalising as well.

The proportion of the rent price to the market price of agricultural land (%) is from 2% (Germany) to -4% (Lithuania). The proportion of the rent price and the market price of AL in the CR was 2.39% (EUROSTAT, 2009).

This paper is not unique with its contents. Similarity of natural and agricultural conditions between different countries can be found, e.g. in Ciutacu et al. (2015). They emphasise differences and similarities between the European model of agricultural and rural development and Romania's agricultural sector. Studying the extent of AL is also still an up-to-date issue. In the long term, shrinkage of agricultural land in the CR has been identically pointed out, e.g. by Bičík et al. (2000), Němec (2004), Ministry of the Environment (CENIA, 2013) and Ministry of Agriculture (MoA, 2015). The extent and exploitation of AL in Europe has been studied with similar results, e.g., by the European Environment Agency (EEA, 2013) and others (Lorencová et al., 2013; Bucała-Hrabia, 2017; Schwaab et al., 2017; Steinhäußer et al., 2015).

Assessment of agricultural land in EU countries by coefficient of ecological stability

For landscape to be able to withstand major and minor change (stress, loading, etc.), it has to achieve a certain level of ecological stability. According to available data from the FAOSTAT for 2009 and 2015, The Czech Republic has $CES_{EU,\ Czechia}$ = 1.64 and 1.73 (methodology, equation 5) and is thus within the medium interval of *CES* classification ($1 < CES_{EU} < 3$; Table 1). The Czech Republic's position is below average in this land assessment (22nd place, 2015).

The lowest CES_{EU} (2015) values in the EU were given to three countries (Malta, Denmark and Hungary). Malta and Denmark were in the third (negative) zone (Table 7), which shows a tendency for ecologically and naturally unstable exploitation of land. Hungary only exceeded the threshold for unstable areas (CES_{EU} = 1) only very slightly ($CES_{EU,\ Hungary}$ = 1.09). The above countries have high tilled land percentages (ranging from 92.51 to 82.38%; Table 2). In addition, Denmark and Hungary have a significant share of agricultural land in the national territories (61.25% and 57.47%, respectively). The majority of the countries

(15 of the EU-27) are in the medium zone (places 12 - 26). The ecological stability values for the EU-27 (Table 7) are ranked from the best at 16.23 (Sweden) for the worst at 0.74 (Hungary). The CES_{EU} (2015) value equals 2.78.

The detailed comparison again focuses on the following countries: Hungary, Poland, Slovakia, Germany and France. Among these countries, the CES_{EU} indicates that least ecologically stable is Hungary (Cropland = 43.7% of the territory). Germany among the other countries is rated better than Hungary (CES_{EU}, Germany = 1.52, Cropland = 32% of the territory). The position of the CR (22nd place) is very similar to that of Poland (21st place). France is 18th; Slovakia is in the 13th place. France has extensive permanent grassland areas (approx. 27% of its territory), while Slovakia has extensive forest areas (45% of its territory) (EUROSTAT, 2015).

Between 2009 and 2015, a positive change is shown in the CR (0.9 increase in *CES*), Hungary (+0.11) and Poland (+0.13). The primary reason for the *CES* increase was the reduced share of cropland in the national territory: CR (-1.6 p.p.), Hungary (-1.97 p.p.) and Poland (-2.1 p.p.) (EUROSTAT, 2009, 2015). The share of unstable areas (built-up areas) increased the most in Germany (+0.6 p.p.) and France (+0.3 p.p.), which led to a slight decrease in the *CES* (Table 7) with a stable share of cropland.

It has to be noted that the *CES* assessment is based on statistical classification of exploitation of surfaces of different countries. Ecological stability should reflect how land cover is exploited qualitatively (land use). Modification of the *CES* has been studied, e.g., by Miklós (1986) or Löw (1986). Instead of distinguishing among relatively stable and unstable areas, Miklós differentiates among their ecological importance by implementing numerical coefficients for different AL crops (equation 6). Another variation of the *CES* can be found in Löw (Agroprojekt, 1986), which classifies elements into categories based on the degree of element quality (equation 7). The use of weighted coefficients in *CES* calculations has mostly not brought better quality results. I in fact believe that the negative impacts of the share of some areas (arable land, built-up areas) on ecological stability (e.g. in the Netherlands, Ireland and Luxembourg) were overestimated.

The *CES* values (regional average) in the CR in 2006 ranged from 0.66 (areas with a high share of arable land) to 2.18 (high share of permanent grassland and forest land) (CSO, 2006). The *CES* values in the CR regions increased in 2015. They ranged from 1 to 2.6 (CVUT, 2015 In: MENDELU, 2016). The growing trend in the *CES* results is positive. In this paper, I apply the *CES* calculation procedure according to Míchal (ratio of stable and unstable areas). Another procedure is a difference between these variables, and the maximum result is the optimum (CSO, 2005). The *CES* calculation has become one of the methodological tools for implementation of principles of the European Landscape Convention (Strasbourg, 2004 In: COE, 2017) in principles of regional spatial development. Conditions

		CES (EU) 2015	CES (EU) 2009				CES (EU) 2015	CES (EU) 2009	
1	Sweden	16.23	15.89	The best CES results	15	Italy	2.12	2.06	Average CES interval
2	Finland	12.34	12.25		16	Lithuania	2.10	2.71	
3	Ireland	9.34	10.64		17	Luxembourg	2.02	-	
4	Slovenia	6.81	7.77		18	France	1.92	1.94	
5	Estonia	5.47	6.54		19	Romania	1.91	-	
6	Latvia	5.28	6.40		20	Netherlands	1.75	1.89	
7	Portugal	4.87	4.40		21	Poland	1.73	1.60	
8	Greece	4.33	3.97	Average CES results	22	Czechia	1.73	1.64	
9	Austria	4.12	4.15		23	Germany	1.52	1.56	
10	Spain	3.04	2.87		24	Belgium	1.50	1.73	
11	Cyprus	3.04	-		25	Hungary	1.09	0.98	Bad CES results
12	United Kingdom	2.80	2.82		26	Malta	1.00	0.68	
13	Slovakia	2.38	2.39		27	Denmark	0.74	0.82	
14	Bulgaria	2.22	-			Total	2.78	2.42	

Note: (-) absence of data in the EUROSTAT
Source: Author by Míchal (1985), EUROSTAT(2015, 2009) and classification by Míchal (1985) – Table 1.

Table 7: Results of CES_{EU} (2015, 2009).

for improvement of landscape protection can also be created based on the *CES* results (Maier, 2012). According to Pešout and Hošek (2013), studying the *CES* is important from the point of view of design of flood and erosion prevention measures, which may promote environmental biodiversity.

Conclusion

In terms of structure of agricultural land (Bičík, 1982), the Czech Republic compares well with Poland, Germany, Bulgaria, Lithuania and Hungary. I applied the calculation principle according to Bičík to a wider range of macroeconomic indicators. It follows from a modification of the calculation (equation 3) that the CR has agroeconomic results similar to Germany, France, Poland, Hungary and Slovakia. My calculations indicate that the average annual decrease in AL (1993-2014) does not exceed 0.1% (approx. 14 hectares a day; FAO, 2003-2014). The Czech Republic shows better results than France (-0.25% p.a.), Germany (- 0.12% p.a.), Hungary (-0.68 p.a.), Poland (-1.28% p.a.) and Slovakia (-1.21% p.a.) (Table 5). In addition, it can be concluded that the countries examined in the detailed comparison show a tendency towards a tilled land percentage to around 70% (except Hungary, which has 82.3% in 2014). The greatest decrease in employment in agriculture has been in the CR (-65% of agricultural employees) and Slovakia (-66%). The reason is the narrower agricultural production, great labour and time demand, decrease in farmed AL, and increasing use of machinery in farming. The comparison of market prices of agricultural land found out that land is cheaper for the nationals, e.g. in France. Purchasing a hectare of AL in France is 0.38 cheaper than in the CR. This means that the attainable size of agricultural land from the net annual income of a French national is 2.63 larger than in the CR. However, the price of soil in France is 1.17 time higher for a CR national (Table 6). The paper thus expands on the outcomes of MoA (2015) and IQ fund management (2015).

In addition, my calculations show that: The CR is in the lower half of the list of the EU-27 countries in 2015 based on the *CES* (Míchal, 1986) ($CES_{EU,\ Czechia}$ = 1.73, 22nd place). Between 2009 and 2015, a positive change is shown in the CR (0.9 increase in *CES*), Hungary (+0.11) and Poland (+0.13). The application of modified *CES* (equations 6, 7) yielded no major results. The ecological stability of land has decreased slightly in Germany and France (2009-2015).

The *CEA* results (equation 3) rate the CR among geographically similar and socioeconomically important countries of Western Europe (France, Germany). The price of the agricultural land is derived, and will be in future, from the price of production and, most importantly, from the added value generated by the land. This provides a potential room for future research – in the area of economic efficiency of the soil as a production factor.

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Current Trends in Training of Managers in the Field of Information And Communication Technologies And Identifying the Barriers to Education of Managers

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Abstract

Lately lifelong learning has become an integral part of the whole society. This is also the reason for the greatest development of new concepts serving just the implementation of lifelong learning policy. These changes in the process of continuous education are in practice much more than a comprehensive adaptation of the education system, which is why this trend is currently understood mainly in the developed countries of the world as a response to the changing labor market. Lifelong learning thus provides individuals with a better perspective and at the same time increases the chances of an organization in which they succeed and differentiate themselves on a global scale. That is why we can designate lifelong learning, learning and constant improving as an essential part of the development of managers. Education and training of human resources in organizations form a significant part of lifelong learning. Employee training focuses on shaping individuals, their skills and increasing their competitiveness on the global market. In today's turbulent and difficult-to-anticipate period, educational activities in management and training are important. This brings the ever-increasing demands for expanding, specialized and retraining education and thus the constant demand for new and more efficient forms of education.

Keywords

Information and communication technologies, business performance, manager, educating of managers.

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Introduction

Human resources and capacities are one of the organization's most important competitive advantages, and therefore their education and development should be given the appropriate attention and should be firmly placed in the corporate strategy. In this paper we will pay the most attention to the education and development of the organization's employees. We present the specific forms and methods of education used today and compare them in terms of effectiveness in relation to the performance of the organization. Performance is a concept whose presence in our everyday life is quite common regardless of a specific professional interest. In general, the more common a term we use in our language, the more natural part of our life and our expectations is. The exception, therefore, is not the demands and expectations that we have in common communication with our partners, employees and associates, and we assume that this term is both accepted and interpreted in terms of content and priority, that they are familiar with its content and understand its meaning. In general the term performance is mostly used in the connection with the main existence of the firm on the market and its success and ability to survive in future (Fulantelli and Allegra, 2003). When evaluating the success the running of the organizazion, the following three terms are mostly used:

- Performance – the term defining the general rate of the effort of an individual and links the contribution, usefullness and the used resources.
- Effectiveness – the term generally defined as the effectiveness of the sources, and means to achieve the set objectives. It is also

a value showing the rate between the incomes and outcomes, or the results of the economic activities and the costs in whole (Ongori and Migiro, 2010).

- Productivity – expresses the performance of the empolyee, organization or a machine as a unit.

The measurement of the performance process should obtain needs and expectations of the parties involved, as it can be searched in two basic levels:

- On the level of the organization as a whole.
- On the level of an individual (Veber, 2004; Erumban and Jong, 2006).

Parallel sets of indicators are very frequent analytical processes. The individual indicators forming the system are equivalent and are grouped according to the area of the company management. An example of a parallel set of indicators is a set of indicator groups reflecting the financial health of an enterprise, which consists of the following five groups (Bresnahan et al., 2002; Adeosun et al., 2009; Ongori, 2009):

- Liquidity indicators.
- Returns indicators.
- Indicators of activity.
- Debt indicators.
- Market Value Indicators.

On the way to achieving such perfection, each organization must first assess its current situation and its possibilities (Hennyeyová and Depeš, 2010), (Hennyeyová et al., 2013). It is the ability to perceive and critically assess your strengths and weaknesses as the starting point for the choice of direction and all the corresponding activities. It enables an enterprise to effectively focus attention on enhancing its strengths and eliminating or minimizing identified shortcomings. Just identifying the nature of the problem and focusing attention on change is a basic prerequisite for success (Pavic et al., 2007; Cohen and Georgilla, 2006).

The development of an information society and the constant expansion of information and communication technologies provide an opportunity to learn and acquire new digital skills and competences that have become necessary for employment, education and training, personal development and social engagement (Šilerová et al., 2015; Šimek et al., 2008). As society becomes more and more a knowledge-based society, it also changes the content of what people need to learn and know. ICT changes the way people work, learn and improve their skills. This process also affects managers of organizations and businesses. It is more than necessary to realize the importance of learning in this area, which is often overlooked. Only then will they be able to meet the requirements of their ICT skills and flexibly respond to the changes brought about by this digital era (Fink and Disterer, 2006).

Boyasitz (1982) defines IT managners' knowledge as "specialized knowledge, a useful set of facts and relevant concepts for a particular job position". Based on this definition, Bassellier et al. (2001) identified three main areas of knowledge that managers should have in order to be able to use ICT in their own benefit and at the same time for the benefit of the organization as such:

- Have the latest information and overview of current ICT activities and opportunities.
- Understand the value and potential of IT.
- Know the potential as well as the current and future IT constraints while also seeing how the competing companies use IT (Dor and Elovici, 2016).

Several authors believe that the main goal of IT managers' knowledge is to enable managers to communicate effectively with IT staff. Many authors define interconnection as a stage in which IT missions, goals and plans support business mission, goals and plans through their mutual alignment. Managers are increasingly aware of the need to constantly flexibly reflect on the current needs of organizations, and naturally expand their horizons through lifelong learning. The issue of lifelong learning is not only about managers but it is an all-society phenomenon that is also anchored in the lifelong learning strategy and lifelong guidance as a tool for forming a knowledge society (Jarolímek and Vaněk, 2003; Stočes et al., 2016; Jones et al., 2003; Šilerová, et al., 2016; Stubna et al., 2014). The most effective way to increase the level of information literacy of the managers is their continuous education. However, learning brings with it barriers that arise from both the external and the internal environment. Barriers arise in an educated subject, a sending organization, an organization providing education, but also a state with its legal regulations. Barriers in the literal sense of the word mean obstacles. We define them as factors that prevent us from doing something, in our case education. The barriers faced by managers in their education are often related to their family situation, education, employment,

and last but not least their psychological condition.

Based on a study of foreign literature, we identified the following major barriers in the training of current ICT managers:

- Lack of time to learn.
- Lack of finance.
- The enterprise does not support education.
- Low education offer.
- Low quality of education.
- One-off, non-systemic.
- Unwilling access of a trainer.
- Fear.

The list is an aggregation of projections from leading forecasters such as the , personal observations and a good dose of guesswork. According the Johnson et al. (2010), the Top 10 Global trends in ICT and education of managers are:

1. Mobile Learning. New advances in hardware and software are making mobile smart phones indispensable tools. Just as cell phones have leapfrogged fixed line technology in the telecommunications industry, it is likely that mobile devices with internet access and computing capabilities will soon overtake personal computers as the information appliance of choice in the classroom.
2. Cloud computing. Applications are increasingly moving off of the stand alone desk top computer and increasingly onto server farms accessible through the Internet. The implications of this trend for education systems are huge; they will make cheaper information appliances available which do not require the processing power or size of the PC. The challenge will be providing the ubiquitous connectivity to access information sitting in the cloud.
3. One-to-One computing. The trend in classrooms around the world is to provide an information appliance to every learner and create learning environments that assume universal access to the technology. Whether the hardware involved is one laptop per child (OLPC), or - increasingly - a net computer, smart phone, or the re-emergence of the tablet, classrooms should prepare for the universal availability of personal learning devices.
4. Ubiquitous learning. With the emergence of increasingly robust connectivity infrastructure and cheaper computers, school systems around the world are developing the ability to provide learning opportunities to students "anytime, anywhere". This trend requires a rethinking of the traditional 40-minute lesson. In addition to hardware and Internet access, it requires the availability of virtual mentors or teachers, and/or opportunities for peer to peer and self-paced, deeper learning.
5. Gaming. A recent survey by the Pew Internet and American Life Project per the Horizon Report found that massively multiplayer and other online game experience is extremely common among young people and that games offer an opportunity for increased social interaction and civic engagement among youth. The phenomenal success of games with a focus on active participation, built in incentives and interaction suggests that current educational methods are not falling short and that educational games could more effectively attract the interest and attention of learners.
6. Personalized learning. Education systems are increasingly investigating the use of technology to better understand a student's knowledge base from prior learning and to tailor teaching to both address learning gaps as well as learning styles. This focus transforms a classroom from one that teaches to the middle to one that adjusts content and pedagogy based on individual student needs – both strong and weak.
7. Redefinition of learning spaces. The ordered classroom of 30 desks in rows of 5 may quickly become a relic of the industrial age as schools around the world are re-thinking the most appropriate learning environments to foster collaborative, cross-disciplinary, students centered learning. Concepts such as greater use of light, colors, circular tables, individual spaces for students and teachers, and smaller open learning spaces for project-based learning are increasingly emphasized.
8. Teacher-generated open content. OECD school systems are increasingly empowering teachers and networks of teachers to both identify and create the learning resources that they find most effective in the classroom. Many online texts allow teachers to edit, add to, or otherwise customize material for their

own purposes, so that their students receive a tailored copy that exactly suits the style and pace of the course. These resources in many cases complement the official textbook and may, in the years to come, supplant the textbook as the primary learning source for students. Such activities often challenge traditional notions of intellectual property and copyright.

9. Smart portfolio assessment. The collection, management, sorting, and retrieving of data related to learning will help teachers to better understand learning gaps and customize content and pedagogical approaches. Also, assessment is increasingly moving toward frequent formative assessments which lend itself to real-time data and less on high-pressure exams as the mark of excellence. Tools are increasingly available to students to gather their work together in a kind of online portfolio; whenever they add a tweet, blog post, or photo to any online service, it will appear in their personal portfolio which can be both peer and teacher assessed.
10. Teacher managers/mentors. The role of the teacher in the classroom is being transformed from that of the font of knowledge to an instructional manager helping to guide students through individualized learning pathways, identifying relevant learning resources, creating collaborative learning opportunities, and providing insight and support both during formal class time and outside of the designated 40-minute instruction period. This shift is easier said than done and ultimately the success or failure of technology projects in the classroom hinge on the human factor and the willingness of a teacher to step into unchartered territory.

These trends are expected to continue and to challenge many of the delivery models fundamental to formal education as it is practiced in most countries.

Material and methods

Data collection was processed in the form of a questionnaire in 2017. The sample of respondents consists of managers of three selected agro-sector organizations of Western Slovakia in the total number of 55. Of the total number of respondents, 71% were men and 29% were women. The questionnaire was made available to a company employee on a web site. Questionnaires were distributed electronically to employees of the company in order to create feedback and to gather respondents' views on the forms of education that the company provides for their personal development. We also tried to save time by means of a questionnaire that was not required to be written but was available in electronic form. The questionnaire was based on collected information about the problem. The questionnaire consists of two parts, where the first part contains questions aimed at identifying and categorizing the respondents. The second, research part, gives respondents the opportunity to comment on the learning opportunities that are provided to them or which they themselves use. The questionnaire contains a total of 20 questions and its output is a view of the satisfaction of the employees of the company with its training program. The questionnaire uses two types of questions. The first type is a closed question with a four-level scale to measure the degree of satisfaction with a particular area of the education system. The second type is semi-closed questions that reveal the gaps in educational programs through the opinions of the respondents. We also added an open-answer option to some questions in order not to limit creativity responses. When creating a barrier list, we learned from several literary sources of domestic and foreign authors. The basic and also the starting point was the analysis of available resources dealing with this issue, especially research conducted abroad.

Several statistical methods have been used for the statistical evaluation. Verification of dependencies between the trait was carried out by use of chi-square test (χ^2), respectively. (χ^2) - square contingency. For the statistical analysis where the Chí-square test of independence could not be used, the Fisher's exact test was applied because the assumption numbers of cells in the pivot table was not followed. Fisher's exact test derives from the pivot table and verifies the null hypothesis of equality of the two units, namely the independence of two binary variables. This test is based on the assumption that all marginal frequencies (totals rows / columns) in the pivot table are fixed. This assumption is rarely met. They are mainly fixed in line frequency or in only the total frequency. If using the parametric methods was not possible because of failure in meeting the preconditions for their use, we applied nonparametric methods. Kruskal-Wallis H test is an extension of the Mann-

Whitney test for three or more samples. The aim of the test was to find out whether the differences found in the sample medians of each group (according to the level factor) are statistically significant (between variables, the relationship) or could not be random (between variables, the relationship). The null hypotheses concerning equality of all medians was tested. If the P-value is lower than the chosen significance level (0.05), the null hypothesis is rejected. This means that the difference between at least one pair of median values calculated from the sample is too large, it can only be the result of random selection. Therefore, it is statistically significant – there is the relationship between the variables. If the P-value equals to or is greater than the chosen significance level, the null hypothesis cannot be rejected. This means that the difference between each pair of medians calculated from the sample can only be the result of random selection, therefore, not statistically significant – there is not the relationship between variables. The questionnaire survey was evaluated with statistical methods for the detection of relevance and relations of the data collected to confirm or refute the hypothesis of statistical indicators. A total number of hypotheses were chosen two for this article:

Hypothesis 1: The use of ICT technology and interest of education in the area of ICT partially depends on the manager s age.

Hypothesis 2: The education in the area of ICT depends on the employee attitute and does not depend on the gender.

Results and discussion

All respondents agreed on the fact that education and staff development really affect the competitiveness of society. Almost 43% of surveyed managers consider development to be a key factor. The remaining 57% of managers are of the opinion that education and development are more likely to affect competitiveness. Up to 77% of surveyed managers are dissatisfied with the education and development opportunities provided by the employer in their company. Of this, 69% of managers are rather dissatisfied. Rather satisfied is 23% of managers. Absolutely dissatisfied with the learning opportunities provided is 8%, and no single manager is satisfied. The most common goal for managers in the field of education that is 45% is willingness to acquire new knowledge and skills. Ability to adopt new work processes is 25% of the managers asked. The same number is to overcome difficult obstacles. Only 7% of managers are satisfied with career growth opportunities and talent development in the organization. Enough support from the organization has 57% and insufficient 43% of managers. The manager lacks a number of areas of day-to-day activities, which the employer has no ambition to deal with. This may then be seen in a higher error rate when performing work tasks or a longer time frame within which managers are required to complete their work.

After quantifying the significance of individual barriers by gender, we tested the statistically significant gender impact on individual barriers. Most data were normally divided by $p > 0.05$. Statistical significance was tested using a parametric T-test. The statistically significant influence of gender was confirmed in the disability barrier, the non-systematic $p = 0.028$. The statistical significance was confirmed in the barrier of lack of quality education $p = 0.015$. After analyzing the significance of individual barriers according to the age group, we tested the statistical significance of the influence of age groups on individual barriers, at the level of significance $\alpha = 0.05$. Most data matched the normal data distribution condition $p > 0.05$. We then used the Anova method to test the normally distributed data. The statistically significant impact of the age group was confirmed by the lack of quality education $p = 0.0312$ and the lack of funding on the company side $p = 0.028$. The impact of the age group on perceptions was tested by a Kruskal-Wallis nonparametric test.

The most significant barrier that the managers consider is the lack of time to learn outside of work. The second most important barrier is the lack of time to learn alongside other activities at work. The third most significant barrier is the lack of funding for education on the part of respondents. As the least significant barrier was the fear. The vast majority of 99% managers use e-mail or computer network at work. Desktop is used by 21% of respondents, while 79% of managers use the laptop at work. The managers use videoconferencing systems especially when communicating with remote clients from abroad. Videoconferencing systems allow managers to share information with other countries in real time, without having to leave. This type of information and communication technology (ICT) is used by only 11% of managers. Out of smart mobile devices, managers use a smartphone that is used by 64% of respondents, while only 16% of respondents use the tablet. The share

of respondents who adapt and learn to control information and communication technologies is 77%. The remaining 23% were managers who learned to control information and communication technologies with difficulties. The biggest problems for managers when working with ICT is setting the specific user settings for the application, as well as switching to higher versions of applications where user interfaces do not coincide with previous versions. Up to 73% of managers have this option.

The hypothesis that the interest in ICT education depends on the age of the manager has not been confirmed. Managers declared interest in ICT education in all age categories. As a reason they said they needed to be constantly educated in ICT and their main interest were about advanced MS Excel and information systems - business modules. The hypothesis that ICT education depends on the attitude of the employee and does not depend on gender has been confirmed. ICT education has been of great interest to both men and women. Men more preferred foreign language education, English or German. Women would prefer ICT education in their native language.

Only 12% of respondents have a problem downloading and sending files, 4% searching for information and services on the Internet and using e-services. Using e-mail, using common applications and controlling their smartphone, tablet does not cause problems to any of the respondents. 44% of the respondents are trained. Their share is smaller than the proportion of managers who do not attend the training that is 56%. This has two reasons. The first is busyness and overloading of managers. In addition to their time-consuming activities and tasks at work, there is no time to further develop their skills and abilities. The second reason is the number of first-level and middle managers who often use standard office applications such as the Microsoft Office suite for their work. The management often does not feel the need to further educate their managers in ICT because they feel that the knowledge gained would not be used in their work and the company's investment in their education would not return. Up to 74% of respondents educate themselves in their free time. As a result, managers who do not have the opportunity to develop in their work are in fact interested in further development. For the reasons outlined above, however, this education and training goes beyond working hours. As a result of the previous question, up to 92% of managers said that education was done in the form of self-education (Table 1).

Barriers in the training ICT	Mean	Standard deviation
Lack of time to learn	5.02	1.12
Lack of finance	4.85	0.93
The entreprise does not support education	4.33	1.25
Low education offer	4.71	1.16
Low quality of education	3.63	1.02
One – off, non - systemic	3.56	1.41
Unwilling access of a trainer	3.31	1.30
Fear	1.56	1.10

Source: own research and processing

Table 1: The importance of barriers to male managers.

In the following paragraph on the basis of SWOT analysis the conclusion of the most important knowledge of educational system in chosen organizations will be presented. They will be divided into three groups. The group of strenghts, weaknesses, opportunities in the trainings the surveyed organizations shown in the following Tables 2, 3, 4.

Strenghts
Training of new employees
Topics of education
Low costs of the proces of education with the use of spreading knowledge and learning in action

Source: own research and processing

Table 2: SWOT strengths of trainings in the chosen organizations.

Weaknesses
Lack of trainings focused on improvement in the area of ICT
One – off, non - systemic
Absence of coaches in ICT
Too much one – sided lectures

Source: own research and processing

Table 3: SWOT weaknesses of trainings in the chosen organizations.

Opportunities
To increase the expenditures focused on the training in the area of ICT
To organize the trainings of ICT in the foreign language
Better time – planning of the trainings
Introduce a separate educational portal for managers in a particular enterprise with learning materials - elearning

Source: own research and processing

Table 4: SWOT opportunities of trainings in the chosen organizations.

For the purpose of the article, it is not necessary to analyze the factors threatening the company's education system, which should be the last part of each SWOT analysis.

Conclusion

When asked whether managers have some experience with ICT education, 88% already had ICT education. 12% of respondents did not take management training. Among the three most used areas, respondents included advanced MS excel for managers, Visual basic for application. As to the extent to which graduates of ICT education apply the acquired knowledge and skills in the performance of the work and how much the managers estimate the application of the acquired knowledge from this education in practice, respondents averaged 60%. The opinion on the most effective form of education was 51% soft skills education, 23% coaching and almost 27% mentoring. As previously mentioned in our survey it did not confirm the hypothesis that the interest in ICT education depends on the age. Our survey shows that managers of all ages need to use modern digital technologies to maintain the high efficiency and quality of their work.

Information technology has become one of the most important factors in the development of the economy. Using the IT technology helps getting quality and timely information for the success of both large and small organizations. Obtaining knowledge in the field of information and communication technologies has become a necessary condition for the success of managers in all areas of economic activity. Education is a demanding and lengthy process that lasts certain time and the personal attitudes of the trainees. These factors can not be circumvented or omitted. Therefore, it is important to highlight the value of education and possible future benefits for the person concerned. Only 17.1% of ICT training is outside the routine office space. This involves self-learning or knowledge transfer or action learning. The effectiveness of these methods is mainly time saving, but the company should consider the amount of external training where employees would come into contact with other managers from other companies and bring new ideas, suggestions and insights into society, find out how similar situations are addressed in other companies. The fact that foreign languages is an indispensable part of the everyday work of each employee is not clear why it is not done more or more systematically in this direction using some of the new educational methods. Improving the presentation, argumentative knowledge in foreign language communication can be a valuable asset. Our survey was aimed at identifying barriers in the education of ICT managers. An interesting finding is that in the last place and as the smallest barrier the respondents chose the fear of education.

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Agricultural Competitiveness of Vietnam by the RCA and the NRCA Indices, and Consistency of Competitiveness Indices

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Abstract

This study measures the static and dynamic agricultural competitiveness of Vietnam by the *RCA* and the *NRCA*. The dynamics of the trade competitiveness indicators are assessed in three ways: OLS regression, Markov matrices, and trend analysis. The paper, moreover, tests the consistency between the *RCA, NRCA,* and *RTA* indices. The results show that (i) Vietnam, generally, achieves strong competitiveness in crop and fishery sectors whilst it has weak competitiveness in livestock and processed food sectors; (ii) the country has the convergent pattern of agricultural competitiveness with the high stability of strong competitive and uncompetitive sectors; (iii) the country's agricultural export strategy and competitiveness pattern are based on the natural-resource-intensive and traditional agricultural products with a slight improvement over time; and (iv) the *RCA, NRCA*, and *RTA* indices are strongly consistent in identifying the degrees of competitiveness and determining whether a country obtains competitiveness while they are weakly consistent in ranking competitiveness.

Keywords

Vietnam, Agriculture, Competitiveness, *RCA, NRCA*, Dynamics, Consistency.

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Introduction

International trade competitiveness is the key theme in the economic literature and the crucial issue in the agricultural market and economy of Vietnam. The concept has been, especially, becoming more interesting and essential topic for managers, politicians, and scholars due to the strong process of regionalization and globalization recently. Despite its high popularity of usage and research, the international competitiveness is viewed as the most misunderstood concept in economic theory (Krugman, 1994) and the most arguing definition of what determinants, perspectives, and components are, especially at macro-levels (Martin, 2003). The conventional economics suggests that a country should take advantages of its scarce resources and specialize in producing agricultural sectors with stronger competitive advantages to produce higher values added and create better social welfare as a result. However, a country's economic development and social welfare growth can be decreased by an incorrect specialization (Lucas, 1988; Young, 1991).

In recent decades, the theoretical and empirical international trade studies have paid attention to investigating both the static and dynamic trade performances as a result of the unstable and changing economies and politics, the strong technology development, and the global economic linkages. The recent literature on economic growth and trade also explain that the international trade flow and trade specialization are dynamic and develop endogenously over time (Brasili et al., 2000). The dynamics of trade performances might commonly reflect deep structural changes in the entire economy of a country, as the resources and competitive advantages cannot change quickly despite sudden shocks, new technology, and institutional systems (Ferto and Soos, 2008).

There are several frameworks to measure the competitiveness based on five disciplines such as trade performance indices, economic indicators, determinants of competitiveness, multidimensional frameworks, and value chain performance approaches. The trade performance indices themselves, moreover, include various

indices such as the *NEI,* the *RCA*, the *RTA*, the *GLI*, the *LFI*, and the *NRCA* (Hoang et al., 2017). These indices consist of different components with different aggregations based on the revealed trade data. Though the indices may indicate different economic implications such as comparative advantage, specialization, intra-industry trade, and export competitiveness and generate different results they all present the international trade performances. Therefore, it is significant to analyze the consistency among the comparative advantage indices.

Vietnam's transiting economy has moved from centrally planned economy to market-oriented economy since the early 1990s with significant events such as becoming the member of the ASEAN and the WTO, signing the FTAs with Japan, Chile, Korea, EEU, and EU. The country has gone through a stark and important transformation with various economic, global trade, and foreign capital outcomes. The agriculture is, moreover, a key contribution to Vietnam's economy with 17.7 percent of the GDP, 17 percent of the total export, and 48 percent of total employment in 2014 (Hoang et al., 2017). It is, therefore, meaningful to comprehend both the static and dynamic agricultural competitiveness of Vietnam.

This study has the research objectives to (i) measure the static agricultural comparative advantages of Vietnam by using the *RCA* and the *NRCA* indices; (ii) assess the dynamics of the trade competitiveness indicators over time by three ways: OLS method, Markov matrix, and trend analysis; and (iii) test the consistency among these trade performance indices. The rest of the paper consists of the literature review on international trade theory and these trade performance indices; the next section describes the methods and materials used for this article; the result and discussion part will present and explain the empirical results; and the final section will conclude the research findings.

Literature review

The traditional economic theory defines the competitiveness based on the concepts of the absolute advantage of Smith and the comparative advantage of Ricardo and measures the concept by the basic production indicators such as productivity, price, and cost. Due to the unavailability of productivity, price, and cost data, scholars have developed measuring models for the empirical studies based on the revealed trade data. Balassa (1965) builds the revealed comparative advantage (*RCA*) index based on the traditional trade theory and the first empirical utilization of Liesner (1958). The *RCA* uses the export flows to compute the ratio of a country's export share of one commodity in the international market to the country's export share of all other commodities. Balassa explains that comparative advantage is revealed in relatively high shares of export markets and comparative disadvantage is revealed in relatively low shares of export markets. The shares have to be compared with others to evaluate which country or commodity is comparative advantage and disadvantage (Gorton et al., 2000). Economics scientists identify the main restrictions of the *RCA* such as: (i) the index serves as export specialization measure; (ii) the *RCA* is static and does not present the dynamics of comparative advantage over time; (iii) it does not include import data; (iv) the distribution of the *RCA* indicators is the asymmetric and non-normal; (v) its range from 0 to + ∞ has problematic matters to interpret and compare; (vi) it double counts the data of a country and a commodity; (vii) the index shows the success in exporting to the world market. The exports, however, can come from incentives and the incentives can explain competitiveness, not comparative advantage (Vollrath, 1991; Kreinin and Plummer, 1994; Dalum et al., 1998; Proudman and Redding, 2000; Hoen and Oosterhaven, 2006; Hoang et al., 2017).

Despite the criticisms and concerns over the trade-distorting effects of government interference and inability to identify the sources of comparative advantage, scholars and the authors maintain the thinking that the *RCA* index, when employed judiciously, still gives useful evidence of the comparative advantages in agricultural sectors. The *RCA* is also one of the most cited and employed indices to investigate comparative advantage in several empirical studies such as Esquivias (2017), Nath et al. (2015), Kuldilok et al. (2013), and Abidin and Loke (2008).

Alternative measures have been proposed to deal with the limitations of the *RCA*. Vollrath (1991) suggests the relative trade advantage (*RTA*) that is calculated as the difference between the relative export advantage, similar to the *RCA* index, and the relative import advantage. Dalum et al. (1998) construct the transformation of the *RCA* that is calculated by (*RCA*-1)/(*RCA*+1) and called as the revealed symmetric comparative advantage

index (*RSCA*). Proudman and Redding (2000) propose arithmetic mean of the country's *RCA* (*WRCA*) to weigh a country's *RCA* index for a particular product and establish the comparability within an individual country. Hoen and Oosterhaven (2006) explain that the limitations of the *RCA* are created by its multiplicative form and they propose an additive *RCA* (*ARCA*) index in order to make the distribution of the original index stable with respect to countries. The sum of a country's *ARCA* scores is constant and equals to zero, which makes the comparison of a country's comparative advantage in different commodities practicable. The *ARCA* index, however, does not create comparability across country as the sum of all countries' *ARCA* scores for an individual commodity is not a constant and the index is also sensitive to the size of a sector (Yu et al., 2009). Cai and Leung (2008) suggest the *RCA* variation (*RCAV*) index to provide a more general measure of the variation in comparative advantage than the simple comparison of the *RCA* over time.

According to Yu et al. (2009), these alternative *RCA* indices might improve the *RCA* index in certain aspects, but none of them successfully overcome all the shortcomings. These scholars, therefore, propose the normalized revealed comparative advantage (*NRCA*) index as an alternative and improved measure of the *RCA* index based on the probabilistic approach of Kunimoto (1977). The *NRCA* index is expressed as the normalized form of the level deviations in actual trade flows from their expected levels.

The *NRCA*, in general, has four properties eliminating the drawbacks of Balassa's index. First, it is symmetrical as its value ranges from -0.25 to 0.25 with 0 being the comparative-advantage-neutral point. Second, the sum and the mean value of a country or a commodity's *NRCA* scores are constant and equal to zero. This reflects the relative nature of comparative advantage as when a country obtains comparative advantage in a commodity, some other countries must lose comparative advantage in this commodity, and when a country obtains comparative advantage in some commodities, it must lose comparative advantage in some other commodities. Third, it is independent of the classification of the commodities and countries. In other words, the aggregation levels of data have no influence on the *NRCA* and the index is additive over country and commodity. Hence, the NRCA index is comparable across country, across commodity, and over time. Fourth, the *NRCA* captures the situation of zero export in a more reasonable way as *NRCA* score for zero export is not invariant. If two countries have zero export of a commodity, the "large" country would have more comparative disadvantage in this commodity than the "small" country; likewise, if a country has zero export in two commodities, the country would have more comparative disadvantage in the "large" commodity than in the "small" commodity (Yu et al., 2009). The *NRCA* has been employed in empirical studies to measure the cross-sector and cross-country comparative advantages over time and to compare with other trade performance indices such as Deb and Hauk (2017), Ceglowski (2017), Seleka and Kebakile (2017), Sarker and Ratnasena (2014).

Materials and methods

Balassa (1965) builds the revealed comparative advantage (*RCA*) index based on the first analysis of comparative advantage by Liesner (1958). The idea of the index is to compare the performance of a country in a commodity with the performance of a reference group of countries by using the observed export patterns or the revealed data. The RCA index can be defined as follows:

$$RCA_{ij} = \left[\frac{X_{ij}}{X_i}\right] \div \left[\frac{X_{wj}}{X_w}\right]$$

where, X_{ij} represents country i's export of product j, X_i is the total export of country i. X_{wj} is the world's export of commodity j, and X_w is the total export of the world. The value of *RCA* ranges between 0 and + ∞, and the comparative-advantage-neutral point is 1. If the *RCA* value > 1, the country has the comparative advantage in the product. If the *RCA* value < 1, the country has the comparative disadvantage in the product. The index reveals a higher comparative advantage, namely an index number of 1.1 will mean that the country's share in this commodity's exports is 10% higher than its share of the total exports. The *RCA* can be interpreted in three ways: dichotomous, ordinal and cardinal (Ferto and Hubbard, 2003). First, the *RCA* is employed to assess the existence of comparative advantage in a product, the second way is useful for ranking countries or sectors, and the third interpretation is to measure the dimension of the *RCA*. This study follows the quartile method in Hinloopen and Marrewijk (2001) to identify the degree of comparative advantage and group the *RCA*

indicators into four classes such as comparative disadvantage, weak comparative advantage, medium comparative advantage, and strong comparative advantage.

Yu et al. (2009) construct the *NRCA* index as a deviation between the expected and actual export of a country. According to these scholars, the idea of the normalized revealed comparative advantage index is to measure the degree of deviation of a specific country's actual export from its comparative-advantage-neutral level in terms of its relative scale with respect to the world export market and thus establishes its comparability across commodity and country. The country's export of commodity j at the comparative-advantage-neutral point, $\hat{X}_{ij}$, is derived from the comparative-advantage-neutral point of the RCA index:

$$RCA_{ij} = \frac{\hat{X}_{ij}}{X_i} : \frac{X_{wj}}{X_w} = 1$$

the $\hat{X}_{ij}$, thus, is characterized by $X_i X_{wj}/X_w$. The deviation of the actual export, X_{ij}, and expected one, $\hat{X}_{ij}$, can be stated as:

$$\Delta X_{ij} = X_{ij} - \hat{X}_{ij} = X_{ij} - \frac{X_i X_{wj}}{X_w}$$

after normalizing ΔX_{ij} by the world total export, X_w, the NRCA index is obtained as follows:

$$NRCA_{ij} = \frac{\Delta X_{ij}}{X_w} = \frac{X_{ij}}{X_w} - \frac{X_i X_{wj}}{X_w X_w}$$

The *NRCA* index ranges from -0.25 to 0.25, the comparative-advantage-neutral point is zero when the actual export is identical to the expected export of the country. The economic interpretations of the *NRCA* index are as follows: the *NRCA* > 0 presents the country i's actual export of commodity *j* is higher than its expected export of commodity *j*, the comparative-advantage-neutral level, thus the country has comparative advantage in the commodity. The *NRCA* < 0 indicates that the country i's actual export of commodity *j* is lower than its expected export of the commodity, thus the country has comparative disadvantage in the commodity. The higher the *NRCA* values is, the stronger the comparative advantage would be, and vice versa. Following Yu et al. (2009), this study rescales the *NRCA* values to facilitate the presentation of the results by multiplying a constant 10,000 without affecting on the result.

According to Hinloopen and Marrewijk (2001) and Hoang et al. (2017), there are at least three types of dynamics of comparative advantage (CA) indicators: (i) the stability of the distribution of the trade performance indices from one period to the next; (ii) the mobility and stability of the competitiveness values for every year of the period; and (iii) the trends of the *CA* values over the period and in the future. Following Dalum et al. (1998), the first type of the competitiveness dynamics is analyzed by using OLS method presented by Hart & Prais (1956) and first utilized by Cantwell (1989) in the context of specialization. The OLS regression of competitive advantage dynamics may be presented as follows:

$$CA_{ij}^{t2} = \alpha_i + \beta_i CA_{ij}^{t1} + \varepsilon_{ij}$$

where, the *CA* represents the agricultural comparative advantage indices, t_1 and t_2 are the initial years and the final years, j is the agricultural sector under study, α is a constant, β is a regression coefficient, and ε_j is a residual term. The *CA* value at time t_2 for the agricultural sector *j* is the dependent variable and tested against the independent variable of the *CA* value at time t_1 for the agricultural sector *j*. Dalum et al. (1998) affirm that the method is useful for comparing cross-sections or cross-countries at two points in time and there is no factor of time in the observations. In this study, it is assumed that regression is linear in parameters and the residual ε_{ij} is normal identically distributed ($\varepsilon_{ij} \sim$ n.i.d.$(0, \sigma)$).

The interpretation of the regression results is as follows. The $\beta = 1$ corresponds to the unchanged pattern of the competitiveness from t_1 to t_2. If $\beta > 1$, the country obtains comparative advantage in sectors with initial strong competitiveness and losses comparative advantage in sectors with initial weak competitiveness. On the other hand, if $0 < \beta < 1$, sectors with initial weak competitiveness gain comparative advantage, whilst sectors with initial strong competitiveness lose comparative advantage. If $\beta = 0$, there is no relation between the *CA* indicators in two periods. If $\beta < 0$, the competitiveness positions of the agricultural sectors are reversed. In other words, those *CA* indicators initially below the average value will be above the average finally, and vice versa.

According to Dalum et al. (1998) and Cantwell (1989), another feature of the regression analysis is to test whether the degree of competitiveness changes over time and $\beta > 1$ is not a necessary condition for growth in the overall specialization

pattern. It can be shown that (Hart, 1976):

$$\frac{\sigma_i^{t2}}{\sigma_i^{t1}} = \frac{|\beta_i|}{|R_i|}$$

where, R is the correlation coefficient from the regression model and σ is the standard deviation of the dependent variable. The dispersion of a given distribution is unchanged when $\beta = R$. If $\beta > R$ (equivalent to the increase in the dispersion), then the degree of the specialization rises. If $\beta < R$ (equivalent to the decrease in the dispersion), then the degree of specialization falls.

The asymmetric problem, however, violates the assumption of normality of the error term in the regression analysis, which makes the t-statistics unreliable. The values of the *NRCA* indicators are in (-0.25, 0, +0.25), thus it eliminates the asymmetric problem. However, the values of the *RCA* indicators are in (0, +∞), the distribution thus violates the assumption of normality of the error term in the regression analysis. Additionally, using the *RCA* indicator in regression analysis gives much more weight to values above one, as compared to observations below one. To deal with the asymmetric problem, Dalum et al. (1998) transform the *RCA* index into the revealed symmetric comparative advantage index (*RSCA*) with the same economic implications as follows:

$$RSCA = \frac{RCA - 1}{RCA + 1}$$

The *RSCA* value ranges from -1 to + 1. The *RSCA* index translates the values from the intervals of *RCA* index (0, 1]; [1, +∞) into (-1, 0]; [0, +1). The main advantage of this index is that it makes below the unity the same weight as changes above the unity.

The second type of stability of the *CA* values is assessed in two ways. First, following the empirical method utilized first by Proudman and Redding (2000), this paper employs one-step Markov chains to analyze the probability of transition among four classes categorized by quartile method in term of its moving from an initial class to other classes in one-step of moving (moving within two adjacent years) and the persistence of stability in the initial class. Secondly, the mobility degree of the *CA* values is analyzed by the mobility index. The index identifies the degree of mobility throughout the entire distribution of the *CA* values and facilitates direct cross-sections comparisons over the full period. The *M* index, following Shorrocks (1978), assesses the trace of the transition probability matrix. This *M* index, thus, directly captures the relative and medium magnitude of diagonal and off-diagonal terms, and the equation of *M* index can be shown as follows:

$$M = \frac{n - tr(P)}{n - 1}$$

where, *M* is Shorrocks index, n is the number of classes, *P* is the transition probability matrix, and *tr(P)* is the trace of *P*. The higher values of *M* index indicate greater mobility while the lower values of M index show lower mobility of the *CA* value among the classes of comparative advantages. The zero value of *M* index means the perfect immobility.

The research, finally, employs the trend analysis to examine and predict the *CA* trend of a particular agricultural sector over the period and in the future. This tool identifies the *CA* gaining, losing, or maintaining trends in an agricultural sector based on comparing the changes of the *CA* values over time. The time trend model can be presented as follows:

$$CA_{ij}^t = \alpha_{ij} + \beta_{ij} t + \varepsilon_{ij}^t$$

where, α_{ij} is a constant; β_{ij} is the regression coefficient showing the *CA* trend; t is the time index; and ε^t_{ij} is a residual term. Vietnam's *CA* in agricultural sector j can be considered stable if the estimated β_{ij} is close to zero (with the significance level of 10 percent). The value of $\beta_{ij} > 0$ indicates a trend in gaining the competitive advantage while the value of $\beta_{ij} < 0$ means a trend in losing the competitive advantage.

The data for this study is obtained from the United Nations Comtrade based on Revision 3 of the Standard International Trade (SITC Rev. 3). The paper follows the definitions of the WTO and the EU for the "agricultural commodities" to cover the codes of "section 0, 1, division 21, 22, group 231, division 24, group 261, 263, 264, 265, 268, division 29, and section 4" in the SITC Rev. 3. This paper calculates the comparative advantages at 3-digit with 61 agricultural commodity groups over the period 1997 – 2014. The study considers the concept "agricultural commodity group" as the "agricultural sector" to ease and clear the writing and interpretations. The authors use the code of commodity for the writing and interpretations with the full commodity description in Table 1.

Result and discussion

Measuring the comparative advantage by the *RCA* and the *NRCA*

Table 1 presents the agricultural comparative advantages of Vietnam by the *RCA* and the *NRCA*. The results show that, in 2014, Vietnam obtains the strongest *RCA* in 246 with the *RCA* value of 18.41 whilst it obtains the strongest *NRCA* in 071 with the *NRCA* value of 1.76. The next top strong *RCA* sectors are 075, 042, 231, 071, 036, and 037 with the *RCA* values of 17.57, 14.00, 12.52, 11.31, 9.54, and 8.92, respectively whilst those by the *NRCA* are 042, 036, 034, 037, 057, and 231 with the *NRCA* values of 1.48, 1.45, 1.18, 0.96, 0.94, and 0.83, respectively. There is a relative difference in the top competitiveness positions of the agricultural sectors between the *RCA* and the *NRCA*. These indices also differently indicate the weakest comparative advantage sectors. The country has the weakest *RCA* in 244, 212, 043, 268, and 023 while it has the weakest *NRCA* in 222, 012, 112, 041, and 011. Though the top competitiveness positions are different between the RCA and the NRCA, these sectors still stay in the top strong competitiveness groups. The positions of the next strong competitiveness sectors are different between the indices.

The degree of agricultural competitiveness will be measured by the classification of the *RCA* and *NRCA* values into four classes by quartile method (Table 4). By the *RCA*, Vietnam has four strong competitive agricultural sectors, four medium competitive agricultural sectors, and 11 weak competitive agricultural sectors. Vietnam achieves the competitiveness in 19 agricultural sectors in 2014, while it has the competitiveness in 22 sectors in 1997 and 23 sectors in the average of the period. There are relative variations between the *RCA* values in 2014 and in 1997. This indicates the change of the *RCA* values over time. By the NRCA, Vietnam has nine strong competitive sectors, two medium competitive sectors, and eight weak competitive sectors in 2014. Vietnam also gains the comparative advantage in 19 agricultural sectors in 2014, while it has the competitiveness in 22 sectors in 1997 and 22 sectors in the average of the period. The difference between the NRCA values in 2014 and in 1997 indicates the change of the *NRCA* values over time. There are, generally, variations between the *RCA* and the *NRCA* in positioning the competitiveness rankings of the agricultural sectors while they are identical to determine whether an agricultural sector is competitive. This is proved by the similar numbers of competitive sectors by the *RCA* index and the *NRCA* index both in 1997 (with 22 sectors) and in 2014 (with 19 sectors).

In overall, by both the *RCA* and the *NRCA*, Vietnam achieves strong comparative advantages in the crop sectors such as spices, rice, coffee, tea, fruit and nut, and vegetables; and the fishery sectors such as crustaceans and fish whilst the country has weak comparative advantages in the livestock sectors such as live animal, meat, and eggs and birds; and the processed food sectors such as chocolate, cheese, butter, and other processed meat and foods. In other words, the country has agricultural export strategy and comparative advantage based on the natural-resource-intensive and traditional agricultural products. The natural-resource-intensive export strategy is important in the initial period of economic development and globalization. However, the strategy is not appropriate and effective to develop the country's economy in the medium and long terms. The dynamics of comparative advantage will be analyzed for more understanding how Vietnam's export strategy and comparative advantage pattern evolve along with its economic growth and globalization process.

Analyzing the dynamics of the agricultural comparative advantage indicators

The general pattern of the *RSCA* (*RCA*) and *NRCA* indicators by OLS method

The estimation results for the *RSCA* indicators result in the values of $0 < \beta < 1$ and values of $\beta/R < 1$ over three periods (Table 2) (the *RSCA* is in replace for the *RCA* for regression without changing economic implications). The results indicate that Vietnam, in general, has the convergent pattern in the agricultural competitiveness. In other words, the country loses the competitiveness in the initial strong competitive agricultural sectors whilst it gains the competitiveness in the initial weak competitive agricultural sectors. The values of $0 < \beta < 1$ also show the process of de-specialization in Vietnam's agricultural export competitiveness. The possible explanation for the result is that Vietnam's agricultural competitiveness pattern is based on natural resources with the primary agricultural products, thus the country's increases in the productions and exports of the strong competitive sectors will result in the utilization of higher opportunity cost resources. Therefore, the competitive advantages of these sectors decrease. On the other hand,

the resources of the new and weak competitive advantage sectors are still abundant with lower opportunity cost resources. Therefore, the competitive advantages of these sectors increase. This result is consistent with the traditional economic theory explaining that a country tends to decrease the competitive advantage in a product when it increases the specialization and exports the product to the world market.

The estimation results for the *NRCA* indicators bring in the values of $\beta > 1$ and the values $\beta/R > 1$ over three periods (Table 3). The results confirm that Vietnam has a divergent pattern in agricultural competitiveness or the country increases in the overall specialization trade pattern. In other words, Vietnam gains the increasing competitiveness in the initial strong competitive sectors whilst it loses the competitiveness in the initial weak competitive sectors. This result of the NRCA, however, seems to be contrary to those of the RSCA indicators.

The mobility and stability of the competitiveness indicators by Markov matrix

The *RCA* and the *NRCA* values are classified into four groups including the comparative disadvantage, weak comparative advantages, medium comparative advantages, and strong comparative advantages. The boundary of competitive and uncompetitive groups is remained and the *RCA* and the *NRCA* values are then divided into 3 classes of weak, medium

No.	Code	Commodity	RCA(1997)	RCA (2014)	NRCA (1997)	NRCA (2014)
1	001	Live animals	0.11	0.03	-0.03	-0.10
2	011	Bovine meat	0.00	0.00	-0.04	-0.21
3	012	Other meat, meat offal	0.66	0.10	-0.03	-0.31
4	016	Meat,ed.offl,dry,slt,smk	0.09	0.01	-0.01	-0.02
5	017	Meat,offl.prpd,prsvd,nes	0.54	0.04	-0.01	-0.09
6	022	Milk and cream	0.02	0.23	-0.04	-0.17
7	023	Butter,other fat of milk	0.00	0.00	-0.01	-0.04
8	024	Cheese and curd	0.00	0.00	-0.03	-0.15
9	025	Eggs,birds,yolks,albumin	4.06	0.14	0.02	-0.02
10	034	Fish,fresh,chilled,frozn	2.74	5.22	0.11	1.18
11	035	Fish,dried,salted,smoked	4.10	1.48	0.03	0.01
12	036	Crustaceans,molluscs etc	20.62	9.54	0.98	1.45
13	037	Fish etc.prepd,prsvd.nes	6.76	8.92	0.18	0.96
14	041	Wheat, meslin, unmilled	0.01	0.00	-0.06	-0.21
15	042	Rice	66.33	14.00	1.61	1.48
16	043	Barley, unmilled	0.00	0.00	-0.01	-0.03
17	044	Maize unmilled	0.51	0.12	-0.02	-0.13
18	045	Other cereals, unmilled	0.12	0.02	0.00	-0.02
19	046	Meal,flour of wheat,msln	0.16	1.49	-0.01	0.01
20	047	Other cereal meal,flours	0.07	0.24	0.00	-0.01
21	048	Cereal preparations	0.32	0.45	-0.03	-0.13
22	054	Vegetables	1.34	1.95	0.02	0.26
23	056	Vegtables,prpd,prsvd,nes	0.94	0.57	0.00	-0.06
24	057	Fruit,nuts excl.oil nuts	2.50	3.22	0.14	0.94
25	058	Fruit,preserved,prepared	5.64	1.03	0.09	0.00
26	059	Fruit, vegetable juices	0.06	0.30	-0.02	-0.05
27	061	Sugars,molasses,honey	0.21	0.89	-0.03	-0.02
28	062	Sugar confectionery	0.55	1.02	-0.01	0.00
29	071	Coffee,coffee substitute	17.45	11.31	0.88	1.76
30	072	Cocoa	0.00	0.04	-0.02	-0.08
31	073	Chocolate,oth.cocoa prep	0.01	0.04	-0.02	-0.12

Source: own calculation based on data of UN Comtrade (2017)

Table 1: Vietnam's agricultural trade competitiveness by the RCA and the NRCA (to be continued).

No.	Code	Commodity	RCA(1997)	RCA (2014)	NRCA (1997)	NRCA (2014)
32	074	Tea and mate	11.38	3.60	0.08	0.09
33	075	Spices	21.29	17.57	0.15	0.68
34	081	Animal feed stuff	0.08	0.71	-0.07	-0.11
35	091	Margarine and shortening	0.05	0.01	-0.01	-0.03
36	098	Edible prod.preprtns,nes	2.70	0.66	0.10	-0.12
37	111	Non-alcohol.beverage,nes	0.84	0.46	0.00	-0.05
38	112	Alcoholic beverages	0.21	0.27	-0.07	-0.26
39	121	Tobacco, unmanufactured	0.07	0.28	-0.02	-0.04
40	122	Tobacco, manufactured	0.09	0.95	-0.06	-0.01
41	211	Hides,skins(ex.furs),raw	0.67	0.08	-0.01	-0.03
42	212	Furskins, raw	0.00	0.00	0.00	-0.02
43	222	Oilseed(sft.fix veg.oil)	2.02	0.02	0.05	-0.34
44	223	Oilseed(oth.fix.veg.oil)	0.25	0.39	0.00	-0.01
45	231	Natural rubber, etc.	19.90	12.52	0.34	0.83
46	244	Cork, natural, raw; waste	0.00	0.00	0.00	0.00
47	245	Fuel wood, wood charcoal	6.53	1.31	0.01	0.00
48	246	Wood in chips, particles	4.99	18.41	0.02	0.57
49	247	Wood rough,rough squared	0.01	0.41	-0.02	-0.04
50	248	Wood, simply worked	0.19	0.79	-0.07	-0.04
51	261	Silk	6.59	0.22	0.01	0.00
52	263	Cotton	0.12	0.21	-0.02	-0.05
53	264	Jute,oth.textl.bast fibr	1.89	1.62	0.00	0.00
54	265	Vegetable textile fibres	3.97	3.98	0.00	0.02
55	268	Wool, other animal hair	0.38	0.00	-0.01	-0.03
56	291	Crude animal materls.nes	4.28	0.27	0.04	-0.03
57	292	Crude veg.materials, nes	0.69	0.28	-0.01	-0.13
58	411	Animal oils and fats	0.01	1.31	-0.01	0.01
59	421	Fixed veg.fat,oils, soft	0.08	0.44	-0.04	-0.09
60	422	Fixed veg.fat,oils,other	1.60	0.20	0.02	-0.15
61	431	Animal,veg.fats,oils,nes	0.03	0.12	-0.01	-0.05
		Max	**66.33**	**18.41**	**1.61**	**1.76**
		Average	**3.72**	**2.12**	**0.07**	**0.11**
		Competitive sectors	**22**	**19**	**22**	**19**

Source: own calculation based on data of UN Comtrade (2017)

Table 1: Vietnam's agricultural trade competitiveness by the RCA and the NRCA (continuation).

1997 - 2005			2006-2014			1997 - 2014		
β	R	β/R	β	R	β/R	β	R	β/R
0.74	0.79	0.95	0.83	0.89	0.93	0.63	0.71	0.89

Source: own calculation based on data of UN Comtrade (2017)

Table 2: The OLS estimation results for the RSCA indicators over three periods.

1997 - 2005			2006-2014			1997 - 2014		
β	R	β/R	β	R	β/R	β	R	β/R
1.05	0.91	1.15	1.36	0.92	1.48	1.34	0.81	1.67

Source: own calculation based on data of UN Comtrade (2017)

Table 3: The OLS estimation results for the NRCA indicators over three periods.

Categories	Interpretation	RCA Values	NRCA values
Class 1	Comparative disadvantage	≤ 1	≤ 0
Class 2	Weak comparative advantage	≤ 4.44	≤ 0.067
Class 3	Medium comparative advantage	≤ 12.26	≤ 0.478
Class 4	Strong comparative advantage	> 12.26	> 0.478

Source: own calculation based on data of UN Comtrade (2017)

Table 4: The classes of the RCA and the NRCA values and the interpretations.

	Obs: 1,037	Class 1	Class 2	Class 3	Class 4
M-Shorrocks	Class 1	94.89	4.82	0.15	0.15
0.19	Class 2	20	73.14	6.86	0
Average stability	Class 3	3.41	15.91	78.41	2.27
85.49	Class 4	0	0	4.49	95.51
Average mobility	Total	66.35	16.88	8.29	8.49
4.84	Long run	70.31	16.74	7.16	5.78

Source: own calculation based on data of UN Comtrade (2017)

Table 5: The M-Shorrocks and Markov transition matrix for the RCA values.

	Obs: 1,037	Class 1	Class 2	Class 3	Class 4
M-Shorrocks	Class 1	94.89	4.96	0.15	0
0.17	Class 2	20.79	73.03	6.18	0
Average stability	Class 3	1.1	12.09	80.22	6.59
87.04	Class 4	0	0	0	100
Average mobility	Total	66.35	16.88	8.2	8.58
4.32	Long run	64.1	3.73	3.87	28.39

Source: own calculation based on data of UN Comtrade (2017)

Table 6: The M-Shorrocks and Markov transition matrix for the NRCA values.

and strong comparative advantages by quartile method (Table 4). Let p_{ij} (i , j = 1, 2, 3, 4) denotes a one-step transition probability, that is the transition probability for the agricultural sectors which are in class "i" of year "t" moving to class "j" of year "t + 1".

The stability and mobility of the *RCA* indicators are investigated by using the Markov transition probability matrix and mobility index for yearly values of the *RCA* values from 1997 to 2014. The diagonal elements of the Markov matrix show the probability of remaining persistently in the initial class. The other elements of the Markov transition probability matrix provide further information on the mobility of the *RCA* values. Specifically, they show the probabilities of moving from one class to another from the year "t" to the year "$t+1$". There is a 4 x 4 matrix with 1,037 observations. The result indicates that the high probabilities of the *RCA* indicators remain in their initial class (high diagonal elements) in which the uncompetitive sectors with 94.89 percent and the strong competitive sectors with 95.51 percent maintain the highest probabilities and they are the most persistent. In other words, the sectors with initial comparative disadvantage seem to stay comparative disadvantage whilst the sectors with initial strong competitiveness maintain to be strongly competitive. The average stability in initial class is 85.49 percent whilst the average mobility to other class is 4.84 percent. There is no sector moving from class 4 backwards class 1 and class 2, and from class 2 forward class 4. The M-Shorrocks of 0.19, generally, shows a relatively low degree of mobility between the classes in Markov matrix (Table 5).

The result in Table 6 shows high stabilities in the *NRCA* indicators over time. The sectors in class 1 and class 4 obtain the highest probabilities of stabilities with 94.89 percent and 100 percent. In other words, the initial weakest competitive agricultural sectors steadily continue to stay in their group over time and the strong competitive agricultural sectors perfectly remain in their initial positions. Several sectors move from class 2

to class 1, class 3 to class 2 while there is no sector moving from class 4 backwards class 1, 2 and 3 as well as from class 1, 2 forward class 4. The average probability of stability or diagonal elements is 87.04 whilst the average value of mobility or off-diagonal elements is only 4.32 percent. The M-Shorrocks index of 0.17 confirms a low degree of mobility of the *NRCA* indicators. The total and the long run distributions in the *RCA's* matrix are relatively similar and this indicates that the Markov matrix accurately captures the underlying distribution of the *RCA* indicators. Whereas the total and the long run distributions are relatively different in the *NRCA's* matrix and that difference indicates that the shares of uncompetitive sectors increase whilst the competitive sectors decline.

The trends of the RCA and the NRCA indicators

The result of trend analysis for the *RCA* indicators during the period of 1997–2014 shows that Vietnam has the gaining trends in 19 agricultural sectors with $\beta > 0$ and the losing trends in 23 agricultural sectors with $\beta < 0$. The sectors of 246, 037, 034 265, and 411 obtain the most growing trend in comparative advantage. This suggests that Vietnam continues to obtain the stronger comparative advantage in these commodities in the future. During the same period, the sectors of 042, 036, 245, 231, and 071 incur the most decreasing trends in comparative advantage (Table 7).

The trend analysis result of the *NRCA* values over the period 1997-2014 illustrates that Vietnam obtains the gaining trends in 14 agricultural sectors with $\beta > 0$ and the losing trends in 37 agricultural sectors with $\beta < 0$. The country has the most increasing comparative advantages in the sectors of 034, 231, 071, 037, and 057. It also predicts that Vietnam might continue to obtain the stronger comparative advantage in these sectors in the future. Conversely, Vietnam has the most decreasing comparative advantages in the sectors of 222, 012, 022, 422, and 112 (Table 8). In general, Vietnam has less gaining trends than losing trends in competitiveness by both indicators.

The dynamics analysis result proves that Vietnam's agricultural export strategy and comparative advantage pattern are relatively dependent on the natural-resource-intensive and traditional agricultural products such as crop and fishery sectors over time. Though there are changes in the competitiveness rankings of the strongest competitive commodities and the convergent pattern in the agricultural competitiveness over the period 1997-2014 which may be considered as a slight improvement of the export strategy and economic growth pattern, the natural-resource-intensive and traditional products are the strongest competitive and main export agricultural sectors of the country.

Code	Commodity	β	p-value	R^2	RCA (1997)	RCA (2014)
246	Wood in chips, particles	1.240	0.000	0.88	4.99	18.41
037	Fish etc.prepd,prsvd.nes	0.396	0.000	0.64	6.76	8.92
034	Fish,fresh,chilled,frozn	0.323	0.003	0.44	2.74	5.22
265	Vegetable textile fibres	0.222	0.066	0.20	3.97	3.98
411	Animal oils and fats	0.140	0.000	0.81	0.01	1.31
046	Meal,flour of wheat,msln	0.103	0.000	0.89	0.16	1.49
062	Sugar confectionery	0.081	0.000	0.60	0.55	1.02
261	Silk	-0.346	0.000	0.66	6.59	0.22
074	Tea and mate	-0.393	0.000	0.77	11.38	3.60
071	Coffee,coffee substitute	-0.448	0.006	0.39	17.45	11.31
231	Natural rubber, etc.	-0.461	0.007	0.37	19.90	12.52
245	Fuel wood, wood charcoal	-0.498	0.063	0.20	6.53	1.31
036	Crustaceans,molluscs etc	-1.226	0.000	0.58	20.62	9.54
042	Rice	-2.468	0.000	0.85	66.33	14.00
	Gaining trend groups	**19**				
	Losing trend groups	**23**				

Source: own calculation based on data of UN Comtrade (2017)

Table 7: The top gaining and losing trends of the RCA indicators (selected).

Code	Commodity	β	p-value	R^2	RCA (1997)	RCA (2014)
034	Fish,fresh,chilled,frozn	0.082	0.000	0.91	-0.03	-0.10
231	Natural rubber,etc.	0.069	0.000	0.78	-0.04	-0.21
071	Coffee,coffee substitute	0.058	0.000	0.57	-0.03	-0.31
037	Fish etc.prepd,prsvd.nes	0.047	0.000	0.85	-0.01	-0.02
057	Fruit,nuts excl.oil nuts	0.040	0.000	0.89	-0.01	-0.09
246	Wood in chips,particles	0.033	0.000	0.80	-0.04	-0.17
075	Spices	0.023	0.000	0.63	-0.01	-0.04
098	Edible prod.preprtns,nes	-0.008	0.000	0.78	-0.01	-0.03
041	Wheat,meslin,unmilled	-0.009	0.000	0.78	0.04	-0.03
112	Alcoholic beverages	-0.009	0.000	0.91	-0.01	-0.13
422	Fixed veg.fat,oils,other	-0.010	0.000	0.87	-0.01	0.01
022	Milk and cream	-0.012	0.002	0.47	-0.04	-0.09
012	Other meat,meat offal	-0.014	0.000	0.84	0.02	-0.15
222	Oilseed(sft.fix veg.oil)	-0.022	0.000	0.90	-0.01	-0.05
	Gaining trend groups	**14**				
	Losing trend groups	**37**				

Source: own calculation based on data of UN Comtrade (2017)

Table 8: The top gaining and losing trends of the NRCA indicators (selected).

Testing the consistency between the *RCA*, the *RTA*, and the *NRCA* indices

This section uses the *RCA*, the *NRCA* indicators calculated in this paper and the *RTA* data computed in Hoang et al. (2017) to test the consistency between the comparative advantage indices of the *RCA*, the *RTA*, and the *NRCA*. The sector-ranking consistency tests for the *RCA*, *RTA*, and *NRCA* indices as cardinal, ordinal and dichotomous measures indicate the general differences and similarities of these indicators in assessing and ranking the competitiveness. The result, generally, shows in Table 9 that these indices are strongly consistent as cardinal and dichotomous measures while they are averagely consistent as ordinal measures. This means that the counting both export and import data in the RTA may not significantly impact on identifying the degrees of the agricultural competitiveness and determining whether a country obtains the competitiveness in an agricultural sector while the counting import data may relatively change the competitiveness rankings of the agricultural sectors.

As cardinal measures, the correlation coefficients of the *RCA* and the *RTA*, the *RCA* and the *NRCA*, the *RTA* and the *NRCA* are relative high with the average coefficient values of 0.96, 0.86, and 0.83, respectively. This means that the *RCA* and the *RTA* are extremely consistent and the *RCA* and the *NRCA*, the *RTA* and the *NRCA* are strongly consistent to identify and explain the degrees and structures of the agricultural competitiveness. As ordinal measures, the correlation coefficients of the *RCA* and the *RTA*, the *RTA* and the *NRCA* are relatively low while the correlation coefficient of the *RCA* and the *NRCA* is relatively high with the mean coefficient values of 0.65, 0.66, and 0.75, respectively. This means that the *RCA* and the *NRCA* are strongly consistent while the *RTA* and the *RCA*, the *RTA* and the *NRCA* are weakly consistent to rank and explain the positions and structures of the agricultural competitiveness. As dichotomous measures, the *RCA* and the *NRCA* are perfectly consistent with the matching shares of 100 percent due to the derivation of the *NRCA* from the neutral-point of the RCA. The consistencies between the *RTA* and the *RCA*, the *RTA* and the *NRCA* are relatively strong with the same matching shares of 80 percent in the average and similar matching shares in all years. In other words, the *RCA* and the *NRCA* are perfectly consistent and the *RTA* and the *RCA*, the *RTA* and the *NRCA* are strongly consistent to determine whether a country obtains the competitiveness in an agricultural sector and explain the competitiveness structures.

	Cardinal			Ordinal			Dichotomous		
	RCA	RCA	RTA	RCA	RCA	RTA	RCA	RCA	RTA
Year	RTA	NRCA	NRCA	RTA	NRCA	NRCA	RTA	NRCA	NRCA
1997	0.98	0.91	0.90	0.79	0.75	0.72	0.75	1.00	0.75
1998	0.96	0.94	0.91	0.64	0.65	0.63	0.84	1.00	0.75
1999	0.97	0.91	0.90	0.64	0.71	0.61	0.77	1.00	0.77
2000	0.98	0.78	0.79	0.64	0.79	0.70	0.77	1.00	0.77
2001	0.96	0.85	0.84	0.70	0.81	0.63	0.75	1.00	0.75
2002	0.98	0.84	0.84	0.63	0.82	0.63	0.74	1.00	0.74
2003	0.97	0.87	0.87	0.60	0.80	0.60	0.74	1.00	0.74
2004	0.94	0.88	0.84	0.62	0.74	0.63	0.80	1.00	0.80
2005	0.94	0.89	0.84	0.61	0.79	0.61	0.77	1.00	0.77
2006	0.96	0.88	0.84	0.57	0.79	0.62	0.75	1.00	0.75
2007	0.97	0.89	0.86	0.63	0.78	0.66	0.82	1.00	0.82
2008	0.96	0.91	0.88	0.67	0.75	0.68	0.89	1.00	0.89
2009	0.96	0.87	0.84	0.65	0.73	0.70	0.84	1.00	0.84
2010	0.93	0.88	0.82	0.65	0.75	0.71	0.87	1.00	0.87
2011	0.95	0.81	0.77	0.62	0.78	0.69	0.82	1.00	0.82
2012	0.94	0.81	0.76	0.63	0.72	0.68	0.82	1.00	0.82
2013	0.92	0.79	0.72	0.63	0.72	0.70	0.87	1.00	0.87
2014	0.94	0.79	0.73	0.68	0.68	0.71	0.84	1.00	0.84
Average	**0.96**	**0.86**	**0.83**	**0.65**	**0.75**	**0.66**	**0.80**	**1.00**	**0.80**

Source: own calculation based on data of UN Comtrade (2017)

Table 9: The consistency between the RCA, the NRCA, and the RTA indices.

Conclusion

The results show that, in 2014, Vietnam obtains the strongest *RCAs* in 246, 075, 042, 231, 071, 036, and 037 with the RCA values of 18.41, 17.57, 14.00, 12.52, 11.31, 9.54, and 8.92, respectively, whilst it achieves the strongest NRCAs in 071, 042, 036, 034, 037, 057, and 231 with the *NRCA* values of 1.76, 1.48, 1.45, 1.18, 0.96, 0.94, and 0.83, respectively. Vietnam, by the *RCA*, achieves the competitiveness in 19 agricultural sectors with 4 strong competitive sectors, 4 medium competitive sectors, and 11 weak competitive sectors. The country, by the *NRCA*, also gains the competitiveness in 19 agricultural sectors with 9 strong competitive sectors, 2 medium competitive sectors, and 8 weak competitive sectors. In overall, by both indices, Vietnam obtains strong comparative advantages in the crop sectors such as spices, rice, coffee, tea, fruit and nut, and vegetables; and the fishery sectors such as crustaceans and fish whilst the country has weak comparative advantages in the livestock sectors such as live animal, meat, and egg and birds; and the processed food sectors such as chocolate, cheese, butter, and other processed meat and foods. In other words, the country has agricultural export strategy and competitiveness pattern based on the natural-resource-intensive and traditional agricultural sectors.

OLS estimation for the *RSCA* indicators shows that Vietnam has the convergent pattern in the agricultural competitiveness. In other words, the country loses the competitiveness in the initial strong competitive sectors whilst it gains the competitiveness in the initial weak competitive sectors. However, OLS estimation for the *NRCA* values results in a divergent pattern in agricultural competitiveness. In other words, Vietnam gains the increasing competitiveness in the initial strong competitive sectors whilst it loses the competitiveness in the initial weak competitive sectors. Markov matrices for both the *RCA* and the *NRCA*, generally, indicate that the comparative disadvantage sectors and strong comparative advantage sectors are the most stable to remain in their initial groups, especially the strong competitive sectors by the *NRCA* perfectly stay in its class. The trend analysis reveals that Vietnam obtains the gaining trends in 19 agricultural sectors by the *RCA* and 14 agricultural sectors by the *NRCA*. The country, however, has the losing trends in 23 agricultural sectors by the *RCA* and in 37 agricultural sectors by the *NRCA*.

The dynamics analysis also proves that, in overall, Vietnam's export strategy and comparative advantage pattern are relatively dependent on the natural-resource-intensive and traditional agricultural sectors such as crop and fishery sectors over time. Though there are changes in the competitiveness rankings of the strongest competitive commodities and the convergent pattern in the agricultural competitiveness over the period 1997-2014 which may be considered as a small improvement of the export and economic growth pattern, the natural-resource-intensive and traditional products are the strongest competitive and main export agricultural sectors of the Vietnam. The natural-resource-intensive export strategy is important in the initial period of economic development and globalization but not appropriate and effective in the medium and long terms. The country, therefore, should re-structure and enhance the effective agricultural production and competitiveness patterns with focusing on the high value added, technology- and capital-intensive, and market-oriented products based on the regional and global integration process.

The consistency analysis between the *RCA*, the *NRCA*, and the *RTA* shows that these indices are strongly consistent as cardinal and dichotomous measures whilst they are averagely consistent as ordinal measures. Especially, the *RCA* and the *NRCA* are perfectly consistent as dichotomous measures due to the derivation of the *NRCA* from the neutral-point of the *RCA*. In other words, the trade performance indices are strongly consistent in identifying the degrees of the agricultural competitiveness and determining whether a country obtains the competitiveness in an agricultural sector while they are averagely consistent in ranking the competitiveness of the agricultural sectors.

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Selection of Communication Routes in Agriculture Equipment Company

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Abstract

Many publications describe problems in businesses and project management that are caused by communication. Team communication is a very complicated process full of soft aspects. One of basic problems represents a choice of an appropriate communication route kind useful for messages transmission between the team members as sources and recipients. It is a complex issue because of necessity to evaluate individual communication routes from many different perspectives. Therefore the suitable communication route of team members can be selected by a multicriterial mathematical model. Since communication can be understood as a distribution of messages, the appropriate model form can be based on the distribution model. The proposed model is derived from the three-dimensional transportation problem. The article discusses the possibility of this approach on the case study of communication modelling in the field of agriculture. Specifically, it is constructed and solved a model of communication problem for small team of agriculture equipment dealers.

Keywords

Team, communication, message, communication route, three-dimensional transportation model, agriculture equipment dealers.

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Introduction

Communication supports mutual understanding representing an important tool in leading of the company (Zulch, 2014). Results of many scientific studies confirm that high-quality communication and its effective coordination is necessary to achieve better performance (Brill et al., 2006; Hsu et al., 2012; Kerzner, 2013). Kerzner (2013) understands communication not only as a means of ensuring that the right person gets the right information at the right time but also as a cost-effective manner. In addition to a cost of communication, its scope, time, and quality, also interrelation among these three indicators are very important for effective management (Zulch, 2014; Kotzé et al., 2008).

In addition to the above mentioned communication factors, the manner of communication performing is very important. Communication between members of the team can take place directly or indirectly. According to Hoegl and Gemuenden (2001), use of indirect communication (that is the use of mediation in communication) is time-consuming and, therefore, it increases a likelihood of incorrect transmission of information. On the other hand, Melnik and Maurer (2004) investigated the impact of direct communication on effective knowledge sharing and concluded that face-to-face communication facilitates achieving a higher team working speed as it enables richer communication due to ability of transmitting multivariate signals (e.g. body language, melody, height, and voice depth, etc.).

Lingard et al. (2006) paid attention to lack of knowledge of the relationship between specific communication practices and possibility to improve collaborative working practices. The authors surveyed a three-member team and, subsequently, found that changing communication patterns influences the team's attention and behaviour. Unfortunately, current publications do not provide either detailed description of applicable methods of operation research or critical evaluation of reasons why a particular application of various methods was successful or unsuccessful (Hämäläinen et al., 2013). Zionts (1979) solved a problem of quantifying communication by multiple-criteria decision-making taking into account cost and quality as the main criteria.

However, multi-criteria decision-making methods do not provide any optimal solution but only a kind of compromise between a set of criteria (Bolat et al., 2014). The model of system dynamics used by Saleh et al. (2010) and Hämäläinen et al. (2013) examined behavioural effects associated with group interaction and communication, changes in the target behaviour, and changes of interest. Kennedy et al. (2011) and Katz and Allen (1982) used empirical methods that highlighted the importance of communication in work performance. Later, Kennedy et al. (2017) applied a linear optimization model of a communication process between members of two teams.

The purpose of this study is to propose an appropriate operational research model of team communication and help to achieve better understanding communication within a team. This model structure is based on the three-dimensional transportation problem and the Kennedy model (Kennedy et al., 2017). They used linear programming, examined selection of optimal communication ways between two teams across different communication routes, and other conditions. Their model contains capacity equations limiting the messages communicated from and to the team members across different communication routes. Further, there are also the flow constraints representing messages demands over the specific communication routes and, concurrently, non-negativity constraints. The model also includes the objective functions minimizing time, cost, and negative quality function, and aggregation of these objective functions.

This article is divided into the three following sections:

- Materials and Methods describing assumptions used building the communication model; specifically, it is a description of the two and three-dimensional transportation problems; further, the communication problem of agriculture equipment dealers and its model are described;
- Results and Discussion analysing results generated by the model of the optimal communication structure according to specified conditions;
- Conclusion offering a summary of the findings, and comparison of suggested model with the Kennedy model (Kennedy et al., 2017).

Materials and methods

Transportation problems

The applications from the field of the linear optimization model dealing with transportation of products from several sources (or suppliers) to several destinations (or receivers) by the same cost of transport are commonly called the transportation problem. This model can be used for representing more general assignment and scheduling problems as well as transportation and distribution problems (Dantzig, 1955; Šubrt, 1999). Two common objectives of these problems represent either (i) minimizing transportation costs of shipping the goods from m sources to n destinations or (ii) maximizing the profit for shipping the goods from m sources to n destinations. Let suppliers offer non-zero amounts a_i, $i = 1,\ldots, m$ and the receivers require amounts b_j, $j = 1,\ldots, n$, respectively. The problem is balanced when the overall supply is equal to overall demand. Each route from each supplier to each receiver is evaluated with a cost coefficient c_{ij}, $i = 1,\ldots m$, $j = 1,.., n$. The simple transportation model is formulated as (1):

$$min \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

subject to

$$\begin{aligned} &\sum_{j=1}^{n} x_{ij} = a_i, \qquad i = 1, \ldots, m \\ &\sum_{i=1}^{m} x_{ij} = b_j, \qquad j = 1, \ldots, n \\ &x_{ij} \geq 0, \qquad i = 1, \ldots, m, j = 1, \ldots, n \end{aligned} \tag{1}$$

where the decision variables x_{ij} represent the amounts to be transported from source locations i to target destinations j. The solution for simple transportation problem exists if the problem is balanced, if the total demand is equal to the total source capacity.

Three-dimensional transportation model

The aim of the three-dimensional transportation model (3DTM) is to find an optimal transportation plan between sets of sources and destinations using different types of transport. Let the suppliers offer non-zero amounts a_i, $i = 1,\ldots, m$ and, concurrently, the target locations demand amounts b_j, $j = 1,\ldots, n$, respectively, and w_k, $k = 1, 2,\ldots, p$ are the capacities of a different type of transport. The problem is balanced if the overall supply equals overall demand. Each route from any supplier to any target

location is evaluated with the cost coefficient c_{ijk}, $i = 1,\ldots m$, $j = 1,..,\ n$, $k = 1,\ldots,\ p$. The three-dimensional transportation model can be formulated in two forms, the planar formulation corresponds to the formulation of simple transportation model, see (2):

$$min \sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{k=1}^{p} c_{ijk}x_{ijk}$$

subject to

$$\begin{aligned}
&\sum_{j=1}^{n}\sum_{k=1}^{p} x_{ijk} = a_i, \qquad i = 1,\ldots,m \\
&\sum_{i=1}^{m}\sum_{k=1}^{p} x_{ijk} = b_j, \qquad j = 1,\ldots,n \\
&\sum_{i=1}^{m}\sum_{j=1}^{n} x_{ijk} = w_k, \qquad k = 1,2,\ldots,p \\
&x_{ijk} \geq 0, \qquad i = 1,\ldots,m, j = 1,\ldots,n, k = 1,2,\ldots,p
\end{aligned} \tag{2}$$

where the decision variables x_{ijk} represent the amounts to be transported from source locations i to target destinations j using k type of transport.

The three-dimensional transportation model can be also formulated in axial form (3):

$$min \sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{k=1}^{p} c_{ijk}x_{ijk}$$

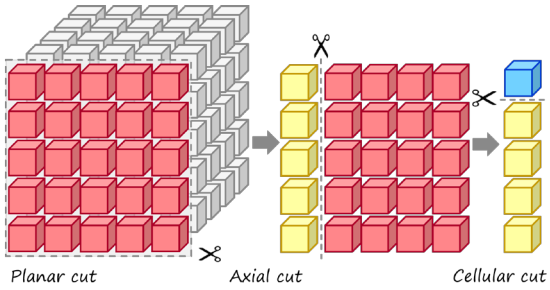
subject to

$$\begin{aligned}
&\sum_{k=1}^{p} x_{ijk} = a_{ij}, \qquad i = 1,2,\ldots,m, j = 1,2,\ldots,n \\
&\sum_{i=1}^{m} x_{ijk} = b_{jk}, \qquad j = 1,2,\ldots,n, k = 1,2,\ldots,p \\
&\sum_{j=1}^{n} x_{ijk} = w_{ik}, \qquad i = 1,2,\ldots,m, k = 1,2,\ldots,p \\
&x_{ijk} \geq 0, \qquad i = 1,\ldots,m, j = 1,\ldots,n, k = 1,2,\ldots,p
\end{aligned} \tag{3}$$

where the decision variables x_{ijk} represent the amounts to be transported from source locations i to target destinations j using k type of transport, transported amounts from source i to destination j by all types of transport a_{ij}, $i = 1,\ldots, m$, $j = 1,\ldots, n$, transported amounts from all sources to destination j by k-th type of transport b_{jk}, $j = 1,\ldots, n$, $k = 1, 2,\ldots, p$, and transported amounts from source i to all destinations by k-th type of transport w_{ik}, $i = 1,\ldots, m$, $k = 1, 2,\ldots, p$. Each route from any supplier to any target location is evaluated with the cost coefficient c_{ijk}, $i = 1,\ldots m$, $j = 1,..,\ n$, $k = 1,\ldots, p$.

Although the conditions of existence of solutions for the planar formulation of the problem are natural, in the case of axial formulation the situation is more complex. The conditions for the existence of solutions of this formulation were described, for example, by Morávek and Vlach (1967) or Vlach (1986).

The variables x_{ijk}, $i = 1,\ldots m$, $j = 1,..,\ n$, $k = 1,\ldots, p$ of the 3DTM create a communication three-dimensional cube in contrast with a simple transport problem where variables x_{ij}, $i = 1,\ldots\ m$, $j = 1,..,\ n$ form a two-dimensional matrix. The view of the three-dimensional cube is possible in three ways – by planes, columns, and cells (Figure 1). The first formulation of 3DTM (2) is called the planar formulation because the solution cube is seen as a set of planar cuts. The planar cut means a cut fixing one coordinate. The planar formulation defines the capacity of sources or transport types or demands. Similarly, it is possible to define the axial formulation of 3DTM (3) as an axial cut, which means fixing two coordinates. This is much more restrictive model formulation form because more precise information on problem solution is needed. The cellular cuts represent the smallest dimensionless element – one value in solution cube; it is a cut fixing three coordinates. Cellular formulation of model is unreasonable because it actually represents the only solution of the whole problem.



Source: own processing (inspired by Urbanek, 2014)

Figure 1: Planar, axial and cellular cuts.

Results and discussion

Model of team communication routes

The problem of team usage of communication routes for messages distribution represents issues of selection of communication routes of a message transfer from and to team members. These communication routes are selected from a set

of communication routes according to three specific criteria – time, cost and quality of message transfer.

The problem of finding the best structure of team communication is not focused on the content of messages. Because it is not important what specific message is passed, we will continue to consider the reports are homogeneous.

Since we find the basic structure of communication and we assume the average amount of transmitted messages, we assume that messages can be divided and their parts can be transmitted through various communication routes. For this reason, we do not require integer solution.

Furthermore, we assume that each member of the team at the same time acts both as a sender and as a recipient of messages. Therefore, the number of senders and recipients is the same.

Since we start from the average number of messages sent and received by individual members of the team, we do not consider the loss of messages or unwillingness to communicate, we assume that the total number of messages sent and the total number of messages received are equal.

The proposed model serves for selection of the best communication routes based on their evaluation and consequently for identification how many communication units will be transmitted between team members via selected communication routes.

We consider a group T consisting of team members $T = (T_1, T_2, ..., T_n)$ having number of the messages $(s_1, s_2, ..., s_n)$ to be sent to the team members and number of the messages $(r_1, r_2, ..., r_n)$ to be received from other team members. The communication volume will be measured as a number of messages containing exclusive data, information, tasks, and knowledge necessary for work performing.

A suitable mathematical formulation of this problem can be derived from the three-dimensional transportation model (3DTM). The communication problem will consist of the senders (the first dimension, sources) and the recipients (the second dimension, destinations) of messages, and the communication routes (the third dimension, types of transport).

The model of the team communication routes works with three indexed variables determining the amount of the messages communicated between the sender and the recipient via the route. The transferred number of the messages from the sender (T_i) to the recipient (Tj) via the selected communication route (W_k) is denoted as x_{ijk}.

The initial data are the total number of the messages $(s_1, s_2, ..., s_n)$ to be sent by senders and the total number of the messages $(r_1, r_2, ..., r_n)$ received by recipients. In addition, we consider a set W of communication routes $W = (W_1, W_2, ..., W_p)$ with maximal or minimal flows $(w_1, w_2, ..., w_p)$ where p denotes the number of the communication routes available for communication within the team (Table 1).

At the same time, the expected average week amount of the messages m_{ij}, $i = 1,...n$, $j = 1,.., n$ the team members passing on is known in advance (Table 2). Very often, some of the amount of the messages o_{jk}, $j = 1,..., n$, $k = 1,..., p$ being sent from all senders to specific recipient via specific communication route or the amount of the messages q_{ik}, $i = 1,..., n$, $k = 1,..., p$ being sent from specific sender to all recipient via specific communication route are required.

T_1	s_1
T_2	s_2
…	…
T_n	s_n

T_1	T_2	…	T_n
r_1	r_2	...	r_n

W_1	w_1
…	...
W_p	w_p

Source: own processing

Table 1: Planar input data tables.

	T_1	T_2	…	T_n	
T_1	0	m_{12}	…	m_{1n}	s_1
T_2	m_{21}	0	…	m_{2n}	s_2
…	...	...	…	...	...
T_n	m_{n1}	m_{n2}	…	0	s_n
	r_1	r_2	…	r_n	

	T_1	T_2	…	T_n	
W_1	o_{11}	o_{21}	…	o_{n1}	w_1
…	...	...	…	...	...
W_p	o_{1p}	o_{2p}	…	o_{np}	w_p

	W_1	…	W_p
T_1	q_{11}	...	q_{1p}
T_2	q_{21}	...	q_{2p}
…	...	...	...
T_n	q_{n1}	...	q_{np}
	w_1	...	w_p

Source: own processing

Table 2: Axial input data tables.

Similarly, in some cases, the amount of the messages v_{ijk}, $i = 1,\ldots n$, $j = 1,\ldots, n$, $k = 1,\ldots, p$ for specific sender, receiver, and route are also required (Table 3).

Description of the conditions of planar, axial, and cellular cuts

We can formulate three basic types of constraints that represent naturally existing conditions of communication.

Planar conditions

The first type of these constraints corresponds to the limitations based on 3DTM planar cuts (2). The first group of planar conditions are the flow constraints representing the expected average weekly amount of the sent messages (4).

$$\sum_{j=1}^{n}\sum_{k=1}^{p} x_{ijk} = s_i, i = 1, \ldots, n \quad (4)$$

The second group of planar conditions are also the flow constraints derived from the expected amount of the received messages (5).

$$\sum_{i=1}^{n}\sum_{k=1}^{p} x_{ijk} = r_j, j = 1, \ldots, n \quad (5)$$

The third group of planar conditions represents the required minimal amount of the messages transmitted by the communications routes. The requirement for minimum use of individual communication routes is given by these conditions (6).

$$\sum_{i=1}^{n}\sum_{j=1}^{n} x_{ijk} \geq w_k, k = 1, \ldots, p \quad (6)$$

Axial conditions

The second type of the constraints in the communication model are based on the 3DTM axial cuts (3). The first of these limitations is the flow constraint representing communication between the sender and the recipient of the message across all the communication routes. If the solution fulfils these constraints (7), the previous constraints (4) and (5) are also satisfied and need not be used.

$$\sum_{k=1}^{p} x_{ijk} = m_{ij}, i = 1, \ldots, n, j = 1, \ldots, n \quad (7)$$

When regular meetings are held in the company, the axial conditions can also describe these requirement conditions. The meetings mean communication face to face through which one of the team members sends the messages to the other team members (8) and, vice versa, through which one of the team members receives the messages from the other team members (9). Generally, such constraints have the following form:

$$\sum_{i=1}^{n} x_{ijk} \geq o_{jk}, \quad j = 1, 2, \ldots, n, k = 1, 2, \ldots, p \quad (8)$$

$$\sum_{j=1}^{n} x_{ijk} \geq q_{ik}, \quad i = 1, 2, \ldots, n, k = 1, 2, \ldots, p \quad (9)$$

Cellular conditions

The last type of constraints in the communication model contains the limitations based on the 3DTM cellular cuts. These are the conditions for communication between two specific team members through a specific communication route (10). General form of such constraints is

$$x_{ijk} \geq v_{ijk}, i = 1, 2, \ldots, n, j = 1, 2, \ldots, n, k = 1, 2, \ldots, p \quad (10)$$

These constraints (8, 9, and 10) may not be stated for all elements of problem.

At the same time, there is a prerequisite for this team member not to communicate with himself (11).

$$x_{iik} = 0, i = 1, \ldots n, k = 1, \ldots, p \quad (11)$$

For the variables, the non-negative condition has to be met (12).

$$x_{ijk} \geq 0 \quad (12)$$

Objective functions

Finally, the communication time, communication cost and quality of communication via different

W_1	T_1	T_2	…	T_n
T_1	0	v_{121}	…	v_{1n1}
T_2	v_{211}	0	…	v_{2n1}
…	…	…	…	…
T_n	v_{n11}	v_{n21}	…	0

…

…

…

…

W_p	T_1	T_2	…	T_n
	0	v_{12p}	…	v_{1np}
	v_{21p}	0	…	v_{2np}
	…	…	…	…
	v_{n1p}	v_{n2p}	…	0

Source: own processing

Table 3: Cellular input data tables.

communication routes of the transmitted message from the sender (T_i) to the recipient (T_j) via the selected communication route (W_k) are denoted as x^c_{ijk}, x^t_{ijk}, x^q_{ijk}. The three objective functions (13) represent a linear combination of the variables and their costs coefficients. This functions are of a minimizing or a maximizing character and can be formulated as follows:

$$\begin{aligned} &min \sum_{i}^{n}\sum_{j}^{n}\sum_{k}^{p} c^c_{ijk}x_{ijk} \\ &min \sum_{i}^{n}\sum_{j}^{n}\sum_{k}^{p} c^t_{ijk}x_{ijk} \\ &max \sum_{i}^{n}\sum_{j}^{n}\sum_{k}^{p} c^q_{ijk}x_{ijk} \end{aligned} \qquad (13)$$

Selection of the best communication routes for agriculture equipment dealers

This case study was based on data from one small Czech company selling agricultural equipment. The core team of this company consists of the owner (O), economist (EC), and two dealers (1D, 2D). Since the company staff has suffered from communication problems and lack of the information transfer, the company owner needs to set some rules of the corporate communication. These rules should provide sufficient information flow to the company members at minimum cost. The problem formulation is based on the information obtained within the frame of consultation with the owner of the company. The company owner assumes that realizing regular meetings, maybe once a week, would be appropriate. In addition, the owner prefers electronic communication (via e-mail) since it allows the recording of transferred messages. The company uses telephone (P), e-mail (E), and face-to-face (F2F) communication routes. The owner of the company estimates the amount of the messages probably transmitted within the company in the period of one week (Table 4).

Planar conditions

Within the company communication, the usual amount of messages must be transmitted. The volume of messages that each team member must pass on is in the column s in Table 4 and, similarly, the volume of messages that each team member must receive is in the row r in Table 4. The last group of planar conditions represents usage of each communication route at least in the range of 15 messages (Table 5).

	O	EC	1D	2D	
owner (O)		20	15	15	50
economist (EC)	20		5	5	30
1st dealer (1D)	10	5		7	22
2nd dealer (2D)	10	5	7		22
	40	30	27	27	

Source: own processing

Table 4: Planar input data for communication problem of agriculture equipment dealers (only non-zero values).

Axial conditions

The communication between the sender and recipient across all the communication routes must correspond to the values in Table 5. Within the meetings, i.e. face-to-face communication routes, the company owner transmits at least 20 communication messages. The last condition is similar however at least the same number of messages must be received.

Cellular conditions

The cellular conditions ensure the owner communication with each member of the team during one meeting. There must be at least three messages from the owner and to the owner (Table 6).

	O	EC	1D	2D
owner (O)		3	3	3
economist (EC)	3			
1st dealer (1D)	3			
2nd dealer (2D)	3			

Source: own processing

Table 6: Cellular input data for communication problem of agriculture equipment dealers (only non-zero values).

	O	EC	1D	2D	
F2F	20				15
P					15
E					15

	F2F	P	E
owner (O)	20		
economist (EC)			
1st dealer (1D)			
2nd dealer (2D)			
	15	15	15

Source: own processing

Table 5: Axial input data for communication problem of agriculture equipment dealers (only non-zero values).

Objective functions

The owner would like to find a solution of the problem in terms of three criteria: time, cost, and quality. All the criteria are equally important to him. The individual communication routes were evaluated using Saaty's pairwise comparison method. The values for the individual objective functions are shown in Table 7.

Since all the criteria have to be assumed for decision making, we need to use some multiple criteria approach. In this case study we calculated so-called partial optimal solutions, i.e. consecutively three optimal solutions of the model with a single criterion. After that, the final compromise solution was obtained as the linear aggregation (LA) of the partial optimal solutions x^t_{ijk} (minimization of time - T), x^c_{ijk} (minimization of the cost - C), and x^q_{ijk} (maximization of quality - Q). The compromise solution x_{ijk} is calculated using the following formula (14).

$$x_{ijk} = \frac{x^c_{ijk} + x^t_{ijk} + x^q_{ijk}}{3}, i = 1, \dots n, j = i, k = 1, \dots, p \quad (14)$$

Results

Using the above-mentioned three-dimensional transportation model with supposed three objective functions, three partial optimal solutions were found (in the following tables in columns T, C, Q) and compromise solution was calculated (column LA).

The recommended use of the face-to-face communication route is shown in Table 8. This is the second most used communication route. The face-to-face communication results correspond to the requirement of using the face-to-face communication based mainly on meetings held together with the company's owner. At these meetings, it is anticipated that each employee reports messages to the owner and, at the same time, the owner reports messages to other team members. For this reason, the owner is the most burdened by the messages. Except the meetings, there is no face-to-face communication because the team members stay in different workplace locations. The total number of weekly messages passing through this route is 40.

Using the communication route via a phone is shown in Table 9. This is the least used communication route through which 33 weekly messages are distributed. Infrequent use of this communication route may be a result of the unique use of the phone when the team members decide to prefer quality and cost criteria of communication and choose the e-mail communication instead.

The zero values below the main diagonal at some

Time (T) - min	F2F				P				E			
	O	EC	1D	2D	O	EC	1D	2D	O	EC	1D	2D
owner (O)		0.51	0.51	0.51		0.10	0.10	0.10		0.39	0.39	0.39
economist (EC)	0.51		0.51	0.51	0.10		0.10	0.10	0.39		0.39	0.39
1st dealer (1D)	0.51	0.51		0.51	0.10	0.10		0.10	0.39	0.39		0.39
2nd dealer (2D)	0.51	0.51	0.51		0.10	0.10	0.10		0.39	0.39	0.39	

Cost (C) - min	F2F				P				E			
	O	EC	1D	2D	O	EC	1D	2D	O	EC	1D	2D
owner (O)		0.73	0.73	0.73		0.19	0.19	0.19		0.08	0.08	0.08
economist (EC)	0.73		0.73	0.73	0.19		0.19	0.19	0.08		0.08	0.08
1st dealer (1D)	0.73	0.73		0.73	0.19	0.19		0.19	0.08	0.08		0.08
2nd dealer (2D)	0.73	0.73	0.73		0.19	0.19	0.19		0.08	0.08	0.08	

Quality (Q) - max	F2F				P				E			
	O	EC	1D	2D	O	EC	1D	2D	O	EC	1D	2D
owner (O)		0.29	0.29	0.29		0.05	0.05	0.05		0.66	0.66	0.66
economist (EC)	0.29		0.29	0.29	0.05		0.05	0.05	0.66		0.66	0.66
1st dealer (1D)	0.29	0.29		0.29	0.05	0.05		0.05	0.66	0.66		0.66
2nd dealer (2D)	0.29	0.29	0.29		0.05	0.05	0.05		0.66	0.66	0.66	

Source: own processing

Table 7: Objective functions coefficients – evaluation of communication routes (only non-zero values).

F2F	owner (O)				economist (EC)				1st dealer (1D)				2nd dealer (2D)				T	C	Q	LA
	T	C	Q	**LA**	T	C	Q	**LA**	T	C	Q	**LA**	T	C	Q	**LA**				
O	0	0	0	**0**	3	3	10	**5.33**	14	3	7	**8**	3	14	3	**6.67**	20	20	20	**20**
EC	3	3	14	**6.67**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	3	3	14	**6.67**
1D	7	7	3	**5.67**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	7	7	3	**5.67**
2D	10	10	3	**7.67**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	10	10	3	**7.67**
	20	20	20	**20**	3	3	10	**5.33**	14	3	7	**8**	3	14	3	**6.67**	40	40	40	**40**

Source: own processing

Table 8: Recommended use of face-to-face communication route.

F2F	owner (O)				economist (EC)				1st dealer (1D)				2nd dealer (2D)				T	C	Q	LA
	T	C	Q	**LA**	T	C	Q	**LA**	T	C	Q	**LA**	T	C	Q	**LA**				
O	0	0	0	**0**	17	0	10	**9**	1	0	0	**0.33**	12	0	0	**4**	30	0	10	**13.33**
EC	17	0	0	**5.67**	0	0	0	**0**	5	3	0	**2.67**	2	0	0	**0.67**	24	3	0	**9**
1D	3	0	0	**1**	0	0	0	**0**	0	0	0	**0**	7	7	0	**4.67**	10	7	0	**5.67**
2D	0	0	0	**0**	5	5	5	**5**	0	0	0	**0**	0	0	0	**0**	5	5	5	**5**
	20	0	0	**6.67**	22	5	15	**14**	6	3	0	**3**	21	7	0	**9.33**	69	15	15	**33**

Source: own processing

Table 9: Recommended use of telephone communication route.

F2F	owner (O)				economist (EC)				1st dealer (1D)				2nd dealer (2D)				T	C	Q	LA
	T	C	Q	**LA**	T	C	Q	**LA**	T	C	Q	**LA**	T	C	Q	**LA**				
O	0	0	0	**0**	0	17	0	**5.67**	0	12	8	**6.67**	0	1	12	**4.33**	0	30	20	**16.67**
EC	0	17	6	**7.67**	0	0	0	**0**	0	2	5	**2.33**	3	5	5	**4.33**	3	24	16	**14.33**
1D	0	3	7	**3.33**	5	5	5	**5**	0	0	0	**0**	0	0	7	**2.33**	5	8	19	**10.67**
2D	0	0	7	**2.33**	0	0	0	**0**	7	7	7	**7**	0	0	0	**0**	7	7	14	**9.33**
	0	20	20	**13.33**	5	22	5	**10.67**	7	21	20	**16**	3	6	24	**11**	15	69	69	**51**

Source: own processing

Table 10: Recommended use of e-mail communication route.

team members do not necessarily mean they do not use this communication route. This means they do not send messages in this direction (they are not initiators of communication) but they can receive messages – see the values above the main diagonal.

The description of the e-mail communication is shown in Table 10. This is the most used communication route as requested by the company owner. This communication route is used for the transmission of 51 weekly messages.

The results of the model show that all team members do not use all types of communication routes but it does not mean they do not use any communication route as the sender or recipient of the message. So, it does not occur the team members would not communicate at all.

Based on the above mentioned results (Table 8, Table 9, and Table 10), the company should use 41 % e-mail communication route, 32 % face-to-face communication route, and 27 % telephone communication route.

Discussion

Communication problems in the selected company confirm the opinion of Zulch (2014) which refers the communication as an important tool in leading of the company. Therefore, it was necessary to design some more efficient manner of coordinating communication to achieve better results and performance inside the company.

To solve this problem, we used an existing environment in which there were known estimates of values entering the model and the transport method by means of which we developed behavioural patterns in utilizing communication routes similarly as Kennedy et al. (2017). Unlike the authors, we focused on communication patterns inside the team. Furthermore, like Zionts (1979), we used the cost and quality as the decision criteria for quantification of communication. We also included the time criterion to cover the basic project management triangle i.e. model of the project constraints. Kennedy et al. (2017) also confirmed

significance of the view of communication inside the project management triangle.

An impulse for extending our communication model by another variable such as loss of information or absence of information response represents a possible extension of the model. This idea is supported by, for example, Radner (1962). There was mentioned that keeping of messages could be so costly that it would be worthwhile to forget some of them.

Nevertheless, many authors consider communication as one of the reasons of project failure (Kerzner, 2013; Kotzé et al., 2008, etc.), the proposed approach can represent the way of influencing and minimizing this issue. Undoubtedly, the team communication can be promoted not only by training communication skills within the team (Švec, 2013) but also by means of an analysis of the communication patterns (Kennedy et al., 2017; Bavelas, 1950). Changing communication patterns can make communication more efficient, quality, and thus more sparing both time and money. If companies would be aware of the amount of ongoing project communication they could retrospectively evaluate the time and costs spent on the project.

Conclusion

This article deals with the basic problem of team communication representing a choice of the communication route kind for messages transmitting. In here, the solved complex issue is shown from many perspectives (the perspective of cost, time and quality of communication routes). As an appropriate multiple criteria mathematical model of team communication, the three-dimensional transportation model (3DTM) was used. The goal of this model is to find an optimal transportation plan (distribution of messages) between a set of suppliers (senders) and set of consumers (recipients) using different types of transport (communication routes).

The article discusses the case study of communication modelling in the field of agriculture. Specifically, it is the communication model for a small team of agriculture equipment dealers. The case study demonstrated the suitability of the proposed model.

Since the aim of this paper was to show the suitability of the proposed approach, a detailed analysis of the possible formulation of constraints is not mentioned in this article. Generalization of the model formulation is the subject of further research and testing.

Nevertheless, the consideration has to be given to the specific criteria used in the model – whether it may be only cost, time, and quality of the communication routes or whether also other criteria can be used to address many other specific situations.

It is also worth to consider possible extensions of the model constrains by the conditions of excessive information or messages receiving by individual team members. If some team member receives more messages than unconditionally necessary to fulfil a particular task then he may be overloaded by information, which may alternatively follow in his failure in completing the task.

Finally, it is necessary to decide how the criteria coefficients should be obtained. In this case, they were obtained using the method of pairwise comparison but they can be also measured by help of expert estimates. Based on experts´ estimation of the criteria coefficients of the communication routes in the company, it is possible to make recommendations for more effective communication or to suggest a more appropriate communication structure.

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The Use of Combined Models in the Construction of Foodstuffs Consumption Forecasting in the Czech Republic

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Abstract

Many authors all over the world attempt to perform time series analyses (at differing levels of expertise) in their published works. Knowledge of quantitative information is necessary for decision making in any domain. Therefore, it is more desirable to enter this field of problems and examine and develop everything that has been offered by these modern methodologies. In time series forecasting, the extrapolation methods are applied most frequently in practice. Currently, the combined models have been increasingly employed in experiments – these represent an aggregation of prognoses obtained from various separate models. The study presented is aimed at such new approaches, i.e. the construction of combined prediction models that are more realistic, more flexible and more concise in the time series modelling. This paper focuses on a subsequent assessment of combined prognoses constructed and a comparison of these with selected separate models having participated in the aggregate prognoses making. In order to obtain an efficient product, the Time Series Forecasting System (TSFS) component has been employed, being a component of the SAS programme system. For quality assessment of the models constructed, the assessment criteria selected in advance have been applied. The results of this empirical study have shown that in the domain of estimation of future foodstuffs consumption development, the techniques illustrated in this paper by examples of long-term time series from foodstuffs consumption area in the Czech Republic (CR), can be employed with success. This way represents a suitable supplement to complex econometric models.

Keywords

Foodstuffs consumption in the Czech Republic, time series analysis, exponential smoothing models, Box-Jenkins methodology, combined forecasting models.

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Introduction

The problem of foodstuffs consumption is always relevant and has been discussed at length and analysed from many different viewpoints. The indicators concerning foodstuffs consumption in the CR have been tracked by statisticians for almost a hundred years. The CSO (Czech Statistical Office) has continuous time series from foodstuffs consumption domain on domestic market available since 1948. This not only makes it possible to follow changes in the eating habits, but to increase precision of the forecasts constructed in this area, since a high quality forecast calls for the knowledge of quantitative information from this area. CSO monitors foodstuffs consumption by means of the Family account statistics (in separate households). Food consumption not only represents one of the fundamental human life necessities, but at the same time is one of the most important factors affecting the environment. For example, Notarnicola et al. (20160) have dealt with this in their works. They have concentrated on the assessment of the foodstuffs consumption effect on the environment in EU countries, using the consumer basket made up of selected foods and drinks (pork, beef, poultry, milk, cheese, butter, bread, sugar, sunflower oil, olive oil, potatoes, oranges, apples, mineral water, roasted coffee and beer) as the analysis tool.

As economists, it is important to be aware of the fact that farmland is an irreplaceable source of foodstuffs production (Pletichová and Gebeltová, 2013), and that foodstuffs are a necessary possession and the satisfaction of this vital need is a necessity for human life. Quality and quantity of foodstuffs represent the two fundamental factors capable of affecting the quality and length of life. Variety

of eating habits differ in every country depending on the level of economics, demography, habits of the population, or on the level of agricultural production. This affects nutrition by its structure and by its absolute volume, then determining this way the quality and quantity structure of foodstuffs consumption. Smutka et al. (2009) performed an analysis of global foodstuffs consumption development and of global agrarian production as well. That included the tracking the global foodstuffs supply and demand development. Foodstuffs consumption can be examined and analysed from many viewpoints and sights. Olsen and Tuu (2017) focused their study on a comparison of values of healthy eating on one side and self-indulgence in eating on the other. This included the consideration of the future consequences of the Vietnamese teenagers´ current consumption behaviour. De Vogli et al. (2014) analysed in their research the fast food consumption, specifically the influence of fast food consumption on BMI. Time series were collected from 25 member countries of the Organisation for Economic Co-operation and Development. Chen et al. (2010) directed their study at an analysis of food consumption in rural areas in China. The research was focused on agriculture land resources and the evaluation of such resources to ensure food security. Náglová and Horáková (2016) analysed one of the key food industry sectors in the CR, which is the meat industry. Their aim, by using a cluster analysis, was to define the quality factors limiting competitiveness of meat industry and the subsequent identification of groups of holdings having a key position.

Whether we are studying production, supply, demand or consumption of foodstuffs, quantitative information is vitally important to us. Quantitative information knowledge is necessary for decision making activities in any domain. Therefore it is necessary to operate within this field of problems and examine and develop everything that the modern methodology offers. Currently, the model tools for economic decision making support show an important path for both the basic and applied research in all the developed countries. The fundamental task of the models is to contribute to the solution of available data transformation problem in a given study area into the data needed (having a structure needed) for decision making at various levels. The time series theory belongs, particularly within the field of economic indicators, to the most significant quantitative methods. Forecasting of economic trends measures future development and plays an important role in the decision making process or in creating business strategies. That is the main target of this study, as well.

The central thesis of this paper is laid out in the examination of properties and the applicability of the separate prediction models offered by the SAS statistical system and subsequent combinations of these for the purpose of foodstuffs consumption forecasts making. There is a heavy emphasis on the study of combined models, possible ways of aggregation and application.

Outcomes of many studies targeted at time series forecasting of various economic indicators by means of aggregated predictions have shown that these modern techniques facilitate construction of more precise prognoses. The SAS system offers a rather wide choice of models, starting from the classical analytical models (Hindls et al., 2000), through adaptive models of exponential smoothing up to Box-Jenkins models. The study deals in particular with the assessment of the applicability of models constructed for description of the indicator´s under study past development and subsequent extrapolation forecasts.

In his study, Kába (1997) dealt with economic indicators´ time series properties examination, specifically with prognostic models´ applicability analysis. However, in the study given, the number of these was limited. The SAS programme system is considered one of the best and most comprehensive statistical programme packets, that satisfies the condition of this study, i.e. to have a really wide choice of various models available. The TSFS (Time Series Forecasting System) offers several univariate time series models to users. The TSFS component facilitates construction of combined models in the form of a simple arithmetic average, as well as a weighted arithmetic average with various weights. At the same time it is possible to aggregate the forecasts based on arithmetic averages of the original time series values of the indicators under study, or by means of the logarithms´ arithmetic average of the original values. As for the proper processing of the time series, it has been recommended by modern methodology to keep to a sequence of stages from primary collection, examination and purification of the data, through a preliminary analysis, design of candidates for the forecast formation needs, preliminary modelling including a precision stability test of the model, up to the final model selection and implementation

(SAS/ETS User´s Guide, Version 6, 1993). This research is focused predominantly on construction and assessment of combined models. This means that from the sequence given above, it will be focused on the stage including the design of suitable candidates for extrapolation forecast needs, inclusive of subsequent statement of precision and stability of the model. The models constructed will be assessed by means of assessment criteria selected in advance.

Techniques of combining the autoregressive (AR) models and the moving averages (MA) models have been applied in the analysis of univariate time series very frequently. The AR and MA models represent special types of the Box-Jenkins methodology. They can be applied both in interpolation as well as in the extrapolation of stationary time series. Through the combination of both of these model types, a so-called mixed model arises, or an ARMA model. However, for ARMA model use, stationarity of the time series is assumed (Martin et al., 2013). ARMA models were analysed by Barreras Serrano et al. (2014) in their study that focused on the analysis and forecasting of univariate time series of beef production in one specific area in Mexico. An augmented Dickey-Fuller test was used for verification of stationarity. In this case, ARMA models application on of real economic time series is required. The time series given should first be stationarized, since most time series does not satisfy the stationarity assumption. A suitable tool for such an adjustment is to obtain the differences of neighbouring values of the time series. An ARMA model applied in modelling of this already adjusted time series is denoted as ARIMA model – an integrated ARMA model (Cipra, 1986). Where the classical trend models fail, ARIMA models can be successfully applied in the description of such time series, as well. Thanks to this, the Box-Jenkins models have been widely applied in a variety of areas.

Köppelová and Jindrová (2017) have analysed as part of their work, the benefits of combined forecasts in the mobile telecom services consumption forecasting in the Czech Republic. The conclusions of this work suggest promising results in the use of combined models in forecasting operations in this area, be it through combination of models in the Box-Jenkins methodology, or in the exponential smoothing models. Christodoulos et al. (2011) concentrated on the exponential smoothing models in their analyses, specifically at the Holt´s damped trend with a modification, Gompertz and Linear Logistic model and combination of these for the purpose of predicting broadband data connection in OECD countries. Tavakkoli et al. (2015) employed a combination of two models from the adaptive models class – specifically the Double and Holt Winters exponential smoothing – with the ARIMA models. They assessed the benefits of the approach given for particleboard consumption forecasting in Iran from 1978 to 2009. The combined methods were applied by Xu and Wang (2010) in the forecasting of natural gas consumption. In addition, Deb et al. (2017), utilized the combined methods in a study dealing with construction and an assessment of the combined models in buildings´ energy consumption forecasting. They reached a conclusion showing that, the combined techniques are much more efficient in time series forecasting than others.

Materials and methods

For proper empirical analysis, data has been applied, having the character of time series and drawn from the Czech Statistical Office surveys resources. All in all, 73 time series of food consumption data with annual frequency have been analysed. The reference period covered the years of 1989 to 2015. The following food groups have been included in the analysis:

cereals and bakery products (15 items)
meat in terms of carcass weight (10 items)
milk, milk products, cheese and eggs (9 items)
fats and oils (6 items)
sugar, sweets and confectionary (7 items)
non-alcoholic beverages (6 items)
vegetables, pulses, potatoes (9 items)
fruits in terms of fresh (11 items)

The process of looking for the optimal model for time series analysis and subsequent forecasting can often times be very demanding, particularly in terms of time. The Time Series Forecasting Systems module (TSFS), being part of the SAS programme system, allows its acceleration. It was this benefit, that was the deciding factor for applying it in our study.

All the forecasts can be constructed both in the point shape and in the interval shape. The SAS system stresses verification of applicability assumptions of the separate analytical and prognostic procedures and it offers a number of diagnostic tools for this purpose. In order to clarify which of the prognostic models implemented are suitable for the forecast generation, SAS performs a series of diagnostic

tests (Log transform test, Trend test, Seasonality test) examining the analysed time series properties. These are sophisticated procedures (Arlt and Arltová, 2009) that are concerned with the assessment of the homoscedasticity of the residues. Furthermore, the presence of the trend component and the seasonality component is examined.

Based on the results of these tests, SAS selects and materializes appropriate corrective actions (log transformation, e.g., to stabilize the variance). It is important to mention that a specification of prognostic models by means of diagnostic tests as used in the SAS system, does not guarantee the establishment of a model with optimal properties. This is the initial stage only of the process of forecast construction, accelerating the whole process usefully, but needing a completion by additional checks and continuous verification of the outcomes obtained. By means of the SAS system selection criteria, all the time series have been identified and diagnosed automatically, and adequate forecasting models are constructed subsequently. At the first stage, individual (separate) models were only considered the most appropriate model and the forecast has been established. At the second stage, the three most appropriate individual models were considered, and based on the aggregation of these models, a combined model was set up. Both of these were in the shape of simple arithmetic averages and in the shape of weighted arithmetic averages with differing weights.

The forecast quality was then reviewed retrospectively by means of the test component of the corresponding time series (hold of sample evaluation). Accuracy of simulated predictions has been assessed by means of the Mean Absolute Percent Error metric (*MAPE*) and of the relative error of the prognosis (*rp*), and then by the average relative error of the prognosis that are defined as

$$M.A.P.E. = \frac{100}{n}\sum_{t=1}^{n}\left|\frac{y_t - y'_t}{y_t}\right| \quad (1)$$

$$rp = \frac{|\,y'_t - y_t\,|}{y_t} \bullet 100 \quad (2)$$

where y_t respectively y'_t (t = 1, 2, …, n) are the actual or the smoothed values of the time series given and n represents the number of the time series observations. The pseudoprognosis has been established for three years. For each year of the estimate, the relative error of prognosis was evaluated and subsequently, for the overall quality assessment of the prognosis, the average relative error was obtained.

MAPE represents one of the most frequently applied measures when assessing suitability of the models constructed for forecasts consisting of various indicators. The popularity of its use is due in particular to its form of expression, i.e. usually, usually as a percent.

MAPE criterion for combined models assessment was used by Mamat et al. (2016), as well. They dealt with the testing of combined models for farm machinery performance prediction. *MAPE* was applied in Reboiro-Jato et al. (2011) study as well, in the assessment of models constructed for forecasting needs in the area of feed mixtures for livestock production. Gang and Weiguo's (2010) work was aimed at the assessment of the advantages or disadvantages of combined models and the use of these for the forecast of natural gas consumption in China. Papagera et al. (2014) used *MAPE* in their research dealing with the forecasting of the indicators studied (indicators from the area of water supply changes) by means of Artificial Neural Networks (ANN).

As a further chance of quality assessment of the models constructed are the autocorrelation function (ACF) and the partial autocorrelation function (PACF) graphs. Seger and Hindls (1993) have stated that, many residuals should be of the so-called white noise type, for the analytical models to be at all applicable. The outcome of the ACF supplies coefficients of correlation between the series Y_t and Y_{t-k}, where t = 2, 3, . . , T and in graphical form also the 95% confidence intervals for the coefficients. These graphical ACF outcomes have been applied in the assessment of suitability of the models constructed for the time series studied. Considering the results presented in the next section it is obvious that the condition laid on the nature of series of the residues, has not been satisfied in all cases. In the overview of models, there are such a case where data had to first be adjusted using log transformation. These can be identified in the overview below, by the „Log" preposition before the model name. Such a modification of the data is needed in case of the ACF value exceeding the confidence interval limit. In this case it means that the residuals needn't be of the white noise type (Sachs, 1984).

Results and discussion

1. Exploitation of the time series individual models

In Table 1, an overall application of all the time series models is presented. It is obvious from the results presented that the case of the individual models use, the adaptive type models have been those most applicable. But it should be noted that the exponential smoothing models and the random walk model, presented in the results, are special cases of the ARIMA models. When parameters of these are estimated numerically, the SAS system applies the Box-Jenkins methodology algorithms. Classical trend models have taken place exceptionally. These were the foodstuffs with slight consumption changes (rice, wheat flour, durable pastry, fish, milk and milk products, potatoes, honey).

Model	Absolute representation
Damped Trend Exponential Smoothing	22
Linear (Holt) Exponential Smoothing	18
Log Damped Trend Exponential Smoothing	8
Double Browm Exponential Smoothing	5
Log Simple Exponential Smoothing	5
Log Linear (Holt) Exponential Smoothing	4
Log Linear Trend	4
Random Walk with Drift	3
Linear Trend	3
Simple Exponential Smoothing	1

Source: Own processing based on data provided by Czech Statistical Office

Table 1: The best individual time series models of foodstuffs consumption.

Model quality has been assessed using *MAPE* of the estimate. It was lower than 5 % in the case of the 31 best individual models, and between 5% and 10 % in the case of 24 models. 17 models had *MAPE* with slightly higher than 10 %. Based on these results, it can be stated that the models have been chosen adequately.

Considering the future development forecasts construction, it is important to assess quality of the forecasts, as well. Here, we needn't consider the same model, having been successful in the description of the indicator´s current motion. For the forecast quality assessment, the time series was shortened by 3 years and the pseudoprognoses were set up for these 3 years. The relative error of the forecast was stated for each year compared and then the average relative error of the three, as well. Relative error values obtained for the separate years, same as the average relative errors confirm suitability for future development forecasting of the indicators studied, of the models given in the Table 1, in most cases.

The average relative error of the forecast value was less than 5 % in the 42 time series given. In case of the 24 indicators that followed, the error value fluctuated between 5 and 10 % and the average relative error of the forecast above 10 % was obtained in the case of the following indicators: other cereals, rye flour, hops, durable pastry, game, canned milk, tea, garlic, pears, apricots.

2. Combined time series models construction for foodstuffs consumption

At the second stage of foodstuffs consumption development analyses, the combined model construction was adopted. Table 2 shows an overview of individual models entering the combined models construction process, inclusive of percentages of their representation. This analysis is directed at an assessment demonstrating whether combined model application actually can improve the forecast quality. Considering that the *MAPE* size three most suitable models are selected, the combined model is set up and its quality assessed by means of *MAPE*. Then the pseudoprognosis for three years is applied again and its quality assessed by means of the relative error of the forecast.

In the combined models construction, both of the two possible ways offered by the SAS system have been utilized. This means the simple aggregation way and the way of aggregation with regression weights. In both cases the *MAPE* measure reached a value of lower than 5 % in 32 models constructed. In 22 models aggregated the simple way and 21 models with regression weights, the value of the error fluctuated between 5 and 10 %. When assessing the forecast quality, the relative error of the forecast in the combined models with equal weights was lower than 5 % in 45 models. In the combined models with regression weights, the same value of the relative error of the forecast, i.e., a value lower than 5 %, was reached for 42 models. Twenty-one combined models with equal weights and 23 models with regression weights produced a relative error between 5 and 10 %.

Model	Proportion in %		
	model on the first place	model on the second place	model on the third place
Damped Trend Exponential Smoothing	30.1	23.3	13.4
Linear (Holt) Exponential Smoothing	24.7	21.9	19.4
Log Damped Trend Exponential Smoothing	11.0	10.9	7.4
Simple Exponential Smoothing	6.8	8.2	-
Log Simple Exponential Smoothing	6.8	1.4	-
Log Linear (Holt) Exponential Smoothing	5.5	4.1	11.9
Log Linear Trend	5.5	1.4	-
Random Walk with Drift	4.1	12.3	20.9
Linear Trend	4.1	4.1	1.5
Double Brown Exponential Smoothing	1.4	4.1	10.4
Log Random Walk with Drift	-	2.8	6.0
Mean	-	5.5	1.5
Log Mean	-	-	9.0

Source: Own processing based on data provided by Czech Statistical Office

Table 2: Individual time series models representation in combined prognoses.

3. Quality assessment of individual models and of the forecast quality of the time series

If a quality comparison is performed of the suitable individual models and the combined models, it can be stated that the results are similar. Slightly different, is the conclusion in the case of the forecast quality assessment. Table 3 offers information on the best models applied in separate food and foodstuffs groups, considering model quality on one side and forecast quality on the other. The following marking has been used in the table:

I – individual model

K1 – combined model with equal weights

K2 – combined model regression weights.

Individual models have been placed in terms of their quality in 35.6 %, in terms of prognosis' quality in 24.7 %. Both in terms of quality and in terms of prognosis, they can be assessed in the cases of the following separate food: cereals in grain value, wheat, wheat bread, total consumption of meat, consumption of sheep meat, consumption of rabbit meat, consumption of sugar and chocolate confectionery, consumption of soda water, total fruit consumption, apples and bananas.

If the model quality is being assessed, the combined models have been placed as the better ones, in 63.4 % of cases. If the size of the separate average relative forecast errors is compared, then in the case of the best individual models selected, the average relative forecast error was 6.91 % (when not including extremes it was 4.22 %). In 66.6 % of the cases of foodstuffs, the error was less than 5 % and in the case of two other, only indicators monitored it exceeded 10 % (garlic consumption, apricots consumption). In the best combined models with equal weights selected, the average relative error reached 4.44 % (when not including extremes it was 3.58 %). 73 % of foodstuffs consumption models showed the relative forecast error lower than 5 % and in two only models of foodstuffs consumption the error was above 10 % (other cereals consumption, canned milk consumption). In the best combined models with regression weights selected, the average relative forecast error was 4.3 % (when not including extremes it was 3.87 %). 65.5 % of foodstuffs consumption models showed the relative forecast error lower than 5 % and only one model had the relative forecast error above 10 % (pears consumption).

	Quality of Model – best models				Quality of Prognoses – best models			
Foodstuffs group	I	K1	K2	TOTAL	I	K1	K2	TOTAL
Cereals and bakery products	4	6	5	15	3	7	5	15
Meat in terms of carcass wieght	4	1	5	10	3	1	6	10
Milk, milk products, cheese and eggs	4	2	3	9	2	4	3	9
Fats and oils	-	4	2	6	1	3	2	6
Sugar, sweets and confectionary	3	1	3	7	2	3	2	7
Non-alcoholic beverages	2	2	2	6	2	2	2	6
Fruits in terms of fresh	6	1	4	11	5	2	4	11
Vegetables, pulses, potatoes	3	2	4	9	-	4	5	9
TOTAL	26	19	28	73	18	26	29	73
TOTAL in %	35.6	26.0	38.4	100	24.7	35.6	39.7	100

Source: Processing based on data provided by Czech Statistical Office

Table 3: Assessment of model quality and forecast quality in separate foodstuffs groups.

Conclusion

The level of foodstuffs consumption depends on a number of factors. Not only on household incomes and foodstuffs prices, but it also depends on higher (need different word) info on foodstuffs quality, contents of preservatives, healthy lifestyle and certain “fashion waves” in liking of certain foods.

Therefore, various model procedures are being prepared for the estimation of expected foodstuffs consumption development. Usually the complex econometric models are taking into account all of the basic factors that are affected at the highest foodstuffs consumption level and structure. This way, the model has its own causal reasoning. Nevertheless, it is useful to realize that construction of such a model is not a simple task.

Here it is best to start not only from the analysis of the basic factors affecting foodstuffs demand and consumption (consumer prices, incomes, food expenditure share on total expenses etc.) but also to focus on the consumer demand research data as well. Such research aims at finding what are the items preferred by consumers, what price variations they are willing to tolerate, and what are their substitution preferences (which commodity they are willing to replace in their consumption by another food commodity) etc. Collection of all data needed and subsequent construction of such a model is an arduous and lengthy job.

Therefore, this paper concentrates on the verification of the changes of time series analysis application in short-time forecast development. Prognostic techniques using the time series model extrapolation are only based on the course of the values over time assumption and the analysis can be satisfied by the past consumption development information only. This is then more easily detected.

The results so far have shown that the prognostic procedures of this type can serve as a good alternative or as a supplement for the complex econometric models in the future foodstuffs consumption development estimation. This is especially true since the short-term prognoses have mostly shown themselves to be of comparatively good quality. Here, the classical trend models have not been applied as much anymore. However, in order to reduce the risk of forecast errors of the adaptive exponential smoothing models, or the Box-Jenkins models play the role eventually, and specifically the possibility of the individual models aggregation into combined forecasts.

Better prognostic properties of the combined models have been confirmed by the outcomes of many studies. Some better quality forecasts constructed by means of combined models have been demonstrated, e.g. in the area of mobile services consumption in the Czech Republic (Köppelová and Jindrová, 2017). In addition, Mamat et al. (2016) confirmed, using their by utilizing their analysis about the advantages of combined models use in farm machinery performance forecasts. Comparison of the individual and combined models has been offered in the studies of many other authors as well. For instance there have been promising results in the use of the combined methods or models for both Tavakkoli et al. (2015) and Deb et al. (2017). The same holds true for this paper. Based on the analyses, it is possible to state that, that in the case of most foodstuffs, these procedures

based on the time series analysis can be applied for short-term foodstuffs consumption forecasts with success. In particular, the combination of appropriate individual models has brought about a reduction of the forecast errors and it offered comparatively high quality forecasts. This procedure can be used for the quick construction of short-term foodstuffs consumption forecasts, which serve the food producers or the business sector.

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Influence of the Correct Management of the IT Department on the Quality of Data And Information Processing

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Abstract

The article examines the influence of the existence of an information system and the existence of an information strategy for the management of information systems and information and communication technologies in the company. Two hypotheses have been identified: H1 - in the monitored sample of enterprises there is an increasing tendency of the existing department of informatics, as a separate unit and H2 - monitored respondents are used to manage information systems and information and communication technologies created information strategy. The article was developed based on scientific methods - using holistic methodology, analysis, synthesis, induction and deduction. The established hypotheses were verified by a questionnaire survey. The questionnaire survey was supplemented by direct questioning. The established hypotheses were not confirmed.

Keywords

Information systems, information and communication technologies, informatics management, information strategy.

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Introduction

Managing large corporations and corporations is not a simple matter today. In fact, it could be said that despite all the technical advances, it is now more difficult than ever before. Often, medium and small businesses face complex situations and regularly face complicated tasks.

Success or failure in business is becoming more and more relevant today. Who can properly use available information has a strategic advantage over others who cannot, or do not have the right information available at the right time. The quality of the entire control process is therefore fully dependent on the way and the ability to extract information and work with it. There are many ways to get information from corporate data sources. As information and communication technologies develop as quickly as possible, approaches to obtaining information on the state of the matter - the economic situation of the company, market situation, production and others according to the specific requirements of the management - are also being developed. Information has gradually become a highly desirable commodity and, in addition to land, labor and capital, is becoming one of the most important business resources.

Knowledge management begins with the identification of sources of information and reusable knowledge that are valuable to meeting the organization's strategic goals. Sources of data, information and knowledge can be found inside and outside organizations. Data, information, knowledge that arises and exist within organizations is relatively easy to access. Data and information are, in most cases, stored in databases of information systems and are available (based on access rights) to authorized users. The external environment provides data and information through media companies (unsorted information, targeted information, via websites, through paid surveys). Relatively easier, businesses get internal information, that is, information from the internal environment. External information and business information is gained less easily. The quality and way of obtaining internal information is fully dependent on the enterprise information system. Business information system

should be fully integrated and should respect the business processes of different functional areas. Therefore, the business information system cannot be created without a clearly defined global and information strategy. The design of the information system must also fully respect partial strategic concepts in the company. Any other approach is very risky. If there is no compliance with the above-mentioned procedure, i.e. the introduction of an information system without information strategy, there are many problems that arise with regularity in all companies (Tchoffa et al., 2013).

The quality of information systems also affects the possibility and ability of the organization's employees to obtain data and information, respectively knowledge from various informal sources. The next step in working with information and knowledge in the organization is to create a plan to use identified sources of information and knowledge and to create a definition of the environment where knowledge will be applied. It is equally clear to define what activities the knowledge will be used for. Knowledge is created continuously and sporadically in the organization's information system. Continuous feedback takes place in the knowledge used, thus enriching knowledge with further experience and gaining new added value. Knowledge in most cases is owned by its owner, i.e. the creator of knowledge - e.g. a company employee. Employees also use their capabilities and abilities, and provide the employees who use them based on the communication model for other activities in the organization - decision-making, new processes, and the use of new technologies.

Information and knowledge have gradually become the necessary business resources that influence business management. The way of their creation and acquisition is fully independent of the way of communication in individual companies. At present, information management and especially knowledge is not addressed in most businesses. Accuracy and up-to-date information is crucial for each organization to further develop, increase competitiveness, improve market position, increase image and improve goodwill. It is not just a static data analysis (mostly historical data), but more and more about data processing in real time. Data and information stored in information systems create support mainly for production, economy, business processes, to optimize processes in a company based on experience with similar processes and their use for the development of existing processes. Lewis (1998) states that tools for better use of data and information will positively influence their further use in management. Interest in strategic management of information systems and information and communication technology (ICT) has increased in the early 1990s due to the collapse of various business information systems. Until then, most businesses used data processing systems to process data and information used by central computers to process them. In most cases, data processing was off-line. Today's information systems are used at the level of data processing or information processing in most cases on-line. Only the wage module is used by most companies in off-line mode. Few companies manage information processes in the field of tactical and strategic planning, and almost no company processes in the field of collecting, distributing and sharing knowledge in the enterprise. The quality of the entire information system is determined by the capabilities and experience of senior management. If the area of information technology is underestimated for a long time, it will also affect the competitiveness of the company (Dohnal and Pour, 1999). In the long run, Voříšek (2015) is engaged in business informatics management, which also addresses the use of data and information throughout the management process. Knowledge in information systems is in most cases not stored in any database at all. The knowledge owner is not interested in, nor does it need to save their knowledge in information systems. It can be said that investments in information systems and information technologies do not guarantee a successful way of managing data, information and knowledge in the enterprise. The management of the whole department of informatics, namely information systems, information and communication technologies, is very demanding in the company. Procedures for solving the life cycle of an information system are also dealt with by Stail and Reynolds (2011). Long-term storage of large volumes of data in companies, their utilization and further processing depend on the quality and functionality of the information system, which is influenced by the quality of the entire controlling process of informatics in the company (Šilerová et al., 2017). The problem of the development of information systems, the quality of company processes and the security of data and information has long been dealt with by Polakovič et al. (2017) and Šmída (2007).

Materials and methods

Despite the declared need for professional management of information systems and information and communication technologies, there is still a department of informatics in many enterprises and in many other enterprises this department is inappropriately included in the organizational structure. The Department of Informatics still has no more than 50% of the companies surveyed, and these departments are under the control of other departments.

The article was developed based on scientific methods - using holistic methodology, analysis, synthesis, induction and deduction. The theoretical part was created using secondary sources, studying scientific and professional articles. Based on the established hypotheses, a questionnaire was compiled, consisting of 15 questions - 12 questions were closed and 3 questions were open. A total of 152 companies from a wide spectrum of production (manufacturing, agricultural machinery, forestry, transport, car-handling, agriculture) were addressed. From the 152 companies surveyed, 42 farms were with an area of more than 1000 ha. All respondents use information systems, the information system is made up of several modules. Modules are not integrated with all respondents. Based on the results of the questionnaire survey, 78 direct enterprises were interviewed directly. Direct survey enterprises were selected according to the questionnaire survey and production specialization. All production specializations were represented in the sample of respondents for direct inquiry. Questions for direct questioning were given to respondents based on the long-term experience of the authors of the article (cooperation with practice) with the mentioned issues of information systems, management of business information systems, and information strategies. Outputs from the questionnaire survey were used to draw conclusions of the established hypotheses.

Two hypotheses will be dealt with in the presented article: H1 - in the monitored sample of enterprises there is an increasing tendency of the existing department of informatics, as a separate unit. The first hypothesis assumes an increase to 62 % from 2008 to 2015, in farms to 12 %. H2 - monitored respondents are used to manage information systems and information and communication technologies created information strategy. The second hypothesis assumes the information strategy developed by 58 % of the respondents, in the farms in 7.5 % of the respondents.

Results and discussion

The quality of the whole information system is due to many factors - the inclusion of the IT department in the organizational structure, the existence of information strategy and information systems architecture, human factor, financial resources that can be used to build an information system and to implement (or innovate) information and communication technologies. One of the main reasons for failure to implement information systems is the absence or incomplete strategic management of the entire IS/ICT area. Most authorities agree on this diagnosis - see such as Cash, McFarlan, McKeney, Donovan, Earl and Ward. Unfortunately, the "strategic management of IS / ICT" often remains at the edge of managers' interest - this is mainly due to the inappropriate inclusion of the entire IT department in the organizational structure of the company, often also by the unclear contribution of information systems and information and communication technologies. Analyzes of the use of information systems in agricultural primary production and processing industry are solved by Hennyeyova and Depes (2010).

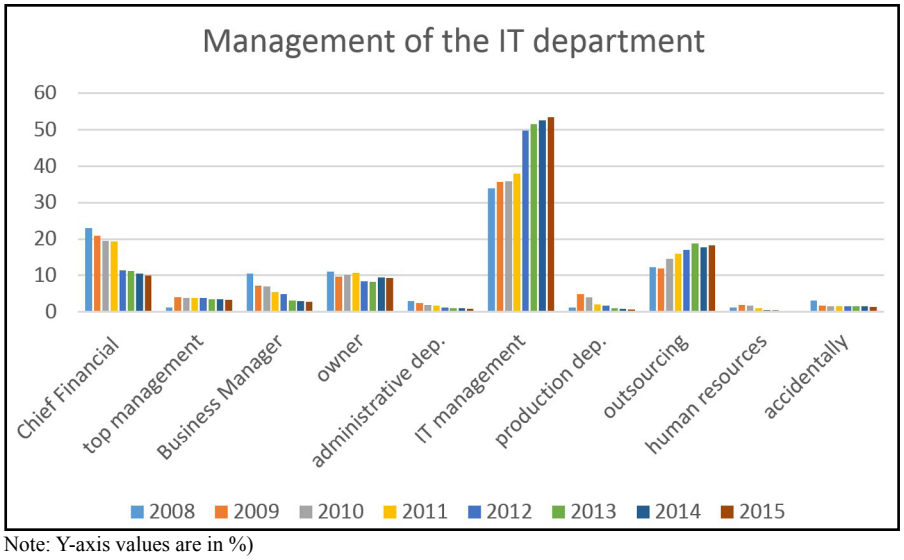
In the period from 2008 to 2015, a selected sample of companies was monitored, including the IT department in the organizational structure, i.e. who controls information systems and information and communication technologies in the company. Historically, IT companies fell under the economic unit. This way of managing informatics was developed throughout the world (the 60s and 70s of the 20th century). In the economic department, the largest volumes of data were processed - accounting, warehouses, wages, property, and consequently, the management of information systems in the economic unit remained. At present, the management of the IT department is still part of the economic unit in about 16% of the companies surveyed. A very similar situation is in many countries around the world, because the way of data processing was very similar here too. However, in the sample of monitored firms, IT is increasingly being managed by IT specialists. In small companies, the owner retains the management of IT and is also responsible for it. In the big companies, the entire top management of the company is involved in the management of informatics, including the IT department manager. The survey shows

that it is possible to combine the question whether the management of IT is directly in the management of the company, or whether it is the responsibility of the management of the IT department that is part of some other company department - in 2012, all top management was involved in managing informatics in 51.5 % and later in 2013 already 52.6 %. It is clear from the above-mentioned survey that in the last years it is no longer subject to IT management of the Human Resources department. In the first years of research, the Department of Informatics was part of the human resources department at 2.57 % of the monitored firms. If informatics is not a separate department in the company, the quality of the whole information science in the company is negatively affected. The results of the survey are shown in Figure 1 - Management of the IT department.

The situation on farms differs significantly. On farms, 95 % of information systems are used only for the processing of historical data, i.e. only for their records. Software that makes possible to use data and information to make predictions on farms is not available. This is also the way in which the field of information science is managed. The Department of Informatics is not in the monitored sample of agricultural holdings. For the management of information systems and the use of information and communication technologies, the owner, the director and the economist are responsible in 98 % of the monitored enterprises. The survey carried out in a selected sample of companies did not confirm H1 (that the IT department will be a separate unit in more than 62 % of respondents and in agriculture by more than 12 % of respondents). H1 has not been confirmed, although there is an increase in the existence of a separate IT unit, but not in such a fundamental way. In agriculture, the situation has not changed in the monitored period. Even on farms, H1 has not been confirmed. On farm businesses, the owner or the entire top management is still responsible for the whole computer science, without the existence of an IT department.

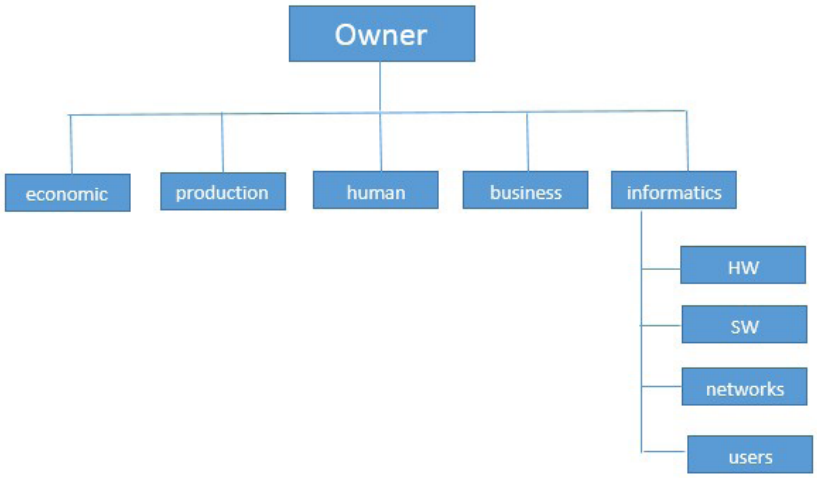
In monitoring the management of the IT department, it would also be worthwhile to monitor the impact of the information system on the results of the business, the competitiveness of the company, the goodwill, the social situation in the company, the cooperation with the suppliers, and the customers. Obtaining such data from companies is unfortunately very difficult because most companies are not tracking them at all, and if they track them, the data is so confidential that it's impossible to get it from companies.

The ideal proposal for inclusion of the IT department in the organizational structure of the company is shown in Figure 2. The design of this method of incorporation of the department of informatics results from the long-term research of the authors dealing with the way of information management and its influence on the development of the company.



Note: Y-axis values are in %)
Source: own processing

Figure 1: Management of the IT department – the proportion of IT departments.



Source: own processing

Figure 2: Organizational structure of the company.

Use of information strategy

A key condition for successful implementation of a business strategy is a clear idea of what outcome ICT will be used and how information systems will be used. The information systems used in companies are relatively complex, they are made up of a large spectrum of functions, often have no user manuals, the management of the IT department is at an inadequate control level. The quality of the whole lifecycle of the information system is heavily influenced by the way of the management of the department of informatics in the company, respectively by working with data and information and their further use. The company's information strategy must always be based on corporate strategy and this is sometimes a problem because corporate strategies are often not carefully developed (Kourdi, 2009).

In order to improve the quality of enterprise information systems, the correct setting of the whole life cycle of the information system is the most valuable. One of the first steps in the life cycle of an information system is to create an information strategy. The created information strategy represents a vision of the creation and use of information systems and information and communication technologies in the company. The quality of information systems, their functionality according to the requirements of the contracting authority, is crucial for almost all processes in the company.

Currently, most large companies expect the need to apply the principles of strategy and management also in the field of informatics. With the increasing complexity of information systems and product diversity, the need for strategic management is growing and is becoming increasingly important for medium and small businesses. Information systems are characterized by heterogeneity and also by more interdependent applications that create different teams often without mutual communication. The dysfunctions and problems that occur in these systems have many negative consequences. The difficulties we encounter when determining the origin and the causes of these problems are proportional to the quality requirements of the data and information being processed. (Tchoffa et al., 2013).

Creating an information strategy is a process that helps to optimize the process of managing the information system building, implementation and operation. The aim of the information strategy is a positive change in the use of information and communication technologies - in all areas of the company where the information systems are used (Drucker, 2002). Among the well-defined objectives of the information strategy we include: defining the architecture of the future information system, defining the definitions of the effective satisfaction of user needs by the information system within the company. Strategic management of information systems must be part of strategic business management and must be tackled in close connection with the marketing strategy, manufacturing strategy, logistics and other business components that are necessary for a successful business.

The architectural design of the information system is an information strategy - defining the requirements of the information system

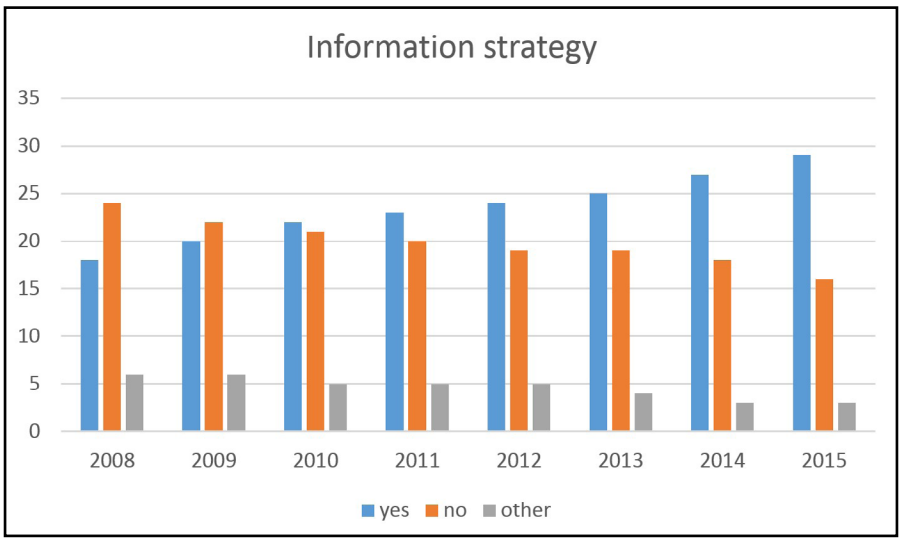
to support as much as possible the business strategy of the company, the ongoing corporate processes and the performance of the individual employees. The information strategy is an important tool for investment in information systems and information and communication technologies not to be too big a bet with an uncertain outcome, with the result that companies do not become a punch in the hands of suppliers (Urban, 2004). The expected benefits and efficiency gains will not only be a dreamy fairy-tale story with no ending. The information strategy represents the enterprise's vision of using enterprise data, information, and knowledge at all levels of management.

In the same sample of enterprises as the monitoring of the existence or non-existence of the IT department, the existence of the non-existence of the information strategy was created - a document which significantly influences the overall quality of the information system (positively). The company's information strategy has been neglected for a long time and has been searching for the causes of problems with information systems in many other factors. They did not think that one of the reasons could be the lack of an information strategy, the absence of a vision.

In the monitored years 2008-2015, the existence of the information strategy has increased significantly. In 2008, the information strategy was created only in 17.9% of the monitored companies, in 2015 it was already in almost 30 % of the monitored companies. In agricultural holdings, the situation is very different, with the monitored sample of farms the information strategy is only created in 5% of the monitored enterprises. These are large enterprises with an area of over 5,000 hectares. The results of the survey are shown in Figure 3 – Information strategy.

Hypothesis H2 was not confirmed too. Only 29.1 % of the monitored enterprises have created an information strategy. The increase in the monitored period is 11.2%, in agriculture it has grown by a whole 5 %, because in 2008 the information strategy was not created in any of the monitored enterprises.

It is verified that the information strategy costs from 5 % to 10 % of the cost of the information system. The system costs, built according to the specified strategy, then move with a 10% tolerance to the predicted - calculated price. On the other hand, the cost of an information system built without a developed information strategy is up to several times higher than the original assumptions. Therefore, many projects are not successfully completed due to the lack of information strategy. Tvrdíková (2015) also considers the possibility of using the principles of cloud computing. If the company thinks about these options, it is still far more responsible to manage all the processes involved. We will think that one of the most valuable corporate resources - data and information - is going outside the company.



Note: Y-axis values are in %)
Source: own processing

Figure 3: Existence of created information strategy.

Conclusion

A key condition for successful implementation of a business strategy is a clear idea of what outcome ICT will be used and how information systems will be used. The information systems used in companies are relatively complex, they are made up of a large spectrum of functions, often have no user manuals, the management of the IT department is at an inadequate control level. Welch and Welch (2007) states that the management of the whole company significantly affects the correct inclusion of the IT department in the organizational structure of the company as well as the existence of an information strategy according to which the whole informatics in the company is controlled. The survey and the proposed inclusion of the IT department in the organizational structure show that the quality of the entire life cycle of the information system is heavily influenced by the management of the IT department in the company, by working with data and information and their further utilization and, of course, by the existence of an information strategy.

Optimal is the inclusion of the IT department directly in the top line. When integrating the IT department directly under the company's owner and over the other management (economist, personnel, logistics), it is often the case that everyone is subject to set-up management directly and does not participate directly in individual steps of the life cycle.The information strategy is a document that is used on a regular and long-term basis throughout the life cycle of the information system. If the information strategy is not created in companies, the whole life cycle of information systems and its use by end users is negatively affected.

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Domestic and Foreign Origin Foodstuff Prices Comparison in Selected Retail Chains

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Abstract

The main objective is to verify whether it is possible to confirm differences in price policy not only in the division of chains according to the format of the shops but also in relation to Czech and foreign food and whether these findings can be clearly identified. The partial objective is to find the difference between Czech and foreign products in the context of chain approach according to other criteria such as price differences among products and among chains. There are eleven chains evaluated in the tables as well as 29 relevant food groups. The used underlying data is based on the data processed from the primary data obtained by the data collection in the retail chains. The average number of observations of one item, which is about 43 observations, of which 37 observations of Czech products and about 29 products with price. Only Lidl has a higher number of price observations from the total number of observations of foreign products. In the area of price policy evaluation (whether it is possible to confirm the differences not only in the division of the chains according to the format of the stores, but also in relation to Czech and foreign foods and identify clearly these findings), the difference is considered mainly according to the "low price“ of food and it can be said that there are noticeable differences among the chains, which also confirm different approach to Czech and foreign food and differences according to the format of chain stores. This paper originated in the context of the exploratory study „Prices of selected Czech and foreign food products in retail chains in November 2016“. The study was created for the needs of the Ministry of Agriculture of the Czech Republic.

Keywords

Foodstuffs, Czech products, foreign products, retail chain, price, format of stores, foodstuff offer, foodstuff price, price policy.

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Introduction

The global food market is nowadays highly concentrated at both regional and national level (Svatoš et al., 2012; Bielik et al., 2013). The food market is dominated by only a limited group of key actors (retail chain owners) who control the decisive share of food supply in the market. A particularly high level of concentration can be observed in the countries of the European Union (Smutka et al., 2016; Maitah et al., 2016). This ongoing process of concentrating the food market can be successfully demonstrated on the example of the Czech Republic. The number of actors active on the Czech market has considerably decreased over the past twenty years (Smutka et al., 2013). Independent stores and supermarkets have disappeared, and due to the worsening market conditions, even some of the larger chains have left the Czech market (Delvita, Julius Meinl, Interspar, Carrefour, etc.).

Major part of the food retail market ceased to be owned by domestic capital, due to the significant concentration of the market. Only the COOP retail chain can be considered as of domestic origin, other actors are owned by foreign capital. These are retail chains from Germany, the Netherlands and the United Kingdom. Since most market players do not originate from the Czech Republic and given that most sales capacities operate as a subsidiary of a global parent company, it can be assumed that

the domestic sales strategies of these chains are not primarily formulated on the domestic market but are prepared in context of broader strategies of parent companies.

Rather speculative question arises, which is occupying both Czech political and professional scene in regards of what have been said. It is a question of a different approach of these companies in relation to the origin of the goods. Whether transnational chains tend to prefer foreign goods to domestic products as part of their wider business strategies. Some representatives in this regard even speculate whether the goal of transnational retail chains is to reduce agricultural production capacities in the Czech Republic and therefore to reduce self-sufficiency in animal production (Špička et al., 2014; Řezbová et al., 2012) and plant production (Pulkrábek et al., 2007). In this respect, speculation has arisen that these supranational chains, by a number of their measures, disadvantage the goods of the Czech production compared to the foreign ones. One example of this disadvantage is the different price margins. This article addresses the issues of price levels in retail chains, in relation to the above.

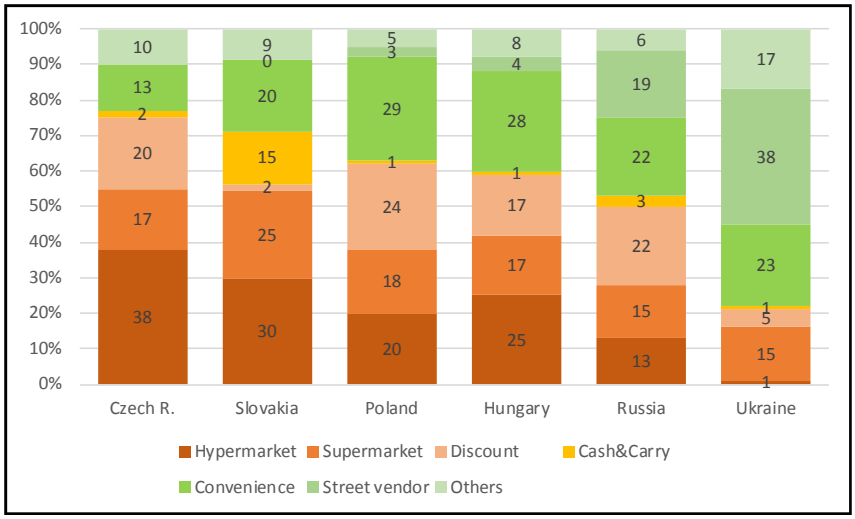
The outcome of this article within the GFK Study (2017) titled as GFK Shopping Monitor has been confirmed claiming that the format of stores is a factor that allows the chain stores to implement their pricing and product strategies in the Czech Republic: 46 % of customers implemented their food shopping in hypermarkets (Albert Hypermarket, Globus, Kaufland and Tesco), 16 % in supermarkets (Albert Supermarket, Billa, Tesco Supermarket) and 23 % in Discount Shops (Lidl, Penny Market) in 2016. An author Ambrose (1979) analyzed the prices of 54 food products in 6 small independent stores, in 4 large independent stores and in 4 stores belonging to the chain of chain stores. All of these shops were located in city centers and in suburban and rural areas of the state of Nebraska. Ambrose (1979) found out that, on average, food prices were higher in small independent stores (0.7% higher than the overall average) and in rural stores (3.8% higher). The largest differences in average prices (10.1%) were found among city center shops and suburban shops for the groups of following product groups: meat, poultry and fish products. Authors Leibtag, Barker and Dutko (2010) used data from the database of Nielsen: Neilsen Homescan to analyze food purchases in approximately 40,000 US households. The authors concluded that prices in so-called "nontraditional discount food retailers" (stores such as Wal-Mart, Costco and Family Dollar) are lower than in traditional supermarkets, this claim was true for 82 % of food products (after checking and comparing brands and package sizes). Expenditure weighted average prices were 7.5% lower in "nontraditional" smaller shops, food prices were lower by 3-28%. Price differences among traditional chains (supermarkets) and other stores were found in metropolitan areas where there is a higher share of other competitors and other types of shops in relation to supermarkets. Authors Hoffmann and Senkler (2011) used data from scanning food codes and prices from 80 shops in Germany within a two-year period to evaluate price competition among different groups of retail formats (hypermarket, supermarket, discount stores, other stores). The authors compared the price levels of food items compiled into the "typical shopping basket" instead of comparing the prices of individual food products. Hoffmann and Senkler (2011) found evidence of ongoing competition among individual retail sales formats (discounts, supermarkets and hypermarkets). The regular shopping basket was compiled of 24 commonly purchased food products, the variation coefficient of a basket cost was 14.9% for discount products and 16.7% for best-selling standard products.

Graph 1 shows the format of stores in selected countries in 2013, as assessed by GFK (also referred to as GfK or Incoma GfK), but the specific parameters for the format of the stores in the GFK outputs were not found, however, it is probable, that the understanding of the formats will be similar to that of Nielsen - see Table 3.

Most of the largest multinational retail chains such as Walmart, Carrefour, Metro Group and Tesco had problems with declining profits and negative revenue growth between 2001 and 2004, not only in their domestic markets but also in their foreign networks. As a result, these companies have begun to invest significantly more in domestic markets, where historically they have made the most profits at the expense of their foreign units. The restructuring of European companies has resulted in an increase in their turnover (sales) within Europe. This is illustrated in Table 1.

Many of the European companies, respectively. groups even sold in the context of the global economic crisis of their business networks in countries where they were not strong, even though these markets are considered strategic with high potential (Table 2).

In 2016, the share of international trade chains in the overall food market in the Czech Republic exceeded 70 percent, according to GfK. The market



Source: GfK 2013, Retail and Future Markets

Graph 1: Formats of stores in chosen countries from middle and east Europe (year 2013, %).

Ord.	Chain/ Group	Turnover in Europe, mld. eur	Place		Ord.	Chain/ Group	Turnover in Europe, mld. eur	Place
1	Schwarz	92-95*	Germany		6	Edeka	50*	Germany
2	Tesco	63xx	Great Britain		7	Aldi	49*	Germany
3	Carrefour	56	France		8	E.Leclerc	43.4xx	France
4	Rewe	55*	Germany		9	ITM	40.2xx	France
5	Metro / Media Saturn	54	Germany		10	Auchan	38.5	France

Note: *estimation, xx turnover within fuel trade
Source: Retail-index.com, Veraart Research Group BV, The Netherlands, 2016, http://www.retail-index.com/Sectors/FoodRetailersinEuropeandworldwide.aspx

Table 1: TOP 10 food retailers in Europe, year 2016.

Group/Company	**Turnover**	**SUM**	**%**	**Chain****
1. KAUFLAND ČR/ Group Schwarz	55.23	55.23	14.1	*Kaufland (124)*
2. AHOLD CZECH REPUBLIC	48.33	103.56	12.3	*Albert hypermarket (91), supermarket (240)*
3. TESCO STORES ČR	41.76	145.32	10.7	*Hypermarket (76), hypermarket Extra (9), supermarket (62), OD/ City/My (6), Expres (45)*
4. LIDL ČR/Group Schwarz	33.66	178.98	8.6	*Lidl (231)*
5. PENNY MARKET/Group Rewe	32.13	211.11	8.2	*Penny Market (360)*
6. MAKRO CASH & CARRY ČR	30.12	241.23	7.7	*Makro (13), Drive In (2)*
7. GECO	29.98	271.21	7.6	*Geco tobacco-newspaper (262)*
8. GLOBUS ČR	22.93	294.14	5.9	*Globus (15)*
9. BILLA / group Rewe	21.62	315.76	5.5	*Billa (205), Billa stop & shop (43)*
10. JIP VÝCHODOČESKÁ	11.40	327.16	2.9	*JIP (35), JIP Plus (144), Cash & Carry (12), Wholesale (17)*
11 – 30. subject	64.77	391.93	16.5	*xxx*
from these group COOP	26.16	x	6.7	*Group COOP*

Note: Turnover = sales in v billion CZK, without VAT, SUM = cumulative sales, % = share of the trader / group on TOP 30 (it means share on the total sales of 30 traders with the highest sales volume in the Czech Republic), **= sum of own markets in October 2016
Source: GfK (2017), Špačková (2016), own calculations

Table 2: Analysis of the largest traders / business groups in the Czech Republic, with the predominance of quick-moving goods, according to sales, year 2015-2016.

was more and more segmented. All major traders have crossed the annual turnover line of CZK 20 billion and have thus been strongly allocated to the rest of the market. Most recently, the group Schwarz (Kaufland and Lidl), followed by Rewe (Penny Market and Billa) Makro Cash & Carry and Globus also had a stable position at the top of the deal, according to Skala, Director of Retail & Shopper research at GfK Czech (Špačková, 2016).

The main objective is to verify whether it is possible to confirm differences in price policy not only in the division of chains according to the format of the shops but also in relation to Czech and foreign food and whether these findings can be clearly identified. The partial objective is to find the difference between Czech and foreign products in the context of chain approach according to other criteria such as price differences among products and among chains.

In this context, the outline of confirming the influence of multinational retail companies on their pricing policy in relation to the market share should also emerge.

Materials and methods

The used underlying data is based on the data processed from the primary data obtained by the data collection in the retail chains as part of the food price survey (Smutka, Řezbová and Škubna, 2017) transformed into aggregated underlying tables for individual chains. There are eleven chains evaluated in the tables as well as 29 relevant food groups. These 11 tables allow Excel to evaluate directly the average numbers of observations. Omitting food with zero observations or price observation is done by manual correction. Determining the number of items without observation with price is done by enumeration. Similarly, the determination of the overall variability, with which the chains operate, is based on the values of the variation coefficient with correction of the zero-point observation and the zero observation with price. Observation with price is more important in these analyzes than the total number of observations in the context of item inclusion in the calculation. The evaluation of the offer (range of assortment) of individual foods is thus processed with the help of manual correction of zero observation of Czech and foreign food of individual chains. The zero observation values are not taken into account for the total number of observations. The number of observations with the price in percentage of the total number of observations is based on the total numbers. Used data about the number of stores and about the market share are based on the data given in Špačková (2016), the calculations are simple divisions and sums.

Average prices are used when ranking prices in chains in order from the cheapest. However, the groups of dairy, meat and other products are used in this case. The division of individual foods into these groups is as follows (and applies to other analyzes performed in this section) - dairy products (milk 1.5%, eidam 30%, eidam 40%, white mold cheese, fresh cheese, cream cheese, white yoghurt, fruit yoghurt, sour cream, butter), meat products (pork legs, pork neck, pork shoulder, beef back, beef front, fine sausages, paprika sausage, pork ham, fresh chicken, frozen chicken) other products (toast bread, sweet pastry - cake , biscuits, eggs, rapeseed oil, sunflower oil, spaghetti, chocolate, gelatin candies). The original divisoin by food was used primarily, not by the chains, and the order of the chains was determined from the 29 food information tables according to the average prices of individual food from lowest to highest. If there were specific food available in all 11 monitored chains, the ranking of values was set from 1 to 11. If the food was not tracked (not observed or not observed with price), it was ranked outside the ranked order. For this reason the order has always been from 1, but the maximum value has often not reached 11. This was done separately for Czech and foreign foods. Overall, it meant the creation of 6 tables with 10 or 9 Czech and foreign food and 11 columns representing individual chains. The focus is set in a simple order. To eliminate possible risks of this evaluation the number of values of chain placement in the order was analyzed among tree cheapest foods. This number of placements is performed by a visual evaluation and sum without the use of computational tools in Excel. Therefore the highest number of placements among the three cheapest foods in a given food group implies an assumption for the chain´s approach to price policy among other chains in terms of maintaining a low price.

The dependencies of the monitored indicators are evaluated in the context of the correlation principles. The dependence of two quantitative variables (when it is not decided which one is independent and which dependent variable) is statistically illustrated by the correlation coefficient. The correlation coefficient (r) has values in the range of -1 to 1 inclusive. If $r = 0$, the quantitative variables are independent, $r = 1$ means direct dependence and $r = -1$ is indirect

dependence. The CORREL function was used in Excel for calculation. It works on the Pearson correlation coefficient principle which means it works with linear dependence. The division of chains is used according the store format of the chain. For this purpose, the prevailing type of shop format was considered. This was consulted with different sources and the resulting division corresponds to the general assumptions about the types of formats of the individual chains. Můj obchod and Žabka are being considered small-format chains according to the type of shops. Most of the chain stores are in the category of medium format stores (supermarkets, discounts) - Albert, Billa, COOP, Lidl, Norma, Penny Market. Large-format chain stores (may be called hypermarkets) are Globus, Kaufland and Tesco. For Albert (medium and large format), Billa (small and medium format), COOP (all types of formats) and Tesco (all types of formats), the classification according to the above mentioned principles corresponds to the prevailing type of store format. COOP is also taken into account when calculating the number of stores.

Results and discusion

There were 15,294 shops with grocery and mixed goods in the Czech Republic in 2016. Their number has fallen by four percent since 2013. Mostly the small shops have disappeared. The number of supermarkets has also decreased by 28 in the last three years. In contrast, 19 hypermarkets have been added. Supermarkets and hypermarkets together represent 80% of the total turnover of the food and grocery stores, which is the highest share in Central Europe. This was the result of the latest Nielsen survey (Nielsen Census, 2016) (Table 3).

There are markable differences among the chains in the range of assortment defined according to 29 analyzed products of Czech and foreign origin (Table 4).

If it could be assumed that an adequate Czech or foreign product could be found in the event of a visit, then it is possible to state that not the whole range of Czech products are in Lidl chain (5 Czech products are missing), Můj obchod (4 products), Norma (4 products), Žabka (4 products) and one missing product is in Penny Market. Analogically, the complete range of monitored foreign products is available only in Tesco, 27 items have Kaufland and Lidl, followed by Albert and Billa (26 items) and Penny Market (22 foreign products). The following would probably be Můj Obchod and Norma (22 foreign products) and Žabka (20 products) but it is unlikely to happen (taking into account not visiting the chains). With a high probability it is possible to state that COOP chain is focused on Czech products in the context of this comparison (in 12 cases it does not offer an adequate foreign product to the offered Czech one) and it is followed by Globus (10 demonstrable cases where it does not offer an adequate foreign product to the Czech one). The behaviour of Globus is also interesting in the context of the other two large-format chains, as their offer of Czech and foreign products is almost complete (Table 5).

With the exception of Můj Obchod chain, it is possible to say that the six chains with the highest number of observations are the same as the six chains with the highest number of stores (Albert, Billa, Kaufland, Lidl, Penny Market, Tesco). However, the availability, with regard to the way of data collection, was reflected in the shops, for example Penny Market, which has 360 stores (2nd place and 1st place without taking in account Můj Obchod chain) was ranked on the 6th place according to observation. On the other hand, Kaufland, which

Parameter	2000	2011	2012	2013	2014	2015	2016	2016/2000
within 50 m²	10 662	8 129	8 158	7 524	7 256	6 969	6 619	62.1 %
51-100 m²	5 254	4 235	4 235	4 408	4 553	4 574	4 679	89.1 %
101 – 200 m²	2 208	1 734	1 679	1 738	1 819	1 830	1 826	82.7 %
201 – 400 m²	837	608	635	613	553	544	518	61.9 %
Supermarket 401 – 2500 m²	900	1 291	1 330	1 362	1 352	1 349	1 334	148.2 %
Hypermarket over 2500 m²	68	273	287	299	309	314	318	467.6 %
TOTAL	19 929	16 270	16 324	15 944	15 842	15 580	15 294	76.7 %

Note: Within 50 square meters Nielsen defines "small grocery stores", 51-400 m² "medium and large grocery stores", 401-2500 m² "supermarkets" and over 2500 m² "hypermarkets"; for "discounts" there is no strict division by area, however, an area of 400-1000 m² can be considered and thus included in a subset of supermarkets; In this context it is possible to include the above mentioned formats into three categories: small format (up to 200 m²), medium format (cca 200 - 2500 m²), large format (over 2500 m²).

Source: Nielsen Census (2016), own calculations, divided by sales formats

Table 3: Number of groceries and mixed goods stores in the Czech Republic for 2000– 2016.

RETAIL CHAIN	Offer of Czech food products in analyzed sample (0 - 29)	„Chain was not visited how many times“ (amount of analyzed food products in the chain)	Offer of foreign food products in analyzed sample (0 - 29)
Albert[2]	29	0(29)	26
Billa[2]	29	0(29)	26
COOP[2]	27	2(27)	15
Globus[3]	29	0(29)	19
Kaufland[3]	29	0(29)	27
Lidl[2]	24	0(29)	27
Můj obchod[1]	16	9(20)	13
Norma[2]	16	9(20)	13
Penny Market[2]	28	0(29)	22
Tesco[3]	29	0(29)	29
Žabka[1]	22	3(26)	17

Notice: [1] small format chains, [2] medium format stores (supermarkets, discounts), [3] large format chain stores (hypermarkets)
Source: Own data collection, November 2016

Table 4: The offer (range of assortment) of individual foods in chains.

RETAIL CHAIN	Number of observations	Number of observations with price	Sum of items without observations with price	Number of observations	Number of observations with price	Sum of items without observations with price
	CZECH PRODUCTS			FOREIGN PRODUCTS		
TOTAL	42.96	37.00		42.96	29.40	
Albert2	82.55	76.17	0	82.55	48.92	3
Billa2	72.66	67.34	0	72.66	46.85	3
COOP2	11.48	10.52	2	11.48	8.13	14
Globus3	15.86	15.24	0	15.86	14.63	10
Kaufland3	67.41	60.00	0	67.41	44.19	2
Lidl2	62.79	38.29	5	62.79	46.85	2
Můj obchod1	7.20	6.88	13	7.20	5.77	16
Norma2	8.00	7.94	13	8.00	6.00	16
Penny	53.48	49.89	1	53.48	30.36	7
Market2	68.07	54.03	0	68.07	53.00	0
Tesco3	23.00	20.64	7	23.00	18.71	12
Žabka1	23.00	20.64	7	23.00	18.71	12

Notice: [1] small format chains, [2] medium format stores (supermarkets, discounts), [3] large format chain stores (hypermarkets)
Source: Own data collection, November 2016

Table 5: Average number of observations per food observed in the chain.

is on the 2nd place in number of observations, has 124 stores and is the 7th, respectively the 6th. From this point of view, the availability by public transportation and location of stores is obvious in this context with regard to the optimization of the route for the purpose of data collection. It is also possible to think about the influence by the methodology of data collection.

The ratio between the number of observations with the price and the total number of observations is given in relative terms in Table 6. It is obvious that the number of observations with price is higher almost in all chains for Czech products than for foreign ones, which corresponds to the overall average. The only exception is Lidl chain, where the observation with price of foreign products is dominant. It is also worth mentioning Tesco stores, where the observations with price for Czech and foreign products are almost equal. From the dependence point of view, there is a correlation coefficient of 0.88 in between the absolute values for the number of observations with price for Czech and foreign products, while the correlation coefficient for comparison

RETAIL CHAIN	Number of obserations with price in % from total number of observations – Czech products	Number of obserations with price in % from total number of observations – foreign products
AVERAGE	83	56
Albert[2]	92	53
Billa[2]	93	58
COOP[2]	92	39
Globus[3]	96	60
Kaufland[3]	89	61
Lidl[2]	50	69
Můj obchod[1]	76	52
Norma[2]	79	49
Penny Market[2]	90	43
Tesco[3]	79	78
Žabka[1]	76	53

Notice: [1] small format chains, [2] medium format stores (supermarkets, discounts), [3] large format chain stores (hypermarkets)
Source: Own data collection, November 2016

Table 6: Number of observations with a price in proportion to the total number of observations.

of number of observations with price and total number of observation is 0,96 and is the same as for foreign products.

The products were divided into three groups (dairy, meat, other) from the price evaluation point of view and not only in the context of Czech and foreign products, but also with the inclusion of product price comparisons among idividual chains. For each product there is a ranking in terms of average prices. Considering that the consumer reacts to the price and at the same time it is important for him to compare the product as "cheaper / more expensive" no matter how cheaper is the product than competition, the order was determined regardless of the relative expression. The aggregate results are shown in Table 7 but it does not show results based on ranking from 1 to 11 (according to the number of chains), but only the aggregated values for the position of the chain at the first three places in the ranking of average food prices from the cheapest to the most expensive. The cheapest dairy products are most often in Lidl, for both Czech and foreign products. Next position has Kaufland and Albert for Czech dairy products and Penny Market with Kaufland for foreign dairy products. The cheapest Czech meat products can be found in Globus, further in Kaufland and Penny Market (both 5 placements). The cheapest foreign products can be found in Albert and Tesco (equally 6 placements) followed by Kaufland. The cheapest Czech products included in the group of other products are offered by Penny Market, and in other places there are 5 chains with three placements. The cheapest foreign products are offered in this group by Lidl, followed by Norma and Penny Market.

If individual placements were aggregated, then Lidl is the cheapest for Czech products (14 placements), followed by Penny Market (13 placemets), and Globus (12 placements) would be closely followed by Kaufland (11 placements). Compared with the assumptions, it is not true that large format chains are cheaper, even Tesco is among the three cheapest products represented less often than Billa, Albert, COOP, Norma and even Můj obchod. On the other hand, the placement of small-format chains corresponds to the assumptions and their focus. The cheapest aggregated placements of foreign products are once again in Lidl chain (21 placements), followed by Penny Market (15 placements) and Kaufland (11 placements). In addition, there are 10 placements in Albert and Norma, Tesco with 7 placements and Billa with 4 placements. Globus as the large-format chain was not very cheap in this comparison (3 placements), and is closer to the small format stores as Můj Obchod (2) and Žabka (1). COOP has also achieved only 2 placements, but its approach to foreign food has already been indicated by the results of other analyzes. When evaluating the approach of the chains to Czech and foreign products in this context, it is difficult to find a generalizable output, which is not appropriate to solve aggregately for a group of other products with a respect of the heterogeneity of the products. Globus and Tesco have the biggest difference in the number of placements of dairy and meat products, Globus is ranked 7 times among the cheapest Czech meat products but not once among foreign meat products. On the other hand,

RETAIL CHAIN	Dairy products	Meat products	Other products	Dairy products	Meat products	Other products
	CZECH PRODUCTS			FOREIGN PRODUCTS		
Albert[2]	4	2	1	1	6	3
Billa[2]	3	3	3	0	3	1
COOP[2]	2	1	3	1	1	0
Globus[3]	2	7	3	2	0	1
Kaufland[3]	4	5	2	4	5	2
Lidl[2]	8	3	3	9	4	8
Můj obchod[1]	1	1	3	2	0	0
Norma[2]	3	2	1	3	1	6
Penny Market[2]	3	5	5	6	3	6
Tesco[3]	0	1	2	1	6	0
Žabka[1]	0	0	1	1	0	0

Notice: [1] small format chains, [2] medium format stores (supermarkets, discounts), [3] large format chain stores (hypermarkets)
Source: Own data collection, November 2016

Table 7: Number of placements of chain among three cheapest food groups.

Tesco is only once placed among Czech products but 6 times among foreign ones. The difference among placements in other chains is up to 3 placements at maximum. If the possible dependence between the placement of Czech products and the location of foreign products according to individual product groups were evaluated, then there is a strong dependence only for dairy products, where the correlation coefficient is 0.75. On the other hand, the coefficient for meat products is only 0.06 so there is almost no dependence. The dependence for the group of other products is 0.19 in terms of the value of correlation coefficient.

Conclusion

When talking about number of observations with price per product, most of the Czech products are in Albert, Billa and Kaufland and foreign food in Tesco, Albert, Lidl and Billa. The total number per average number of observations of one item is about 43 observations of which 37 Czech products observations and about 29 of foreign products with price. It is also an evidence in favor of Czech products and its superiority compared to foreign products within the analyzed 29 foods which have been selected. Only Lidl has a higher number of price observations from the total number of observations of foreign products. The number of shops of individual chains is used not only for these reasons but also because it can be related to space availability of the stores and to other parametrers.

It is also important to mention the overall figure per the average number of observations of one item, which is about 43 observations, of which 37 observations of Czech products and about 29 products with price, which is an evidence in favor of Czech products and its superiority compared to foreign products within the analyzed 29 foods which have been selected.

However, according to the methodology used in data collection, it is necessary to specify that the listed average numbers of product observations are also affected by the space availability of the shops. The average number of observations per product was 82.55 in Albert, followed by Billa with 72.66 observations, followed by Tesco (about 68 observations), Kaufland with 67.41 observations and Lidl with 62.79 observations. There were 7.2 observations the least and it was in Můj Obchod, followed by Norma with 8 observations and the COOP chain with about 11.5 observations. When evaluating whether there is any difference between Czech and foreign products in the context of approach of the chains according to other criteria such as the price difference among products and among the chains, this is evaluated mainly by correlation coefficients which indicate possible dependence of monitored indicators within individual chains and which point to some differences, however, these are not statistically conclusive. In the area of price policy evaluation (whether it is possible to confirm the differences not only in the division of the chains according to the format of the stores, but also in relation to Czech and foreign foods and identify clearly these findings), the difference is considered mainly according to the "low price“

of food and it can be said that there are noticeable differences among the chains, which also confirm different approach to Czech and foreign food and differences according to the format of chain stores.

The authors Richards and Hamilton (2006) show in their study that the US food chains choose their competitive advantages based on two parameters: the price level and the width (range) of food products. The significant impact of household income on the level of food prices in the basic consumer basket was also reflected in the study by the team of authors Binkley and Conner (1996).

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Strategic Importance of the Quality of Information Technology for Improved Competitiveness of Agricultural Companies And Its Evaluation

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Abstract

The article discusses the issue of the use of information technology in the search for potential competitive advantages in agricultural companies. Information technology in agriculture should provide a clearly defined benefit for the management's decision-making. If information technology is not being used to its full potential and if the results are interpreted incorrectly, the overall impact may be damaging to the position of companies in the competitive environment. Investment in information technology requires considerable sums that should return in the form of faster and better decision-making in which digitalized corporate processes play a complex role. Strategic decision-making concerning investments in information technology in various types of agricultural businesses varies depending on their size, focus, economic situation etc. In the context of the current state of agriculture in the Czech Republic and after a detailed analysis of available literature, the authors conclude that the issues of quality of information technology have not yet been systematically examined and resolved in Czech agricultural companies. For this reason, they consider it fruitful to focus their attention on this subject. The main objective of the paper is to develop and apply a methodological model for evaluating the quality of information technology in an agricultural business. In addition, we want to examine the broader impact of the criterion of IT quality from the perspective of its strategic importance for competitiveness and the extent to which it supports strategic management in practice.

Keywords

Strategy, decision-making in management, competitiveness, information technology, information processes, IT quality evaluation, methodological model.

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Introduction

The development of agricultural companies is influenced by changes in the economic, technical and social environment, both within the sector (microenvironment) and outside (macroenvironment). These changes are a source of uncertainty that complicates decision-making, increases costs and reduces competitiveness. For a company to be successful, it needs highly competent and well-trained managers.

The company management must be prepared to start using new opportunities, particularly those that have a strategic potential for the future. Efficient use of information technology (or IT) and the quality of information processes in a company is generally considered a particularly strong opportunity. The use of IT in agricultural enterprises as a source of competitive advantage is recommended (Šimek et al., 2018).

The importance of an information system to a company is evaluated through its characteristics. Most researchers emphasise the following two: functionality that corresponds to business processes and quality (Bruckner et al., 2012). Other authors (Kožíšek and Vrana, 2017; Kruczynski, 2010) call for the correct modelling of business processes as a basis for the processing of software applications. The importance of process diagrams in modelling business processes is emphasides by (Jošt et al., 2016).

An important role is here played by the strategic management process which primarily aims to secure its own future through deliberate development and maintenance of a competitive strategic position. The concept of this article is based on a validation of theoretical principles using examples from practice and on the authors' own research of the key role of strategic management processes in real-life companies, focusing on the quality of IT and information processes in smaller agricultural companies and specifically on the quality of work with SW tools. The Department of Information Technology has been devoted to the evaluation of research on the development and adoption of information technologies by agricultural enterprises (Vaněk et al., 2008).

The importance of the quality of information technology and information databases in the management of agriculture is very significant and is considered a factor of success – as noted by (Tyrychtr and Vostrovský, 2017; Vaněk et al., 2010).

Materials and methods

The main objective of this article is to propose a model for evaluating the quality of the use of IT in primary agricultural production, to verify this model in the context of smaller farms and to establish the conditions for its use and formulate recommendations that could improve the quality of information processes in this sector. The principle behind our model for the evaluation of the *quality of information processes in an agricultural company* (QIPAC) is that of a methodological model. The model is based on quality standards ISO/IEC 25010, 25023 and 25021. In its development, we also took into account various other standards: ISO/IEC 25021, 2011; ISO/IEC 25023, 2013; ISO/IEC 25010, 2014 and Sommerville (2013).

The main objective is supported by a partial objective which examines the fulfilment of other, and in terms of competitiveness the most important, requirements for SW in terms of its support of management processes, particularly strategic management.

The methodology of the QIPAC model is based on a concept in which QIPAC is the result of an evaluation of three areas of quality. These are the *quality of software* (QSW), the *quality of hardware equipment* (QHW) and the evaluation of computer literacy, or *user quality* (UQ). The development of a detailed methodology and the parametrisation of the QIPAC model requires the establishment of an expert group (Kubata, 2017).

The proposed structure of main and partial characteristics used in the model was designed by an expert group on the basis of a managed interview using ISO/IEC standards and results from the analytical part described in methodology steps 1, 2.a and 2.b.

Another output of the expert group is the methodology of the model and the definition of etalon values for measurements of the individual and partial characteristics (or sub-characteristics) in the model.

Metrics and attributes of model quality evaluation were determined in accordance with the standards ISO/IEC 25010, 25023 and 25021. The measured values are related to the selected etalon or a determined maximum. In the case of attributes used in the model, measured values are expressed by a percentage. Selected measures use an absolute and ordinal scale and the questions used in the evaluation were designed to lead towards unambiguous answers. The benefit of this approach is that it allows easy comparison of values and is independent of used units.

Results and discussion

1. Proposal of the initial reference model for evaluating the quality of information systems in companies

In order to propose a model for the evaluation of IT in an agricultural company, we have developed an evaluation procedure based on the reference model for the evaluation of quality of a software product (Vaníček, 2006). A modified process diagram (variant extended with further specifics of IT evaluation) has been designed through analysis and synthesis of available literature and known practical needs of agriculture (Figure 1).

The methodological model for evaluating IT (Buchalcevová, 2016) in an agricultural company (Fountas, 2015; Shifeng et al., 2011) was developed with reference to the principles of IT audits (Vrana, 2005). The validity of the model was then experimentally verified in a case study, identifying and evaluating the outputs including found limitations and shortcomings. The case study is described in the following part of this article. The conclusions of measurements made in the case study are interpreted in a table

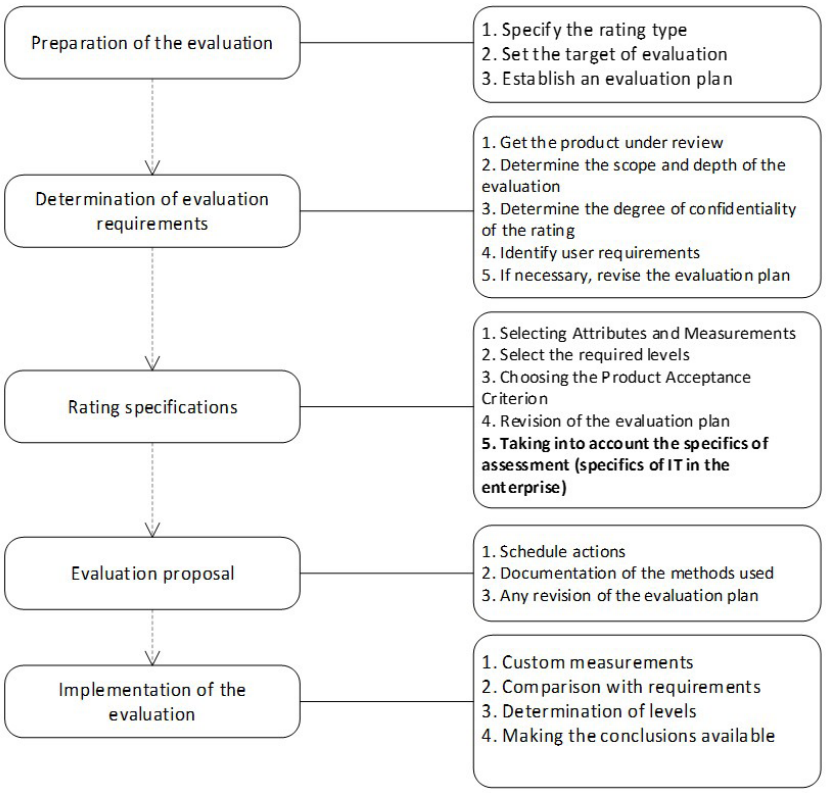

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Figure 1: Diagram of the reference model of the quality evaluation of a software product.

with a final evaluation comment on the individual parts of QIPAC and a radar chart.

An important difference is t at the application of the basic model of IT quality evaluation in an agriculturals must respect the proposed procedure as well as the specifics of information processes in agricultural company (Sorense et.al.,2010) and the availability of the evaluation of public services (Rysová et al.,2013). For this reason, the reference model used as the basis has been expanded with the specifics of evaluating ICT in an agricultural company (Vaněk et.al., 2011). This is a new feature that can be considered essential for the selected area of primary agricultural production.

The actual procedure of the evaluation of the quality of information processes in an agricultural company is shown in the Figure 2.

The procedure shown in Figure 2 should be interpreted as follows:

Horizontally: the top line shows the individual participants (identified by their role in the expert team) in the quality evaluation process; each of these persons is assigned certain activities (vertical).

Vertically: the individual stages of evaluation: Preparation, QME Identification, Development of a Model and Measurement Evaluation.

In order to apply the procedure evaluating the quality of information processes in an agricultural company, the following roles must be established:

Client – submits a request for an evaluation of quality (usually company management or owner)

Expert – understands in detail the issues of IT implementation in the specific agricultural company. In the group, the expert provides estimates that are used to develop the model.

Evaluator – applies the evaluation methodology in practice; is in charge of the entire quality evaluation process (as a relatively impartial and objective moderator)

User – user of IT components in the agricultural company who understands the issues in detail and has been appointed by company management to take part in the evaluation process (competent user).

Preparing the form – information and company specifics – QME selection – this is a **newly added**

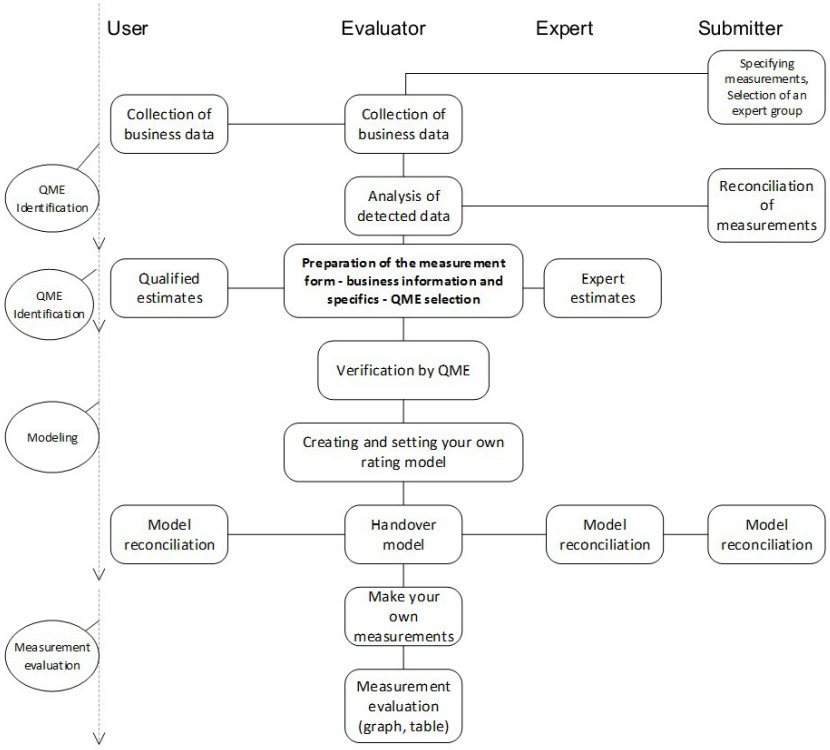

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Figure 2: Diagram of the evaluation of the quality of information processes in an agricultural company.

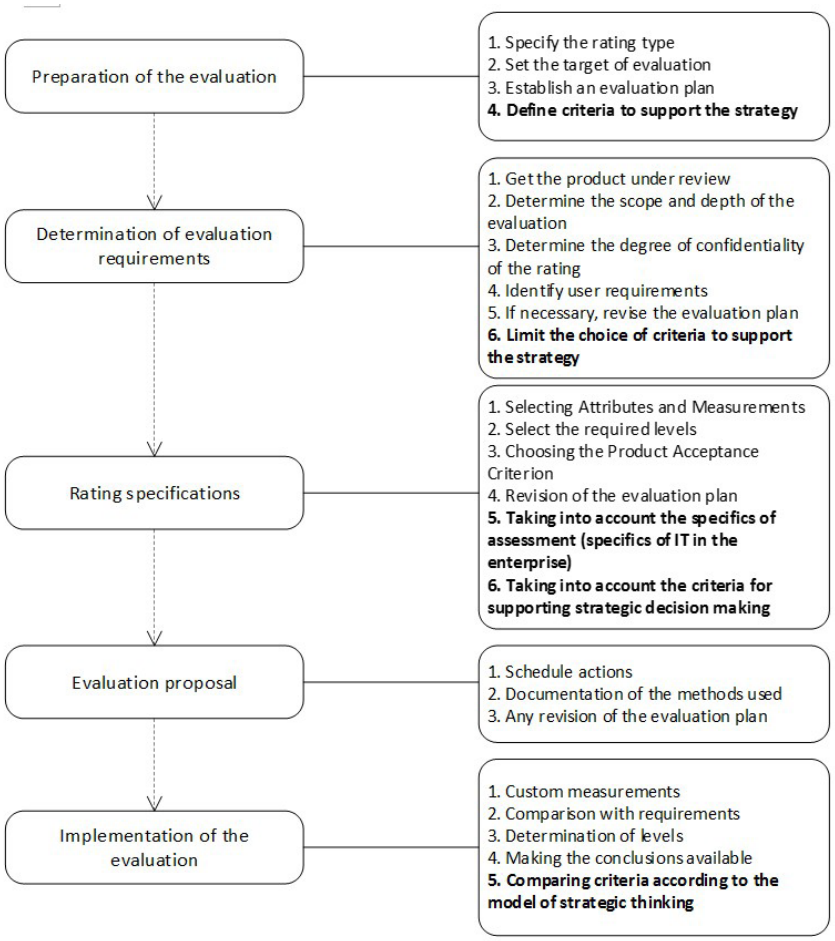
part to the reference model of quality evaluation applied in the "QME Identification" step.

The design of the model had to first decide on the form of the modelling (method and used tool) in order to describe the methodological procedure and its application in a SW tool (application prototype). To achieve flexibility and adaptability, we have decided to select from the three most widespread modelling languages as described by Kožišek and Vrána (2017): process-oriented BPMN, the most general UML and the event-driven process chain diagram, or EPC. We have selected a combination of UML (for user interaction, to capture the workflow and to map processes) and BPMN for a more detailed description of partial processes, using prepared data (controlling decision-making procedures in the decision-making tree based on the results of questions and user selection) in the workflow and a set of questions in the form of an Excel table that was imported directly into the database.

In further considerations of the future development of the methodological model and proposals for future research, we have decided to discuss a new variant of the model that would allow a closer look at the methodological approach in the selection of criteria. The objective of this variant is to not just evaluate the quality of information processes based on the requirements of individual sectors and typical factors of competitiveness, but also to view the issue from the perspective of the support of strategic development of a competitive position (see Figure 3). For further research, we proposed a solution that assumes the use of integrating software for strategic management and defined requirements that should be met by the methodological procedure (applied in the prototype application as the basic workflow) in the form of a succession of decision-making points in evaluation stages and nodes in the decision-making tree for a selected type of strategy. According to Vanderfeesten (2008), there is a certain similarity between a software programme and a workflow process.

The procedure shown in Figure 3 should be interpreted as follows:

The newly added elements in the evaluation of the quality of IT use and the quality of individual SW tools supporting strategies could be implemented in various ways. Either the expert team uses the methodology as guidance in asking questions, or also uses the SW application (still in prototype stage) to evaluate the newly added strategic decision-making support criterion. The basic principle of the application-supported evaluation



Source: own work

Figure 3: Diagram of a modified reference model for evaluating the quality of SW with support of strategic decision-making.

lies in the use of a pre-defined set of questions for all nodes of the decision-making tree and the evaluation of answers to determine whether the node is in line with strategy support or not. This could be partially implemented through an interactive form with no particular requirements for the time of the expert team. To ensure the questions give a clear picture of the situation and to simplify their formulation, various types of questions are used. The majority are binary questions allowing YES/NO answers (e.g. if the SW is purchased to perform activities that are not directly or indirectly mentioned in the company strategy, it does not support said strategy etc.). There are also multiple choice questions (allowing one answer) and questions asking for clear symptoms of a certain phenomenon (e.g. the amount of dead capital is a symptom of low adaptability of a strategy; a low degree of innovation in licensed SW is a symptom indicating that the strategic position of a company with respect to competitors will not improve etc.).

The final summary is, at this stage of development, left to the competence of the expert team. It is however recommended to include from all the 32 decision-making nodes at least the key elements of strategy support in the workflow, namely: *character of a strategy, existence of a vision, adaptability, uniqueness, thinking, efficiency and verification (or verification metrics)* (Štůsek, 2008; Morris and Gotel, 2012). .

Figure 4 illustrates the methodology procedure for evaluating strategy support criteria in the form of a snapshot of the structure of data used to fill in the workflow map in the application prototype. The set of questions for individual nodes is extensive and represents a knowledge base open for modifications based on the needs of the expert team. The team is responsible for adapting the questions to the situation in the company. For example the question concerning a mainframe can be reformulated and extended to the entire backbone infrastructure, use of the cloud, outsourcing etc.

Model	Model variant	Model code	Model identification	Strategic thinking model
Decision-making tree	1	STM	Strategic thinking model	
Model variant	**Type of strategy (submodel)**	**Type code**	**Type identification**	
STM	1	SHORT	short-term strategy	
STM	2	MEDIUM	medium-term strategy	
STM	3	LONG	long-term strategy	
STM	4	CONTINUOUS	continuous strategy	
STM	5	POSITION	position strategy	
STM	6	KEY	key strategy	
STM	7	INTEGRATED	integrated strategy	
Model component	**Decision-making phase**	**Phase code**	**Phase identification**	**Workflow (link to previous phase)**
STM	1	STRUCTURE	Basic documentation – describing the structure of the general model	0
STM	2	OPTIONS	Landing dialogue of the application – selecting options corresponding to the issue that the user is trying to resolve	1
STM	3	METHODOLOGY	A framework methodology covering the process from the start of the problem until it is resolved (achieving a long-term competitive strategic advantage)	2
STM	4	PROBLEM	Support of decision-making in the definition of the problem (checking compliance of the user's approach with methodology)	3
STM	5	SOLUTION	Support of decision-making in the process of resolving the problem (checking compliance of the user's approach with methodology)	4
Corresponding phase (workflow)	**Decision-making node**	**Node code**	**Node identification**	**Workflow (link to previous phase)**
STRUCTURE	1	PROJECT	Description of the structure of methodological models in a project	S
STRUCTURE	2	MODEL	Description of the structure of the general model	S
STRUCTURE	3	PROTOTYPE	Description of the structure of specific models in the application – prototype 3a	S
OPTIONS	4	USERS	Selection of user type (manager, student, stakeholder)	O
OPTIONS	5	MODES	Selection of options (modes of operation) from the programme branches	O
OPTIONS	6	SELECTION	Selection of options: a) verification of a proposed solution, or b) search for a new solution	O
OPTIONS	7	OFFERS	Selection of offers prepared for specific models	O
METHODOLOGY	8	MOTIVATION	Methodological guidance towards the realisation of the impact motivation has on style of work, progress and result	M
METHODOLOGY	9	MISSION	Methodological guidance towards the realisation of the mission of a company and a personal mission	M
METHODOLOGY	10	VISION	Methodological guidance towards expressing the vision of a company's future position and role	M
METHODOLOGY	11	INTENTIONS	Methodological guidance in the transformation of a vision into objectives	M
METHODOLOGY	12	CONCEPT	Methodological assistance in discussions concerning the conceptualisation of objectives and possible approaches	M
METHODOLOGY	13	OBJECTIVES	Support in the formulation of the basic ideas, intentions and approaches to define a framework objective – key problem	M
METHODOLOGY	14	MAPPING	Definition of the broadest possible scope of activities where the process of solving the key problem could start	M
METHODOLOGY	15	LOCALISATION	Support in the definition (targeting) of narrower potential opportunities for strategic competitive development	M
METHODOLOGY	16	DEFINITION	Support in the conversion of localised potential opportunities into a standardised form	M
METHODOLOGY	17	SPECIFICATION	Support in the process of expanding the definition with partial objectives, directions and procedures	M
METHODOLOGY	18	VARIANTS	Support in the definition of all conceivable variants of the proposed strategy	M
METHODOLOGY	19	EVALUATION	Support in the analysis and optimisation of all variants – mechanism selecting the best variants	M
METHODOLOGY	20	DECISION-MAKING	Support of the standard procedure for selecting a final variant of the strategy	M
METHODOLOGY	21	VERIFICATION	Support of a consistency check between the solution, the original vision and implementation possibilities	M

Source: own work

Figure 4: Illustration of the procedure for evaluating strategy support criteria in the form of a snapshot of the structure of data used to fill in the workflow map in the application.

We have concluded that a suitable SW tool of this type that would support strategic thinking is very necessary for current practice. However, the research required for the development of this tool must, in our opinion, also emphasise other attributes (integral properties) of the strategic thinking model that are essential for implementation in practice. In terms of SW quality requirements, the main attribute is interactivity. Interactivity is therefore (in the strategy design and verification process) provided in the logic of a dynamic selection of questions based on context, the result of previous answers and (in the ex-post evaluation of a finished strategy) the availability of a what-if analysis.

2. Preparation – collection and analysis of data for model parametrisation

Measurement brief – the actual task given by the management to evaluate the situation and create an environment for the evaluation. Selection of the experts who will carry out the measurement.

Collecting data on the company – the evaluator together with the user identifies problematic aspects of IT in the agricultural company based on objective and subjective findings; examples include poor economic performance, information processes that are insufficiently linked to one another or doubts about proper functioning of the IT system in the company coming from the management (owner, director). Data collection is not limited just to these issues, but involves a description of all factors related to IT in the agricultural company. The examination itself has the form of a directed interview which is recorded in a structured format.

In the modified variant (that includes the criteria of strategic decision-making support), there are also additional questions concerning symptoms that aim to determine whether the issue lies in the development of a strategy or its implementation – in other words, whether the issue is strategic or not. If an integrating SW is used, the procedure follows the workflow of the application (interactively using the methodology in a decision-making tree); otherwise, a directed interview is carried out using the same methodological diagram.

Analysis of obtained data – identification of objective and subjective reasons for the evaluation of the IT environment in the agricultural company and an analysis of the structured output. The next stage in this step is approval of the measured results by the management, obtained by the evaluator. If the need to measure the quality of information processes in the agricultural company is not clearly stated, then there is no reason to perform any measurement. Should this situation occur, for any reason, there is no point in starting the measurement process.

If integrating SW is used, the requirements listed in the previous stage also include support of strategic decision-making. Should the result be negative,

the expert team may continue in the evaluation with the caveat that the SW is not primarily intended to support strategic decision-making in a company.

QME Identification

Preparing the measurement form – based on the outputs of the analysis, a form is created that includes the aspects of quality measurement. The creation of the form uses the basic QME set from the ISO/IEC 25021 standard and the results of the performed analysis. The next activity in this stage, i.e. the stage of discussions in the expert team (consisting of the user, evaluator and expert), is to propose and verify etalon values in the model.

3. Creation of the model – parametrising the model based on real conditions

Verification of identified QME – the evaluator verifies elements of quality measurement (QME) by comparing them with data about the company and the real state of IT processes in the agricultural company. The results are used to specify the requirements for adding more necessary characteristics and metrics to the quality levels.

Creation and set-up of a model – based on the previous verifications, the evaluator selects characteristics and sub-characteristics and assigns selected metrics.

Handover of the model – the model is approved by all involved parties (the entire expert group).

The measurement itself – the evaluator carries out all the pre-defined measurements by filling in the tables that are part of the model.

The measurements must be performed accurately and objectively within one time period.

The obtained values must be carefully recorded in the measurement evaluation table.

If the strategic decision-making support methodology is used in the form of the decision-making tree that enables performing an interactive what-if analysis, its conclusions are added to the other quality criteria.

Evaluation of the measurement – the evaluator performs the evaluation in the form of a radar chart and an evaluation table, supported by written comments on the results of the measurement. This article provides the example of one measurement evaluation (due to length constraints, this example does not include the strategic decision-making support criterion).

4. Case study – verification of the model in practice

The case study verifying the model and the procedure for evaluating the quality of the information environment in an agricultural company was carried out in farms engaged in primary agricultural production at a size not greater than 1,000 ha, following the defined limitations.

The participants were selected randomly; they were informed in detail about the model and the procedure aiming to evaluate the quality of their information processes as well as its purpose. They were also asked to be as objective a possible while carrying out their evaluations performed to verify the model. Before the measurement itself, the procedure was approved together with the client who ordered the evaluation and an expert group was selected. The evaluation was anonymous and followed an original methodology created exclusively for this research.

5. Case study – results of the evaluation of the quality of information technology in an agricultural company

The following part provides a selection of the resulting values of attribute metrics used in the case study of the evaluation of the quality of information processes in an agricultural company (tested company TC1). For the case study, 30 agricultural companies were contacted in total, and 5 agreed with the evaluation of their information environment (performed through measurement); the results have been recorded in tables. Every measurement in this research was evaluated separately (table of calculated values, resulting chart).

The interpretation of the results of each measurement (calculated values, charts) is expanded with written comments on the overall evaluation of the information environment in the agricultural company.

Tested company 1 (TC1)

The evaluation used the full scale of results obtained in this research of primary agricultural production.

Question	Value	Answer
Acreage?	ha	820
Engaged in plant production?	yes/no	yes
Engaged in animal production?	yes/no	no
Number of people working with a PC?	number of persons	6
Connected to the internet?	yes/no	yes
Receives subsidies?	yes/no	yes
Which accounting system do you use?	name	Premier
Are you planning to invest in production technology at your company?	yes/no	yes
Are you planning to invest in production and storage areas?	yes/no	yes
Are you planning to invest in human resources?	yes/no	yes
Are you planning to invest in information technology – modernising HW?	yes/no	yes
Are you planning to invest in information technology – innovating company IS?	yes/no	yes
Are you planning to invest in information technology – investment in SW used in production?	yes/no	yes
Are you planning to invest in information technology – investment in office SW?	yes/no	no
Is the deciding factor in investment planning the company's budget?	yes/no	yes
Do you evaluate your return on IT investment?	yes/no if so, state how	yes – the system must be efficient
Who decides on IT investment (director, owner, chairman)?	position	owner
What is the impact of information technology on the fulfilment of the company's objectives?	Select an option from A, B or C	B
A – essential		
B – only a necessary technological solution		
C – no impact		

Source: own work

Table 1: Identification of the agricultural company where the evaluation of the quality of information environment (IE) was carried out.

	Question	Values	Metric	Answer
1	Is your IS and its parts useful and beneficial in meeting the company's production needs?	0 % – the system is not very useful 50% – the system is useful 100% – the system is very useful	insert %	70
2	Does your information system support the functions necessary to enable your company's production processes?	% – the system supports most or all of the necessary functions 50% – the system supports only some of the necessary functions 100% – the system supports few of the necessary functions	insert %	50
3	Does your system support other functions suitable for your business processes beyond the scope of what is necessary (used e.g. in company development)?	0% – the system supports most or all of the other functions 50% – the system supports only some of the other functions 100% – the system supports few or none of the other functions	insert %	60
4	Is your system compatible with other systems (special SW outside the company's main IS in individual operations, e.g. plant production, animal production, precision agriculture etc.)?	where n is the number of systems working alongside the main company IS max. (n) is the number of all systems in the company	insert number	n = 4 n (max) = 10
5	Does your system allow data transfers to and from other systems (XML, WMS, CSV)?	0% – the system does not enable open communication 50% – the system enables open communication only when further SW modification and development services are purchased 100% – the system enables open communication	insert %	100 %

Source: own work

Table 2: Questions for the evaluation of the information environment in an agricultural company (IE) (to be continued)

Question		Values	Metric	Answer
6	Is documentation for your IS available to end users?	0% – documentation is not available 50% – information has the form of initial training or the option to contact helpdesk and support 100% – documentation is fully available	insert %	100 %
7	Is your system easy to use for end users?	0% – the system is not easy to use 50% – the system is not particularly easy to use 100% – the system is easy to use Etalon 50 %	insert %	100 %
8	How many steps (clicks) does it take to issue an invoice?	where n is the number of steps to issue an invoice max. (n) is the highest number of steps in your system stated by the manufacturer (seller) in the documentation	insert the real number of steps n and n (max.) from manual or support	n = 5 n (max.) = 5
9	Measuring error rate (in SW operation – e.g. wrong printout, wrongly edited characters, wrong calculation etc.) in standard operation (8 h).	0 errors (n = 5) 3 errors or fewer (n = 4) 6 errors or fewer (n = 3) 10 errors or fewer (n = 2) more than 10 errors (n = 1)	insert number of errors	1
10	Is your system's external communication secured (e.g. using a password, communicating under a security protocol, firewall settings etc.)?	0 % – the system is not safe 50 % – the system is not very safe (there is a security issue) 100 % – the system is safe	insert %	100
11	Number of security incidents (e.g. in communication with a bank, farmer portal etc.) in the last 12 months	0 % – the system is not safe (there was a security incident) 100 % – the system is safe (there was no security incident	insert %	100
12	Is it possible to update your system based on: 1) external factors, such as new legislation (finance) 2) communication with another system within the company – e.g. when extending production?	100% – the system supports updates of external and internal factors 50% – the system partially supports updates of external and internal factors 0% – the system does not support updates of external and internal factors	insert %	100
13	How old is your central PC used for IE?	excellent – less than 2 years (n = 3) good – less than 4 years (n = 2) insufficient – 4+ years (n = 1)	insert age – years	3
14	CPU (processor) performance – measured with the Benchmark tool	80 % – Core i3 (or equivalent) 100 % – Core i5 (or equivalent) 120 % – Core i7 (or equivalent)	insert %	100
15	RAM (system memory) capacity – measured with the Benchmark tool	4 GB – RAM capacity (n = 1) 8 GB – RAM capacity (n = 2) 12 GB and more – RAM capacity (n = 3)	insert %	50
16	What is the highest achieved education of the IE user in your company?	1. vocational (n = 1) 2. certificate of apprenticeship (n = 2) 3. secondary school (n = 3) 4. tertiary school (n = 4)	insert number	4
17	Do you take part in ongoing education (training) to ensure high quality of IE operation?	1. every course (n = 5) 2. most courses (n = 4) 3. only the most important courses (n = 3) 4. irregularly (n = 2) 5. never (n = 1)	insert number	1

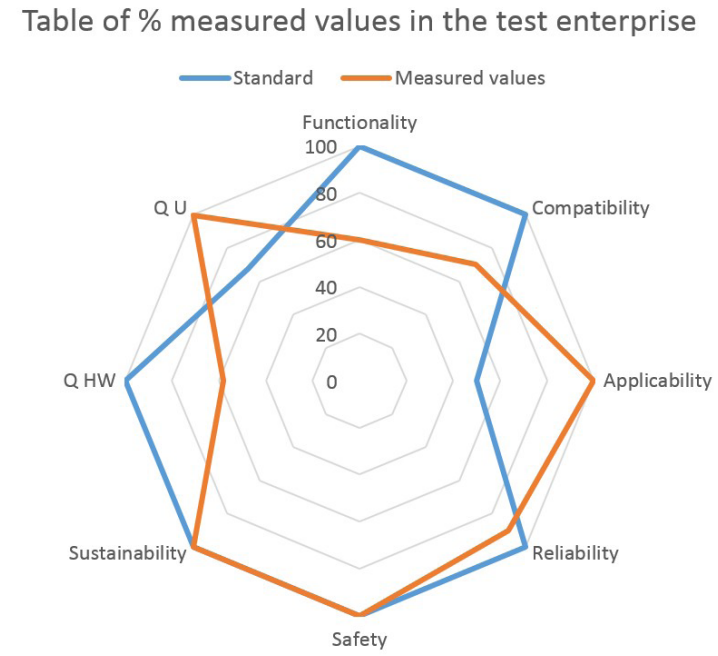
Source: own work

Table 2: Questions for the evaluation of the information environment in an agricultural company (IE) (continuation).

	Quality QSW						QHW	QU
	Functionality	Compatibility	Applicability	Reliability	Safety	Sustainability		
Standard	100	100	50	100	100	100	100	67.5
Measured values	60	70	100	90	100	100	58	100

Source: own work

Table 3: Table of measured % values in the tested company 1 (TC1).



Source: own work

Chart 1: Chart of measured % values in the tested company 1 (TC1).

Overall status evaluation QIZP		
QSW	**QHW**	**QU (user)**
Rating good	Rating good	Rating excellent

Source: own work

Table 4: Overall evaluation of the quality of information processes in the agricultural company TC1.

6. Case study – interpreting the results of the model

Interpretation of the state of QIPAC – comments and suggestions for improvement of the determined state (TC1)

QSW criteria:

Functionality – in terms of functionality, it is recommended to more extensively use the support of the developer/vendor of the company's main IS to better understand how it can be used in a broader scope in the company and better match the structure of production.

The farmer's statement: we only use some simple modules.

Compatibility – the values of this characteristic are relatively low, mainly because the main IS does not communicate with most other systems.

This is not merely a fault of the main IS, but the other systems' lack of communication features as well.

There is significant room for improvement here. In the other characteristics, the results of the measurement do not indicate the need for any changes.

Criteria: QHW – Improvement was not necessary at the time of evaluation, but the purchase of new HW will be necessary within 2 years.

Criteria: QU – Improvement was not necessary at the time of evaluation (education level – a university degree in a related field).

Interpretation of the overall state of QIPAC – comments and overall evaluation of the state of information processes in the agricultural company TC1

In the area of investment linked to the development of the information environment directly related to production in an agricultural company, the company is planning to invest and, which is a positive finding, is planning to invest in human resources – users of IT in the agricultural company. The company's approach to IT is however not ideal, as it sees the impact of IT on the achievement of its objectives as a "necessary technological solution".

Based on the defined model, procedure and the implemented case study evaluating the quality of information processes in the agricultural company, it was determined that the model is useful and easy to understand for the evaluator.

Conclusion

It has been established that in contemporary primary agricultural production, particularly in the case of small farms, not enough emphasis is placed on maximal possible use of information systems and IT in the broader context of information processes in agricultural companies in general. In other analysed companies, the results (differences against etalon values) were even more pronounced.

When selecting and specifying the objective of our research, we started with the state that we had encountered in our earlier research and practical collaboration with agricultural businesses.

The efficiency of the use of IT is poor, or, to be more accurate, very different and varied. Partial problem areas or controlling technology (lines, sensors, animal feeding systems, data gathering and collation etc.) and database and information sources are generally at a relatively high level of quality, but for example expert knowledge systems rarely support strategic management. Systems managing plant protection and nourishment are typically also excellent, but our experience from smaller farms indicates they are not used because they are too complicated and not seen as suitable for typical practical situations.

As an example, we could mention a moment from a case study in which a small farmer, based on the results of leaf analysis, uses cheaper combined fertilisers (the limiting factor being nitrogen which is used as per need) and before stock fertilizing needs to know the balance of nutrients including the impact of nutrient loss (caused by the removal of the crops from the field, washed away or tied to the soil complex) in order to optimise stock fertilizing and implement it as additional fertilizing, thus significantly reducing costs compared to competing large companies; as an additional effect, this would improve yields and help conserve the environment. Being given this task, we started looking for software that would contain an expert knowledge base including optimisation curves that could be linked to the results of soil and plant analysis on the site, but could not find any.

The reason for this situation is that neither the systematic and holistic view of partial processes in for-profit companies, nor strategic management are very well understood by SMEs (and, it seems, by software developers) as a path leading to a more certain future. In large companies that have the capacity and the means and are subjected to greater pressure by the owners (even though the managers may of course be sometimes wrong), the situation is better, but the more complex situation also means that it's difficult to trace back any errors to their root causes.

From the perspective of strategy support, we have concluded that every information system that is to efficiently support a company's strategy must on the one hand be able to implement (bring in from the outside) good practice and principles of strategic decision-making into the process of creating and implementing a business strategy, forcing the company management to utilise experience and best practices described in theory and practice. On the other hand, however, such information systems, including individual SW tools, must undoubtedly also allow the inclusion of good practice and know-how of the company's own management, as this knowledge is specific to the company itself and as such irreplaceable.

Of course there is software on the market that meets generally accepted methodology standards. This, however, is just looking at the issue from the perspective of prerequisites. In terms of the requirements for the information system, the entity guaranteeing its quality is the company management itself; key role is then played

by the management's ability to navigate the offer of software useful for the support of strategic and operational decision-making. A large proportion of the software that the company IS connects to or uses directly (sometimes free of charge) is deployed because of other entities such as ministries or non-governmental institutions (e.g. the agriculture portal agris.cz or an application maintaining records of land use and matching subsidies etc.). In the case of these entities, an analysis of information systems, both mandatory and optional, in smaller farms shows that a targeted support of strategic management is practically non-existent. And where it does exist, it's usually a strategy that is more beneficial to suppliers and consumers. For this reason, we have decided to conclude this article with recommended requirements that should be taken into account by everyone who influences the practical usability of software that improves the competitiveness of agricultural companies and optimises their strategic decision-making. The list of some of the recommendations drawn from the research is as follows:

- The proposed model and its methodology enable objective evaluations of the quality and use of information technology and processes in an agricultural company. It covers the quality of software, hardware and computer literacy of users (QSW, QHW and QU).
- It has been confirmed that a well configured information environment in an agricultural company can support its competitiveness. This competitiveness must be perceived in a long-term context taking into account the structure and character of agricultural production in the company.
- We recommend applying the model once a year with respect to proposed changes in legislation and ICT development. The methodology also includes a process for evaluating quality which was in the "Specification of the evaluation" step extended with a new important item – "Taking into account the specifics of information technology in an agricultural company".
- The outcomes of the research include also conclusions and recommendations of requirements that should be taken into account by everyone who influences the practical usability of software that improves the competitiveness of agricultural companies and optimises their strategic decision-making.
- IT tools and processes in the company must be directly linked to production and business processes in compliance with all security standards.
- Each part of the information system of an agricultural company should have a clearly defined role and especially inputs and outputs.
- The added value should lie in a specific tangible benefit for the company's competitiveness and the ability to support easier strategic decision-making while developing a long-term strategic competitive position.
- The information environment in an agricultural company must allow clear, transparent and unambiguous interpretation of data.
- The knowledge level of the users must correspond to the general requirements to ensure that use and control of the technology is efficient and the outputs useful; at the same time, it is important to stress the need for user-friendliness wherever possible and wherever it has an impact on efficiency (intuitive interfaces, reducing data redundancy, maximum automation of data entry and outputs to reduce user workload, advanced verification and validation systems, rapid response, visualisation of results, minimisation of steps, ergonomy…).
- This must be supported by the management of the agricultural company in the deployment and innovation process and continuously for the entire time in which the system is deployed at the company.

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Analytical System with Decision Tree for Economic Benefit

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Abstract

Data processing is an important aspect of business decision support systems (DSS). A good analytical system to process these data is essential to implement as a primary pillar for the development of complex expert systems. Businesses themselves are constantly confronted with deciding on investment opportunities to improve their performance. An important criterion for selecting investment is its profitability which cannot be easily determined when investing in analytical systems. Currently, there are two types of approaches to evaluating investments into information systems: normative and positive approaches. The simplest form of decisional analytical modeling is the decision tree (normative approach). The purpose of the article is to illustrate decision tree analysis as a component of an analytical system for evaluating two decision alternatives. The test case is demonstrated on an example of decision-making in agriculture.

Keywords

Analytical system, decision tree, decision rules, economic value, agriculture.

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Introduction

Farmers face a large number of day-to-day decisions about a number of activities linked to their production (animal changes, material shifting, land maintenance and planning, veterinary checks, etc.) and investment decisions (purchase and sale of animals or produce, modernization of buildings, stables or machines etc.). In connection with this necessary decision-making activity of the owners of agricultural companies, there is a need for the use of analytical systems, allowing for interactive and flexible data analysis (for example in relation to the evaluation of the current development of performance according to various aspects and time series) and on the other hand on agricultural activities.

The investment costs of analytical systems (i.e. hardware, software, and to a certain extent personnel costs) are represented by the market price. However, the actual benefits of the system (i.e. the effects of an analytical system on agricultural business performance) cannot be expressed in this way. The field of economic evaluation of systems is a non-trivial problem, which is well described in the study (Verstegen et al., 1995). In general, there are two approaches to assessing the economic value of information systems: a normative and positive approach. Normative approaches are based on decision making by means of theoretical (etc. decision tree analysis (Lahtinen et al., 2017), Bayesian information economics (Kleijnen, 1980)) or analytical approaches (etc. simulation or linear programming). Positive approaches are based primarily on experimental designs (time series, econometric modeling).

An objective approach to assessing the economic benefits of analytical systems is to use a measure that identifies the evolution of the revenues from the analytical system. Such information may be useful not only for farmers who are considering investing in a new analytical system but also for companies that design and sell these systems.

Analytical system

Analytical systems serve to support strategic decision making and to reveal hidden information to easily understand and anticipate user needs. The analytical system generally consists of three layers: the layer for data transformation (Extraction-Transformation-Loading (ETL) tools (Zekri et al., 2017)), the data storage layer (data warehouses, data markets and operational databases) and a layer for analytical data processing. Currently the most advanced types of analytical systems are systems for on-line analytical data processing (OLAP) (Wrembel, Koncilia, 2007), which are used in Business Intelligence (Rouhani

et al., 2012, Tyrychtr and Vasilenko, 2015). Ways of storing data in analytical systems can be solved by designing so-called multidimensional databases. Multidimensional databases (Pedersen and Jensen, 2001) are suitable for storing (multidimensional) data of analytical type, over which analyzes and overviews are used most frequently for self-decision. The term multidimensional data represents the data of aggregate indicators generated by different grouping of relational data designed for OLAP. OLAP describes a decision support approach that aims to gain knowledge from a data warehouse or data markets (Abelló and Romero, 2009). The very way of organizing data in multidimensional databases is solved through a construction of a data cube. Data cube is a data structure for storing and analyzing large amounts of multidimensional data (Pedersen, 2009). The data cube represents an abstract structure, which, unlike the classical relational structure in the relational data model, is not defined unambiguously. There are many approaches to the formal definition of data cube operators (a comprehensive overview is available in the post (Vassiliadis and Sellis, 1999)). In general, the data cube consists of dimensions and measurements. Dimension is a hierarchically ordered set of dimensional values that provide categorical information that characterizes a particular aspect of data (Pedersen, 2009b). Measurements (monitored indicators) of the cube are primarily quantitative data that can be analyzed.

Decision support system

From analytical systems it is possible to load aggregated or summarized data for further processing in decision support systems (DSS), (Burstein and Holsapple, 2008). Currently, DSS consists of a range of decision support applications or technologies such as model and data-oriented systems, multidimensional data analysis, query and reporting tools, online analytical processing (OLAP), Business Intelligence, document management, spatial DSSs, and executive information systems. All of these technologies and applications are designed to support decision making. However, the main characteristic of DSS is that it provides users with options for decision-making.

Expert system

Expert system (Wagner, 2017, Ugolnitskii and Usov, 2008) represents the knowledge base of control models that can be conditionally divided into two parts. In the first part is the known information from already existing control models (subsystems). This section includes a database of predictions of specific situations obtained using a pre-created scenario. The second part of the expert component uses information, models and expert-type data based on the knowledge, experience and intuition of experts. This section should constantly get new data.

Current state and motivation

Principles of decision trees are generally known from a number of areas. The way of representing knowledge in the form of decision trees is a clear and easy to interpret way of analyzing data. The goal of decision trees is to identify objects described by different attributes into classes. They do not require any special data preparation and process both categorical and numerical variables. Trees are relatively easily able to find non-linear relationships between input attributes. The result of the analysis is a graphically illustrated tree that can be, as a rule, easily interpreted. The algorithm of the decision trees method determines which attributes are key and which, on the other hand, do not matter and it is appropriate to drop them from the model. This property can be used to select dimensions when designing an OLAP database (Shmueli et al., 2017). Most commonly decision tree methods are used within Data Mining in Business Intelligence (Vercellis, 2011; Shmueli et al., 2017). However, these methods are currently neglected in some areas.

An example is the agricultural sector. For example, the survey of state of Business Intelligence in agriculture in the Czech Republic (Tyrychtr et al., 2015) shows that the level of use of analytical systems is rather marginal (1% of agricultural entities use an analytical system). At the same time, the results of the analysis of the current state of information needs in agriculture (Tyrychtr and Vostrovský, 2017) show that if the need for information on farms is higher, it also requires a higher level of ICT and DSS systems. Many of the farm problems that accompany these activities require timely and qualified decision-making. Given the high information needs in this sector, the farm management information systems (FMIS) must be able to use functions that are typical for expert and analytical systems and effectively support farmer's decision taking or their management. If a farmer decides to invest in analytical systems, it is essential that these systems support automated and easy-to-use analytical functions that are easy to interpret for his economic benefit.

The aim of the paper is to apply decision

tree principles as a potential functionality of the analytical system to be used in the agricultural sector to support decision making. If the analytical system serves to support the decision-making of the farmer's main activities with an impact on economic benefits, such a system can represent a significant economic value for an enterprise.

Materials and methods

In order to calculate the economic value of the analytical system, the principles of the decision tree are used by the author. When making a decision tree, the followed method is used "*divide and conquer*". The training data is gradually divided into smaller and smaller subsets (tree nodes) so that examples of one class predominate in these subsets. At the beginning, the whole training data consists of one set, at the end are subsets made up of examples of the same class (Quinlan, 1986). This principle is called *top-down induction of decision trees classifiers* (Rokach and Maimon, 2005).

For the choice of suitable attribute for the tree branching the attribute's characteristics are used (Berka, 2005): entropy, information gain, relative information gain, χ^2 or Gini index.

Entropy is the degree of disorder of a system and is defined as follows:

$$H = -\sum_{t=1}^{T}(p_t \log_2 p_t),$$

where p_t is the probability of occurrence of class t and T is the number of classes. If $p = 1$ (all cases belong into the class) or $p = 0$ (no case belongs to the class), the entropy is zero. If both classes are represented by the same number of examples ($p = 0.5$), the entropy is at its maximum.

The calculation of entropy for one attribute is done in the following way. For each value v, which may be assumed by attribute A is calculated according to the entropy formula $H(A(v))$ on a group of examples that are covered by the category $A(v)$

$$H\big(A(v)\big) = -\sum_{t=1}^{T}\frac{n_t\big(A(v)\big)}{n\big(A(v)\big)}\log_2\frac{n_t\big(A(v)\big)}{n\big(A(v)\big)}.$$

Medium entropy $H(A)$ is counted as a weighted sum of entropy $H(A(v))$, where the weights in sum are the relative frequencies of categories $A(v)$ in dat

$$H(A) = -\sum_{v\epsilon Val(A)}\frac{n\big(A(v)\big)}{n}H\big(A(v)\big).$$

The attribute with the smallest entropy is then selected for tree branching $H(A)$.

Information gain measures the reduction of entropy due to the choice of attribute A. It is defined as the entropy difference for the target attribute and for the considered attribute:

Gain(A) = H(C) - H(A),

where

$$H(C) = -\sum_{t=1}^{T}\frac{n_t}{n}\log_2\frac{n_t}{n}.$$

Relative information gain also takes into account the number of attribute values and is defined as follows:

$$Gain\ ratio(A) = \frac{Gain(A)}{Furcation(A)},$$

where

$$Furcation(A) = \sum_{v\epsilon Val(A)}\frac{n(A(v))}{n}\log_2\frac{n(A(v))}{n}.$$

Data set

For the model example the data of a farmers in the Czech Republic is used. In the context of their agricultural activity they records the decision to sell or dispose of cattle in the Farmer's Portal information system operated by the Ministry of Agriculture of the Czech Republic. All data about movements of animals in the farm are recorded in the Register of animal (IZR). Specific data values are not significant for design decision tree principles as a potential functionality of the analytical system. This dataset from IZR is simplified for the clarity of the decision tree induction algorithm. In table 1 the data is stated without numerical attributes.

Cow	Age	Weight	Sex	Disease	Sale/Transfer
c1	high	high	cow	no	yes
c2	high	high	bull	no	yes
c3	low	low	bull	no	no
c4	low	high	cow	yes	yes
c5	low	high	bull	yes	yes
c6	low	low	cow	yes	no
c7	high	low	bull	no	yes
c8	high	low	cow	yes	yes
c9	low	middle	bull	yes	no
c10	high	middle	cow	no	yes
c11	low	middle	cow	yes	no
c12	low	middle	bull	no	yes

Source: own work

Table 1: Data for creation of decision tree.

Results and discussion

In this section, the concept of the analytical system is designed by the author and a test example is created with the decision tree induction procedure. The result is the identification of the economic value of the analytical system for the enterprise.

Concept of analytical system

The relationship between the analytical system, the DSS and the expert system can be represented in the form of a pyramid (Figure 1). Within the analytical system, data is analyzed by means of summarizations, aggregations and filtrations. New data sets are created presenting important data from different points of view. This data enters the DSS to create various variants of monitored data - reports, dashboards, and various multidimensional reports to support decision-making. The last part of the pyramid is an expert system which, on the basis of the analyzed and processed data and information, will allow the user, based on already recorded knowledge, to provide expert evaluation of variants and prediction assessment.

Decision theoretical approaches

An analytical system that enables to efficiently analyze data through data mining methods can help increase the economic value of a business information system. In the next section, the author has made the entire decision tree induction process.

These calculations are made from the data listed in Table 1. Four-column tables are created from this table. Table 2 shows the values for Age and Sale/Transfer.

	Sale yes	Sale no
Age high	5	0
Age low	3	4

Source: own work

Table 2: Four-pole table for Age and Sale/Transfer.

1. step: Selection of attribute for the tree root

Initially, all examples are in one set. The attribute selection for the first branching is in all 12 examples selected based on the calculation of entropy for the individual attributes. Entropy for the Age attribute is calculated from the data in Table 2, i.e.

$$H(age) = \frac{5}{12}H\big(age(high)\big) + \frac{7}{12}H\big(age(low)\big),$$

where

$$H\big(age(high)\big) = -p_+ \log_2 p_+ - p_- \log_2 p_- = -\frac{5}{5}\log_2\frac{5}{5} - \frac{0}{5}\log_2\frac{0}{5} = 0,$$

$$H\big(age(low)\big) = -p_+ \log_2 p_+ - p_- \log_2 p_- = -\frac{3}{7}\log_2\frac{3}{7} - \frac{4}{7}\log_2\frac{4}{7} = 0.985,$$

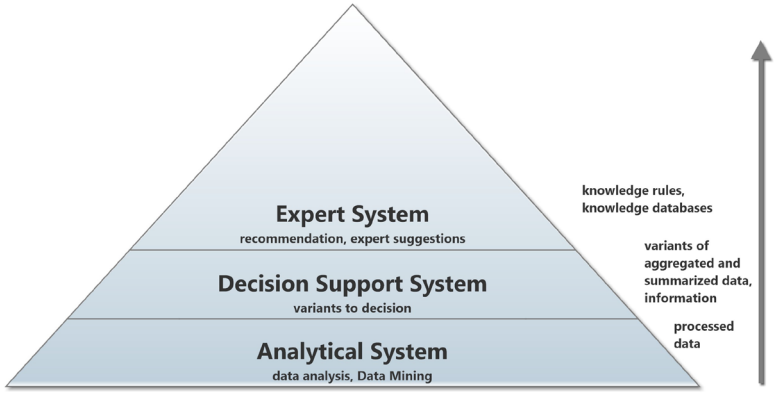
therefore

$$H(age) = \frac{5}{12}0 + \frac{7}{12}0.985 = 0.574.$$

The entropy for other attributes is counted similarly:

H(weight) = 0.667,
H(sex) = 0.918,
H(disease) = 0.825.

For branching of the decision tree, the attribute *Age* is selected. This way were obtained two subsets of data. The first subset are examples included in category *age(high)* and belonging to the class *sale(yes)*, examples covered by the category *age(low)*, belong to other classes for which other attributes will be sought. Meaning that will be look for attributes which belong to the class of low age. The entropy is again calculated, this time for 7 examples – cattle with low age.



Source: own work

Figure 1: The visualization of analytical system concept.

2. step: Selection of attribute for various classes

$$H(weight) = \frac{2}{7}H(weight(high)) + \frac{3}{7}H(weight(middle)) + \frac{2}{7}H(weight(low)) = 0.394,$$

$$H(sex) = \frac{4}{7}H(sex(bull)) + \frac{3}{7}H(sex(cow)) = 0.965,$$

$$H(disease) = \frac{5}{7}H(disease(yes)) + \frac{2}{7}H(disease(no)) = 0.979.$$

Cattle with low age will be branched according to the weight. Examples covered by category *weight(high)* belong to the class *sale(yes)*, examples covered by category weight(low) belong to the class *sale(no)* and examples covered by category weight(middle) belong to various classes for which additional branching will be needed.

Entropy will be calculated again for the remaining attributes sex and *disease*:

$$H(sex) = \frac{2}{3}H(sex(bull)) + \frac{1}{3}H(sex(cow)) = 0.667,$$

$$H(disease) = \frac{2}{3}H(disease(yes)) + \frac{1}{3}H(disease(no)) = 0.$$

It is obvious from the results that the attribute disease is chosen and till cover the rest of the examples.

3. step: Creation of tree

Based on the above entropy calculations for individual attributes, a decision tree is created (Figure 2). The tree nodes have attributes used for branching, tree leaves are class assignment information, and edges of leaves match attribute values.

4. step: Transfer to knowledge rules

Each tree path from root to leaf corresponds to one rule. The attributes appear in the rule's prerequisitive and the leaf node will appear in the action rule (the action rule will appear in the leaf node). Decision tree from Figure 3 can be rewritten as follows:

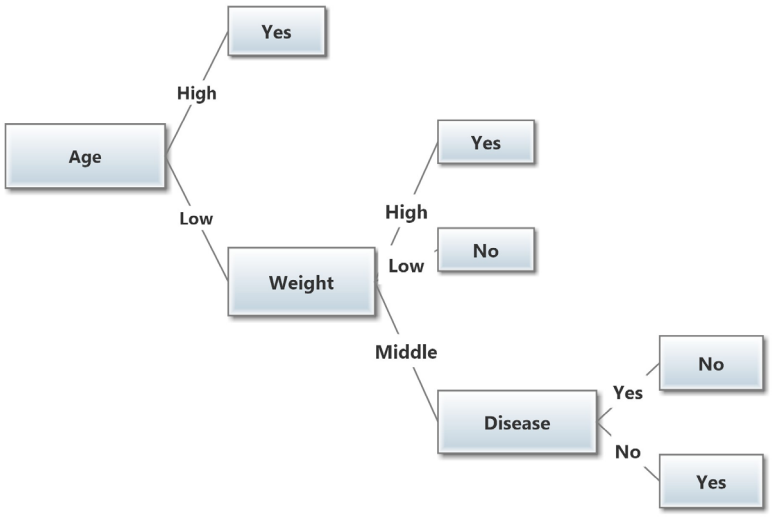
$IF\ age(high)\ THEN\ sale(yes)$
$IF\ age(low) \wedge weight(high)\ THEN\ sale(yes)$
$IF\ age(low) \wedge weight(low)\ THEN\ sale(no)$
$IF\ age(low) \wedge weight(middle) \wedge disease(no) THEN\ sale(yes)$
$IF\ age(low) \wedge weight(middle) \wedge disease(yes) THEN\ sale(no)$

Source: own work

Figure 3: From the decision tree to the rules.

Discussion

In this work was introduced the concept of an analytical system in the context of an expert system and a DSS type system. Emphasis was placed on presenting the potential of current analytical systems, which can be considered an important component for data processing in enterprises and organizations. Currently, these systems are characterized by principles based on OLAP technology. This has the potential to directly enrich these OLAP approaches via methods such as decision trees, Bayesian classification, and other statistical methods. The advantage of such a solution would be a complex analytical system, without the need to own more sophisticated tools for Data Mining such as statistical software, tools for working with neural networks etc. In this article was applied



Source: own work

Figure 1: Figure 2: The decision tree.

a simple method for classifying data - decision trees. Below author of this article assess the validity of the results achieved in this work:

The concept of the analytical system is based on the categorization and the possibility of differentiating the DSS system, expert systems and analytical systems. In literature, it is no exception that these systems are interchanged or form a common entity but mostly the DSS is usually discussed.

The example of the data model is selected from real business situations, but it is very simplified. The purpose was not to model the decision tree for a specific activity in organizations but to demonstrate how such a model could be useful in the analytical system.

For the development of the analytical system, the procedure was not translated into the algorithm. Algorithms of decision trees are generally known. However, it would be necessary to directly link them to the OLAP functional principles so that data from OLAP can be categorized directly through the decision tree.

Conclusion

In this article, author has been working on approaches that could improve the value of analytical systems in a business. The concept of the analytical system was designed by the author and a decision tree was created from the example data of agricultural decisions. The result was the identification of the economic value of the analytical system for the enterprise.

These systems can easily help company management interpret data analysis from which it is possible to gain relevant knowledge about their economic performance. Through an analytical system using a simple decision tree method, the user can choose to sell (in this case livestock) or some other action important to the business or organization. A correct decision e.g. concerning sales, represents an economic benefit for the users of the analytical system in the form of a per piece payment.

The example presented in this article demonstrates the importance of introducing these methods into analytical systems solutions. The purpose is to make decision trees and other methods directly part of these systems. If analytical systems directly incorporate functionality for classification and further data processing, it is possible to clearly define the economic benefits of such a system for an enterprise. The proposed approach provides system engineers with a methodological framework for designing the OLAP system, respectively structures of multidimensional databases. Because similar research has not yet been carried out, the results and benefits of this article offer new insights into the development of analytical systems.

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