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Application of System Thinking Approach in Identifying the Challenges of Beef Value Chain

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Abstract

In this study, the system thinking approach was used to explain the challenges of the beef value chain in Mashhad, Iran. Due to the complexity of the system and its dynamic nature, rich picture and CATWOE analysis were used to structure the problem. After structuring the problem, the relationships between the chain actors were drawn in the causal loop diagram. Then, the system archetypes were identified. Results showed that the dynamics of this value chain could be explained by limit to growth, fixes that fail and shifting the burden archetypes. The results indicated that the beef import policy has not been effective to regulate the domestic market. Also, it can be concluded that beef cattle production in Mashhad is largely dependent on sustainable supply of livestock feed. So, enhancing cattle production requires policy making to increase availability of livestock feed. Therefore, it is recommended to plan for increasing its production through changing irrigation system and using early maturing and drought-tolerant varieties of corn.

Keywords

Value chain, beef, rich picture, causal loop diagram, system archetype.

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Introduction

In recent years, study on food value chain management has attracted the attention of many researchers (Zarei et al., 2011). Responding to changing consumer demand for food, is only possible through agri-food value chain management (Naik and Suresh, 2018). The value chain of food is important to achieving food security in national and global policies (Neven, 2014). Investigating the challenges in the path of production and distribution of agricultural products requires recognizing the value chain, due to the importance of gaining competitive advantage and increasing the income of the actors. By identifying the strengths and weaknesses of the food value chain, policymakers and planners will be able to improve the efficiency of the value chain.

While patterns of food consumption have changed over time, meat remains a main meal component for consumers (Grunert, 2006). The major source of meat production is cattle. About 45 percent of the value added of agriculture is related to livestock and about 3 million people are directly involved in the livestock sector in Iran (Fatemi and Mortezaei, 2013). Consumption of red meat in Iran, particularly in rural regions and in low-income groups compared to developed countries, is undesirable (Rahimi et al., 2014). The average global per capita consumption of red meat is about 30 to 45 kg (FAO, 2015), whereas the per capita consumption of red meat in Iran is about 12.5 kg (FAO, 2016). However, the desired consumption of red meat in the 2025 horizon is considered to be 20.39 kg in Iran (Ebadi, 2015). The instability and fluctuations in the price of red meat and livestock feed have led to reduced domestic production and increased imports (Alijani and Saboohi, 2009). Based on the Ministry of Agriculture Jihad (2007), one of the most important factors influencing the price increase of red meat is the animal feed. Iran import of animal feed is about 3 billion dollar

every year (Iran feed industry association, 2017). Corn is the first imported product of Iran and is one of the most important items of livestock input, which due to low domestic production, considerable amount of it is imported every year (Ghasemi, 2016). Iran's economy is centrally planned, based on five year plans. It is specified by a large hydrocarbon sector, small scale private agriculture and services and significant government presence in large manufacturing and finance sectors (World Bank, 2010). Iranian government supports the agriculture sector in a several ways. For instance, the government allocates subsidized foreign currency to import forage like corn every year in order to decrease prices. Also, the government supports the consumers with allocating subsidized foreign currency to import beef. However, this subsidies have failed in decreasing prices, because importers and distributers sell imported beef and corn at several times the imported price. Therefore, they benefit from the difference between subsidized currency and free market currency, whereas, beef price and corn price do not decrease in domestic market. Unfortunately, there is no control over distribution of imported beef and corn. Due to the lack of proper market regulation policies by the government, the red meat market in Iran has often faced price fluctuations or shortages (Ministry of Agriculture Jihad, 2018). So that, meat producers are always dissatisfied with the low prices on the farm and consumers are also dissatisfied with the high retail prices (Hosseini and Shahbazi, 2010).

Management of animal production systems is difficult because they are dynamic and complex. In these systems, the performance of each level depends on previous level decisions and exogenous factors (Tedeschi et al., 2011). Grohs et al. (2018) stated that system thinking is an appropriate tool and framework for understanding complex and ambiguous systems and their related aspects.

Investigating the beef value chain requires the use of appropriate system thinking approaches, given that the beef value chain has a complex and dynamic nature and involves several actors; also, the relationships between these actors are not well known. Furthermore, the elements of this system are resistant to policies. In spite of the various policies implemented by the government in the past years, there has been no improvement in the beef value chain of Iran.

Khorasan Razavi province has appropriate conditions for livestock production. The total production of red meat in Iran was 835.2 thousand tons in 2017, this province ranked first in the production of red meat with 72.6 thousand tons (Ministry of Agriculture Jihad, 2018). Mashhad is the second largest population metropolis of Iran, which is located in this province. Mashhad has a population of 3 million people and 27 million pilgrims enter the city each year. Accordingly, there is a high demand for livestock products (Kharasan Razavi Provincial Government, 2016). Several studies have been conducted in the field of livestock and poultry supply chain, in the following, some of these studies are mentioned. Matulova et al. (2010) studied the dairy value chain using econometric analysis and concluded that a difference in the leverage of individual factors affecting the price at different levels of the milk value chain. Tedeschi et al. (2011) identified feedback loops for sheep and goat production systems and extracted system archetypes. Shamsuddoha and Nedelea (2013) modeled the Bangladesh poultry supply chain using system dynamics and examined the ability to recycle waste and create more employment. Piewthongngam et al. (2014) investigated the dynamics of Thai pork supply chain using system dynamics and analyzed the effects of various scenarios such as herd restructuring and changing in breeding rate on pork production and productivity. Setianto et al. (2014) applied soft system methodology (SSM) to structure the problematic situation of beef smallholders in Indonesia. They also drew the causal loop diagram (CLD) and extracted the system archetypes. They concluded that the unavailability of livestock feed and increased livestock sales were limitations for cattle production. Banson et al. (2018) identified the archetypes of Ghana's pork industry using system thinking and concluded that using causal loop diagram and system archetypes could help pig herders as well as policymakers understand the behavior of the whole system.

By reviewing previous studies, it can be concluded that the focus of researchers is more on the poultry industry, and the meat value chain, especially in Iran, has been neglected. Despite numerous challenges in the value chain of this product in Iran, no studies have been conducted to analyze the dynamics of the beef value chain considering the interaction among all actors. Therefore, in order to fill this gap, this study investigated the problems of beef value chain in Mashhad by using soft system methodology and causal loop diagram.

Materials and methods

Most people think that complexity is defined in terms of the number of elements in a system or the number of combinations that needs to be

considered in effective decision-making. Such problems have combinatorial complexity or detail complexity. In contrast, dynamic complexity which is the ability of a system to be able to develop into different states over time, can arise even in simple systems with low detail complexity. This kind of complexity is due to the interactions among agents over time (Sterman, 2000). Dynamically complex systems are policy resistant. So many evident solutions fail or aggravate the situation (Sterman, 2000). Complex systems generally have interconnected structures, so that behaviors and actions in one part of the system affect other parts of the system. They are specified by nonlinear and incomprehensible behavior; nonlinearity occurs when several factors influence decision making (Groff, 2013). Van Mai (2010) believes that system thinking is a powerful tool for addressing complex problems and identifying leverage points for intervention because of its capability to describe the interrelationships among economic, social and environmental subsystems. System dynamics as one of the most widely used and validated approaches in decision making is a way of applying system thinking in modeling that describes relationships among variables (Tedeschi et al., 2011). One of the most important features of system dynamics is the identification of system archetypes. They are the behavioral patterns of a system that are considered as generic structures or typical system outlines (Armendàriz et al., 2015). System archetypes consist of a set of loops that result from the interaction of all the factors that cause a problem. The most common system archetypes are balancing process with delay, limit to growth, shifting the burden, eroding goals, escalation, success to successful, tragedy of the commons, fixes that fail and growth and underinvestment (Zare Mehrjerdi, 2011).

The point of entry into the system dynamics is problem identification which is defined as problem structuring. This step is important in clarifying the purpose of the whole system dynamics process. However, the system dynamics approach has limitations at this step, because system stakeholders have different interests and there is no tool to consider multiple stakeholder interactions. To solve this problem, soft system methodology is used in the problem structuring step (Setianto et al., 2014). Soft system methodology as one of the system thinking approaches is useful to address problem situations from a systemic viewpoint (Phillips and Kenley, 2019). The soft system methodology which focuses on the learning process is in contrast to the hard system methodology which, is mainly goal-oriented.In hard systems, the effort is on making a mathematical model to achieve a specific goal and consider variables that seem to affect the problem, whereas soft systems look for key variables that determine system reliability (Jackson, 2007). The two main tools of the soft system methodology are the rich picture and CATWOE analysis that help the researcher to identify the actors involved in the system, their role and their relationships with each other.

Rich picture helps the researcher to better understand the actual situation when there are multiple relationships in the system (Checkland and Poulter, 2006). According to Checkland and Poulter (2006), using rich picture in the early stages of system identification can simplify problem understanding for all stakeholders and encourage them to become involved in the analysis process.

CATWOE analysis is another approach of soft system methodology that used to engage the stakeholders in analysis about the problematic situation (Hart and Paucar-Caceres, 2014). It helps researchers focus on six factors: customer, actors, transformation, weltanschauung, owner and environmental constraints. These factors are defined as follows (Bergvall-Kåreborn et al., 2004; Cox, 2014).

Customer: beneficiaries or victims affected by the transformation. Researchers recommended that replacing “Customers” by “Affectees”.

Actors: participants in the system who would carry out the transformation process.

Transformation: the purposeful activities which are necessary to convert input to output.

Weltanschauung: the worldview that makes the transformation process meaningful.

Owner: people or groups that have the power and responsibility for the system.

Environmental constraints: external and internal constraints which can affect the transformation process in the system.

CATWOE analysis is used to develop root definitions which are one or more sentences that describe the system, its goal and its actors (Mehregan et al., 2012). These root definitions help build a conceptual model that is later translated to the causal loop diagram (Setianto et al., 2014). The causal loop diagram represents the causal relationships among variables; it also demonstrates cause and effect behavior from a system perspective (Banson et al., 2018).

In this study, to structure the problem, beef value chain actors and their relationships are identified using rich picture and CATWOE analysis. After that, the root definitions are expressed. Then, the causal loop diagram is extracted. Finally, system archetypes are determined. To identify causal relationships, a series of interviews have been undertaken with a group of 60 cattle herders of industrial fattening farms in Mashhad. Also, another set of interviews was conducted with experts of Agricultural Jihad, industrial dairy and livestock farmers union, industrial dairy and livestock cooperative and slaughterhouse in Mashhad. Vensim software was used to build a causal loop diagram and Visio software was used to draw rich picture.

Based on the interviews, model assumptions are defined and reflected in the model structure. The local cattle production is modelled and analyzed. The production, breeding and slaughtering cattle and breeding stock is aimed to earn income from the herder's viewpoint. Part of the beef demanded quantity by consumers is responded by domestic production and the other part is responded by imports. Beef production involves cattle production through the fattening process and slaughtering breeding stock. Herders do not receive subsidies for livestock feed. They purchase livestock inputs from the free market. However, the government allocates subsidized foreign currency to import forage and beef every year in order to decrease prices.

Results and discussion

Rich picture and CATWOE analysis

Using the results of interviews with the beef value chain experts, rich picture of the beef value chain in Mashhad is drawn and shown in Figure 1. The main actors and their interests are shown in the rich picture. After drawing the rich picture, CATWOE analysis has also been

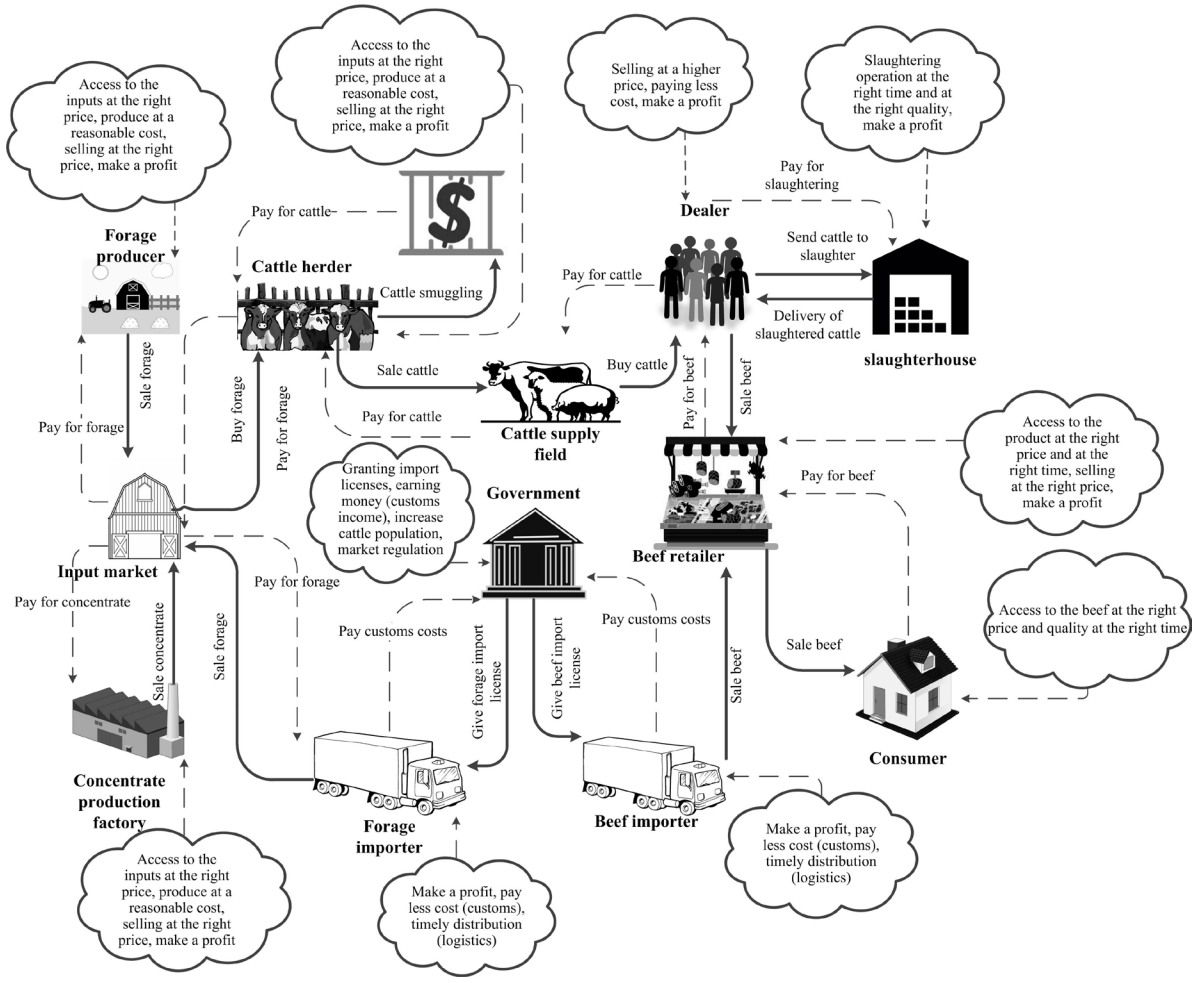

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Figure 1: Rich picture of the beef value chain in Mashhad.

performed to define the current farming situation. In the following, based on the rich picture and CATWOE analysis, root definition is expressed

CATWOE elements

Customer: herders, dealers, consumers, importers

Actors: forage producers, herders

Transformation: beef production with reasonable price to respond consumer's demand is not met >> beef production with reasonable price to respond consumers demand is met

Weltanschauung: beef production with reasonable price to have sustainable beef production and increase welfare of herders and consumers is feasible and desirable, it can be planned and organized

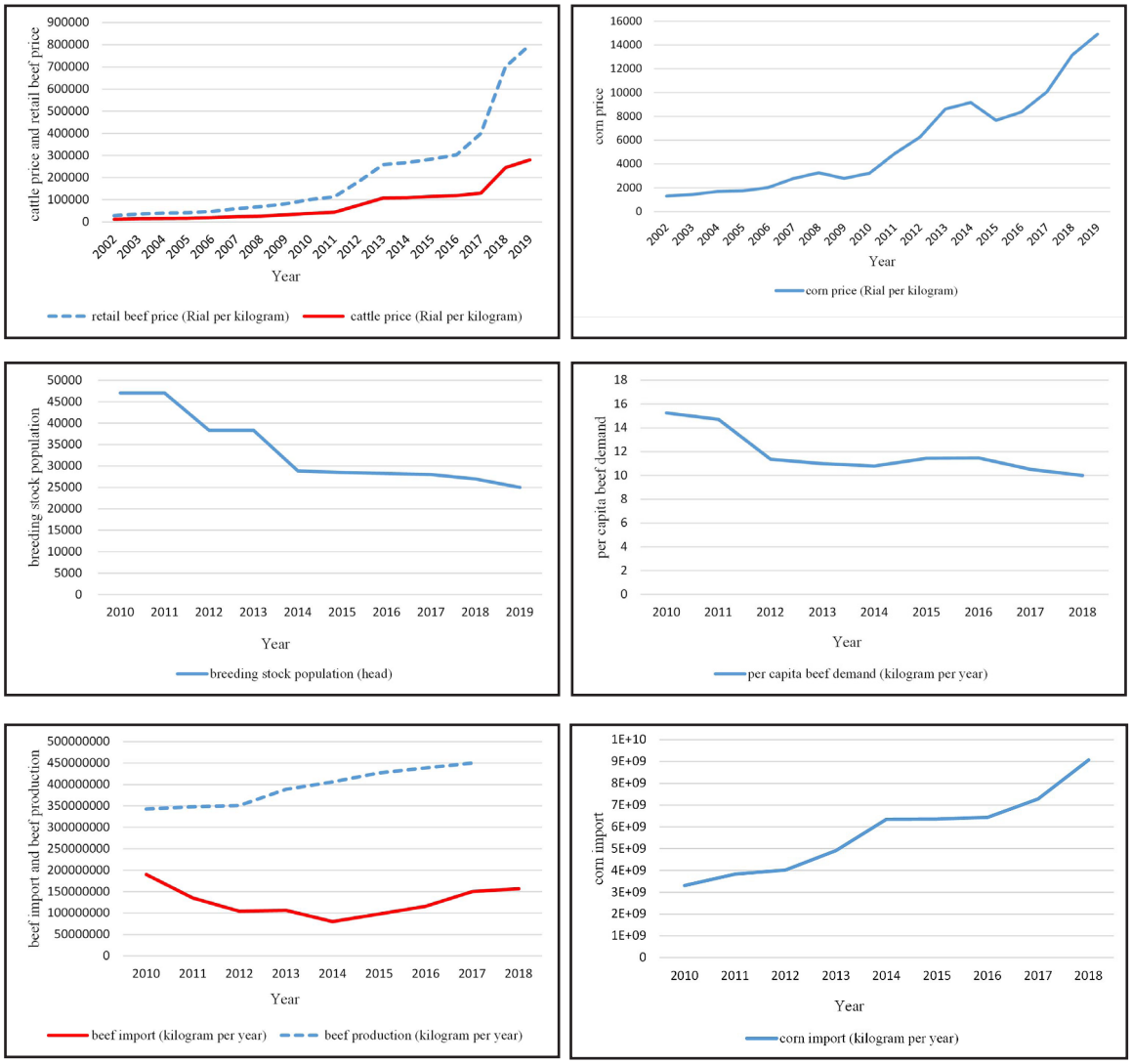
Owner: government, farmers' cooperatives

Environmental constraints: access to forage, access to market, forage price, beef price

Root definition: a value chain to ensure that beef production with reasonable prices to respond consumer's demand by herders and forage producers is met by government and farmers' cooperatives.

Reference mode diagram of the core variables of the beef value chain in Mashhad

The reference mode diagram of some important variables of the beef value chain in Mashhad is represented in Figures 2. As can be seen, the retail beef price has grown enormously in recent years whereas the cattle price has not grown much. So that, the gap between the retail beef price



Source: Ministry of Agriculture Jihad, 2018; Iran Customs Administration, 2018

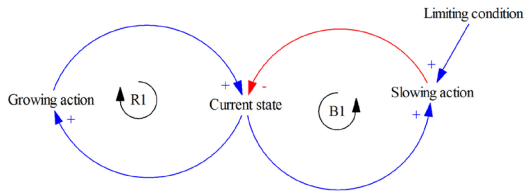
Figure 2: Reference mode diagram of the core variables of the beef value chain.

and cattle price has reached to its maximum value in 2019. However, since 2014, beef import quantity has also increased, this increase in beef import quantity has not been effective in decreasing the retail beef price. Additionally, increasing the retail beef price has reduced per capita consumption of this product in recent years. On the other hand, corn price which is the most important livestock feed, has increased significantly in recent years. Due to the sharp increase in livestock feed price and consequently, increasing cattle production costs and the slight increase in cattle price, the price cost ratio of cattle has reduced in recent years. This has led to an increase in slaughter of breeding stock; so, the breeding stock population has declined. Also, beef production has increased in recent years as a result of increased breeding stock slaughtering.

Causal loop diagram and identification of system archetypes

In this section, according to the results of the problem structuring based on rich picture and CATWOE analysis, a causal loop diagram is extracted and system archetypes are identified. System archetypes of the beef value chain in Mashhad include limit to growth, fixes that fail and shifting the burden which is described below.

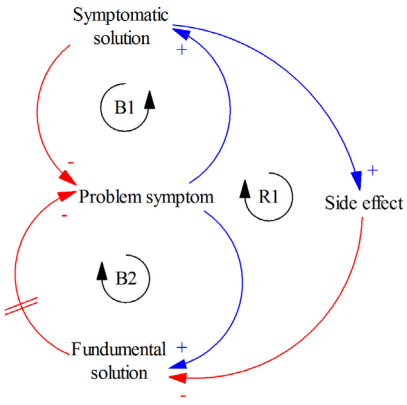
Limit to growth: this archetype shows a growth process (R1 loop) that faces a balancing process (B1 loop) in the following (see Figure 3).



Source: Senge, 2006

Figure 3: Limit to growth archetype.

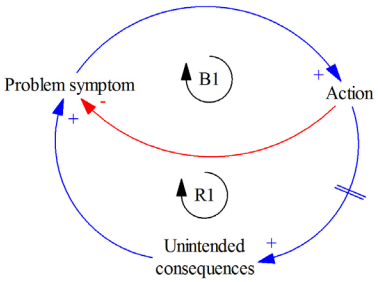
Shifting the burden: in this archetype, problem symptom is fixed using a short-term solution (B1 loop). Whereas, a fundamental solution can be used to solve the problem (B2 loop). Also, in this archetype a reinforcing loop is formed which results from becoming accustomed to using a short-term solution that leads to neglect taking the fundamental solution (R1 loop). So, the problem is getting worse (Posthumus et al., 2018). This archetype is shown in Figure 4.



Source: Posthumus et al., 2018

Figure 4: Shifting the burden archetype.

Fixes that fail: as shown in Figure 5, sometimes a corrective action can be effective in short-term (B1 loop). But it will have unintended consequences in the long-term (R1 loop). So over time, the problem symptom goes back to the previous level or becomes worse (Posthumus et al., 2018).



Source: Posthumus et al., 2018

Figure 5: Fixes that fail archetype.

The causal loop diagram of the beef value chain in Mashhad is shown in Figure 6, which represents 17 feedback loops including 8 reinforcing loops and 9 balancing loops. Each of these loops along with the identified archetypes are described below.

Consumer beef demanded quantity and cattle production capacity (shifting the burden archetype): as retail beef price decreases, beef demanded quantity by consumers increases. So, the gap between beef inventory and demand increases. In other words, inventory to demand ratio of beef decreases. To solve this problem, beef import increases. As a result, problem symptom (gap between beef inventory and demand) decreases in the short term (B1 loop). This easy and short term solution has two side effects that indirectly weaken the possibility to implement long term solution. These side effects happen through

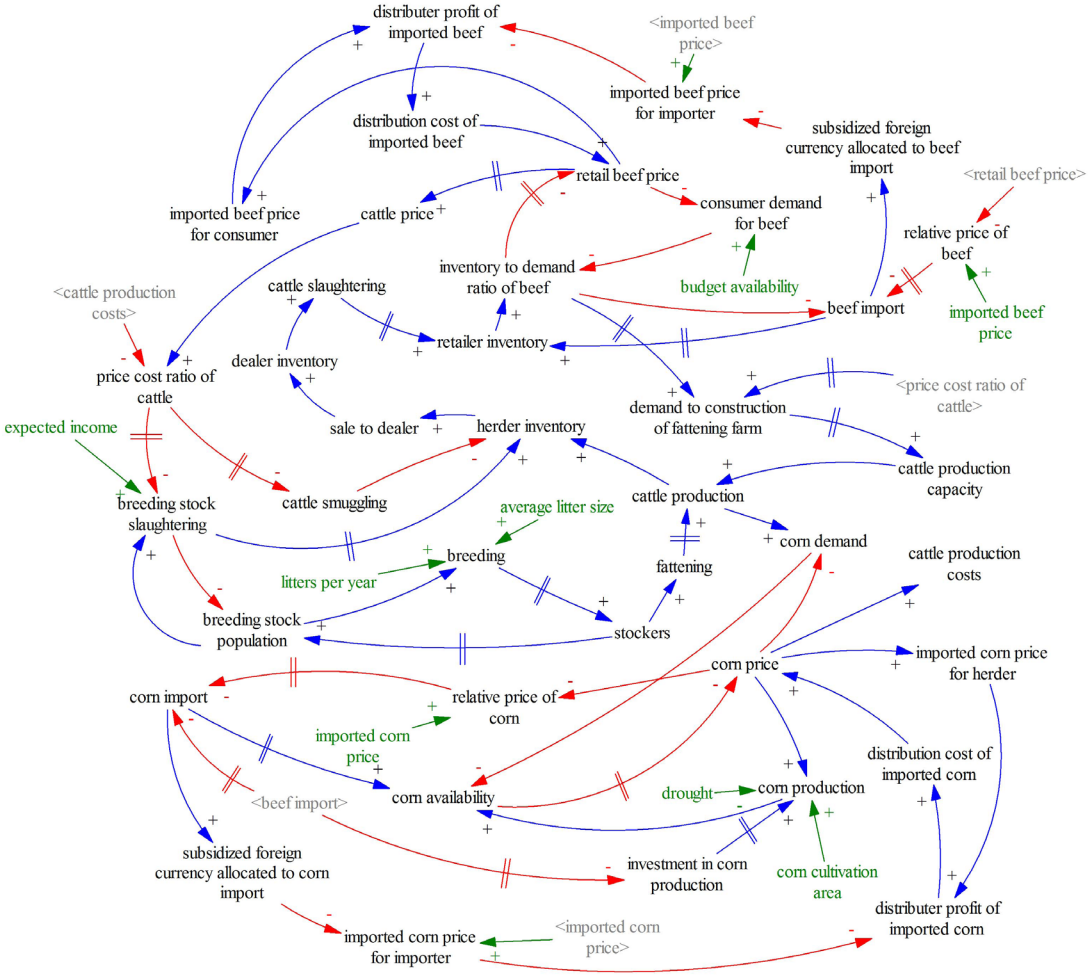


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Figure 6: Causal loop diagram of the beef value chain in Mashhad.

decreasing in corn import and decreasing investment in corn production which lead to decrease in cattle production capacity and cattle production, then decreases beef inventory and increases the gap between beef inventory and demand (see Figure 7, R1 and R2 loops).

The fundamental solution that can be used to solve this problem is to increase cattle production to respond the consumer demand for beef (B2 loop). This can be achieved through government intervention by supporting cattle herders to invest in the construction of new fattening farms. This finding is consistent with that of Parsons et al. (2011) stated that access to capital and sufficient area of land is essential to success in livestock production.

Breeding stock population loops (limit to growth archetype): as Figure 8 shows, with increasing the breeding stock population, breeding rate increases. Also, breeding rate is affected by average litter size and litters per year. Normally, average litter size of cattle is 1 animal/litter. Furthermore, litters per year for cattle is 1 litters/animal/year. Breeding produces stockers after 9 months gestation delay and 3 months of weaning period. With the assumption of 50 % chance of female, half of the stockers are allocated to breeding stock population after 9-12 months delay (R3 loop). This reinforcing loop leads to breeding stock population growth. However, there is a balancing loop which limits its growth (B3 loop). The limiting condition is "expected income". Herders need to slaughter their breeding cattle in order to earn income because they could not afford to feed all their livestock. As a result, breeding stock slaughtering exceeds the breeding rate, with the unintended and perverse outcome of a reduced rather than increasing breeding stock population. These loops together create limit to growth archetype. As Figure 2 shows, since 2010

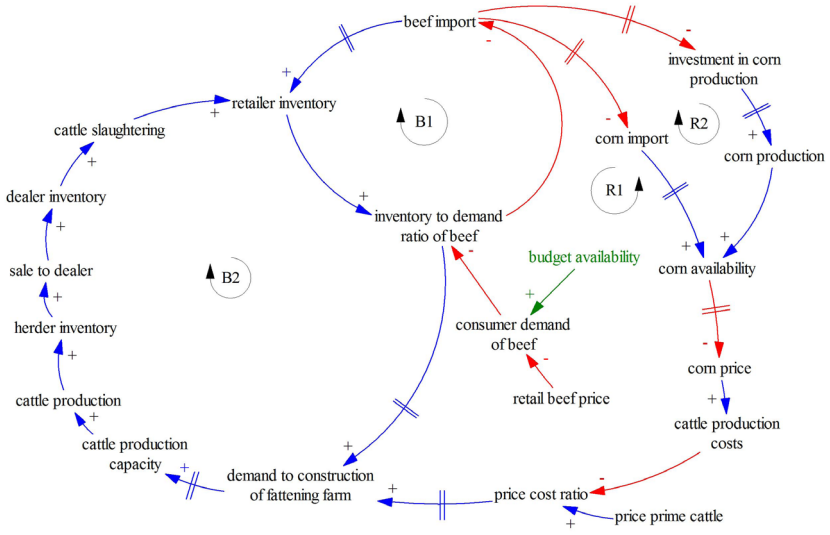

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Figure 7: Consumer beef demanded quantity and cattle production capacity (shifting the burden archetype).

breeding stock population has decreased. This is due to increase breeding stock slaughtering which limited the growth of breeding stock population. These results are consistent with that of Guimarães et al. (2009) and Tedesch et al. (2011) concluded that reproduction process should be considered in the analysis because it is related to the ability of a herder to develop his production. Additionally, Li et al. (2012) showed that the more rapid slaughter rate leads to decline the total number of beef cattle. Also, Mwanyumba et al. (2015) pointed out that if the government does not intervene to balance the herd dynamics to increase reproduction and decrease slaughtering, the livestock population will be annihilated over time.

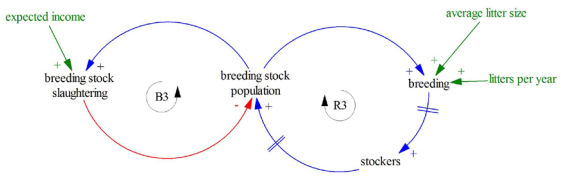

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Figure 8: Breeding stock population loops (limit to growth archetype).

Beef import loops (fixes that fail archetype): based on imperfect substitute model of trade, the relative price of import (import price to domestic price ratio) is one of the most important factors affecting imports of goods (Goldstein and Khan, 1985). Also, the relative price of beef (import price to retail price ratio) is an important factor affecting beef import in Iran. As shown in Figure 9, increasing retail beef price and decreasing beef relative price lead to increase beef import, which increases the retailer inventory and decreases retail beef price (B4 loop). On the other hand, with increasing beef import, subsidized foreign currency allocated to beef import also increases. This leads to decrease imported price of beef for importers. Therefore, importers buy imported beef at a lower price. This increases the profit of importers. So, distribution costs of imported beef rise and finally lead to increase the retail beef price (R4 loop). Also, importers pricing the imported beef for consumers based on the retail beef price, as retail beef price increases, they supplied imported beef at a higher price. It increases their profit and intensifies the reinforcing loop R5. In fact, imported beef should supply in domestic market at a lower price than domestic price to be effective in regulating domestic market. But unfortunately, there is no control over distribution of imported beef. So, the importers and distributers sell imported beef at several times the imported price. Consequently, these subsidies have failed in decreasing prices. This situation represents the archetype of fixes that fail. Actually, in this situation, beef import is increased to decrease retail beef price. But, this action is unsuccessful and the retail beef price is not decreased. As Figure 2 shows, since 2014 beef import has increased. However, retail beef price continued to rise. This result is consistent with that of Suryani et al. (2016) stated that beef import is unable to resolve the problems of shortage of beef production and higher prices. In this case,

monitoring on distribution of this product could be effective in decreasing beef price.

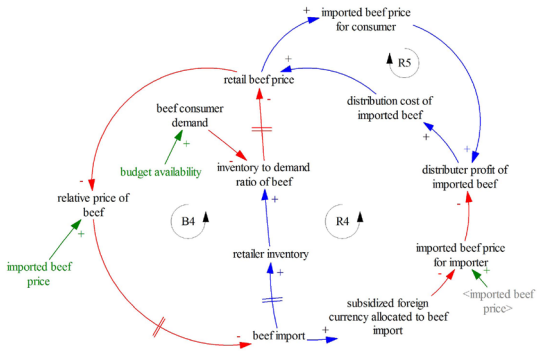

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Figure 9: Beef import loops (fixes that fail archetype).

Corn import loops (fixes that fail archetypes): as corn price increases, corn production increases with delay to balance the corn price (see Figure 10, B5 loop), but due to the water problem in Iran and corn cultivation area constraint, this negative loop has a weak effect in balancing the corn price. So, it needs to import corn to deal with high prices and corn shortage. Therefore, with increasing corn price and consequently decreasing relative price (import price to domestic price of corn), corn imports increase (B6 loop). On the other hand, with increasing corn import, subsidized foreign currency allocated to corn import also increases. This leads to decrease imported price of corn for importers. Therefore, importers buy imported corn at a lower price. This increases the profit of distributers. So, distribution costs of imported corn rise and finally lead to increase corn price (R6 loop). Also, importers pricing the imported corn for herders based on domestic corn price, as domestic corn price increases, they supplied imported corn at a higher price. It increases the profit of distributers and intensifies the reinforcing loop R7. Actually, imported corn should supply in domestic market at a lower price than domestic price to be effective in regulating domestic market. But unfortunately, there is no control over distribution of imported corn. So, the importers and distributers sell imported corn at several times the imported price. Consequently, these subsidies have failed in decreasing prices. This situation represents the archetype of fixes that fail. In fact, in this situation, corn import is increased to decrease domestic corn price. But, this action is unsuccessful. So, the corn price continues to rise. As Figure 2 shows, since 2010 corn import has increased. However, corn price continued to rise. The long-term solution is to change irrigation systems and irrigation management in corn production to increase water productivity. Also, using early maturing and drought-tolerant varieties of corn can improve corn yields. Additionally, given that reaching self-sufficiency in corn production in Iran is not possible and part of the corn demanded quantity is met through imports; it is necessary to closely monitor the import and distribution of this input to break the monopoly of importers and distributers. One solution is to hand over the distribution of imported forage to livestock farmers' cooperatives. This could be effective in reducing corn price and cattle production costs. Also, training the herders to improve feed utilization and reducing feed wastage could be effective in decreasing cattle production costs. This result corroborates the findings of Abdulla et al. (2016).

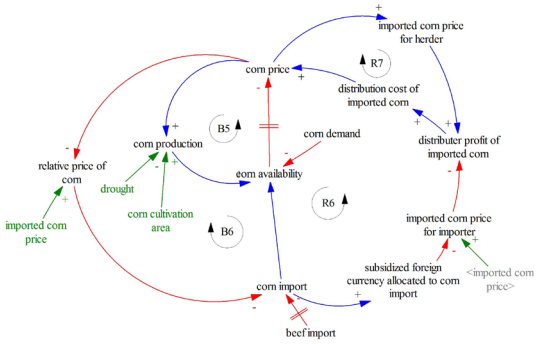

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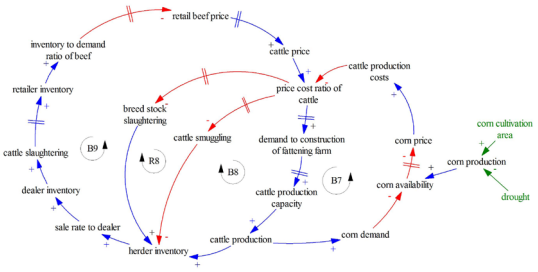
Figure 10: Corn import loops (fixes that fail archetype).

Beef production loops: it should be noted that beef production (Figure 2) involves cattle production through the fattening process and slaughtering breeding stock. Figure 11 shows that as cattle price increases, the price cost ratio of cattle increases and demand to construct new fattening farms increases. This leads to increase in cattle production capacity and cattle production. Therefore, sale to dealer and dealer inventory increase. So, with increasing slaughtering, retail beef price decreases. As retail beef price decreases, also cattle price decreases with delay (B9 loop). On the other hand, with increasing cattle production, corn demand also increases and leads to decrease in corn availability. Also, corn availability is affected by corn production. Corn cultivation area and drought limit the corn production. Decreasing in corn availability leads to increase in the corn price. As corn price rises, cattle production costs increase. So, the price cost ratio of cattle decreases and leads to decrease in cattle production capacity and cattle production (B7 loop). Moreover, with increasing cattle price and price cost ratio

of cattle, cattle smuggling decreases. As a result, herder inventory increases and this loop continues as B9 loop (B8 loop). These negative loops balance the cattle production and herder inventory. Beside these balancing loops, there is a positive loop of breeding stock slaughtering which leads to herder inventory growth. As Figure 11 shows, with increasing in cattle production costs, the price cost ratio of cattle decreases. Since, herders unable to feed all their livestock, they send some of the breeding stocks to the slaughterhouse. As breeding stock slaughtering increases, herder inventory, sale to dealer and dealer inventory increase. This increases retailer inventory, which leads to decrease in retail beef price and consequently decrease in cattle price. So, the price cost ratio of cattle decreases again (R8 loop).

As Figure 2 shows, corn price has been rising during the time. This has limited cattle production. However, it can be seen that beef production has been rising since 2012. It is due to the reinforcing process of breeding stock slaughtering which increases herder inventory. So, the effect of reinforcing loop of breeding stock slaughtering overcomes the balancing loops that limit the cattle production. Therefore, beef production continues to rise. This leads to significant decrease in breeding stock population (see Figure 2). But it is clear that breeding stock slaughtering could not continue to growth limitlessly. Increasing breeding stock slaughtering decreases breeding stock population, which limits the breeding stock slaughtering growth (see B3 loop in Figure 8). Therefore, the combination of balancing loops B3, B7, B8 and B9 with reinforcing loop R8 can arise limit to growth archetype in the near future. So, balancing loops will limit the breeding stock slaughtering and herder inventory. It leads to decrease in beef production and increase in beef price. The limiting conditions are “drought” and “corn cultivation area”. These parameters affect the corn production. It could limit the herder inventory. Another limiting condition is “expected income” which limits the breeding stock population. It could limit the breeding stock slaughtering and consequently herder inventory. These results support the earlier research by Abdulla et al. (2016) indicated that low beef price cost ratio made worse the production. Given the high production costs of the fattening farms and due to this fact that more than 70% of production costs are related to livestock feed, providing forage at affordable prices for cattle herders could decrease production costs and cattle smuggling. To reach this goal, it is necessary for the government to invest in forage production by changing irrigation system and using early maturing and drought-tolerant varieties of corn. These results are consistent with that of Conrad (2004) which concluded that the low production cost is a preventative measure to protect cattle population and decrease beef price.



Source: own processing

Figure 11: Beef production loops.

Conclusion

In this study, the challenges of the beef value chain in Mashhad were investigated. Due to unstructured problems, dynamic nature and multiple factors, soft system methodology including rich picture and CATWOE analysis was used. By using these tools, the actors involved in this value chain and their relationships were explained. Then, the causal loop diagram and system archetypes were identified based on problem structuring in the previous step. In this value chain, 3 different generic archetypes were extracted including limit to growth, fixes that fail and shifting the burden. Fixes that fail and shifting the burden archetypes indicated that the beef import policy has not been effective to regulate the domestic market. This has only made the system accustomed to supply the required beef through imports and neglected fundamental solutions. Also, the corn import policy has not been effective in decreasing corn price and cattle production costs, given the lack of monitoring on imported corn distribution and distributing imported corn at a high price. The limit to growth archetype indicated dynamics of balancing loop of breeding stock slaughtering which limits the reinforcing loop of breeding stock population. Also, the results showed that the effect of reinforcing loop of breeding stock slaughtering overcomes the balancing loops that limit the cattle production. Therefore, beef production continues to rise. But breeding stock slaughtering could not continue to growth limitlessly. Therefore, combining the reinforcing loop of breeding stock slaughtering with negative loops which limited

the breeding stock slaughtering and herder inventory can arise another limit to growth archetype in the near future. It leads to decrease in beef production and increase in beef price. Based on the results, it is suggested that the government supports the herders to invest in the construction of new fattening farms in order to increase cattle production capacity. It can be concluded that beef cattle production in Mashhad is largely dependent on sustainable supply of livestock feed. So, enhancing cattle production requires policy making to increase availability of livestock feed. Since corn is one of the most important inputs in livestock production and given that rising its price in recent years led to a sharp increase in cattle production costs and beef price, it is necessary to plan for increasing its production by changing irrigation system and using early maturing and drought-tolerant varieties of corn. On the other hand, given that reaching self-sufficiency in corn production in Iran is not possible; it needs to closely monitor the import and distribution of this input to break the monopoly of dealers and distributers. This could be useful in reducing corn price and cattle production costs. Also, training the herders to improve feed utilization and reducing feed wastage could be effective in decreasing cattle production costs. This study showed that system archetypes could be used to identify problems in the livestock value chain. Because it would give a big picture of the system to planners and policymakers in order to decision-making in this sector. Since, system thinking and its tools are qualitative methods and they are the entry point to system dynamics modeling, it is suggested that future studies simulate the impacts of the proposed policies on the beef value chain system.

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Determinants of International Beer Export

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Abstract

The aim of this paper was to identify factors influencing dynamics of international beer export. The Poisson pseudo maximum likelihood estimator was employed to estimate the export determinants of the biggest global beer exporters to 199 destinations between 2000 and 2017. We estimated that international beer export is positively influenced by gross domestic product of importing countries and cultural similarities. Trade between countries that share common borders, same language or colonial links has shown to be a very strong and positive determinant. We found a significant role of customs unions and signed free trade agreements; however, this result was not robust across all estimated models. Beer export is negatively affected by the distance between trading countries and their landlockedness, which confirms the relevance of transport cost in beer trade. Beer exports are declining with rise in population of importing countries, which signals an advantage in targeting countries with less differentiated beer supply.

Keywords

International trade, export analysis, gravity model, PPML, beer

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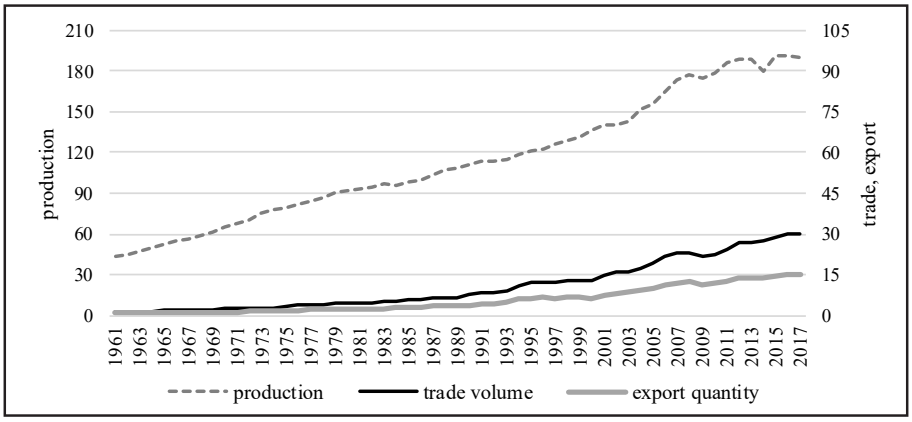
Introduction

The last few decades have been characterised by significant changes in the global beer markets. Historically highly fragmented global beer industry has gone through a process of consolidation via mergers and acquisitions (M&As). Increasing concentration lead primarily by utilization of the economy of scale reduced the number of competitors on the market and resulted in less variety and unification of beer products (Tremblay and Tremblay, 2004; Madsen and Wu, 2016). At the same time, a trend of premiumisation of the production motivated by consumers' interest in new, exclusive and origin-specific products has taken off (Goméz-Corona et al., 2016). In the US and Western Europe, the craft beer segment expanded substantially, bringing back high product diversity to consumers who nowadays drink less but they search for higher quality products. Formation and expansion of craft breweries started in the 1970s in the USA. Western Europe joined the trend in 1980s, while in Eastern Europe, Slovakia including, the craft beer revolution started after year 2000 (Pokrivčák et al., 2019 and 2017).

Changes in the structure of beer markets have significant influence on international trade. From the early decades of the 20th century, the beer production has been growing globally. Initially, Europe was the biggest producer of beer. After the 1950s, however, American and Asian countries gradually begun to catch up with the European levels of production, what together with other factors contributed to the rise of world beer trade. Despite growing international beer trade, only around 15 % (in 2017) of the global beer production is traded (Figure 1).

Global beer export more than doubled since the year 2000, and currently it amounts to 15.1 billion litters a year (value of 14.3 billion dollars). The top world beer exporter Mexico is followed by the Netherlands, Belgium and Germany, while the largest amount of beer is produced in China, the United States, Brazil, Mexico, and Germany. In 2017, the European countries contributed to the global beer export with 57.1 % and North American share reached 32 %. On the other hand, the leading beer importing area is North America (42 % of the world beer imports) followed by Europe with the share of 35 %.

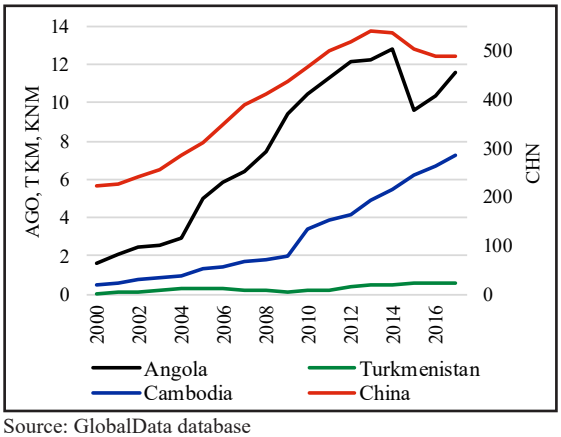
Beer trade is also driven by changes in beer consumption. Consumption in typical beer countries such as United Kingdom, Germany, Denmark



Source: FAO and Kirin Beer University database, UN Comtrade

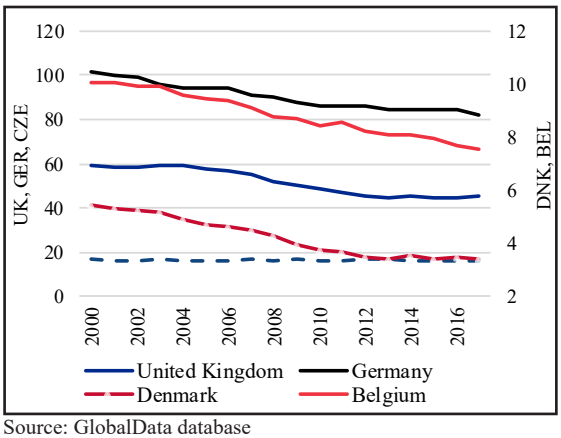
Figure 1: Development of world beer production, trade volume and export in billion litters.

or Belgium shows a downward trend; in case of the world's leading per capita beer consumer, Czechia, the consumption does not rise in the long run (see Figure 2). On the other hand, a significant increase in beer consumption has occurred in emerging economies and in Asian and African countries. According to Swinnen (2017), globalization and income are the main factors responsible for changing beer drinking patterns. As income rises, poorer people spend more on beer but at some point, the positive effect of income growth on beer consumption reverses. One possible explanation is that people become more aware of health risks of alcohol consumption, another that with higher income, they can buy also more expensive alcoholic drinks such as wine or spirits. Other important factor influencing global beer consumption and trade is religion. Some religions, e.g. Islam, Buddhist or Mormon, do not allow the consummation of alcohol (Ashley and Rankin, 1988). That accordingly limits trade with countries where the share of non-drinkers is substantial.



Source: GlobalData database

Figure 2: Development of beer consumption of selected countries in 2000 – 2007 in million hl. (1st part).



Source: GlobalData database

Figure 2: Development of beer consumption of selected countries in 2000 – 2007 in million hl. (2nd part).

Beer comprises mostly water, thus, its trade costs are high. Because of high trade costs, firms in the beer industry tend to localize their production near consumers (Olper et al., 2012). As an answer to the decline of beer consumption, brewing companies were forced to consolidate and to use in-country production licences (McGowan and Mahon, 2007). Furthermore, many countries use protectionist policies (e.g. tariffs, government standards and laws, certifications, testing of consignments, excise duties), which create additional restrictions to trade with alcoholic beverages (Bjelić, 2016). The effect of tariff barriers can be lowered when regional and preferential trade agreements (RTA and PTA) exist between the trading partners. Zeigler (2008) finds that free trade agreements (FTA) lead to reduction of trade barriers, they increase competition in the alcohol industry and by that contribute to the decline of alcohol prices. FTAs affect both tariff and non-tariff barriers; they contain services, investment or intellectual property rights (Wine institute, 2019).

Gravity and trade

Quantity and value of beer exports to foreign markets depend heavily on characteristics of domestic and world markets. Gravity model of trade is often used to study the effects of characteristics of domestic and international markets on trade. Most studies using gravity model analyse total foreign trade. A smaller number of studies focuses on analysing foreign trade changes of specific commodities such as alcoholic beverages in general or beer in particular. For example, Pinilla and Serrano (2008) evaluated the role of trade policies in Spanish table wine export. Balogh (2015) examined global wine trade flows with the conclusion that cultural similarities and trade agreements between trading partners lower the cost of wine export. Bouët et al. (2017) found that as it is in case of other luxury products, the distance elasticity of cognac exports is negative but relatively small, while the elasticity to GDP is positive and relatively large. According to Dal Bianco et al. (2015), trade costs do matter considerably in case of wine trade: tariffs have the largest impact followed by geographical distance. The findings of De Matteis et al. (2018) suggest that technical barriers to trade adversely impacted the exports of distillers dried grains with solubles to an extent larger than the influence of tariff. In case of beer, gravity with combination of pricing to market model was used by Dreyer et al. (2017) to identify factors enhancing German beer export. The authors found that German beer export is strongly affected by the membership of trading partners in the EU and introduction of the Euro.

To our knowledge, there are only few studies investigating factors influencing beer exports, i.e. why beer is traded to particular countries and which factors stimulate the beer trade positively and otherwise: Dreyer et al. (2017) examined German beer exports during 1991 – 2010; Olper et al. (2012) analysed EU bilateral beer and wine exports during 2000 – 2009; McGowan and Mahon (2007) analysed the impact of NAFTA on US beer trade flows during 1992 – 2001. In this paper using gravity modelling, we aim to identify the factors stimulating current international beer export dynamics. It is important to know how structural changes in global beer market affected trade with beer. Based on empirical studies presented in the introduction of the paper, we expect some of the selected variables to act as trade attractors and other as trade frictions. Regarding that, we test the following hypotheses:

H1: GDP of importing countries and beer exports to these countries have a directly proportional relationship.

H2: Exporting beer to countries sharing a common language lowers trade cost and increases beer export.

H3: Beer export rises with a decrease in geographical distance between trading countries.

H4: Trade liberalisation (FTAs, customs unions) positively affects beer export.

Materials and methods

Gravity model is used for modelling the allocation of traded goods transmitted from the export country (i) to the destination (importing) country (j). In terms of international trade assessment, the model origins with Tinbergen (1962), who proposed that bilateral trade flows between countries can be approximated by employing the Newton's gravity equation. In its basic form, the gravity equation for trade can be written as

$$T_{ij} = a_0 Y_i^{a_1} Y_j^{a_2} D_{ij}^{a_3} \varepsilon_{ij}, \quad (1)$$

where T_{ij} is trade flow from country i to country j, which is directly proportional to the gross domestic product (GDP) of i and j and inversely proportional to the distance between i and j. a_0, a_1, a_2 and a_3 represent unknown (estimated) parameters and ε_{ij} is the error term. In empirical studies the basic model is extended by variables, which according to the trade theory can influence the trade flows between countries: economic attractors of export, semi-economic or political factors, trade frictions and factors representing trade costs.

The estimation of the gravity equation can be done by different methods. First, the natural logarithms of all variables can be taken to create a log-linear gravity equation standardly estimated by Ordinary least squares (OLS):

$$\ln T_{ij} = \ln a_0 + a_1 \ln Y_i + a_2 \ln Y_j + a_3 \ln D_{ij} + \ln \varepsilon_{ij}. \quad (2)$$

The data, however, includes zero trade observation, i.e. situation when in a particular time period some pairs of countries did not trade or when there are missing values. As the logarithm of zero is not defined, it creates a problem for the use of the log-linear gravity equation. The zero trade flows could be omitted in the sample, but we would lose a part of trade information, or/and it could lead to biased results (Burger et al., 2009). One of the techniques used for treating zero values is employing the Poisson pseudo maximum likelihood (PPML)

estimator as proposed by Silva and Tenreyro (2006), which can be applied to the original nonlinear form of gravity model. Another benefit of PPML is that it accounts for heteroscedasticity, which is an often characteristics of trade data. Pokrivčák et al. (2013) used PPML to model global dairy trade and estimate the impact of Russian NTMs on dairy imports.

We extend the equation (1) by including all the relevant variables affecting beer exports. As our dataset includes zero export flows, we will estimate the multiplicative gravity function with PPML estimator. The estimated model takes the following general form

$$EX_{ijt} = \exp(\ln a_0 + a_1 \ln gdp_{it} + a_2 \ln gdp_{jt} + a_3 \ln pop_{jt} + a_4 \ln prod_{it} + a_5 contig_{ij} + a_6 comlang_{ij} + a_7 curcol_{ij} + a_8 smctry_{ij} + a_9 curr_{ijt} + a_{10} FTA_{ijt} + a_{11} CU_{ijt} + a_{12} \ln dist_{ij} + a_{13} land_{ij} + a_{14} island_j + a_{15} Eur_j + a_{16} \ln ndrel_j + \mu_{ijt}) \quad (3)$$

where:

EX_{ijt} – volume of beer export from export country i to import country j in year t in millions of litters and billions of US dollars

a_1- a_{16} – estimated elasticities of variables

a_0 – constant

μ_{ijt} – country-specific and time-specific factors estimated as fixed effects capturing unobserved variability

ε_{ijt} – error term

gdp_{it} and gdp_{jt} – gross domestic product of i and j in billion USD

pop_{jt} – population of j in millions of people

$prod_{it}$ – beer production of i in millions of litters

$contig_{ij}$ – dummy variable (dummy) equal unity when i and j have common borders

$comlang_{ij}$ – dummy equal unity when i and j share the same official language

$curcol_{ij}$ – dummy equal unity when currently i and j have a colonial link

$smctry_{ij}$ – dummy equal unity when i and j are/were part of the same country

$curr_{ijt}$ – dummy equal unity when i and j use common official currency

FTA_{ijt} – dummy equal unity when i and j have a signed free trade agreement

CU_{ijt} – dummy equal unity when i and j are members of a customs union

$dist_{ij}$ – average distance of i and j in km

$land_{ij}$ – dummy equal unity when i or j are landlocked countries

$island_j$ – dummy equal unity when j is an island

Eur_j – dummy equal unity when j is a European country

$ndrel_j$ – share of adherence of religions that do not allow alcohol consumption

Description of variables and data sources

To estimate effects of factors influencing the international beer export, a balanced panel dataset is created, i.e. the zero observation of the dependent variable are included. International beer export is represented by export volumes of the biggest global beer exporting countries (Belgium, China, Czech Republic, Denmark, France, Germany, Ireland, Italy, Mexico, Netherlands, Poland, Spain, Portugal, United Kingdom and USA); their exports account for more than 87 % of global beer export (Table 1). The dependent variable is the annual volume of export in mil. litters and in billion US dollars from 15 selected reporters to 199 importing countries in the period of 2000 – 2017. Export data was extracted from UN Comtrade Database (corresponding to the harmonised system code HS4 2203).

Reporter	2000 – 2017	Share, %
Mexico	34.0	19.5
Netherlands	31.4	18.0
Germany	20.4	11.7
Belgium	17.1	9.8
United Kingdom	12.5	7.2
USA	6.4	3.7
Ireland	5.5	3.2
Denmark	5.5	3.1
France	5.2	3.0
Czechia	3.5	2.0
Portugal	2.9	1.6
Italy	2.2	1.3
China	2.1	1.2
Spain	2.0	1.1
Poland	1.6	0.9
Total world export	174.1	
Share on global export		87.4

Source: UN Comtrade, 2019

Table 1: World beer export in 2000 – 2017 in billion US dollars.

First explanatory variables are conventional gravity model variables gross domestic product (GDP) of exporting countries i and GDP of importing countries j. Data on GDP is expressed in million USD (current prices) and retrieved from the World Bank database. In case of exporter, GDP represents its productive capacity. We expect that increase

in GDP will increase the exporters' production possibilities and by that the availability of goods for export. GDP of importers represents a proxy for purchasing power of consumers. As beer is considered a normal good, we expect an income growth to cause a rise of beer demand.

The population of importing country represents potential consumers of beer. However, no a priori relationship between population and trade has been identified in other studies. A positive sign would mean that bigger countries (in terms of population) can absorb more of goods traded; a negative sign according to Giorgio (2004) means that growing population has a need for more differentiated supply of goods or that the more populated the countries are, the larger is their own production of goods. Data on population size of the 199 importing countries is taken from the World Bank database.

The production variable is used as a proxy for output capacity (supply) of exporters. We expect the coefficient of the variable be positive. Production data are drawn from Food and Agriculture Organization Corporate Statistical database (FAOSTAT) and Kirin Beer University database.

Data on average distance between the trading countries comes from CEPII database, which calculates distance between countries considering the 25 most populated cities of each country weighted by the share of the cities in country's total population. Distance variable is used as a proxy for transport costs of trade. According to Buch et al. (2004) and Márquez-Ramos et al. (2007), the magnitude and sign of the distance coefficient are related to the importance of bilateral activities with partners that are far away relative to those that are located nearby. We expect that beer export will be negatively influenced by the geographical distance of trading partners.

CEPII database was also used to acquire data on common official language, common borders, colonial history of trading countries and data on countries that once were or currently are a part of the same state. Trade with neighbouring countries can be beneficial, as it reduces transport costs. We included a dummy variable to control for this effect and expecting its coefficient to be positive. Other variables related to transport costs are dummy variables: $land_{ij}$, which takes the value of 1 when i or j from a trading country-pair is landlocked, and $island_j$ equal unity when j is an island. In both cases, a country being isolated by water or by other countries hindering the water access creates additional transport costs of trade. We do not use an island dummy for the exporters; even if United Kingdom and Singapore are island countries, they are using man-made causeways for ground transportation.

Trade costs not only include costs of transportation, they also can be related to exchange rates. The logic behind that is that common currency of a trading country-pair reduces the exchange rate volatility (Costa-i-Font, 2010) and eliminates transaction costs due to use of different currencies (Albertin, 2008), i.e. it decreases the cost of trade. To capture this effect, we include the variable common currency (data taken from World atlas.com). Many studies were done on this topic, however, there is no consensus on significance of the effect of common currency on trade. Some studies found a positive influence of common currencies and monetary unions on trade volumes, e.g. Rose and Stanley (2005) or Baldwin et al. (2005), who analysed the effect of euro, but no significant effect was determined by Thom and Walsh (2002) in case of Anglo-Irish trade and sterling currency union or Berger and Nitsch (2008) in case of European economic and monetary union. We expect a common currency used by trading countries to lower the trade costs and enhance beer trade.

The language variable is added to capture possible effect of common official language of trade partners on export. Speaking the language of the trading partner is essential in terms of negotiating contracts, handling legislative formalities but also for consumers who need to have sufficient information about the product on the label. We expect the language factor to have a positive effect on beer trade. A positive coefficient sign is expected in case of variables common colonial link of trading countries and the fact that they are/were a common country as well.

Data on adherence fractions of population of different religion groups and atheists in 2000 was retrieved from the World Christian Database. We estimated the share of people belonging to religions not allowing alcohol consumption (Muslims and Buddhists) on countries' total population number. The expectation is that the higher the share of non-drinkers in importing country, the lower the beer export.

Beer consumption in typical European beer-drinking countries is currently falling, which can influence beer exports to Europe. The variable Eur_j is included to capture these changes on the international beer market.

As mentioned in the literature review, the relatively high trade cost of beer can be lowered when creating political and semipolitical relations to other countries, e.g. customs union, trade agreements. Customs unions (CU) allow free movement of goods and services, free trade agreements (FTA) decrease or eliminate tariffs and trade barriers. We expect, therefore, a positive coefficient of customs union and FTA variables. Data on CU and FTA comes from the Regional trade agreements information system (RTA-IS) of WTO.

We include fixed effects represented by a different set of dummy variables to control for other unobserved and omitted variables: time fixed effects capture the export variation over time and shocks affecting export flows; bilateral country pair fixed effects capture any unobserved relations and effects between country pairs constant over time; and exporter and importer fixed effects are used to control for variables specific to exporter or importer country, e.g. factor endowments, geographic terms, other factors specific to an exporter or importer of beer.

Statistical analysis

For econometric estimation, we use the STATA 13.1 software. As dataset includes zero observation of the dependent variable (i.e. when no trade between i and j occurs), we applied the PPML estimation method suggested by Silva and Tenreyro (2006).

We estimate several models with dependent variable expressed in value and in quantity terms differing in fixed effects included to account for different kinds of unobserved variability. For models A and D, we introduce exporters and time fixed effects; for models B and E, we additionally include importer fixed effects; and for models C and F, we introduce bilateral country pair and time fixed effects.

To test the adequacy of the estimated models, we perform the Ramsey regression equation specification error test (RESET) (Ramsey, 1969). The null-hypothesis states that all coefficients are zero. When the corresponding p-value is lesser than 0.05, the null-hypothesis is rejected, and the model suffers from misspecification (i.e. another functional form is more fitted).

As suggested in Shepherd (2013), the robust option in STATA is employed to estimate standard errors robust to arbitrary patterns of heteroscedasticity. We assume that the error term is uncorrelated across clusters (i.e. across pair of trading countries) but correlated within a cluster. Thus, the distance variable ($dist_{ij}$) specific to each country pair is used for clustering in data to avoid understated standard errors (Moulton, 1990).

Results and discussion

The estimation results for all estimated models are reported in Table 2. To test models' adequacy, the RESET test was performed, and its p-values are displayed at the bottom of table 2. In case of model A and D, we reject the null hypothesis, which indicates that these models are inappropriately specified. Other models pass the RESET test, and we will use them for interpretation. Together with explanatory variables these models explain 87 – 95 % of the variability in international beer export. Most of the explanatory variables are statistically significant, and coefficients have the expected signs.

GDP of importing countries is according the estimated p-value statistically significant at the 1 % level, and its coefficient has a positive sign for both models in terms of quantity and in terms of value. This confirms the hypothesis H1 and suggests that an increase in the importing country's GDP would be followed by an increase in exports to the country. Specifically, the estimated coefficients have the value of 0.66 – 0.89 for value of export and 1.06 – 1.27 for quantity of export. We can conclude that by its consumers, beer is considered a superior good. Our results are consistent with other studies, which report the income elasticity of beer be positive; for most countries and products, the coefficient ranges from 0.35 to 0.9 (Fogarty, 2010), in case of German beer export from 0.60 to 0.96 (Dreyer et al., 2017). The income growth in exporter country proved to have no significant influence on international beer export.

Exporter's supply capacity was proxied by the production variable. The authors of the study by Olper et al. (2012) dealing with European wine and beer export state that the standard level on the product level is frequently less than 1.0. However, we could not confirm a statistically significant influence of the production variable. Results reveal that change in beer exports is not significantly linked to a change in production of the exporters. It could mean that exporter countries produce enough beer to allocate it abroad, and there are other factors determining the changes of export activity (e.g. consumption changes in export countries, economies of scale).

	PPML (A)		PPML (B)		PPML (C)		PPML (D)		PPML (E)		PPML (F)	
	FE i, t		FE i, j, t		FE ij, t		FE i, t		FE i, j, t		FE ij, t	
	Export in value						Export in quantity					
	Coef.		Coef.		Coef.		Coef.		Coef.		Coef.	
ln gdpjt	1.016	***	0.659	***	0.890	***	1.196	***	1.057	***	1.269	***
	(0.108)		(0.191)		(0.153)		(0.114)		(0.150)		(0.125)	
ln gdpit	-0.013				-0.110		0.077		0.070		-0.057	
	(0.211)				(0.208)		(0.176)		(0.172)		(0.190)	
ln popij	-0.278	***	1.081		-1.601	**	-0.419	***	-1.371	**	-1.354	***
	(0.096)		(0.854)		(0.693)		(0.094)		(0.597)		(0.480)	
ln prodit	-0.030				-0.086		-0.999		-0.112		-0.958	
	(0.238)				(0.229)		(0.305)		(0.311)		(0.283)	
contigij	0.852	***	0.974	***	n.e.		0.774	**	0.869	***	n.e.	
	(0.302)		(0.223)				(0.318)		(0.240)			
comlangij	0.457	*	0.721	***	n.e.		0.500	**	0.760	***	n.e.	
	(0.245)		(0.240)				(0.234)		(0.234)			
curcolij	1.070	*	1.384	**	n.e.		1.359	**	1.443	***	n.e.	
	(0.561)		(0.538)				(0.581)		(0.522)			
smctryij	-0.046				n.e.		-0.156		-0.208		n.e.	
	(0.396)						(0.339)		(0.274)			
currijt	-0.211		-0.505		0.094		-0.208		-0.706	*	0.111	
	(0.318)		(0.329)		(0.153)		(0.340)		(0.376)		(0.155)	
FTAijt	0.401	*	0.230		0.493	***	0.202		0.064		0.384	***
	(0.230)		(0.238)		(0.118)		(0.234)		(0.268)		(0.125)	
CUijt	0.765	***	0.443		0.342	**	0.700	***	0.507		0.356	***
	(0.230)		(0.282)		(0.171)		(0.251)		(0.355)		(0.174)	
ln distij	-0.605	***	-0.849	***	n.e.		-0.592	***	-0.824	***	n.e.	
	(0.115)		(0.154)				(0.117)		(0.166)			
landij	-0.736	***	-1.516	***	n.e.		-0.665	***	-1.371	***	n.e.	
	(0.235)		(0.457)				(0.214)		(0.507)			
islandj	-0.084		n.e.		n.e.		-0.011		n.e.		n.e.	
	(0.284)						(0.278)					
Eurj	-1.611	***	n.e.		n.e.		-1.661	***	n.e.		n.e.	
	(0.207)						(0.212)					
ln ndrrelj	-3.820	***	n.e.		n.e.		-3.940	***	n.e.		n.e.	
	(0.741)						(0.773)					
Constant	4.373	**	-2.463		408.30	*	2.873	**	-3.754		288.32	
	(1.850)		(2.794)		(242.0)		(1.398)		(2.556)		(349.3)	
Observations	41 670		41 670		41 634		41 670		41 670		41 634	
R-squared	0.816		0.872		0.940		0.815		0.869		0.952	
RESET p-value	0.001		0.810		0.377		0.000		0.056		0.675	

Note: Significant at: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors are displayed in parentheses; the fixed effects are omitted for brevity; n.e. denotes variables, which were dropped to avoid perfect collinearity with fixed effects
Source: own estimations

Table 2: Estimation results.

The population variable is significant and has a negative sign. We can interpret this results in accordance with Giorgio (2004), thus, for the beer exporters, it has a greater advantage to export to less populated countries with smaller self-production or less differentiated supply of beer. Similar result is obtained also in Ekanayake et al. (2010) or by Anderson (1979).

Some trading countries in our sample use the same official language. This variable is especially important in the case of bottled or canned beer, which has to contain detailed product information (on the label) in the language of the importing country. This variable is strongly statistically significant (i.e. hypothesis H2 is confirmed at the 5 %

level) and ranges between 0.72 – 0.76. It shows that trading countries sharing common language tend to trade 105 – 114 % (exp(0.72) -1 = 1.05) more than otherwise. In contrast, the language variable was not significant in case of European (Olper et al., 2012) and German (Dreyer et al., 2017) beer export. According to Olper, the insignificance can be due to multicollinearity between contiguity and language, as EU countries sharing common border shared also a common language.

Another factor, which was expected to have a positive effect on international beer export, is trade with neighbouring countries. The variable is strongly statistically significant, the coefficient varies between 0.87 (in terms of export quantity) and 0.97 (in terms of export value). Countries sharing common borders tend to trade 139 – 164 % more other countries. The fact that trade between contiguous countries is enhanced is also reported in the study of Olper et al. (2012), where the effect for European beer export was 228 % and for wine export 153 %.

Colonial links between trading partners positively influence international beer export (coefficient 1.38 – 1.44). Importers currently having a colonial link to the exporter trade approximately 297 – 322 % more than countries without a current colonial link. The influence of trading partners being a part of one country was found not statistically significant.

We found (model C and F) a significant and positive effect of signed FTAs and membership in customs unions on the volume of beer exports; the trade creating effect ranges between 40 – 63 % compared to countries, which are not members of CU or without FTAs. However, these results failed to be significant according other estimated models, therefore, we consider the hypothesis H4 not confirmed. The free trade agreement effect in beer sector was analysed also by Dreyer et al. (2017) in terms of the membership of German beer importers in the EU, and while the least square estimation showed a positive influence of FTAs on export, this result was not robust according to PPML. Next, we estimated the influence of common currency used by trading country-pairs. As the variable is not statistically significant, it shows that beer exports are not sensitive to a use of common currency. Dreyer et al. (2017) found a beer trade-increasing effect of Euro, but the effect of the variable does not appear in our sample, which includes countries sharing also other currencies.

Our further findings show that transport costs (proxied by geographical distance, landlockedness and island separation) play an important role in beer export dynamics. Geographical distance is a conventional gravity model variable. Its coefficient proved statistically significant at the 1 % level and it ranges between -0.82 and -0.85. It proves the hypothesis H3 that trade falls with distance, specifically, a 10 % increase in distance between trading countries lowers the international beer export by 8.2 – 8.5 %. This result is consistent with the result for European beer exports estimated by Olper et al. (2012), coeff. -0.91. The influence of the landlockedness is strongly significant and the coefficient is negative as expected. We found that if at least one of the trading partners is land-locked, their trade is 74 – 78 % lower than otherwise. The effect of importing countries being islands could not have been estimated in the corresponding fixed effect models.

Because of multicollinearity issue, the effect of religion and importer country belonging to the European continent could not have been estimated in the well-specified fixed effect models, and we cannot comment on their trade changing effect.

To conclude, international trade with beer is enhanced by cultural and geographical proximity of countries and trade cost play a significant trade-reducing role. Our findings are generally in line with the development on the international beer market outlined in the literature review of this paper; the estimation brings robust results across the specified models. This paper adds to the existing literature in following ways: we use a methodological approach appropriate to deal with zero trade flows and heteroscedasticity of trade data (PPML); we introduce fixed effects for controlling for the multilateral resistance terms; we adopt a great number of observations and create a vast database on beer trade-influencing factors, which can be used as a base for further research.

Conclusion

The objective of this paper was to identify determinants of international beer export using the gravity model approach with fixed effects. The estimated models explain more than 87 % of the international beer export variability. The unexplained variability could be related to factors such as trade openness of countries, changes of specific tariffs or exchange rates, not covered by our model.

According to estimation results, international beer exports in the period of 2000 – 2017 were

positively influenced by the gross domestic product of importing countries. We estimated the income elasticity of beer to be positive, which indicates that beer is considered a superior good. Countries sharing common borders, same language or colonial past tend to trade beer more than countries without such relationships. Trade between contiguous countries benefits from low transport costs. The knowledge of the trading partner's language is especially important in the case of bottled or canned beer, which contains information about the traded product on the label. Furthermore, common language reduces transaction costs. In addition, we found a positive effect of FTAs or/and customs unions, which members tend to trade more than non-members. Results reveal that for our sample of countries, beer exports are not sensitive to a use of common currency.

Beer export activities are negatively influenced by the distance between trading countries and their landlockedness – proxy variables for transport cost of beer in international space. According to the results, change in beer exported is not significantly linked to changes in its production, which means that there are other more important factors determining how much beer produced is being exported (e.g. changes in own consumption in exporter country, results of economies of scale). As importer's population size and trade are negatively correlated, beer exporters can benefit from exporting to less populated countries with smaller self-production or less differentiated supply of beer.

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The Impact of Official Development Assistance on the Productivity of Agricultural Production in Ghana, Cameroon and Mali

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Abstract

African economies depend largely on agriculture. Most people in Africa spend most of their lives in rural areas. Agriculture is an important sector of African industry and economy, it employs more than half of the population and accounts more than half of the national income. Due to population increase the food security remains an issue. In accordance of the lack of domestic capacities of African countries to deal with the problem, it is particularly important to increase assistance from developed countries. African States are expected to demonstrate the ability to implement policies that will change with the funds received / while receiving funds. However, for various reasons, despite numerous aid packages, it/Africa remains backward. This article examines the impact of foreign aid on agricultural productivity and the impact of the quality of management on development aid flows. As examples, it was decided to take such countries as Ghana, Cameroon and Mali. The purpose of this article is to confirm the hypothesis that development assistance correlates positively with the productivity of agriculture. The second hypothesis suggests that development aid flows respond to the quality of public administration. As for the results, the impact between the variables was recorded, but the results were ambiguous.

Keywords

Africa, official development aid, agriculture, public administration, Ghana, Cameroon, Mali.

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Introduction

The economies of developing countries are dependent mainly on agriculture. Despite the rapid pace of urbanization, most people in the poorest regions of the world still spend all their lives, or its biggest part, in earning a living in rural areas.

African states are a prime example. Their economic structure still suggests a wide involvement of the agricultural sector to the economy and the bulk of the population still belongs to the category of predominantly rural population. Agriculture is an important sector of the African industry and economy, employs more than half of the population and accounts for more than half of the national income.

According to the long-term forecast of the United Nations (UN) the population of Africa by the mid-century will double. The problem of food security does not lose its importance and standing on the first place in the program of the development of Africa and the world in general. This problem can be solved by increasing the area of arable land, water availability and provision of appropriate infrastructure. Particularly important is the need to increase yields from already existing processed lands, not only increase the number of hectares. It is important to develop a process of sustainable development, but it is difficult without increase of assistance from the developed countries.

Limited investment to African agriculture is one of the main barriers for the expansion of agricultural production in the region. For most of the African countries current domestic investment in agriculture is delayed due to the limitations of the state budget and deficit of accumulated savings. This means that the increase of investment in agriculture is a bottleneck of funds for the development of such important sectors as medicine, education, and so on. Therefore, to fill this gap developing countries need more help from rich or developed countries and other multilateral organizations.

In today's economic environment the aim of reducing the negative effects of differences in income level between the countries of the rich north and the poor south was acquired by high level of foreign aid or its particular part – official development assistance.

It is expected that African countries will demonstrate the ability to carry out policy that will change them with the help of the funds raised. However, for various reasons, such as the weakness of the government, bad management, corruption and lack of accountability in the implementation of the policies, the region, despite the numerous aid packages, remains backward.

This article examines such countries, as Ghana, Cameroon and Mali, with specific examples of the impact of development aid in Africa; the work also examines in particular the impact of foreign aid on the productivity of agricultural production in these countries, and how it affects the quality of public administration on the flows of development assistance.

The aim of this article is to confirm the hypothesis that development aid positively affects the productivity of agriculture. The second hypothesis assumes that the flows of development assistance respond to the quality of public administration.

Literature overview

In the literature, due to the diversity of authors and works devoted to research in the field of development, we meet with a variety of terms, such as "foreign aid", "official development assistance" or "development cooperation"; therefore, we consider it appropriate to give a few definitions. One of the most complex definitions of foreign aid or official development assistance (ODA) served the Development Assistance Committee(DAC) of the Organization for economic cooperation and development(OECD), according to which aid includes grants and loans to developing countries and territories, 1) which are determined by the official sector of the country of the donor, 2) aimed at promoting the economic development and welfare in recipient countries as the main objective and 3) provided on favourable financial terms, which must include a subsidy component, which constitute not less than 25 percent. In response to these financial flows in ODA to initiate technical cooperation, even if grants, loans and credits for military purposes are excluded without regard to their concession character (OECD, 2018).

Factors that decrease the effectiveness of foreign aid associate researcher as Abramova (2011) into two groups depending on the performance of donor countries and beneficiaries. She mentions that one of the main reasons of limiting the effectiveness is lack of coordination of the activities of the supplier countries. An example of such a practice is Brazil, where is a system for developing programs in the area of provision of foreign aid and control over their implementation is decentralized. In 1997, the country created the Department for international development with a wide range of powers (Barder, 2005) which resulted in improvements of the aid efficiency.

Another factor reducing the efficiency of the assistance provided is its volatility. Reduction in the volume of foreign aid leads to a reduction of the expenditure of the state budget, mainly through the social sector, and also increasing tax rates, is thus a direct impact on the economic growth of the country (Kapitsa, 2013; Fengler and Kharas, 2011). The complexity of the forecasting of the flows of foreign aid serves as serious limitations on the effectiveness of long-term and medium-term national development strategies in recipient countries. The experience of Mozambique suggests that the ability of forecasting / estimating a three-year period, budget spending was granted in 2007 a limited number of donors active in the country, and the African development bank, Finland, France, Germany and Sweden (Wheeler, 2011).

When examining issues of volatility of development aid, it stresses the positive effect of such practices in the case of armed conflicts or natural disasters in developing countries. In such situations the assistance is mainly focused on solving humanitarian tasks. In 2000, a sharp increase in the volume of provided assistance to Mozambique for flood relief efforts was recorded and in 2002 in Ethiopia due to drought (Markandya et al., 2010).

Another factor is the economic and political situation in the involved recipient country, including the lack of ability of beneficiary countries to properly use the provided funds in the existing level of development, the weakness of the national financial institutions, high level of corruption and the instability of political systems. Corruption was the main theme in most of the literature on foreign aid. An international non-profit non-governmental organization is fighting against corruption. A large part of the corruption in developing countries stems from the flow of funds on the line to help. Help ends

up in the pockets of corrupt officials in the system of those states where there is lack of responsibility. As has noted development economist Peter Bauer, foreign aid is "an excellent way to transfer money from rich countries to the poor to rich people in poor countries" (Moyo, 2009; Radelet, 2016).

Poor countries suffer not so much from lack of help, as from the low quality of its management. When the United States and other non-governmental organizations such as the UN and the World Bank, are increasing aid to poor countries around the world, it doesn't change the situation, because most of these countries are plagued with corruption (Werlin, 2005). Zambia has received millions of dollars in aid in the period from 1964 to 2000, but the average income fell from $ 540 up to $ 300. Zambia receives more aid per capita than any other country, however, an increase in foreign aid in recent years in any case does not affect the standard of living or economics. The author believes that corruption in Africa is the cause of extreme poverty in the region. No matter how much money enters into the economy, if the problem of corruption is not solved, economic growth will not bring any benefits. He claims that the Nigerian state system suffers from corruption and, therefore, the World Bank could just stop borrowing money Nigeria. He also proposes to provide assistance only if the country transforms its civil service, the police and the judiciary (Werlin, 2005).

Easterly (2003) discusses the relationship between the economic policy of the recipient countries and aid effectiveness. He uses the work of Burnside and Dollar (2000) as a guide for his arguments. The author argues that aid stimulates growth in favourable political conditions. Easterly claims that the governments of poor countries do not have incentives to increase the production capacity of the poor population, especially when it can lead to political activity threatening the current political elite.

It is important also to mention such negative effect as the "Dutch disease", which hits the countries receiving assistance. The concept of the Dutch disease represents a negative effect that may strengthen the real exchange rate of the national currency on economic development as a result of the boom in a particular sector. The effect got its name according to the events in Holland in 1950, when deposits of natural gas were discovered, after which the extending export of fuel has resulted in an increase of inflation and unemployment and a reduction in manufacturing exports (Malahova, 2011; Moyo, 2009).

In Africa, lot of foreign aid goes to agriculture. This sector plays a key role in the development of states in sub-Saharan Africa as the main source of income, food, employment and an effective means for poverty reduction. "African bank group" with its strategy "Feed Africa" reported that in 2016 more than 70 % of the population of Africa lives in the rural areas and relied on agriculture as the main source of livelihood. The development of the agricultural sector has a greater impact on poverty reduction compared with growth in non-agricultural sectors (Mellor, 1999; Christiaensen et al, 2011). Africa has the largest share of arable land, yet the continent suffers from high degree of malnutrition. About 20% of the inhabitants of the continent is not able to meet the daily energy needs and the average African is faced with a lack of food. Food intake represents a 156 kilocalories per person per day (FAO, 2014).

African agricultural systems also show a low level of mechanization. The share of manual labour in agriculture in Africa is 70 %. This means that the mechanization of production in agriculture is only 30 %. Lack of storage facilities, transport systems and modern slaughterhouses also affects the quality and quantity of African products entering the market. Agricultural businesses in rural agricultural communities reduce post-harvest losses and at the same time provide added value to primary agricultural products. This will lead to higher and more stable prices and at the same time it creates more opportunities for employment. This, in turn, will lead primarily to reduction of poverty, the suppression of the growth of the urban population and ensuring a more sustainable development in rural areas (Blizkovsky, 2017). Another area of agricultural development is a functioning infrastructure. Without good roads and other transport facilities, farmers have limited access to markets, which gives them fewer opportunities to sell surpluses and to obtain favourable market prices, as well as buy modern resources. Infrastructure is related with business and export opportunities (Abramova, 2010). Development aid aims at helping increasing the productivity and sustainability of the African agriculture as well as the efficiency of public sector in general. The paper searches for evidence whether it is successful.

Materials and methods

The established hypothesis has been verified on the basis of correlation analysis using Pearson correlation coefficient (r). It is a measure

of the linear relationship (magnitude of association) between the variables as well as the direction of the relationship (Emerson, 2015). The correlation analysis has limitations as its result do establish a causal connection between the phenomena.

In addition, we also run a Spearman correlation coefficient. The reason for using this second measure was to deal with the extreme data values. Instead of arbitrary elimination of such values from the Pearson correlation coefficient calculation we used Spearman correlation coefficient. It is a suitable tool for cases of unknown probability distribution (De Winter, Gosling and Potter, 2016).

The value of the correlation coefficient varies in the interval (-1;1) where $r > 0$ means a positive relationship between X and Y, $r < 0$ means a negative relationship and $r = 0$ means no relationship (Ratner, 2009). For establishing the level of correlation, we use the following values: r = 0 linear correlation independence $|r| = 0.01$ - 0.30 weak correlation, $|r| = 0.31$ - 0.50 moderate correlation, $|r| = 0.51$ - 0.70 medium correlation, $|r| = 0.71$ - 0.90 high correlation, $|r| = 0.91$ - 0.99 very high correlation and $r = 1$ functional correlation (Biskup, 2009).

The statistical significance of both Pearson and Spearman correlation coefficients was evaluated by p-value. In the paper we consider results where $p < 0.05$ (5 % significance level) as statistically significant.

Data were collected from the database of the Credit Reporting System of the OECD (2016) and from FAOSTAT (2016) and World Bank (2016). The time period for this research was provided in the time interval from 2002 until 2016 inclusive. All the indicators used in the study were tested on correlation with the indicator "development assistance to agriculture", that was further divided into three separate indicators: the total official development assistance (ODA) to agriculture, bilateral ODA for agriculture and multilateral ODA to agriculture. The data came from the database of the OECD (2016) and are measured in millions of dollars fixed price.

As a proxy for the productivity of agricultural production were used the cereal yield (kg/ha). This indicator was chosen because it includes large part of the plant production and includes cereals, such as rice, corn, barley, oats, rye, millet, sorghum, buckwheat and mixed grains, most of which is grown in the three studied countries.

For measuring the quality of public administration we used the management indicators of the World Bank (2018). They range from -2.5 (worst) to 2.5 (best). As indices of the quality of the state administration we selected (1) political stability and absence of violence and (2) control of corruption. The Index Political Stability and Absence of Violence includes indicators that measure the stability of state institutions, the probability of drastic changes, a change in policy, the destabilization and overthrow of the non-constitutional methods or by the use of violence. The index of control of corruption shows the level of use of state power for mercenary purposes, the existence of corruption at a high political level, the level of participation of elites in corruption or impact of corruption on economic development. Both aggregate indicators combine the views of a large number of enterprise, citizen and expert survey respondents in industrial and developing countries. They are based on over 30 individual data sources produced by a variety of survey institutes, think tanks, non-governmental organizations, international organizations, and private sector firms (The World Bank, 2019).

Results and discussion

The results for correlation between the official development aid to agriculture (bilateral, multilateral and total), agricultural production (expressed by cereal yield), the political stability and absence of violence and the control of corruption are presented for each of the three countries.

The case of Ghana

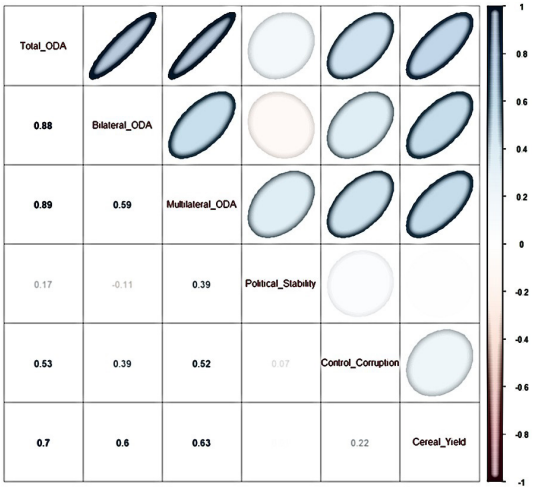
In case of Ghana (Figure 1, Table 1) the correlation analysis measured by Pearson coefficient confirmed the hypothesis on the positive impact of the total, multilateral and bilateral foreign aid for the agricultural sector in the country (statistically significant medium correlation).

The correlation between the political stability and absence of violence includes indicators that measure the stability of state institutions, the probability of drastic changes or political destabilization. The results indicate a weak positive and statistically non-significant correlation between the amount of total and multilateral aid Political Stability and Absence of Violence and total and multilateral aid flows for development. In case of the bilateral aid this correlation is even negative (statistically non-significant).

As for corruption, Ghana has achieved considerable success in the fight against corruption with the transition to civilian government in 1992.

This is confirmed by a positive medium level of correlation between the control of corruption and multilateral and total official development aid (statistically significant). The correlation for bilateral aid was moderate and statistically non-significant).

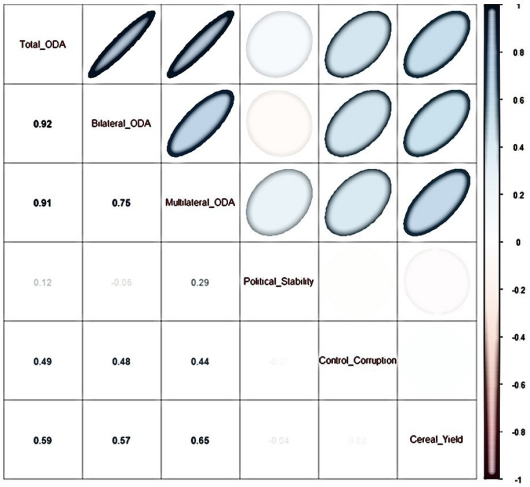
The Ghana results are the largely confirming the research hypothesis on positive correlation between official aid and selected political indicators as well as on the agricultural productivity.



Source: Source: OECD (2016), FAOSTAT (2016) and World Bank (2016)

Figure 1: Correlation between official development aid (bilateral, multilateral and total), the political stability and absence of violence, the control of corruption and agricultural production (expressed by cereal yield) in Ghana for the period 2002-2016 (Pearson coefficient).

The results for Ghana measured by Spearman coefficient (Figure 2, Table 2) provided for a similar correlation pattern as in the case of the Pearson coefficient. The correlation between all types of official aid and political stability and absence of violence was statistically non-significant and weak and even negative (bilateral aid). Also statistically non-significant was the correlation between the official aid and corruption control. Cereal productivity was positive at medium level (statistically significant).



Source: Source: OECD (2016), FAOSTAT (2016) and World Bank (2016)

Figure 2: Correlation between official development aid (bilateral, multilateral and total), the political stability and absence of violence, the control of corruption and agricultural production (expressed by cereal yield) in Ghana for the period 2002-2016 (Spearman coefficient).

	Total ODA	Bilateral ODA	Multilateral ODA	Political Stability	Control Corruption	Cereal Yield
Total ODA		**0.0000**	**0.0000**	0.5534	**0.0413**	**0.0034**
Bilateral ODA	**0.0000**		**0.0209**	0.7064	0.1529	**0.0171**
Multilateral ODA	**0.0000**	**0.0209**		0.1516	**0.0469**	**0.0117**
Political Stability	0.5534	0.7064	0.1516		0.816	0.9765
Control Corruption	**0.0413**	0.1529	**0.0469**	0.816		0.435
Cereal Yield	**0.0034**	**0.0171**	**0.0117**	0.9765	0.435	

Note: p-values bellow 0.05 mean that correlation coefficient je statistically significant on the above 5% level (in bold).
Source: Source: OECD (2016), FAOSTAT (2016) and World Bank (2016)

Table 1: Probability value (p-value) for the correlations for Ghana for the period 2002-2016 (Pearson coefficient).

	Total ODA	Bilateral ODA	Multilateral ODA	Political Stability	Control Corruption	Cereal Yield
Total ODA		**0.0000**	**0.0000**	0.6757	0.0664	**0.0198**
Bilateral ODA	**0.0000**		**0.0013**	0.8298	0.0687	**0.0272**
Multilateral ODA	**0.0000**	**0.0013**		0.2957	0.1014	**0.0087**
Political Stability	0.6757	0.8298	0.2957		0.9698	0.8894
Control Corruption	0.0664	0.0687	0.1014	0.9698		0.9496
Cereal Yield	**0.0198**	**0.0272**	**0.0087**	0.8894	0.9496	

Note: p-values bellow 0.05 mean that correlation coefficient je statistically significant on the above 5% level (in bold).
Source: Source: OECD (2016), FAOSTAT (2016) and World Bank (2016)

Table 2: Probability value (p-value) for the correlations for Ghana for the period 2002-2016 (Spearman coefficient).

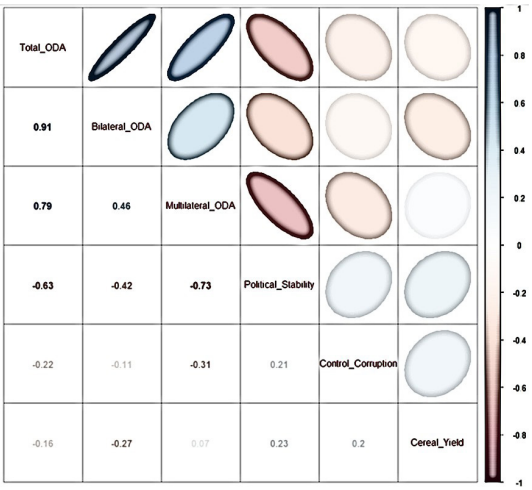
Case of Cameroon

As for Cameroon, measured by Pearson coefficient (Figure 3, Table 3), there is a multilateral development assistance at weak positive and statistically non-significant level (r = 0.07), but bilateral and total foreign aid has a negative effect (r = -0.27 and r = -0,16).

The correlation between official development aid and political stability and absence of violence was even negative at moderate (bilateral aid) and medium levels for total aid (r = -0.63, statistically significant) and multilateral aid (r = -0.73, statistically significant).

Also the correlation between official development aid and control of corruption was negative although at a weak and statistically non-significant levels.

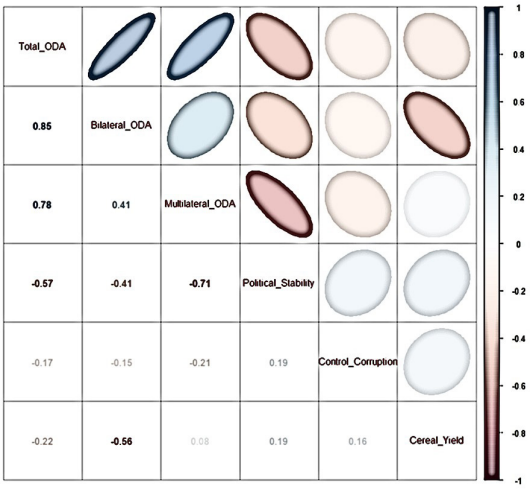
Unlike the case of Ghana, the results are not confirming the research hypothesis on positive correlation between official aid and selected political indicators as well as on the agricultural productivity.



Source: Source: OECD (2016), FAOSTAT (2016) and World Bank (2016)

Figure 3. Correlation between official development aid (bilateral, multilateral and total), the political stability and absence of violence, the control of corruption and agricultural production (expressed by cereal yield) in Cameroon for the period 2002-2016 (Pearson coefficient).

The results for Cameroon measured by Spearman coefficient (Figure 4, Table 4) given comparable correlation results as it was the case of the Pearson coefficient. The correlation between all typed of official aid and political stability and absence of violence was negative. It correlation was at moderate level and statistically significant on case of total aid (r = -0.57) and multilateral aid (r = -0,71). The correlation between the official aid and corruption control was statistically non-significant, negative and weak. Cereal productivity correlated negatively with total (r = -0.22) and bilateral aid (r = -0.56, statistically significant).



Source: Source: OECD (2016), FAOSTAT (2016) and World Bank (2016)

Figure 4: Correlation between official development aid (bilateral, multilateral and total), the political stability and absence of violence, the control of corruption and agricultural production (expressed by cereal yield) in Cameroon for the period 2002-2016 (Spearman coefficient).

	Total ODA	Bilateral ODA	Multilateral ODA	Political Stability	Control Corruption	Cereal Yield
Total ODA		**0.0000**	**0.0005**	**0.0121**	0.4322	0.5709
Bilateral ODA	**0.0000**		0.0823	0.1228	0.69 ncsl47	0.0171
Multilateral ODA	**0.0005**	0.0823		**0.0022**	0.2679	0.8147
Political Stability	**0.0121**	0.1228	**0.0022**		0.4593	0.4165
Control Corruption	0.4322	0.6947	0.2679	0.4593		0.4718
Cereal Yield	0.5709	0.3256	0.8147	0.4165	0.4718	

Note: p-values bellow 0.05 mean that correlation coefficient je statistically significant on the above 5% level (in bold).
Source: Source: OECD (2016), FAOSTAT (2016) and World Bank (2016)

Table 3: Probability value (p-value) for the correlations for Cameroon for the period 2002-2016 (Pearson coefficient).

	Total ODA	Bilateral ODA	Multilateral ODA	Political Stability	Control Corruption	Cereal Yield
Total ODA		**0.0000**	**0.0006**	**0.0249**	0.5327	0.4277
Bilateral ODA	**0.0000**		0.1320	0.1320	0.5848	**0.0284**
Multilateral ODA	**0.0006**	0.1320		**0.0030**	0.4588	0.7710
Political Stability	**0.0249**	0.1320	**0.0030**		0.4910	0.4910
Control Corruption	0.5327	0.5848	0.4588	0.4910		0.5760
Cereal Yield	0.4277	**0.0284**	0.7710	0.4910	0.5760	

Note: p-values bellow 0.05 mean that correlation coefficient je statistically significant on the above 5% level (in bold).
Source: Source: OECD (2016), FAOSTAT (2016) and World Bank (2016)

Table 4: Probability value (p-value) for the correlations for Cameroon for the period 2002-2016 (Spearman coefficient).

Case of Mali

For Mali the correlation analysis measured by Pearson coefficient (Fig. 5, Tab. 5) showed that the agricultural productivity measured by cereal yields was positive for all types of development assistance. The strongest correlation was for the total aid (r = 0.60, statistically significant). Positive addiction agriculture in Mali on bilateral aid can be explained using a number of aid donor countries. Between 2002 and 2016 provided by donor countries to 1.01 billion dollars for the development of agriculture, compared with 693 million dollars provided by the international organizations (OECD, 2016).

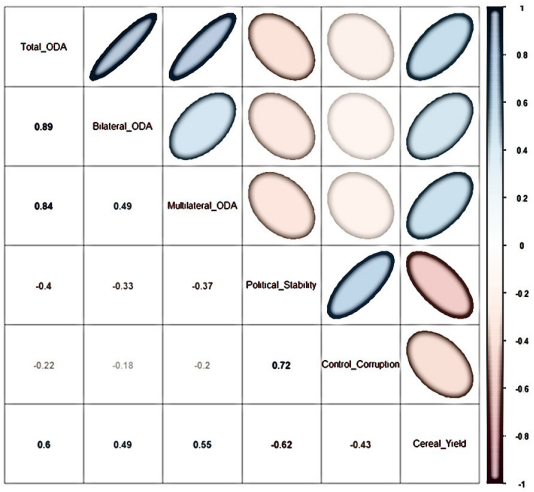
The correlation between the political stability and absence of violence includes indicators that measure the stability of state institutions, the probability of drastic changes or political destabilization. The results indicate a weak positive and statistically non-significant correlation between the amount of total and multilateral aid Political Stability and Absence of Violence and total and multilateral aid flows for development. In case of the bilateral aid this correlation is even negative (statistically non-significant).

As for corruption, Ghana has achieved considerable success in the fight against corruption with the transition to civilian government in 1992. This is confirmed by the a positive medium level of correlation between the control of corruption and multilateral and total official development aid (statistically significant). The correlation for bilateral aid was moderate and statistically non-significant).

Similarly to Cameroon, also in Mali the correlation between political stability and absence of violence coefficient and official aid was moderately negative (statistically non-significant). shows a value of r = -0.43 and r = -0.53. This negative correlation dependence can be explained by a possibility that the raising funds for the development plays an influence of panacea. The negative dependence in Mali can also be explained by the fact that the instability caused by the conflict was observed on the northeast of the country, where there had been virtually no active agricultural activities.

Also the control of corruption and official aid correlation was weakly negative (statistically non-significant). This can indicate that the donors aid is insufficiently linked with the anti-corruption mechanisms.

The results are not confirming the research hypothesis on positive correlation between official aid and selected political indicators. The research hypothesis can be however confirmed for the case of the agricultural productivity.



Source: Source: OECD (2016), FAOSTAT (2016) and World Bank (2016)

Figure 5: Correlation between official development aid (bilateral, multilateral and total), the political stability and absence of violence, the control of corruption and agricultural production (expressed by cereal yield) in Mali for the period 2002-2016 (Pearson coefficient).

The results for Mali measured by Spearman coefficient (Figure 6, Table 6) are very close of those obtained by analysis based on Pearson coefficient.

	Total ODA	Bilateral ODA	Multilateral ODA	Political Stability	Control Corruption	Cereal Yield
Total ODA		**0.0000**	**0.0000**	0.1348	0.4213	**0.0187**
Bilateral ODA	**0.0000**		0.0635	0.2325	0.5285	0.0662
Multilateral ODA	**0.0000**	0.0635		0.1765	0.4649	**0.0319**
Political Stability	0.1348	0.2325	0.1765		**0.0027**	**0.0128**
Control Corruption	0.4213	0.5285	0.4649	**0.0027**		0.1064
Cereal Yield	**0.0187**	0.0662	**0.0319**	**0.0319**	0.1064	

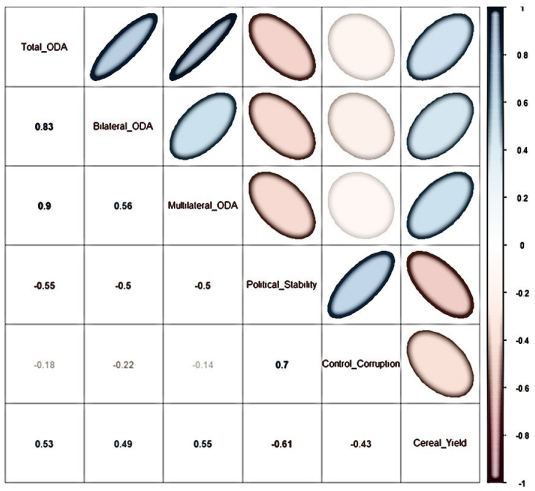
Note: p-values bellow 0.05 mean that correlation coefficient je statistically significant on the above 5% level (in bold).
Source: Source: OECD (2016), FAOSTAT (2016) and World Bank (2016)

Table 5: Probability value (p-value) for the correlations for Mali for the period 2002-2016 (Pearson coefficient).

	Total ODA	Bilateral ODA	Multilateral ODA	Political Stability	Control Corruption	Cereal Yield
Total ODA		**0.0001**	**0.0000**	**0.0323**	0.5243	**0.0412**
Bilateral ODA	**0.0001**		**0.0310**	0.0598	0.4201	0.0664
Multilateral ODA	**0.0000**	**0.0310**		0.0577	0.6296	**0.0323**
Political Stability	**0.0323**	0.0598	0.0577		**0.0034**	**0.0148**
Control Corruption	0.5243	0.4201	0.6296	**0.0034**		0.1110
Cereal Yield	**0.0412**	0.0664	**0.0323**	**0.0148**	0.1110	

Note: p-values bellow 0.05 mean that correlation coefficient je statistically significant on the above 5% level (in bold).
Source: Source: OECD (2016), FAOSTAT (2016) and World Bank (2016)

Table 6: Probability value (p-value) for the correlations for Mali for the period 2002-2016 (Spearman coefficient).



Source: Source: OECD (2016), FAOSTAT (2016) and World Bank (2016)

Figure 6: Correlation between official development aid (bilateral, multilateral and total), the political stability and absence of violence, the control of corruption and agricultural production (expressed by cereal yield) in Mali for the period 2002-2016 (Spearman coefficient).

Our analysis can be translated as having the following economic, social and political impact. Economically speaking, the performance of agriculture can be improved via more effective foreign aid. Societally, the sustainability risk related to the agricultural production is increasing. Therefore, the volume of financial resources should increase to the development of agricultural research, which is focused on the development of resistant seeds and modern methods and technologies of work with the soil, which will increase the yields of food agricultural crops, such as rice, yam, cassava, millet and more. Also, due to the gradual climate change should increase the volume of financial resources on the development of irrigation infrastructure and water resources. It will be important to increase funding for post-harvest losses.

The political aspect of the problem of development assistance to foreign aid could solve the current agricultural problems in Ghana, Cameroon and Mali, and it requires strong political will. Deficiencies in this respect is one of the main reasons for the incorrect allocation of foreign aid. Foreign aid will work best in countries with good policies and institutions, such as Ghana. Similarly, the improved agricultural performance is likely to contribute to the stabilization of the political situation in the given country.

Discussion

This paper examined the effects of agricultural development assistance on agricultural productivity in Ghana, Cameroon and Mali. The paper had a regional focus in comparison with the researches of a number of authors who have dealt with the influence of foreign aid on a global level (Alabi, 2014; Ssozi et al., 2017). For example, Alabi examined the impact of foreign aid on agricultural productivity on the example of the 47 countries in Africa. The results of the regional and global studies have varied results. As for the impact of bilateral

aid on agricultural productivity, he has in the three countries and at the global level assistance from the DAC a significant impact on agricultural productivity.

As far as the multilateral agricultural aid on agricultural productivity, at the global level revealed no significant addiction. But in this study help from organisations has a significant impact in Ghana and less of an impact on Mali. Alabi (2014) explains this by saying that the volume of bilateral aid is usually higher than the volumes of multilateral assistance. A regional example of Ghana, however, shows the opposite trend. It gives impetus to the study of the impact of both forms of assistance on the example of other countries in the African continent.

The example of Cameroon and Mali has confirmed a match with some of the authors that despite the constant high level of corruption, financial support will be provided and it may be increased (Alabi, 2014; De la Croix and Delavallade, 2013). The quality of public administration in the case of Ghana, however, endorsed the proposal of several authors, that the assistance will be effective and will increase in the country, where there are good governance (Knack, 2001; Collier and Dollar, 2001).

Based on the analysis of countries such as Ghana, Cameroon and Mali, and its results, we would like to offer a series of recommendations.

The primary recommendation would be the growth in the volume of foreign agricultural aid with a view to increase its impact on the performance of agriculture and its contribution to the economy of Ghana and Mali. It will be important to increase the volume of agricultural development assistance from both donor countries and the international organizations. In case of Cameroon, the weak correlation between foreign aid to agriculture sector and actual agricultural productivity means that there are other limiting factors hampering the agricultural growth than the inflow of capital to the sector. We suppose that these systemic blocks should be removed by Cameroon before external aid increase.

It will be essential to grow the volume of agricultural aid to those subsectors of agriculture of Ghana and Mali, which carry the most risk for agricultural productivity. The volume of financial resources should advance the development of agricultural research, which is focused on the development of resistant seeds and modern methods and technologies of work with the soil, which will increase the yields of food agricultural crops, such as rice, yam, cassava, millet and more. Also, due to the gradual climate change, the volume of financial resources on the development of irrigation infrastructure and water resources should be improved. It will be important to increase funding for post-harvest losses.

What concerns the political aspect of the problem of development assistance to foreign aid could solve the current agricultural problems in Ghana, Cameroon and Mali, it is the necessary strong political will for the implementation of good public policy practice. A large part of the literature confirms that the objectives in the field of economy and development goes hand in hand with the political objectives. This is one of the main reasons for the incorrect allocation of foreign aid. Foreign aid will work best in countries with good policies and institutions, as in Ghana.

Conclusion

The paper focused on the analysis of the impact of development aid on the productivity of agricultural production in Ghana, Cameroon and Mali. The role of agriculture in the economic development of the African continent was analysed and it was shown that agriculture plays a leading role in the economic development of the continent. In addition, the main problems of its development were analysed, with an emphasis on sub-Saharan Africa. The aim of work was to determine: 1) whether the development assistance positively correlates with the productivity of agriculture and 2) whether the quality of public administration correlates with the flows of development assistance. For the analysis of the total assistance in the area of agricultural development divided into bilateral and multilateral, to determine which of them has the greatest impact. The analysis showed that the development aid correlated positively with agricultural productivity measured by cereal yields in Ghana and Mali. The multilateral agricultural aid correlated most with the agricultural productivity. In Cameroon, no significant correlation was observed.

When it comes to "political" hypothesis, here we analysed the effects of the quality of public administration on the flows of agricultural aid. In Ghana, the hypothesis was confirmed that the volume of assistance provided depends on the quality of public administration. As for Cameroon and Mali the aid flows have a negative and/or non-significant dependence on the quality of public administration.

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Readiness for ICT Based B2C Information Flow – Case Study of the Hungarian Food Sector

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Abstract

The complexity of information flow and cooperation among enterprises operating in a supply chain is growing. This process has a significant impact on the economy and the objective is that both traditional and new ICT (Information and Communication Technology) solutions meet the pressing needs for more efficient business processes. The current paper focuses on enterprises belonging to the food supply chain and analyses some indicators supporting the information flow within the company and with partners (being either a partner enterprise or the final consumer). Our Institute has prepared a survey to examine the ICT usage and attitude by enterprises operating in the agri-food sector. The importance of business processes supportable by ICT had to be assessed by companies. In this study we evaluated the importance of some ICT indicators supporting information flow in the chain. The main objective of the current article is to determine the difference between food enterprises divided by different grouping factors regarding their evaluation of the chosen indicators. In our opinion, competitive advantage may be reached using ICT solutions for widening and maintaining relations through a more effective information flow with partners and consumers.

Keywords

Food sector, information flow, ICT, readiness, B2C.

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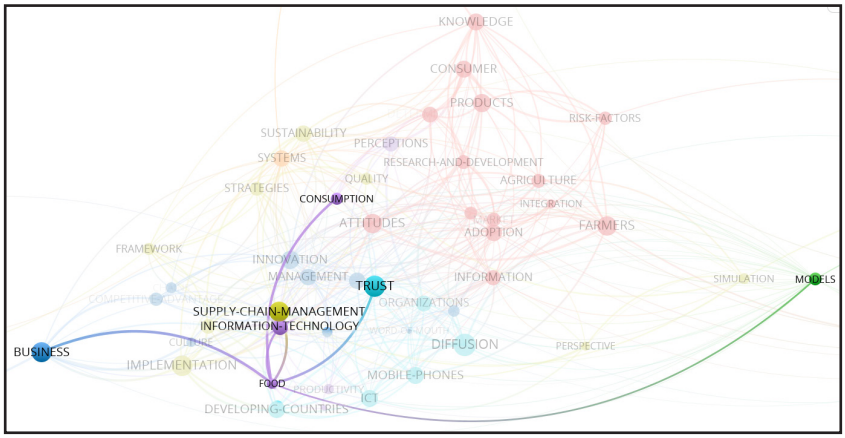
Introduction

Over the last two decades, many empirical and case studies have been published on the advantages that information systems may offer in decentralized supply chains. For this study, we first made a network analysis of literature to highlight those keywords and research topics that are mainly in connection with our research topic. Figure 1. provides information on those research topics that are in close connection with the food sector and ICT.



Source: own processing according to Web of Science, 2019

Figure 1: Map of the research field based on keyword combinations.

The main keyword connections with the keyword 'FOOD' are highlighted on the figure. This means that the analyses on food are considered a major research topic together with supply chain management, information technology, trust, consumption, business and models.

Regarding supply chains, arguments in favor of using information systems, advantages of information-sharing methods and impacts of the level of ICT usage are described both in synthesizing papers (Chen, 2003; Consoli, 2012; Viet et al., 2018) and empirical studies (Wu and Jia, 2018; Costantino et al., 2015). Good practices are also proposed in many papers and there are several case studies on this research field that analyse the information flow between different parts of the supply chain (Bian et al., 2016; Dominguez et al., 2018). Several models carried out and published in articles confirming the role of data collection and the importance of cooperation and information sharing among chain members (Fiala, 2005; Kirilova and Vaklieva-Bancheva, 2017).

In this paper we analyse the agri-food supply chain (comprising enterprises operating in agriculture or food manufacturing). Similar to any other sectors, SMEs have a key role; 99% of the enterprises belongs to this size category and they have a considerable share in indicators representing the agri-food sector (Felföldi et al., 2017). However, agri-food SMEs operate in an adverse economic environment compared to large companies (e.g., productivity, bargaining power, partnerships or the volume of marketable production). Regarding the usage of ICT, proving traceability and transparency is one of the main application fields in the agri-food sector. The role of traceability practices supported by ICT has been identified as a factor increasing food safety and quality in many empirical papers (Füzesi et al., 2016a; Maloni and Brown, 2006; Grimm et al., 2014; Dabenne and Gay, 2011; Ding et al., 2019; Bourlakis et al., 2014), however, ICT devices used for traceability purposes could provide information for the management too and it may be relevant for smoothing material flow and maintaining the continuity of information flow throughout the chain (Füzesi et al., 2016b), including consumers. ICT solutions have to be classified as one of the five criteria of transparency of food supply chain (Trienekens et al., 2012) and a more intensive deployment of ICT is founded to need not only for optimization of the company's internal processes but also for the successful involvement in e-business (Ahmedova, 2015). The increase of information transparency requires an infrastructure that proves a continuous information flow and data share with partners (Pant et al., 2015).

But besides advantages, implementation of an information system or a supply chain practice has to be financially sound for enterprises (Zhou et al., 2014) and company size seems to be a hindering factor. There is a sound literature due to the costs of ICT implementation (Taruté and Gatautis, 2014; Plumb and Zamfir, 2008; Modimogale and Kroeze, 2011). As large companies are moving to exploit the advantages offered by ICT, smaller companies face difficulties (European Commission, 2018). Stimulating the agri-food SMEs is important for both EU and national strategies. The eFoodChain project, provided by the European Commission, is one of the measures demonstrating the real benefits of ICT and eBusiness solutions for agri-food companies operating in the cereals, fresh fruits and vegetables and dairy sectors (FAO, 2016).

Today, open-source and free cloud services also can offer good solutions to overcome the reasons against using ICT. Látecková et al. (2018) confirm that the use of new ICT solutions could make agricultural enterprises more efficient and strengthen their competitive positions. ICT and innovation, as dynamic capabilities, are strategic resources that support to maintain a sustainable competitive advantage (Yunis, 2018). Cloud computing is an attractive option for many SMEs and several case studies from different countries reinforce the advantages (flexible cost structure, scalability, privacy and usage features) the technology could bring for SMEs (Sultan, 2011; Gupta et al., 2013; Tutunea, 2014; Vasiljeva et al., 2017). Open-source software and content management systems are broadly used in areas such as agriculture or rural development (Masner et al., 2018). Although, the relative advantages of these technologies can only be achieved if adequate resources are allocated (Hassan, 2017). Knowledge Management could also be a tool to contribute to an adequate level of supply chain information flow and SMEs could further increase the impact of it by better exploiting the opportunity offered by the new ICTs (Cerchione and Esposito, 2017.

Overall, there is a vast amount of literature on ICT characteristics in the context of the food supply chain, agri-food sector and SMEs, however, there is still a further need for analyses. In part because enterprises, in many cases, underestimate the potential offered by ICT, or cannot exploit them (Fawcett et al., 2011). In part, because there

is still a shortage of empirical and case studies to substantiate advantages (Teunter et al., 2018). In 'Results and discussion' we show our analysis on some ICT indicators that can support information flow from business to consumer (B2C) in the case of food-producing and food processing companies. In 'Conclusions' we present some opportunities to an advanced B2C connection and future research directions.

Materials and methods

Our institute of the University of Debrecen prepared a questionnaire to survey the ICT usage characteristics of enterprises operating in the agri-food supply chain. Data of our survey analysed in current paper was collected in the fourth quarter of 2017. Respondents were Hungarian enterprises operating in sectors related to agriculture (producers) and the food industry (processors). The questionnaire was structured, responses were recorded by a market research company contacting the leaders or a management member of the enterprises. The sample has been selected by stratified sampling based on statistics of the Hungarian Central Statistical Office (HCSO). A total of 500 questionnaires were recruited for this study. The exact codes of the sample enterprises included in our research can be seen in Table 1.

A – Agriculture, forestry and fishing
01.11 – Growing of cereals (except rice), leguminous crops and oil seeds
01.13 –Growing of vegetables and melons, roots and tubers
01.21 – Growing of grapes
01.24 – Growing of pome fruits and stone fruits
01.41 – Raising of dairy cattle
01.46 – Raising of swine/pigs
01.47 – Raising of poultry
C – Manufacturing
10.1 – Processing and preserving of meat and production of meat products
10.3 – Processing and preserving of fruit and vegetables
10.5 – Manufacture of dairy products
10.7 – Manufacture of bakery and farinaceous products

Source: Eurostat, 2008

Table 1. NACE Rev.2 Codes of Respondent Enterprises.

The number and share of enterprises in the sample database were compared, by sector, to the number of the whole population obtained from the database of Hungarian Central Statistical Office (HCSO), and the result can be seen in Table 2.

The sample size was compared to the total population by size categories and the regions of Hungary and it shows a similar distribution; thus, the sample can be considered representative.

Sector code	Population (in HCSO in 2017)	Share from Total	Number of samples	Share from Total	% of population represented by sector
Food-producers (01)	**16 133**	**83.22%**	**355**	**71%**	**2.20%**
01.11	7 860	40.55%	234	46.8%	2.98%
01.13	2 627	13.55%	16	3.20%	0.61%
01.21	890	4.59%	6	1.20%	0.67%
01.24	1 763	9.09%	5	1.00%	0.28%
01.41	778	4.01%	28	5.60%	3.60%
01.46	842	4.34%	19	3.80%	2.26%
01.47	1 373	7.08%	47	9.40%	3.42%
Food processors (10)	**3 252**	**16.78%**	**145**	**29%**	**4.46%**
10.1	581	3.00%	37	7.40%	6.37%
10.3	556	2.87%	37	7.40%	6.65%
10.5	119	0.61%	10	2.00%	8.40%
10.7	1 996	10.30%	61	12.20%	3.06%
Total (01+10)	**19 385**	**100%**	**500**	**100%**	**2.58%**

Source: own survey, 2017; HCSO database, 2017

Table 2: Share of respondent enterprises by sector.

In this study, we evaluated three questions due to the relevance of information flow from business to consumer:

- Evaluate the importance of ICT solutions for marketing activities (Variable 1)
- Evaluate the importance of regular update of website information (Variable 2)
- Chose the technology that your company use for product identification

Descriptive Statistics, Ordinal Logistic Regression and Two-sample t-test were used to analyse our data and the software package used was R statistics and Microsoft Excel.

Respondents assessed Variable 1 and 2 on 5-point Likert scale; thus Ordinal Logistic Regression was used to determine the probability for Likert values of respondents grouped by different economic factors. Ordinal Logistic Regression is an extension of binomial logistic regression. This methodology is used to predict the dependent variable with ordered multiple categories and independent variables. In our case, dependent variables were indicators assessed on a Likert scale from 1 (not important) to 5 (very important) and independent variables were the grouping factors, such as main food sectors (producer or processor), size categories (small, medium or large). The model calculated the significance of coefficients and intercepts and since the p-value was <0.05 for all variables, they are statistically significant at a 95% confidence interval.

To determine whether there is a significant difference in the importance of ICT for business activities between sample groups clustered by food sectors we used two-sample t-test too. Our data sets contain two independent data sample and before comparing sample means, an F-test was used first if the standard deviations of the two populations are equal. We chose the F-test instead of the Levene-test as the latter is strongly significant for large and equal sample size. Our sample sizes are smaller and not equal; thus F-test was used and in output tables showing the results of two-sample t-tests also report the result of the F-test. To determine the difference between score means Two-sample t-test was used assuming equal and unequal variances on our Likert-scale data (Norman, 2010), based on the results of the F-test. The difference is considered significant if Sig.(2-tailed)<0,05.

Results and discussion

Information flow is crucial between partners in the supply chain and we consider cooperation and contact with final consumers would be important too, from both the point of view of food-producers and food processors. In recent years, there is an increasing demand for information on food products. Information on the packaging, however, is not only to respond for the customer demand, but the advantage for them is also considerable and their choice could be more conscious. In this chapter we show our results on the importance of some ICT indicators which means a general measure in ICT development and which could support this aim. Ordinal logistic regression was used to calculate the probability that a given type of enterprise will recognize an ICT solution important or not.

First, we calculated the probability values for food-producers and food-processors separately. Our aim was to determine whether any difference between enterprises operating in a different stage of the food supply chain. Table 3 lists the mean scores for the two variables.

	Variable 1	Variable 2
Food-producers (n = 355)	3.18	3.00
Food processors (n = 145)	3.53	3.38

Source: own survey, 2017

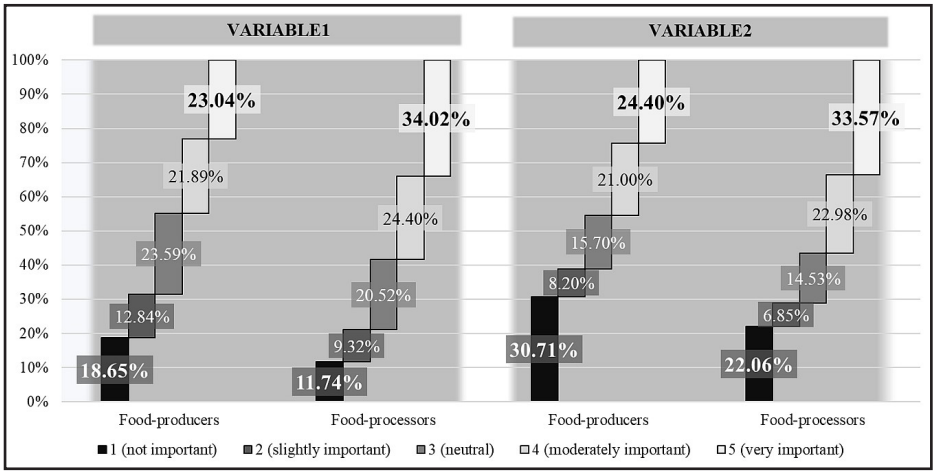
Table 3: Mean scores of variables by main food sectors.

We note from Table 1 that food processors have a higher mean score for both variables. Figure 2 shows the probability of what score would be given by companies operating in the food production and food processing sector on a 5-point Likert scale for the two analysed variables.

Our results show that the probability that a food processing company will consider ICT for marketing activities ‘moderately important’ or ‘very important’ is a bit higher than 58%, while this value is slightly slower than 45% in the case of food producers. The result is similar in the case of the importance of continuous and regular update of information on website, the probability for ‘important’ or ‘very important’ is ~56% for food processors and only ~45% or producers.

Further analyses were done by size categories and processing subsectors.

The sample size enables us to apply two-sample t-test to determine whether the difference between food-producers and food processors is significant. Table 4 details the descriptive statistics of the two variables.



Source: own survey, 2017

Figure 2: Forecast values for the variables by respondent enterprises.

Variables	"Food producers Observations: 355"			"Food processors Observations: 145"		
	Mean	Std.Deviation	Std.Error Mean	Mean	Std.Deviation	Std.Error Mean
Importance of ICT for marketing activities	3.1887	1.3491	0.0716	3.5310	1.5140	0.1257
Importance of continuous and regular update of information on website	3.0028	1.5793	0.0838	3.3862	1.5509	0.1288

Source: own survey, 2017

Table 4: Group statistics of the scores given by food producers and food processors.

Variables	F-test for Equality of Variances			Two sample t-test for Equality of Means						
	F	"Sig. (2P)"	F-crit	t	df	"Sig. (2-tailed)"	Mean difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Importance of ICT for marketing activities	0.7940	0.0903	0.7992	-2.4828	498	0.0133	-0.3423	0.1378	-0.6132	-0.0714
Importance of continuous and regular update of information on website	1.037	0.8109	1.2675	-2.4759	498	0.0136	-0.3833	0.1548	-0.6876	-0.0791

Source: own survey, 2017

Table 5: Output Table of Two Sample T-test.

Variable means are higher in both cases for food processors; however, these means are all under 4. This means that enterprises do not consider important these basic ICT-based services to make the opportunity for a more effective information flow. The difference is approximately 0.4 for both variables and Table 5 lists the result of the two-sample t-test.

The results suggest that there is a significant difference between producers and processors in food sector. The mean scores given by food processors were significantly higher both for the importance of ICT for marketing activities (Sig. (2-tailed) = 0.0134 and t-value = -2.4829) and for the importance of continuous and regular update of information on website (Sig. (2-tailed) = 0.0136 and t-value = -2.4759). In fact, the food processing sector is closer for consumers as these companies have more data on food products, but our result still indicates a willingness to a more effective cooperation within the supply chain. As manufacturing companies can share information on labels and packages, a higher evaluation of these ICT opportunities suggests a tendency to provide easy access to information and to have an impact on consumer choice. Food-producers produce mainly raw food materials, but they could also participate in information flow in the chain. Producing companies can also use an online platform for sharing indicators that consumers are interested in.

Difference by sector and size category

Within sectors, we considered an important issue with measuring differences by size categories. Revealing the relative positions of size categories (micro, small, medium and large) regarding the ICT usage and tendency of adoption could be useful for both policy makers and company owners. Mean scores of the importance of ICT solutions in marketing activity (Variable 1) and the importance of Regular update of website information (Variable 2) are presented first by size categories in the production and processing part of the supply chain. Large category is excluded from this analyse for the small sample size (n = 8). Table 6 lists the score means.

Mean scores of food processing companies clearly exceed the mean values of food-producers. Regarding the size categories, values of medium-sized companies are higher in three cases. Figure 3 demonstrates the result of the logistic regression and shows the probabilities for evaluating variables important or not.

Figure 3 shows a clear growing trend between size categories; the larger the size of a company, the higher the percentage considering a variable 'very important'.

We analysed the situation of companies separately by NACE Rev.2 codes; our aim was to determine the impact of activities on ICT evaluation. Due to the size of food-producing companies, this analysis was made only for food processing activities. The score means of variables calculated by food processing activities can be seen in Table 7.

	Variable 1	Variable 2
Processing and preserving of meat and production of meat products	3.57	3.57
Manufacture of dairy products	3.70	2.40
Processing and preserving of fruit and vegetables	3.57	3.49
Manufacture of bakery and farinaceous products	3.50	3.54

Source: own survey, 2017

Table 7: Mean score of variables by the processing sector.

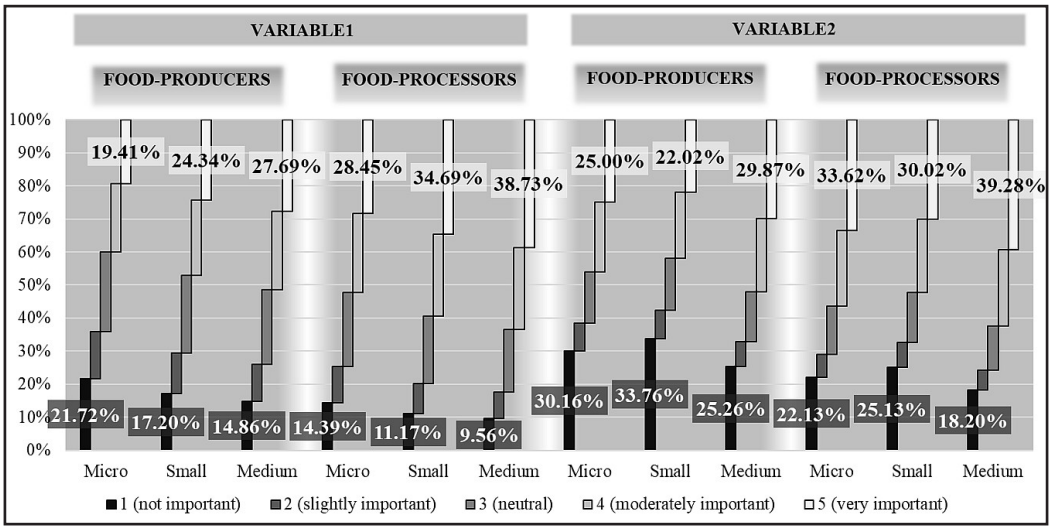
There are only minor differences between score means by activities; however, in the case of dairy manufacturing the mean score is significantly lower than the others. Figure 4 shows the percentages for probabilities by food processing sectors.

The probability for evaluating the variables at least 4 (moderately important) is much higher when the sample is grouped by activities. For Variable 1,

	Variable 1			Variable 2		
	Micro	Small	Medium	Micro	Small	Medium
Food-producers	3.09	3.26	4.07	3.06	2.88	3.14
Food processors	3.14	3.53	3.19	3.27	3.21	3.85

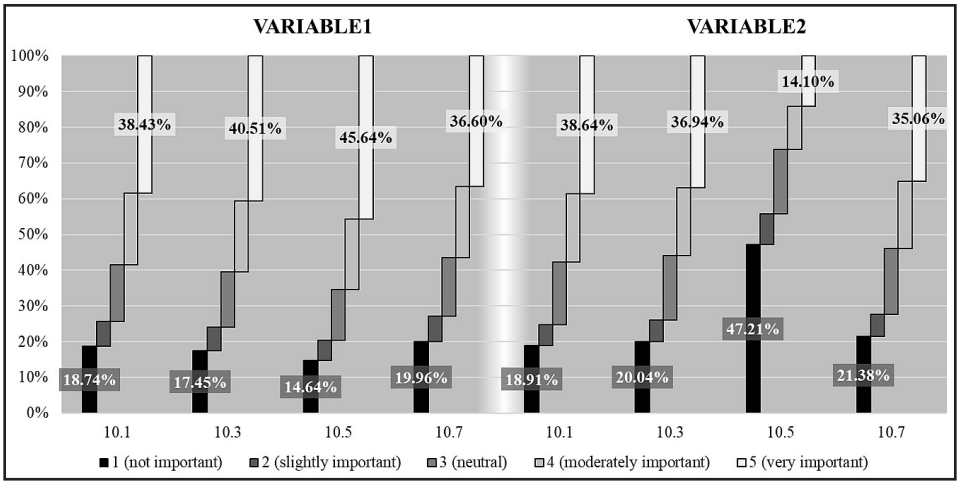
Source: own survey, 2017

Table 6: Mean scores of variables by main food sectors and size categories.



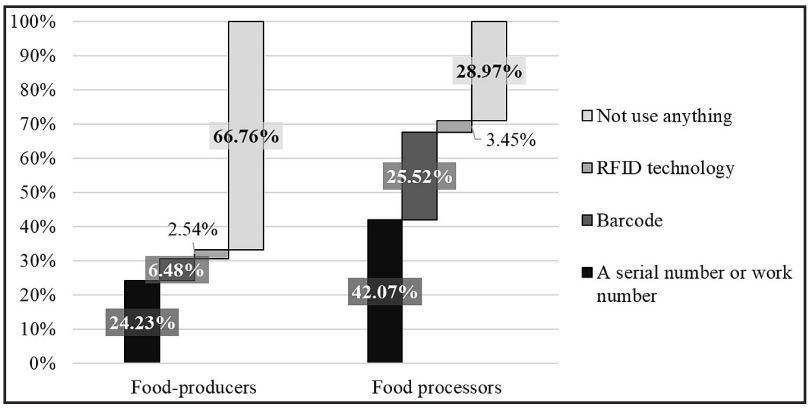
Source: own survey, 2017

Figure 3: Forecast values for the variables by main food sectors and size categories.



Source: own survey, 2017

Figure 4: Forecast values for the variables by food processing sectors.



Source: own survey, 2017

Figure 5: Share of respondent enterprises by sector and product identification technology.

the chance of an evaluation under 4 is less than 40% in almost all cases. For Variable 2, this probability is a little bit higher; furthermore, the chance for assessing it to 1 (not important) is extremely high. We assume that the dairy sector is concentrated and online appearance is much less important for them because there is an already established up- and downstream cooperation within the sector.

Finally, we present here the share of applying different product identification technologies as we consider important these technologies to create an 'information handover point' between companies and consumers. Regarding information flow, our research targeted mainly the tools supportable by ICT which can help data and information exchange between partners and consumers. Product identification technology may be used in order to easy and effective information transfer towards consumers. Figure 5 shows the share of the most widely used technologies.

In the case of food-producers, the application of a serial or work number has the highest proportion (24%). This type of identification is widely used in the processing sector as well (42% of the respondent enterprises); furthermore, the barcode also has a high ratio (25.5%). These codes could be used for applications on the consumer side for displaying information on the products. By a digitalized way and using a collaboration of the ICT-based information platforms, consumers could access all the information they need easily and immediately, even for the moment when they choose a product. Providing the opportunity for consumers using these technologies may support them in conscious food consumption.

Conclusion

The current paper is a pre-study for analysing the readiness of enterprises operating in the food sector for an appropriate level information flow with partners and mainly consumers. We analysed the opinions on the importance of two variables: ICT for marketing activities (Variable 1) and the continuous and regular update of information on website (Variable 2). The grouping factors were the main food sectors (producing and processing), food processing subsectors and enterprise size categories. Our result from ordinal logistic regression suggests that food processors are ahead of food producers in the importance of online contact. Probability values for the variables are considered 'very important' or 'moderately important' were higher with 13 and 11%, respectively, in the favour of food processors. Two-sample t-test showed that the assessment given by food processors is significantly higher (Sig. (2-tailed) < 0,05) for both variables compared to food-producers. The t-values for Variable1 and Variable 2 were -2.4829 and -2.4759, respectively. Our experiments are in line with those results claiming that applying ICT solutions supporting different business activities is generally driven by larger companies. Our analyse by enterprise size categories (micro, small and medium) showed a clear growing trend; the larger the size of a company, the higher the percentage considering a variable 'very important'. The average difference between micro and medium-sized companies was between 5 and 10%. Larger companies assess an ICT solution important with a greater probability than smaller enterprises. However, this process may also promote smaller enterprises and agricultural farms to improve the level of ICT infrastructure and usage.

In our opinion, a dedicated strategy supporting the ICT development of smaller enterprises is required. Regarding SMEs, several studies have been published. There is a need for support by policy makers in prioritizing small farms, forming a national agricultural strategy and creating an RDP support structure (Veveris et al., 2019). At the policy level, a high priority should be given to advancing ICT skills, especially for the human capital of SMEs (Giotopoulos et al., 2017). Analyses on the business activities supportable by ICT can contribute to a more effective information share and this could lead to more conscious food purchasing decisions at the end of the supply chain. Information display is also an important issue as a complementary service for consumers. Papers analysing food information that consumers are interested in means a good starting point for an effective information flow. For instance, Kubicová et al. (2019) analysed the dairy sector and they determine great importance on factors that could be appeared digitalized. Further data collection on the requirements from the consumer side will be our following research direction.

We believe that providing advanced information service for food consumers would be an advantage for companies, including SMEs. Taking into account their financial situation, cloud services, applications for smartphones and using currently available technologies (e.g., barcodes, websites, marketing opportunities) mean a cost-effective option for them. Our suggestion aims mainly for SMEs as ICT adoption is crucial for them. ICT solutions are widely used for different business activities and enterprises can reach a competitive advantage by applying them. In our view, ICT based information flow has a positive effect throughout the food supply chain and the connection between agri-food companies and the consumer could increase customer satisfaction through an informed choice and more conscious purchasing.

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Recruitment Aspects in the Agricultural Sector: Survey of Enterprises in the Czech Republic

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Abstract

Recruitment is one of the most important human resource management tools in the field of agriculture with reference to the current state of the labour market and the concept Agriculture 4.0. The first part of this article concentrates on the recruitment, on-line recruitment and recruitment methods. The second part evaluates the results of a quantitative survey carried out in the Czech Republic. The principal aim of this research project is to identify aspects in recruitment in the field of agriculture. Data were obtained by means of an electronic questionnaire completed by Czech agricultural enterprises (N=980). For data evaluation Chi-squared test was used. The survey shows that agricultural enterprises mostly prefer traditional methods for recruitment i.e. employee referral – 91.4%; internal recruitment – 81.4%. If on-line recruitment is used, then the website of the enterprise (55.1%) is usually exploited. Moreover, the enterprises surveyed make less use of "mobile recruiting" – such as pracezarohem (11.4%).

Keywords

Human resource management, labour market, agriculture, job analysis, recruitment, recruitment methods.

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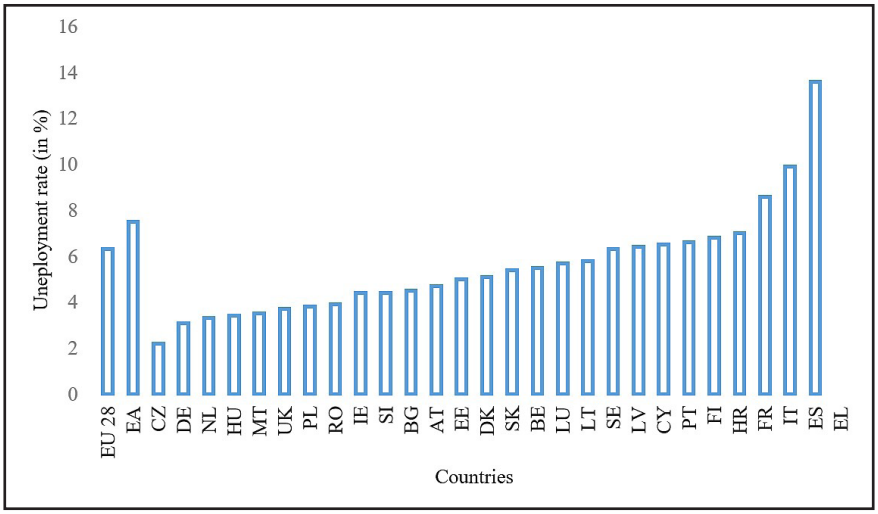
Introduction

The labour market in the Czech Republic is undergoing widespread transformation, in response to many challenges faced by Czech enterprises. In March 2019 the unemployment rate in the Czech Republic was 2.7% (actually 1.9% according to EUROSTAT methodology), this being the lowest for member states in the European Union (Figure 1). Consequently the average number of applicants per vacancy in this period was 0.6 (MPSV, 2019). Thus there is a significant problem finding qualified employees in general (Hedvicakova and Kral, 2018).

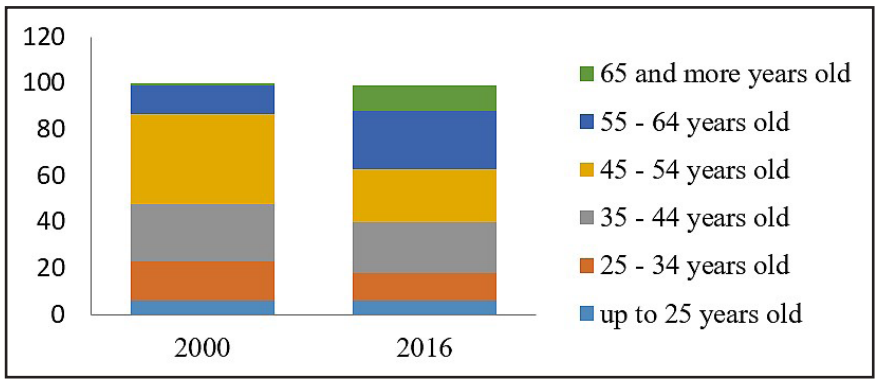
The agricultural sector represents a very small part of the national economy (ca. 2%) and this, in part, is a disadvantage for the sector in its efforts to increase the number of well qualified employees (Trexima, 2018; Ministry of Agriculture, 2019). The proportion of agricultural employees in the total labour force in the Czech Republic has decreased progressively over the last 20 years. Whereas in 1993 almost 6 % of employees worked in agriculture, in 2016 this had fallen to 3%. In Romania, Bulgaria, and Greece there is employment rate in agriculture more than 10% (EUROSTAT, 2017). In January 2015, there were 16 skilled applicants per vacancy in the sector of agriculture, but in January 2018 there were only 2 applicants per vacancy. Within the traditional occupations, farms have difficulty in finding the right workforce not only for managerial positions (25% of enterprises report problems), but also for auxiliary, unskilled employees (24 % of enterprises) (Czech Statistical Office, 2016; Trexima, 2018). This is also reflected, for example, in Sweden, where many agricultural positions are being filled by immigrants (Stenbacka, 2019).

One problem in the Czech agriculture labour market is that farm managers and owners are not sufficiently well qualified in agriculture. Another issue is that the average age of employees (45 years and over) is increasing – as illustrated in Figure 2 (Trexima, 2018; Czech Statistical Office, 2016). With comparison with the average age of agriculture workforce in European Union, it is the similar situation: 31.8 % employees was below 40 years, 59.2 % of those working in agriculture were 40-64 years old and 9.0% were older than



Note: EU – European Union, EA – European Area, CZ – Czech Republic, DE – Germany, NL – Netherlands, HU – Hungary, PL – Poland, MT – Malta, RO – Romania, UK – United Kingdom, SI - Slovenia, EE – Estonia, BG – Bulgaria, AT – Austria, DK – Denmark, IE - Ireland, LU – Luxemburg, BE – Belgium, SK – Slovakia, LT – Lithuania, SE – Sweden, PT – Portugal, FI – Finland, CY - Cyprus, LV – Latvia, HR – Croatia, IT – Italy, ES – Spain, EL - Greece
Source: EUROSTAT, 2019b

Figure 1: Unemployment rates in the EU (March 2019).



Source: according to Trexima, 2018

Figure 2: Changes in the age structure of the workforce in Czech agriculture (in %).

64. A half of people working in agriculture reach medium level of education (EUROSTAT, 2017).

By 2020, employment in the agricultural sector is predicted to fall by around 10%. In the next 10 years, formal job requirements are expected to increase in this sector in the Czech Republic than has been the case so far (Truhlikova et al., 2017). From these data, it can be concluded that an outflow of agricultural employees can be expected in the coming years and that employees, as they retire, will have to be replaced as a priority by a new generation. "*The interest of young people working in agriculture is low because of high demand for unskilled labour, low wage levels in comparison with industry and the overall national economy of the Czech Republic*" (Grigoryeva, 2012). Furthermore, it can be stated that the agriculture sector is not competitive within the labour market because the median monthly gross wage ranks in 13th position out of a total of 19 sectors. In addition, working in agriculture has a number of disadvantages: differing workloads during the year, variable weather effects, requirement for overtime, low job prestige, low wages, together with weekend shift-working. In the past two years, up to 85% of agricultural enterprises have faced labour shortages (Trexima, 2018), that have negative impact on the effectiveness of the agrarian sector as the whole. Human resources are crucial factor of the agrarian sector. Janecka et al. (2019) says that employees and cost on employees have impact on performance of farms. This lack of workforce could be solved the immigrants or the automation, robotics, and digitization, what represent massive

investment of farmers. Zabmon et al. (2019) add that next step with agricultural sector "*includes digitally-integrated enterprise, which rely their production processes using robotics and some forms of artificial intelligence Agriculture 4.0*". Thus it is necessary to attract qualified candidates to agricultural sector by using effective and low cost recruitment methods.

The aim of this project is to identify aspects in recruitment in the agricultural sector. The partial aim is to identify recruitment methods used in Czech agricultural enterprises.

Recruitment

Recruitment is a process for attracting candidates to a vacancy, which involves the selection of candidates identified from external and internal sources (Brandão, Silva and dos Santos, 2019). The main goal is to hire motivated, engaged employees in appropriate quality and quantity (Laumer, Eckhardt and Weitzel, 2010; Stokes et al., 2017). The recruitment process consists of creating a pool of candidates, maintaining their interest and stimulating their choice (Kahlert, Botero and Prügl, 2017). Factors such as brand, corporate culture, the reward system, corporate prestige, job security and the variety of job functions play a role in decisions by candidates (Jones, Willness and Madey, 2014; Leekha Chhabra and Sharma, 2014; Kahlert, Botero and Prügl, 2017).

Traditional recruitment methods (Table 1) make sense from an employer's perspective rather than from an employee's point of view. In 2014, job portals were popular among students (Leekha, Chhabra and Sharma, 2014), but this is no longer the case. Technological advances have reshaped methods of recruiting (van Esch, Black and Ferolie, 2019). It is necessary to adapt recruitment to the Web 2.0 environment, including social networks (Ladkin and Buhalis, 2016). Recruiting employees through social networks is one of the methods that proves to be a suitable and effective tool. And this applies both to active recruitment of candidates, and to the passive, global recruitment of candidates, for example through LinkedIn – this was reported to be 61% in 2015 (El Ouirdi et al., 2016). Traditional recruitment has higher costs than online recruitment (Brandão, Silva and dos Santos, 2019). Ahmed (2012) concluded that cost issues play an important role in recruitment. According to Wenzelmann, Muehlemann and Pfeifer (2019) the costs of recruiting are twice the monthly salary for a vacant job position and "… the costs of job postings increased by 53 %" in recent years. The fees charged for job portals are high. Social media can reduce recruiting cost and save recruiting time (Hou and Li, 2017): in fact recruiting costs via social media have been shown to be nine times less than by traditional methods (Melanthiou et al., 2015).

Traditional methods of recruiting	Online recruitment
Referrals	Job portals
Direct applicants	Enterprise (Career) webpages
Advertisement in news	Social media (Facebook, Twitter, Google+, Instagram, Pinterest)
Labour offices	Professional networking sites (LinkedIn, Facebook jobs, XING, Research Gate)
Head hunters	E-mail communication
Personnel agencies	
Cooperation with colleges and universities	
Enterprise databases	

Sources: Koch, Gerber and de Klerk, 2018; Bohmova and Pavlicek, 2015; Gaupp-Berghausen et al., 2019; Holm and Haar, 2019; Iannotta and Gatti, 2015

Table 1: Recruiting methods.

Online recruitment (otherwise known as internet recruitment or e-recruitment) means using advanced communication systems for attracting candidates (Brandão, Silva and dos Santos, 2019). Online recruitment enables pre-selection testing with concentration of all information in the one place. It is even possible to edit job adverts after posting. Candidates can be targetted in a better way than by traditional recruiting methods and this can cause a snowball effect. This helps create databases (which are permanent) with minimal sources required for collecting and managing data. E-recruitment can provide accurate information about candidates (because of possible screening within social networks), cut costs and increase efficiency. There is also a benefit for candidates in reducing their costs. Online recruitment has only a few disadvantages: first, there can be high numbers of applicants; next, there is the cost of implementation; and finally, there is a potential risk to the privacy of candidates (by screening the profile) (Brandão, Silva and dos Santos, 2019; Laumer, Eckhardt and Weitzel, 2010; Stokes et al., 2017; Hou and Xing, 2017).

According to Brandão, Silva and dos Santos (2019) the current trend in recruitment is moving towards online recruitment (Table 2). Breaugh (2013) add: "*The way an organization recruits can influence the type of employees it hires.*"

Enterprise/Career webpages	They are focused only on active job seekers, who are interested in the company.
Job portals	They are really expensive.
Social media (Facebook, LinkedIn, Pinterest, Instagram, Xing)	Social media used in recruiting reduce recruiting costs and save recruiting time. Recruiting costs are nine times less than traditional methods. Empirically Stokes et al. (2017) found that they gained more candidates through Facebook than LinkedIn. Facebook itself has around 5 200 000 unique users in the Czech Republic. It has also been proved that Facebook is an effective tool for recruiting low earning women through posting advertising and surveys on Facebook. "The reason why social media sites are suitable for recruitment is the fact that there is no limitation by salary, education or geography on the internet."
Mobile recruiting	In 2016, a smart phone with internet access was used by 58% of Czech citizens; 42% are online via mobile as frequently as they use a computer.

Source: Bohmova and Pavlicek, 2015; Hou and Li, 2017; Melanthiou et al., 2015; Stokes et al., 2017; Lorenc, 2018; Hou and Li, 2017; Google, 2017

Table 2: Trends in recruitment.

Materials and methods

A quantitative survey was conducted in the Czech Republic from December 2018 to January 2019 to identify aspects in recruitment as used in the field of agriculture and to evaluate attitudes towards them. A subsidiary aim was to identify recruitment methods currently used by agricultural enterprises in the Czech labour market. The quantitative survey was carried out on the basis of a questionnaire comprising of 15 questions, five of which were qualitative in nature. 9 questions were based on multiple choice.

The sample group consisted of 980 agricultural enterprises. The questionnaire return rate was 12.04% (118), of which micro-enterprises (up to 9 employees) accounted for 15.3%, small enterprises (from 10 employees to 49 employees) for 53.4%, and medium-sized enterprises (from 50 to 249 employees) accounted for 31.4% of the sample. It is not possible to determine the exact number of agricultural organizations with more than 250 employees, as the size of large agricultural organizations is usually measured according to the area of agricultural land rather than the number of employees. The classification of enterprise size was according to the European Commission Recommendation (No. 2003/361/ES).

In terms of their areas of production, the most frequent types were mixed production (83.1 %), followed by animal husbandry (9.3%), while 7.6 % enterprises were focused on plant production.

The data obtained were processed by means of absolute and relative frequencies. Based on two qualitative variables the data were sorted into a contingency table. Testing was carried out using the Pearson Chi-Square test in contingency tables. To interpret the strength of relationship coefficients (Cramer's coefficient), a scale according to Rezankova (2011) was used. If the conditions of the Pearson Chi-Square test were not complied with, Fisher's Exact Test was used. For testing statistical hypotheses and for subsequent analysis, a level of significance $\alpha = 0.05$ was used. The conditions for testing by means of the Pearson Chi-Square test in contingency tables are that no more than 80 % of cells have an expected count of less than 5, and other cells have an expected count value less than 1. The practical calculations were made using MS Excel and the statistical software SPSS (version 24).

Results and discussion

A) Recruitment methods applied in agricultural enterprises in the Czech Republic

This survey has shown that agricultural enterprises use traditional methods of recruitment, rather than on-line recruitment. Among the reasons for not utilising on-line recruitment more extensively, one factor may be that in agricultural enterprises it is usually the CEOs who set the job requirements (depending on the position in the company: from 37.3% till 89%) rather than HR representatives (depending on the position in the company: from 0.8% till 5.9%) in cooperation with senior managers (depending on the position in the company: from 11.9% till 75.4%).

It is mainly the managers directly involved who know what type of employees are needed for a particular vacancy (LMC, 2019). An HR specialist might only have an advisory role and serve as manager of the process. Another reason for not using online recruitment more often could be that agricultural enterprises do not carry out job analysis (59.3%) prior to starting the recruitment process. If they do, then it is mostly for management positions (62.5%) and specialists (47.9%). Job design and job analysis represent the basic pillars of other personnel activities and these are the key elements of the recruitment

process. Moreover, it is mostly small-sized enterprises (50%) and medium-sized enterprises (35.4 %) that conduct job analysis (Table 3).

However, agricultural enterprises usually carry out job analysis when they create a new job position (91.7%) and when any change of a job position occurs (85.4%). It is the most effective way to recruit high quality future employees, who fit the current requirements for a vacancy. The senior managers directly involved with a post usually conduct job analysis (97.9%), and are the best qualified to do this.

In this survey 81.4% of agricultural enterprises stated that for recruitment they mostly use the following: employee referral (94.1%), direct applications (86.4%), internal sourcing (81.4%) and cooperation with a local Labour Office (80.4%). In the Czech Republic 75% of enterprises post their vacancies on enterprise websites; and more than half have a profile on Facebook and LinkedIn (Eger at al., 2017). According to a survey in Slovakia companies prefer internal recruiting (Delgadova, Gullerova and Ivanova, 2017). Stenbacka (2019) reports that employee referrals function well in Sweden – occasionally they use personnel agencies and other external services for recruitment (16.1%). The use of personnel agencies does not depend on the enterprise size or the area of production (Table 4). Swedish farmers see personnel agencies as being problematic (Stenbacka, 2019). On the other hand Iannotta and Gatti (2015) conclude that: "Traditional recruiting systems have been gradually replaced by online recruitment." Koch et al. (2018) agree: "Traditional job advertising is moving to electronic advertising." Brandão et al. (2019) add that in Portugal on-line recruitment is very much underutilized method. Traditional methods is considered ineffective and expensive, so it is necessary to focus on online recruitment.

In addition, they rarely work with a database of potential candidates (22 %). The database is permanent and it is possible to contact candidates immediately, but the quality of the database is important. Also, agricultural enterprises contact potential candidates directly (31.4 %). Choosing to directly contact potential candidates does not depend on the size of the enterprise or the area of production (Table 5).

B) Aspects in employee sourcing used by agricultural enterprises in the Czech Republic

Agricultural enterprises advertise mainly on their own enterprise web-pages (55.1%). The results confirmed that advertisements on their own web-

Job analysis		Enterprise size		
		Micro-sized enterprises	Small-sized enterprises	Medium and large-scale enterprises
Yes	Relative Frequency	14.6%	50%	35.4%
No	Relative Frequency	15.7%	55.7%	28.6%

Source: Authors' survey, 2019

Table 3: Carrying out job analysis according to enterprise size.

Number of hypothesis	Null hypothesis (H_0)	P-value	Rejection of H_0
1	The use of external sources - personnel agencies does not depend on the size of an enterprise	0.410	No
2	The use of external sources - personnel agencies does not depend on the production field	0.471	No

Source: Authors' survey, 2019

Table 4: The results of the qualitative characteristics test for hypotheses 1 and 2 .

Number of hypothesis	Null hypothesis (H_0)	P-value	Rejection of H_0
3	The use of external sources - directly contacting potential candidates does not depend on the size of an enterprise	0.283	No
4	The use of external sources - directly contacting potential candidates does not depend on the area of production field	0.099	No

Source: Authors' survey, 2019

Table 5: The results of the qualitative characteristics test for hypotheses 3 and 4.

pages are mostly used by small and medium-sized agricultural enterprises (Table 6). These webpages are considered to be "a vital source of information for job candidates" – as confirmed by Banks et al. (2019), whose research showed that 98.2 % of respondents used employer websites for their job searches. Priyadarshini et al. (2019) add that „*providing relevant, accurate, and timely information on the corporate website will serve as a central cue for the job seekers to self-select or opt-out themselves from the recruitment process*". However, they seldom use mobile recruiting – and agricultural enterprises make little use of websites for smart mobile phones, such as pracezarohem (11.4 %). Nevertheless, in the Czech Republic one million people have downloaded the pracezarohem application (LMC, 2019).

Currently, agricultural enterprises seldom use job portals (37.3%). If they use job portals for advertising for recruits, then they use the two largest Czech job portals – jobs.cz (79.5 %) and prace.cz (65.9 %). After these the other job portals used are: dopraprace.cz (18.2%) and profesia.cz (2.3%). The present results show that job portals are becoming more popular for recruitment in agriculture.

Agricultural enterprises do not use social media for sourcing employees if they use mainly small sized enterprises (87.3%). According to EUROSTAT (2019b) the use of social networking in enterprises is increasing. Within the EU, only 9 % of enterprises used social networks to recruit in 2013 - this increased to 23 % in 2017.

The smaller enterprises mainly use social media for employee sourcing, as do micro-sized enterprises (Table 7). According to EUROSTAT (2019b) 72 % of large enterprises used social networks to recruit, while only 45% of small enterprises used social networks as a tool for recruitment.

According to European survey considering the invested working hours, Facebook as a social medium was also one of the most time-efficient recruitment methods (Gaupp-Berghausen et al., 2019). The advantages of social media are aiming not only to active candidates but even to passive candidates. And using social medias could have positive impact on employer brand, improvement of image agricultural sector and increasing of young people interest in agriculture sector.

Conclusion

Currently, many managers and owners in the field of agriculture in the Czech Republic are not sufficiently well qualified. Also, the average age of employees (45 years and over) is increasing. So employees as they retire must be replaced by a new generation. The choice of recruitment method to meet this challenge is crucial for future success as well as for maintaining competitive advantage. This survey shows that agricultural enterprises mostly prefer traditional methods for recruitment, namely: employee referral – 91.4%; internal recruitment – 81.4%; direct application – 86.4%; Labour Office – 80.5%. Personnel agencies and other external services are seldom used for recruitment (16.1%). The use of personnel agencies does not appear to depend on the size of an enterprise ($p = 0.410$), nor on the area of production ($p = 0.471$). Moreover, databases of potential candidates are not often used for recruitment (22 %). If on-line recruitment

Job advertisement on enterprise web-pages		Enterprise size		
		Micro-sized enterprises	Small-sized enterprises	Medium and large-scale enterprises
Yes	Relative Frequency	7.7%	53.8%	38.5%
No	Relative Frequency	24.5%	52.8%	22.6%

Source: Authors' survey, 2019

Table 6: The use of job advertisements on enterprise web-pages in relation to enterprise size.

Social media		Enterprise size		
		Micro-sized enterprises	Small-sized enterprises	Medium and large-scale enterprises
Yes	Relative Frequency	13.3%	60%	26.7%
No	Relative Frequency	15.5%	52.5%	32%

Source: Authors' survey, 2019

Table 7: Use of social media for recruitment according to enterprise size.

is used, then enterprise websites (55.1%) are utilised, mostly by small (53.8%) and medium-sized (38.5%) agricultural enterprises. On the other hand, agricultural enterprises tend not to use mobile recruiting based on smart mobile phones – via the websites pracezarohem (11.4%), social media (12.7%) and job portals (37.3%).

Among the reasons for on-line recruitment not being used, one factor may be that it is usually CEOs of agricultural enterprises who set job requirements, rather than HR representatives in cooperation with senior managers. Another factor may be that agricultural enterprises do not carry out job analysis (59.3%) prior to recruitment. If they do, then this is only for certain positions, often during creation of a new post (91.7%), or when there is a change in a job position (85.4%). Small-sized agricultural enterprises use social media as an effective recruitment method. This method is inexpensive, saves time and attracts more candidates who are suitable. Social media might be used for really specialized posts and also for posts requiring low qualifications, when there are no geographical limitations (Bohmova and Pavlicek, 2015; Hou and Li, 2017; Melanthiou et al., 2015; Stokes et al., 2017; Lorenc, 2018; Hou and Li, 2017; Google, 2017). Job portals are becoming more popular for recruitment in agriculture than in the past. So it is proposed that agricultural enterprises should focus on using online recruitment, to attract the best candidates, face the lack of workforce and thereby gain competitive advantage. Recruitment has its economic aspect - it means cost. E.g. in USA companies spend on hiring an average of $4,129 per fill one vacancy (Cappelli, 2019). Average the costs of recruiting are twice the monthly salary for a vacant job position and it is expected their increasing by 53% in recent years in Europe. Online recruitment methods are more effective, they enable companies to attract more candidates and they are effective in reducing the cost, time, and efforts. Using social networks is cheapest, recruiting costs are nine times less than traditional methods (Brandão, Silva and dos Santos, 2019; Wenzelmann, Muehlemann and Pfeifer, 2019). Besides the agricultural sector face the challenge of Agriculture 4.0 and it will need enough qualified employees.

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Exploring the Consumers Willingness of Using E-Commerce to Purchase Geographical Indication Based Crops, a Case Study of Udupi Jasmine

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Abstract

Udupi jasmine cultivation has proven to be a successful viable community-based enterprise (CBE) in coastal Karnataka of India. Jasmine cultivation plays a major role in the socio-economic status of this CBE. This study focuses on exploring the consumers willingness of using e-commerce to buy Udupi jasmine. An e-commerce test web application was built and was demonstrated to consumers. Demographic details, jasmine buying purpose and frequency, online shopping details and willingness of consumers to buy jasmine online was captured. Study showed positive correlation between consumers willingness of using e-commerce to buy jasmine and recommending the e-commerce web application to others. The study validates the e-commerce framework using which the web application was built to market Udupi jasmine which has a Geographical Indication (GI) tag. Hence the study provides new approaches in marketing crops that are specific to a geographical location and presents new direction in the sector of GI based crops.

Keywords

Geographical Indication, Udupi jasmine, e-commerce, community-based enterprise, socio-economic, policy making, ICT.

D´souza, D. J. and Joshi, H. G. (2020) "Exploring the Consumers Willingness of Using E-Commerce to Purchase Geographical Indication Based Crops, a Case Study of Udupi Jasmine", *AGRIS on-line Papers in Economics and Informatics*, Vol. 12, No. 2, pp. 63-69. ISSN 1804-1930. DOI 10.7160/aol.2020.120206.

Introduction

The role of ICT in socio-economic development of an individual, society and nation is considered central to rural and national development (Gupta, 2006). Bhatnagar and Schware (2000) shows the successful use of ICT in rural development by enriching the existing processes. ICT encompasses various technologies including e-commerce as it uses ICT for it for its operations and extension (FAO, 2017). The use of e-commerce in agriculture has helped in promoting agricultural products to a wide range of consumers. In this digital age, e-commerce has become a symbol of globalization and represent a whole new way in which business is conducted (Aydın and Savrul, 2014). The advent of e-commerce has provided numerous prospects and challenges for commerce around the world. E-commerce can be defined as the process of buying, selling, transferring, or exchanging products, services, and/or information via computer networks, including the internet (Turban et al., 2008). It has become a cornerstone for the success of any industry. E-commerce application in agricultural sales will enable farmers to plan the production of crops on a rational basis and thus avoid the asymmetry in information, which is the general case in traditional farming. There has been much evidences that e-commerce offers an important opportunity for cost reduction and demand enhancement (Leroux, 2001). E-commerce in agriculture have revolutionized the way agricultural produces are sold and has changed the way of interaction between agribusiness and consumers through communication channels (Folorunso et al., 2006).

Geographical indications are important identifiers developed as a Trade Related Intellectual Property Rights (TRIPS) by World Trade Organization (WTO). It is used to identify a good as originating in the territory of a Member, or a region or locality in that territory, where a given quality, reputation or other characteristic of the good is

essentially attributable to its geographical origin. Based on their scientific importance or nutritional contents equivalent to a geographical location, Geographical Indication (GI) tags are given to such products (WIPO, 2004). The GI tag is awarded as a community intellectual property for a product. Many GI products are from the agriculture sector, it helps in creating an export marker with the GI mark. With the GI mark a regional product will have an edge as it will get a boost in the exports and more visibility internationally. It gives a competitive edge to farmers of a region over individuals who sell counterfeit products (Banerjee, M. and Nausahd, 2010). Geographical Indication Registry, of India, as of 2019 has identified and sanctioned GI status to 615 products (GI: Intellectual Property India: Government of India, 2019). Udupi Jasmine is a good example of an intellectual property owned by a community was registered under the Geographical Indication (GI) tag in 2013 (K'taka gets highest number of GI tags | Business Standard, 2018).

The Udupi jasmine community-based enterprise, by the rule of thumb has developed a working system of pricing, supply, distribution and marketing. This community has kept poverty at bay through mutual trust and cooperation for generations. Cultivation of jasmine has a prominent socio-economic impact on the growers. Despite having other sources of income, cultivation of jasmine still proves as an important source of income (D'souza and Joshi, 2018). Agricultural marketing using the internet poses several challenges like quantity, shelf life, location, storage and price. Udupi jasmine is one among several crops that are specific to a geographical location in India. As the ground conditions differ for each crop existing e-commerce framework cannot be applied to these crops. In order to market such crops e-commerce localization is necessary (D'souza and Joshi, 2019). Thus, an e-commerce framework specific to market GI based crops like Udupi jasmine will prove highly beneficial (D'souza and Joshi, 2019). Hence, the study explores the willingness of consumers towards the usage of e-commerce website to purchase jasmine online. In order to achieve this an e-commerce web application was built using the framework proposed by D'souza and Joshi (2019). This application was used to gauge the willingness of consumers in using e-commerce to buy jasmine. This will provide necessary impetus to develop a full-fledged web application to market crops that are specific to a geographical location.

Materials and methods

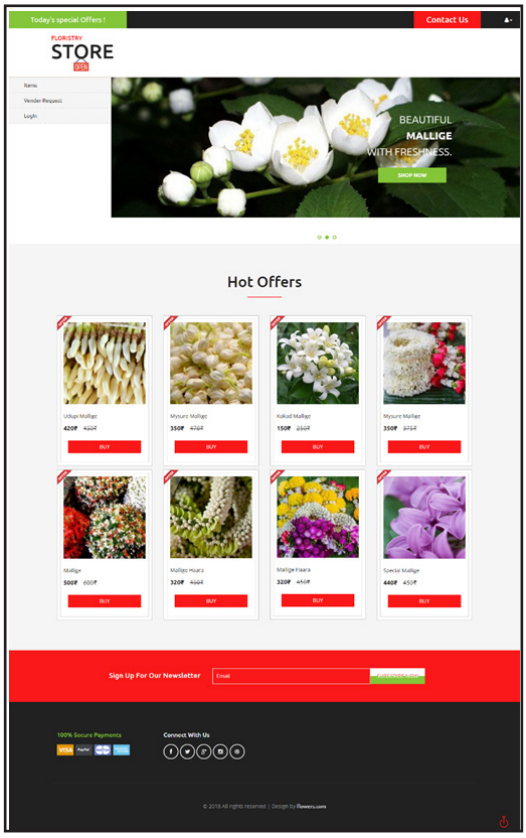
Delivery of information to the key stake holders involved is critical for an e-commerce project. The study is conducted to explore the consumers willingness of using e-commerce to purchase GI based crops with specific reference to Udupi jasmine. By doing so the study attempts to validate the e-commerce framework for strategic marketing of Udupi jasmine proposed by D'souza and Joshi (2019). The framework proposed is localized to market Udupi jasmine and the framework considers several factors that govern the entire jasmine growing community-based enterprise. Based on the framework proposed the e-commerce test web application was built. The test application was built using Hypertext Markup Language (HTML), Cascading Style Sheets (CSS) and JavaScript. The web application incorporated the complete features as proposed by the framework. The application had various features that would assist the user in buying jasmine online. The test web application had the following features to buy jasmine:

- Landing page: The page contained general information and price information of various flowers including Udupi jasmine. The user selects the product "Udupi Mallige (jasmine)" and redirected to the next page for selecting quantity and date.
- Product details page: The page contained information on the product "jasmine" and options to select a date of delivery. The page also displays price trends for the present month and any future month the user selects. Price analysis is generated using the "Price Analyzer" function of the model. Once the user selects the date of delivery a notification message is displayed with information that the future prices displayed are approximate prices and actual price will be conveyed via SMS/ email on the day of delivery. User is then redirected to the login page.
- Login page: Login options were provided in this page where new user will be redirected to the sign-up page and existing users will be redirected to the shopping cart page.
- Shopping cart page: The page displayed the items selected by the user along with the price information. The user is provided with an option to select

the quantity. If the user has selected a future date for delivery, during the selection of quantity a notification message is displayed with information that the delivery of the quantity selected will be confirmed one day prior to the date of delivery via SMS/email. An advance amount (1/4) of the total amount is charged to complete the order. Complete amount is charged one day before the actual date of delivery. For users who have selected the present date complete amount is charged. The user is then redirected to the payment gateway page.

- Payment gateway page: The page provides the user with various options of payment such as cash on delivery, bank cards, net banking etc. Once the user selects the mode of payment the user will check out and the order is placed.

The web application was demonstrated to the general public who purchase jasmine from the market. Data collection was done based on personal interviews. Ninety-six correspondents from Mangalore and Udupi district of coastal Karnataka, India were interviewed based on quota sampling technique, the most important sample in the group of non-probabilistic samplings.



Source: own research and processing

Figure 1: Snapshot of the web-application.

A quota sampling is often used in market research because of its simplicity and relatively good results. From all non-probabilistic samples, quota sample is, by its logic, the closest to a probabilistic sampling (Yang and Banamah, 2014). The snapshot of the web application is shown in Figure 1. A face to face interview was conducted with the selected jasmine buyers. Even though it was a difficult proposition, the fieldwork was done in a justifiable manner with the purpose of understanding the response of jasmine buyers. The characteristics used for the selection of candidates were based on those who purchased jasmine from the market and familiarity with online shopping. All the constructs were measured using multiple-item 5-point Likert scale, with strongly disagree (1) and strongly agree (5) as the anchors. The collected data were analyzed using SPSS.

An important requirement in using the questionnaire form of research instrument is that the instrument needs to be subject to the test of reliability. Cronbach's Alpha Coefficient was used as a measure to test reliability. The closer Cronbach's alpha is to 1, the higher the internal consistency reliability (Sekaran, 2003). The Cronbach's Alpha coefficient helps to examine whether all the items in the scale really tap into one Factor. Generally, a Cronbach's Alpha of 0.70 is considered a 'satisfactory' measure of internal consistency and reliability in measuring inter-item correlations which tap together to form a 'Construct'. A pilot study is conducted to measure the internal consistency. Before directing a questionnaire or structured interview schedule to a sample selected, pilot study is always considered advantageous. As pilot study test the questionnaires to ensure that they are as effective as possible before the main study starts it is considered quite essential. A pilot test can serve to reduce the measurement error that is associated with a faulty survey instrument (Bryman and Bell, 2011). If the alpha scores were less than 0.70 when measuring the factor, the same question was modified to bring back the alpha coefficient to 0.70 to measure good reliability in the final survey. For the questionnaire measuring the willingness of consumers to buy jasmine online a value of 0.76 advocates a good internal consistency.

Results and discussion

The demographic details, jasmine buying pattern and online shopping pattern of the respondents is shown in Table 1.

	Category	Percentage (%)
Gender	Male	43
	Female	57
Occupation	Student	10
	Employed	54
	Un-employed	20
	Homemaker	16
How often do you buy jasmine from the market?	Daily	0
	Weekly	48
	Monthly	20
	As needed	33
What is the purpose of using jasmine?	Personal Use	21
	Religious Use	23
	Both	56
How comfortable are you with shopping online?	Extremely comfortable	34
	Quite comfortable	64
	Not at all comfortable	2
How often do you do online shopping?	Weekly	28
	Monthly	21
	Sometimes	51
What kind of device do you use for online shopping?	Smartphone	56
	Computer	10
	Both	34

Source: own research and processing

Table 1: Demographic details, jasmine buying pattern and online shopping pattern. (N = 96).

The sample was made up of 43% males and 57% females. Nearly 54% were employed and 20% were unemployed. While 10% were students and 16% were homemaker shows a wide range of consumers regardless of their economic background buy jasmine. In terms of jasmine buying pattern 48% bought jasmine on weekly basis, 20% on monthly basis and 33% as needed goes to show that jasmine purchase is done frequently.

Majority of the respondents (56%) purchased jasmine for both religious and personal use. While doing online shopping majority (64%) were quite comfortable and 34% were extremely comfortable. Similarly, in terms of frequency of doing online shopping was also found to be considerably good. Majority of respondents (56%) used smartphones for online shopping while 34% used both computers and mobile phones for shopping.

To gauge the willingness of the correspondence of using e-commerce to purchase jasmine a test web application was demonstrated to the correspondents and were subjected to a questionnaire the same is demonstrated in Table 2. The response of the consumers was collected using a 5-point Likert scale and the results in percentage are shown in Table 3.

Question No	Question
Q1	I find buying jasmine online is more effective than buying from a market.
Q2	I find buying jasmine online is convenient than buying from a market.
Q3	This proposed online shopping site to buy jasmine is helpful.
Q4	This proposed online shopping site to buy jasmine is easy and simple to use.
Q5	This proposed online shopping site to buy jasmine improves my performance (e.g. saving time or money)
Q6	It is beneficial to have an option to buy jasmine on future dates.
Q7	It is beneficial to get information on jasmine price on future dates.
Q8	Receiving notification on daily price of jasmine is helpful.
Q9	Buying jasmine online is trustworthy.
Q10	Overall, I am satisfied with the features with the proposed online retail site.
Q11	I would buy jasmine online if an online retail store is provided.
Q12	I would like to recommend this proposed jasmine shopping retail site to friends or a family member.

Source: own research and processing

Table 2: Questionnaire to check the willingness of using e-commerce to buy jasmine online.

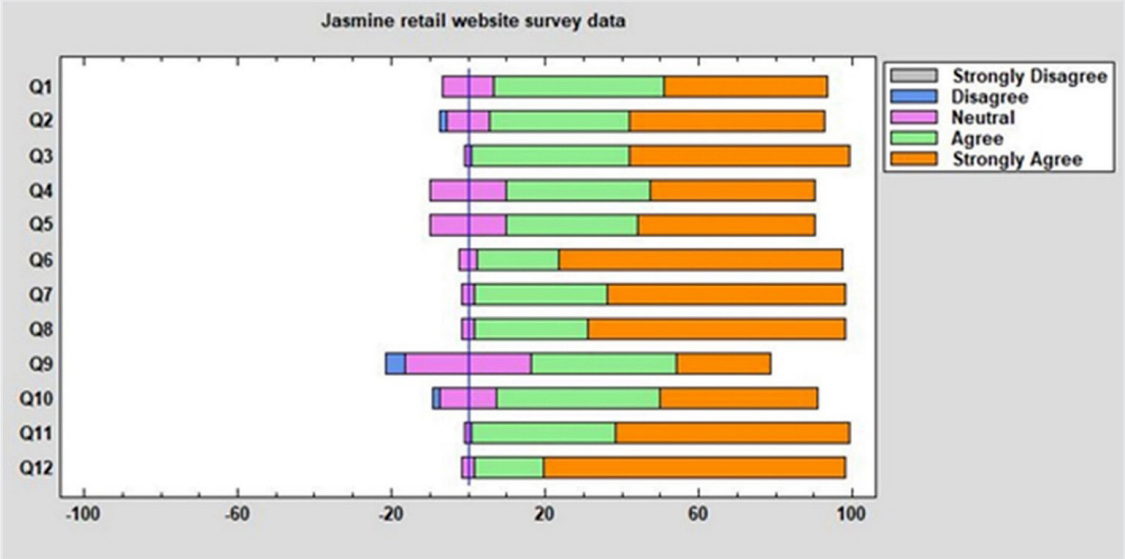
The analysis of the responses obtained is shown in Graph 1. The analysis of the data shows that most of the correspondents show a positive response towards buying jasmine online and with the features of the framework. For those who responded to this survey, it is found that there is a positive correlation between satisfaction of the correspondents with the features of the proposed online jasmine retail site with their likelihood in buying jasmine online if an online retail store is provided, with $r = 0.11$. Similarly, there is a positive correlation between correspondents buying jasmine online if an online retail store is provided with the likelihood of the correspondents recommending the proposed jasmine shopping retail site to friends or a family member, with $r = 0.36$.

The result shows that if the consumers were to be provided with an option of buying jasmine they would most likely buy it online and they would be willing to recommend the web application to their friends or relatives. For any e-commerce model to succeed validation from the end consumers is

Questions	1 Strongly Disagree	2 Disagree	3 Neither Agree nor Disagree	4 Agree	5 Strongly Agree
Q1	0	0	13	44	43
Q2	0	2	11	36	51
Q3	0	0	2	41	57
Q4	0	0	20	38	43
Q5	0	0	20	34	46
Q6	0	0	5	21	74
Q7	0	0	3	34	62
Q8	0	0	3	30	67
Q9	0	5	33	38	25
Q10	0	2	15	43	41
Q11	0	0	2	38	61
Q12	0	0	3	18	79

Source: own research and processing

Table 3: Results in percentage of acceptance to the proposed e-commerce framework (N = 96).



Source: own research and processing

Graph 1: Analysis of willingness to the proposed e-commerce framework.

critical. These results show a positive consumers willingness of using e-commerce for buying jasmine. This would be useful as it lays a pathway for further investigation of acceptance of technology among consumers if they were to be provided with web application to buy GI based products.

Conclusion

In India there are over 270 GI products with extraordinary market potential and inimitable characteristics. But in Indian scenario these products have not succeeded in reaping the various benefits of their potential geographic diversity, long heritage and uniqueness. The future for several agricultural GI products in India depends on gaining attention and acceptance to a wide range of customers. Udupi jasmine grown by a small set of growers has not succeeded in attainting a GI identity and a large market. This faltering block can be observed as in opportunity than an interference for associations, growers and organizations to use ICT especially e-commerce to create a wide market. As there is an acceptance among people in buying the product online, there is a potential for the product to reach a wide range of consumers thereby improving farmers income. As there is willingness among consumers in buying jasmine

online the following recommendations are suggested:

- **Encourage e-commerce cooperation**

  With cross-border trade facilitation, encouraging e-commerce cooperation can strengthen agricultural e-commerce in India. E-commerce cooperation can influence existing and future e-commerce projects to use ideas and concepts that are successful. This will also eliminate the time, effort and resources required to start new e-commerce projects at rural level.

- **Encourage agricultural e-commerce investment**

  With the evident profitability of e-commerce in different areas, promote investors to invest in agricultural e-commerce through government support system. This will encourage entrepreneurs to explore different agricultural areas that can take advantage of e-commerce. This subsequently will also attract researchers to delve into doing research in agricultural e-commerce. This will help the rural community-based organizations to market their produces on a larger scale.

- **Promotion of GI based crops**

  With many crops having GI tag in India, government assistance in promoting these crops is quite essential. The government at the state level needs to form special teams to identify the communities that are involved in producing such GI crops and provide assistance to framing communities that are involved in growing these crops. Assistance can be in the form of modern agricultural techniques, use of ICT, marketing, and promotion. This will strengthen these community-based farmers in exploring new techniques that will enhance agricultural production.

The areas for further research keeping the above aspects in mind are enumerated as follows:

1) There are many other GI products in the horticulture sector and similar studies can be conducted.
2) Technology Acceptance Model (TAM) can be further used to validate the framework where a larger sample can be taken and techniques like Structural Equation Modelling (SEM) can be employed to analyze the relationships between various TAM constructs.
3) An e-commerce application can be built based on the framework in association with government agencies and can be deployed.

Udupi jasmine is a case of Community based Enterprise (CBE), which has characteristically emerged in an environment of economic stress and thrives on the community's tradition of collective action. E-commerce can be used as a viable solution for marketing this crop which is specific to a geographical location. Doing so could provide much needed thrust in marketing this crop to a wide range of consumers. The willingness of consumers in using e-commerce to buy jasmine reinforces the aspect that GI based agricultural products can be sold online. The most important question arises is that if it is possible to market GI based crops using e-commerce and if yes, can it be extended to other GI based crops. This could pave wave for developing e-commerce applications to market other GI based crops as well.

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Geographical Indications as Factors of Market Value: Price Premiums and Their Drivers in the Hungarian Off-Trade Wine Market

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Abstract

Using the name of the production zone to differentiate agricultural products has a longstanding tradition. Theory suggests that some of these names have a market value as they represent the common reputation of the producers and thus may contribute to dissolving the information asymmetry between producers and consumers. This study takes the example of the Hungarian off-trade wine market to show that price premia are attainable by using some GIs. It is revealed that group homogeneity is an essential factor of collective decisions on higher quality standards, which are important drives of price premia. Moreover, barriers to entry and the quality of the demarcated area are also related to the prices attainable by using GIs.

Keywords

Geographical indications, hedonic price index, off-trade wine market, common pool resources, collective action, Hungarian wines.

Gal, P. and Jambor, A. (2020) “Geographical Indications as Factors of Market Value: Price Premiums and Their Drivers in the Hungarian Off-Trade Wine Market", *AGRIS on-line Papers in Economics and Informatics*, Vol. 12, No. 2, pp. 71-83. ISSN 1804-1930. DOI 10.7160/aol.2020.120207.

Introduction

A large amount of scientific literature has been dealing with the determinants of wine prices recently. By mainly applying hedonic pricing models, the vast majority of these studies quantify the relationship between wine prices and, inter alia, origin, subjective and objective quality and labelling elements like variety, vintage or brands. Despite the large number of research on the topic, the role of geographical indicators is somehow understudied. This paper aims to estimate the effect of using geographical indications on the prices of wines and to reveal the factors influencing the performance of geographical indications on the market.

The paper is structured as follows: in Section 2, we analyse the concept and economic aspects of geographical indications and the relation of the production zone and quality. Here, we analyse previous research on the relation of GI use on wine prices as well. The hypotheses and the research methodology are detailed in Section 3, while results are presented in Section 4 and conclusions are drawn in Section 5.

Wines serve as a great example for the illustration of the economic benefits of using geographical indications. Wine products are experience goods (Strorchmann, 2012), because the consumers can only assess their quality after consuming them. Applying the findings of Akerlof’s (1970) model on market of lemons, it is vital for producers to differentiate and signal the quality of their products to obtain higher prices. There are several ways to do so, e.g. trademarks, communication via the media or geographical indications.

The area of production has always been an important factor of the wine market and labelling geographical names on wines has a long tradition. For a better understanding, the relation of wines and their place of origin shall be detailed. There are four groups of factors that influence wine quality (Gál, 2006): the place of origin (production zone – including physiographic, edafic, climatic and biotic dimensions), vintage year, grape varietal and technology. The weight of these factors is different for each wine, and their reproducibility varies as well. Certain grape varieties can be planted at any location where grape growing is possible, and technology is transferable, too. However, effects

of human action on weather are non-controllable, and the production zone cannot be moved from one place to another. Therefore, place of origin has a major and inevitable role in differentiating wines. The actual biological manifestation of these impacts is described in detail by van Leeuwen et al (2004). Moreover, even the role of the elements of the place of origin is different in each wine region. Place of origin or production zone is often described as terroir; however, the latter has a different meaning as it encompasses the human factors: traditional know-how and technology (OIV, 2010).

As the key of the real, non-reproducible uniqueness of wines is the place of origin, it may be a profitable strategy for wineries to produce wines that carry characteristics related to their geographical origin (or rather, the terroir). At the same time, government measures regulating the practice of labelling the name of the production zone have been introduced since the beginning of the 20th century – yet, regional regulations on the delimitation of the area were applied much earlier in Porto, Chianti or Tokaj (Meloni and Swinnen, 2018). Despite the single European legislative framework, we distinguish between two substantially different approaches of GIs: the German and the Latin. For short, the German approach emphasises grape maturity (and thus, quality level), Latin the approach focuses on the typical products and of territory (see Barham, 2003 for a detailed description of the French concept serving as a base for the Latin approach). GIs have an important role in the EU's agriculture and are vital for the European wine sector. As signals for unique quality, using a GI can raise the price of the product, which is essential given the competition of the more efficient New Wine World (Tóth and Gál, 2014).

The legal protection of geographical indications is provided by measures on intellectual property and four distinctive EU quality regimes (wine products, agricultural products and foodstuff, aromatised wines and spirit drinks – see regulations No. (EU) 1308/2013, 1151/2012, 251/2014 and (EC) 110/2008 respectively). In the case of wine products, the European Union's wine law determines two types of geographical indications: protected designation of origin and protected geographical indication. By definition, the first represents a strong and exclusive relationship between the product and its place of origin, and the second implies a much weaker and limited relationship. As an essential provision of the EU regulation, producer organisations must regulate the use of GIs in so-called product specifications. These documents include all the rules on the whole production process, e.g., geographical delimitation of the production zone, quality standards for raw material, winemaking practices, provisions on chemical composition and organoleptic characteristics.

Contrary to individual brands, GIs have a collective nature. The reputation of GIs can be assessed as a sum of individual reputations of group members (Tirole, 1996). Wineries that use GIs are interdependent on the one hand and competitors on the other and strive to differentiate themselves from the rest of the group by using their own individual brands (Patchell, 2008). Therefore, given the limited demand for products bearing a given geographical indication, the reputation of the group is exploited to the detriment of each other (Castriota and Delmastro, 2012).

From this point of view, the reputation of GIs is a common pool resource (Mike and Medgyesi, 2016) as we can observe the same type of contrast between short term individual and long-term group interest. Contrary to Hardin's (1968) suggestions on privatisation or government legislation, Ostrom (2003) proposes common governance as a solution. In the latter case, it is the group members who determine the conditions of access and use of the common pool resource. This is the same approach that the European Union's new regulatory framework on geographical indications applies.

The credibility of geographical indications is of crucial importance as consumers have to believe that the actual product using a GI differs from other products, and that is why it may be worth paying a price premium. Credibility or incredibility is a function of the availability of information on past individual performance. If this information is available, the actual products are traceable; credibility is easier to maintain (Tirole, 1996). Also, stricter rules in the product specifications yield result in reputation (Marchini et al., 2014).

Collective branding enables investment in quality under conditions when individual companies would not invest (Fishman et al., 2018). Evans and Guinnane (2007) show that a common reputation is worth to be created for high-cost groups or groups with members not too different from each other, and if marginal cost is declining. Moreover, increasing group size facilitates free riding as incentives of keeping the quality level weaken. This is echoed by Castriota and Delmastro (2014), stating that the relationship between

group size and collective reputation is non-linear and an optimum for group size exists. However, Marchini et al. (2014) show that the increase of the group increases the reputation due to the accumulating investments in marketing.

As a darker side of GIs, collective brands often lack the focus on the consumer side, and even the INAO (the French government agency for GIs) acknowledged that consumers deemed it easier to recognise the varietal-based marketing approach of the New Wine World especially in the low-end and mid-priced markets (Tregear and Gorton, 2005). Therefore, the role of GIs is limited (Combris et al., 2006), and not all of them are associated with a positive price premium.

A series of studies show that different GIs have different impact on wine prices – Arancibia et al. (2015), Benfratello et al. (2009), Cardebat and Figuet (2004), Cardebat and Figuet (2009), Carew and Florkowski (2010), Landon and Smith (1998), Shane et al. (2018), Thrane (2009), Troncoso and Aguirre (2006) – even when controlling for the varietal composition of the wines – Ling and Lockshin (2003), Noev (2005) and Roma et al. (2013). Moreover, studies of Bordeaux (Ali and Nauges, 2007 and Blair et al., 2017), Burgundy (Combris et al., 2000) or Italian (Levaggi and Brentari, 2014) wines found that the place of the GI in the local or national GI hierarchy is also related to the price and smaller geographic units – such as parcels – may have a price premium as well (San Martin et al., 2008). Angulo et al. (2000) and Di Vita et al. (2015) even argue that GI are the most important price determinants in the Spanish and the Sicilian markets, respectively. Schamel and Anderson (2003) advocates that the role of origin in determining wine prices is increasing. Studies of Bordeaux wines show an indirect impact of GIs on prices as they may affect the impact of expert ratings (Ashton, 2016, and Hay, 2010). Ugochukwu et al. (2017) shows that using GIs results higher prices, but not vice versa: higher prices are independent of the producers' choice on the use of GIs.

Producer groups have to find a right balance between being too tight or too loose when setting the rules in product specifications, e.g. imposing higher production cost vs lacking meaningful differentiation (Tregear and Gorton, 2005). Minimum quality standards and effective enforcement are fundamental drivers of group reputation (Castriota and Delmastro, 2014). Probability of free riding grows along with group size as the growth of the number of producers using the collective reputation weakens the incentives for keeping the quality level (Winfree and McCluskey, 2005; Tregear et al., 2007) – which may be avoided by testing the actual hedonic value of the products.

The actual role of GIs may also be influenced by a set of factors describing the socio-economic characteristics of the producer's community. Well-founded and organised communities can act more efficiently to the benefit of their members (Carter, 2015). Even partial information of the consumer and setting standards (regarding both character and quality level) can result in welfare gains. The costs of information and the creation of quality schemes shall be set according to these gains.

Materials and methods

Hedonic price index is an obvious method to assess the impact of GIs on wine prices. Rosen's (1974) model regards goods as an aggregate of their characteristics. Therefore, differences in prices reflect differences in the set of features. These models are often applied in the literature of wine economics, however, as Unwin (1999) denotes, the execution of the methodology is usually not flawless as competition is not perfect on wine markets, model specification is rather data-driven, and multicollinearity distorts significance levels. On the other hand, Thrane (2004) advocates that hedonic price indices are meaningful if econometric methods are well applied and results are interpreted in a good manner. Hedonic price indices are not intended to estimate consumer behaviour, but are basically supply-oriented, that is, how some supply side characteristics impact prices.

This study is based on hedonic price indices calculated on a sample of 2,672 wines. Contrary to the previously mentioned studies, data was not collected from the wine press, as the prices and the use of geographical indications were observed in the Hungarian off-trade sector (main wine shops and supermarkets). If a wine was observed on multiple sites, the lowest price was included in the dataset. The scope of the study extended only to wines, other grapevine products (such as sparkling wine) were excluded. All wine prices were recalculated for an amount of a 0.75 litre bottle. 33 of the 37 Hungarian wine GIs were observed. However, 5 GIs had to be omitted due to the low number of wines in the sample. Certain geographical indications are segmented into two or three quality levels using additional terms to the name itself (e.g. Eger Superior or Villány

Prémium). To deal with this phenomenon, these geographical indications were treated as two or three separate names (depending on the actual number of quality levels); therefore, in the end, 33 GIs were included.

In the first step of the study, the price premiums of GIs were estimated by hedonic price index models. As heteroskedasticity occurred, (1) robust standard error models were used instead of ordinary least squares models (White, 1980). Furthermore, (2) quantile regressions were also run (for medians). There are two advantages of using quantile regression models in this case: tackling heteroskedasticity (as suggested by Di Vita et al, 2015) and the distortion of averages by outliers (such as expensive wines sold in small quantity). Given the findings of previous studies, the following hypothesises were developed.

H1.1 Geographical indications have a positive price premium in the market.

As literature showed, GIs are expected to have a (positive) price premium under certain conditions regarding the producer group (Carter, 2015), the interconnection of individual and group reputation (Patchell, 2008 or Castriota and Delmastro, 2012), the motivation for investing in quality (Fishman et al., 2010), consumer legibility (Tregear and Gorton, 2005). Each observed GI would get its own dummy variable, as the reference group would be the wines without geographical indication. Furthermore, the impact of labelling crus (parcels) should be assessed by adding a common dummy to the model for single vineyard wines.

H1.2 Individual brands have a price premium as well.

Although individual brands are not the most important element for the Hungarian consumers, it is assumed that individual brands serve as an important factor in achieving price premium for wines. Given the large number of possible brands, they are grouped according to their performance on the two most important prizes that wine makers can get in Hungary. The first tier (dummy) consists of producers who have received either of the two awards, and the second tier (dummy) contains those that were nominated and the information on the nomination is available for consumers. The rest of producers form the reference group.

H1.3 The concentration of compounds is positively linked to prices.

According to an alternative formulation of this hypothesis, in general, the more concentrated (or, the less diluted) a wine is, the higher its price may be. An evident cost reason supports this hypothesis: the production of more concentrated wines costs more. The question, however, is whether this is also reflected in the price. When examining this hypothesis, we take into account the sugar-free extract content (g / l) and the residual sugar content (g /l). Alcohol is still an important compound, but we omit it in the models to avoid multicollinearity. The role of sugar is examined by colour, as we assume that the relationship between sugar content and price is different for white and other (rosé, red) wines (as all great natural sweet wines are white). Data were provided by the wine authority.

H1.4 The age of wine is positively related to the price.

We assume that the price of more mature wines is higher than that of younger wines. The higher cost of production justifies this, but the consumers' belief that wines will only get better and better over time may have a more serious impact, too. The age of the wine is the difference between the date (year) of data collection and the date (year) of the harvest of the grapes used as the raw material. For items where this information is not available (or which are from multiple vintages), we consider the year of the last harvest period before marketing to be the vintage year.

H1.5 The quantity (lot size) impacts the price in a negative way.

Obviously, the less the available quantity is, the more the price will be (because of various reasons such as lower selling pressure, higher average cost). From another point of view, the assumption is that wine makers are better off producing and selling higher priced wines in a smaller quantity (for reasons of quality control capacities etc.). Data were provided by the wine authority.

The design of models E1.1-E1.2 is shown below:

$$\ln P = \beta_0 + \beta_i * GI_i + \beta_j * IB_j + \beta_1 * SV + \beta_2 * SFE + \beta_3 * SUGAR * WHITE + \beta_4 * SUGAR * NONWHITE + \beta_5 * AGE + \beta_6 * \ln Q + \varepsilon$$

where:

P: price

GI_i: GI dummies

IB_j: individual brand dummies

SV: dummy for single-vineyard wines

SFE: concentration of sugar-free extract

SUGAR: sugar content

WHITE: white wine dummy

NONWHITE: dummy for rosé or red wines

AGE: age of the wine

Q: lot size

The second step aimed to reveal the factors influencing the performance of geographical indications on the market by applying several models. Market value can be measured in several ways, hereby I consider (1) the ln of mean prices of GIs and (2)-(3) the price premia for each GI estimate during the first step. As literature suggested, the following factors were considered.

H2.1 The more homogenous the group of producers is, the easier the collective action is; hence, higher prices and revenues can be reached.

As geographical indications are of a collective nature, their management requires high quality collective action. Group homogeneity is an important issue of collective action (Carter, 2015; Evans and Guinnane, 2007). This factor is measured as group heterogeneity by the standard deviation of the total amount of wines marketed by a single producer with the geographical indications concerned. Data were provided by the vine and wine interbranch organisation (HNT).

H2.2 The stricter the rules of using a GI, the higher the prices are.

GIs, by theory, signal distinctive product quality. Thus, the wine quality (e.g. quality standards or rules on organoleptic characteristics) set in the product specification shall be easily and meaningfully differentiated. Here, we consider the maximal yield as a good measurement for the rigour of rules. Usually, the higher the yields, the lower the quality level is. Quality regulations were observed in the product specifications of the GIs (see AM, 2019).

H2.3 The stricter the rules of using a GI, the higher are the entry barriers.

Barriers to entry hinder new competitors to enter the market and contribute to higher prices by lowering the amount of supply and the level of competition. In case of geographical indications, the most effective barrier is the delimitation of the production area. Determining such an area is based on viti-vinicultural factors such as (micro-) climate or soil. However, from an economic point of view, it serves as an effective entry barrier as a newcomer may not use the geographical name for products originating or produced outside the delimited area. This factor is measured as the percentage of the area covered by vineyards compared to the whole size of the delimited area. The higher this percentage is, the harder is to enter the market, therefore the higher should be the prices. Data on area size were provided by Department of Geodesy Remote Sensing and Land Offices of the Government Office of Budapest.

H2.4 The better the geographic area is, the higher the prices are.

As place of origin is an important factor of wine quality, it is obvious that the better the delimited area is, the higher quality will be. Quality of the area (from a viticultural point of view) is measured by a 400-point system (cadastrial points). Data were provided by the Department of Geodesy Remote Sensing and Land Offices of the Government Office of Budapest.

As the number of GIs observed is limited, multiple regression analysis including all variables would face substantial methodological obstacles. Therefore, we analyse the hypothesises in two groups, the first for the GI rules (H2.1 and H2.2) and the second for other factors (H2.3 and H2.4). In addition to hypothesis H2.1 and H2.2 we test whether they are interconnected by using two-stage least squares model, where the rigour of GI rules (maximal yield) is instrumented by group heterogeneity. For control reasons, restricted models are calculated for each variable.

The design of the 2SLS models (models E2.1-E2.3) for testing hypothesises H2.1-2.2 is showed below:

$$MV = \beta_0 + \beta_1 * YIELD + \varepsilon$$

$$YIELD = \beta_0 + \beta_1 * GROUP + \varepsilon$$

where:

MV: market value of the GI, measured by the ln of mean price or the estimated

GROUP: producers' group heterogeneity

YIELD: maximal yield for using the GI

The design of the models (models E2.4-2.6) for testing hypothesises H2.3-2.4 is showed below:

$$MV = \beta_0 + \beta_1 * BE + \beta_2 * CADPOINT + \varepsilon$$

where:

MV: market value of the GI, measured by the ln of mean price or the estimated

BE: barriers to entry

CADPOINT: average cadastrial points of the delimited area

The descriptive statistics are presented in Tables A1-A2 of Annex.

Results and discussion

The regression analyses of the first step were first carried out in a restricted manner (only containing GI dummies), then extended models containing all variables were calculated (reflecting the suggestion of Thrane, 2004). Thus, it was possible to estimate the difference in the gross and net shadow prices of GIs.

Results of the first step (summarised in Table 1) confirmed the two hypothesises as the models showed a positive price premium for 24-25 geographical indications out of the 33 observed depending on the model (which is in line with H1.1). This means that GI wines can be sold at a higher price for the consumers as expected. However, the value of the price premium was negative for one GI, suggesting that the name of "Duna-Tisza közi" region reflects cheaper prices (are usually sold cheaper). The differences in the estimated coefficients of restricted and extended models show that at first glance, GIs may incorporate important other factors like chemical composition, lot size, age or individual brands.

The first step of the study also proved that segmentation based on quality level within geographical indications makes sense, as the price premium was substantially higher for the wines in concern. In addition, the study revealed that prices had a strong and robust relation to individual brands (confirming H1.2; +46-48% for the 1st tier and 34% for the 2nd tier). The results underline that producers tend to position their single vineyard wines high as the indication of a vineyard's name raised the price by 46-49%. This has very important implications for wine marketing and reputation.

The models show that chemical composition (sugar-free extract) is positively related to the price; an additional gram to the average (median) of 25.58 (24.40) g/l would cost 0.93% (0.71%) more (H.1.3). Older wines cost more, the impact of an additional year of ageing is 11-12% (H1.4). The relation of the lot size and the price is negative, with 1% of the increase in quantity the prices decrease by 0.22% (H1.5).

The results of the first step underline that in general, geographical indications may influence wine prices, however, this is not true for all of them and the impact may be negative as well. On the other hand, negative coefficients show that some geographical indications are positioned low, which may be a conscious common action of the producers. GIs with positive effects mainly include the most known ones with larger production area and well organised producers' group or small ones with special wine character.

All factors included showed the expected relationship with the three proxies of market value; thus, results proved that the socio-economic factors involved impact the market value of GIs significantly (see Table A3 of Annex). Tables 2 and 3 summarise the results of the extended models.

The rigour of production rules has a positive impact on market value in all models. The mean price of a GI where an additional hl of wine is allowed to be produced on one hectare is 2.81% lower, while the impact on implicit prices is -1.38 – -1.47. Group heterogeneity is strongly connected to the market value of GIs as the mean price of wines with a GI with an additional hl of the standard deviation is 0.92% lower than the average. Therefore, GIs reflect quality and GI wines can be sold at a higher price. The application of two stage least square models proves that these two variables are interconnected. Moreover, these models estimate the impact of regulation on maximal yield as an additional one hectolitre increase is paired with a 4.25% drop of the mean price and a 2.16-2.33-point drop in the previously estimated implicit prices. The comparison of the R^2 values (which are higher in the model using mean price) suggest that the rigour of the production rules impacts other price-affecting dimensions, too, which is in line with oenological theory (i.e., lower yields result in higher concentration of compounds). Group heterogeneity is significantly related to the rigour of the rules as a hectolitre increase in the standard deviation of the supply increases the maximal yield by 0.22 hectolitres per hectare.

All restricted models and extended models E2.4-E2.6 confirm the hypothesis regarding barriers to enter as the mean price of a GI with an additional percentage point of land use is 3.20% higher, while using an extended model would lead to an estimated impact of 2.77%. The impact of a 1-point rise of land use ration on estimated implicit prices of GIs varies between 1.53-1.54 points (decreasing to 1.48-1.34 points in the extended model).

Variable	R1.1 (robust standard errors)	E1.1 (robust standard errors)	R1.2 (quantile regression for the median)	E1.2 (quantile regression for the median)
Sugar free extract (quadratic)		0.0001***		0.0002***
White*Sugar		0.0024***		0.0025***
Non-white*Sugar		-0.0060***		-0.0054***
Age		0.1213***		0.1119***
Lot size (log)		-0.2236***		-0.2165***
Badacsony	0.8541***	0.3139***	0.8484***	0.2726***
Balaton	0.3527***	0.3462***	0.3681***	0.3064***
Balatonboglár	0.5729***	0.2869***	0.5113***	0.2546***
Balaton-felvidék	0.5539***	0.2616***	0.6371***	0.2034*
Balatonfüred-Csopak	0.7078***	0.3067***	0.6937***	0.3441***
Bükk	0.6744***	0.2188	0.6943***	0.2042
Duna	0.4599**	0.1201	0.4066***	0.3423*
Dunántúli	0.0776	0.1733**	0	0.1063
Duna-Tisza közi	-0.7893***	-0.4621***	-0.8905***	-0.5973***
Eger Classicus	0.4401***	0.2901***	0.5113***	0.2525***
Eger Superior	1.4709***	0.6720***	1.5416***	0.6250***
Eger Grand Superior	1.8768***	0.6731***	1.7119***	0.7934***
Eger before 2010	1.4692***	0.2397*	1.4674***	0.2138*
Etyek-Buda	0.5055***	0.3555***	0.4422***	0.3394***
Felső-Magyarország	0.4134***	0.2052***	0.4641***	0.2163***
Hajós-Baja	0.2745**	0.1314	0.3208***	0.0801
Káli	1.2758***	0.8412***	1.1984***	0.7222***
Kunság	0.2976***	-0.0294	0.3296***	-0.0425
Mátra	0.2230**	0.0151	0.2804***	0.0329
Mór	0.4745***	0.2551***	0.5113***	0.2586*
Nagy-Somló	0.8569***	0.3838***	0.8949***	0.3699***
Neszmély	0.5128***	0.1835**	0.4422***	0.1185
Pannon	0.3224***	0.3195***	0.4066***	0.2765**
Pannonhalma	0.7370***	0.5400***	0.7991***	0.5188***
Pécs	0.5769***	0.2508***	0.5119***	0.1645*
Sopron/Ödenburg	0.9230***	0.3623***	0.7640***	0.3302***
Szekszárd	0.7760***	0.3488***	0.7430***	0.3032***
Tokaj wine specialty	2.2646***	0.6634***	2.1815***	0.5620***
Tokaj non-wine specialty	0.9692***	0.3439***	0.9394***	0.2831***
Tolna	0.3603**	0.0644	0.4780***	-0.0106
Villány Classicus	0.5705***	0.3252***	0.5759***	0.3039***
Villány Prémium	1.6922***	0.8359***	1.7119***	0.7523***
Zala	0.5610***	-0.0128	0.5759***	0.0247
Single vineyard wine		0.3776***		0.3972***
Tier1 individual brand		0.3898***		0.3756***
Tier1 individual brand		0.2935***		0.2961***
Constant	6.8311***	8.6380***	6.8013***	8.5877***
Adjusted-R^2/Pseudo-R^2			0.2262	.

Note: *: 10%; **: 5%; ***: 1% level of significance
Source: own calculation

Table 1: Results of the first step regression analyses.

Variable	E2.1	E2.2	E2.3
Dependent variable	Mean price (log)	Estimated implicit price (model E1.1)	Estimated implicit price (model E1.2)
Maximal level of yield	-0.0425***	-2.1633***	-2.3267***
Constant	11.8060***	346.4681***	358.5228***
Dependent variable (first stage regression)	Maximal level of yield	Maximal level of yield	Maximal level of yield
Group heterogeneity	0.2164**	0.2164**	0.2164**
Constant	92.7287***	92.7287***	92.7287***
N	33	33	33
R^2	0.4419	0.2751	0.3433

Note: *: 10%; **: 5%; ***: 1% level of significance
Source: own calculation

Table 2: Results of the extended models containing local regulations.

Variable	E2.4	E2.5	E2.6
Dependent variable	Mean price (log)	Estimated implicit price (model E1.1)	Estimated implicit price (model E1.2)
Barrier to entry	2.7733***	1.4752***	1.3433***
Cadastral point	0.0073***	0.4485***	0.3389**
Constant	4.8410***	-31.7796	0.5963
N	33	33	33
adjusted R^2	0.45	0.3973	0.3028
AIC	46.9161	319.4429	320.7158
BIC	51.4057	323.9324	325.2054

Note: *: 10%; **: 5%; ***: 1% level of significance
Source: own calculation

Table 3: Results of the extended models containing external factors.

GIs with an additional point higher average quality of the demarcated area have a mean price 0.94% higher (shrinking to 0.73% in the extended model). The impact on the estimated implicit prices is between 0.44-0.56 higher than the average (0.34-0.45 in the extended model).

Both Aikike and Bayesian information criteria show that models using mean price as a measurement for market value fit better. Moreover, adjusted R^2 values show as well that these models have higher explanatory value. However, models E2.5-E2.6 (and R2.1-R3.4) use a better estimation of the actual market value of GIs as the dependent variable is cleared from other possible impacts on the price (age, individual brand, chemical composition, quantity).

The extended models show that the socio-economic parameters of GIs explain 30-40% of the variations in wine prices. As expected, the coefficients of the given variables decreased in all cases comparing the restricted and the extended models.

Conclusion

This study focused on the role of GIs in the market by analysing the situation of the Hungarian off-trade wine market. The analysis confirmed that the use of geographical indications may allow producers to achieve a price premium, hence can be a vehicle of maintaining the presence of traditional quality products in the market despite the potential higher costs. Thus, GIs are incentives for investment to quality.

However, not all GIs represent a price premium; moreover, in one of the cases, the price premium is negative. The valuable information on GI products is not that they are special in some way – it is why they are special, and a well-functioning GI shall bear this information. Moreover, this raises the issue of the factors laying behind the market performance of GIs. As GIs are of a collective nature, collective action is a crucial issue. As literature suggested, the structure of producer groups is an essential factor.

The results of the first step confirm that the higher the concentration of compounds, the higher the price of wines. Therefore, setting higher minimal values for these compounds in the product specification should result in higher prices. However, a measure in this manner shall be taken with caution as the character of a wine can be biased. This kind of action shall likely target the minimal price.

Producers tend to position their single vineyard wines high, which is reflected in the relatively high shadow price of vineyard names on the label. Therefore, it seems to be worth to introduce special regulation on the use of these names.

Geographical indications are a quite regulated field of the vine and wine sector. On the one hand, a large amount these regulations are created by the local communities (mainly specific rules), on the other hand, some vital framework legislation exists, provided by the EU or national governments. This study highlights the vital role of producers' communities in the market success of geographical indications. Thus, policies aimed at empowering and strengthening these communities may result in more valuable GIs as well.

The analysis underlined the role of collective action as the more homogenous a producer group is, the more likely they behave and think about the geographical indication(s) they use. This draws attention to a new dimension of the positioning of new GIs or repositioning existing ones. To have a meaningful differentiation, a GI shall reflect on special product quality. This can be attained more easily if the quantity of products labelled with the same GI does not vary by group members on a large scale.

The role of delimited production area is an essential issue in case of GIs regarding the link between origin and the quality of the final product. The actual size and quality of the production area is an important policy tool as it serves as a barrier to entry into the market. Thus, all initiatives on the enlargement of the production area shall be treated with particular caution.

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Appendix

Variable	Observations	Mean	Std. deviation	Min	Max
Price (0.75 litre bottle)	2672	2693.231	5856.222	194.85	194330
Lot size	2672	20084.92	39199.5	120	607568
Sugar	2672	13.22216	37.67067	0	578
Sugar free extract	2672	25.57687	6.893633	15.6	124.6
Age	2672	2.538922	1.919959	1	17

Source: own calculation

Table A1: Descriptive statistics – first step.

Variable	Observations	Mean	Std. deviation	Min	Max
Mean price	33	2822.652	2939.132	502.4947	16876.8
Estimated implicit price (model A)	33	137.3513	37.75101	62.99593	231.9148
Estimated implicit price (model B)	33	133.6054	35.78275	55.02954	221.0901
Maximal level of yield	33	96.66667	17.48511	35	120
Group heterogeneity	33	18.20166	33.36183	0.2948969	188.8688
Barrier to entry	33	22.87153	11.7276	5.214826	49.14261
Cadastral point	33	301.8485	32.70524	219	333

Source: own calculation

Table A2: Descriptive statistics – second step.

Model	(R1.1) ARM	(R1.2) ARS	(R1.3) ARP	(R1.4) ARK	(R2.1) RRM	(R2.2) RRS	(R2.3) RRP	(R2.4) RRK	(R3.1) QRM	(R3.2) QRS	(R3.3) QRP	(R3.4) QRK
Dependent variable	Mean price (log)	Mean price (log)	Mean price (log)	Mean price (log)	Estimated implicit price (model A)	Estimated implicit price (model A)	Estimated implicit price (model A)	Estimated implicit price (model A)	Estimated implicit price (model B)	Estimated implicit price (model B)	Estimated implicit price (model B)	Estimated implicit price (model B)
Maximal yield	-0.0281***				-1.3781***				-1.4723***			
Group heterogeneity		-0.0092***				-0.4680**				-0.5034***		
Cadastral point			0.0094***				0.5583***				0.4388**	
Barrier to entry				0.0320***				1.7349***				1.5394***
Constant	10.4138***	7.8606***	4.8523***	6.9615***	270.5661***	145.8702***	-31.183	97.6720***	275.9307***	142.7681***	1.1396	98.3961***
N	33	33	33	33	33	33	33	33	33	33	33	33
R^2	0.5986	0.2331	0.2342	0.3478	0.4074	0.1711	0.234	0.2905	0.5176	0.2203	0.1609	0.2546
AIC	36.6507	58.0143	57.9693	52.6691	319.014	330.0895	327.4853	324.9574	308.6904	324.5362	326.9588	323.0524
BIC	39.6438	61.0074	60.9623	55.6621	322.007	333.0825	330.4783	327.9504	311.6834	327.5292	329.9518	326.0454

Source: own calculation

Table A3: Results of the restricted models of the second step of the regression analysis.

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Animal Food Demand in Indonesia: A Quadratic Almost Ideal Demand System Approach

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Abstract

This research aims to analyze the impact of the price change, the income, and the household size on the demand for five commodity groups, i.e. eggs, chicken, beef, fish and powder milk. The data utilized in this study is based on the Indonesian National Socio-Economic Survey 2016. There are 291,414 data of households in Indonesia which was analyzed by Quadratic Almost Ideal Demand System. The result shows that all of the price elasticity was negative and the income elasticity was positive. The effect of income causes the demand for animal foods in Indonesia to be more elastic rather than other commodities with the highest demand of elasticity, i.e. beef, powder milk, fish, meat and eggs by 2.19%, 1.96%, 1.53%, 1.43%, and 0.53% respectively. The beef has the most sensitive effect to changes the income. Therefore, the government requires maintaining the stability of beef prices to increase beef consumption in Indonesia

Keywords

Food demand system, elasticity, price change, Indonesia.

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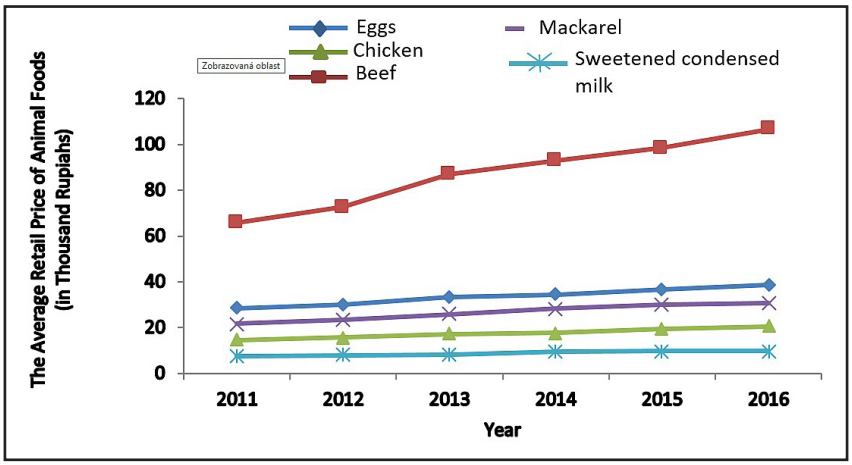
Introduction

Worldwide and Indonesia currently deal with the significant fundamental change. McKinsey Global Institute in 2012 reveals that Indonesia’s fast-growing economy reaches the sixteenth biggest in the world. There are 45 million Indonesian people that are included in a consumptive cluster. There are 53% of residents in Indonesia living in urban lifestyle. In addition, there are 55 million skilled workers in business economics. Also, there is $ 0.5 trillion market opportunities in some fields such as in consumer services, agriculture, fisheries, resources, and education. One of the consumptive class expenditure and urban lifestyles is the share of expenditure after the staple food, i.e. the animal foods (Fabiosa, 2005). It is important to consume animal foods because it contains beneficial nutrient for the body. Also, it should be consumed by the community (Akaichi and Revoredo-Giha, 2014). Animal foods such as eggs, chicken, beef, fish, and milk contain all types of essential amino acid which cannot automatically be produced by the human body (Legendre et al., 2008). Therefore, nutrients fulfillment depends on consuming food and beverage. Most countries in the world classify animal foods as luxury commodities (Vu and Glewwe, 2011; Elijah Obayelu et. al., 2009; Uregia et al., 2012). It is expensive and has a fluctuated demand (Sacli and Ozer, 2017).The impact of protein deficiency can worsen for people, more specifically for babies. The protein deficiency suffered by babies can affect permanently and can have a long-term impact, as well as cannot be recovered (Cupák at al., 2015).

The increasing price of animal foods can cause the decreasing capability to purchase animal foods. Also, the declining real income can trigger the declining of animal foods consumption. In this case, the households may have a deficiency of protein from animal foods. There are only 3% of households in Indonesia consuming beef (Statistik, 2015). However, align with the increasing income and public awareness of nutrition and food quality, the pattern of eating consumption has changed to consume animal foods (Baharumshah and Mohamed, 1993). The growth of income will shift the consumption of high-carbohydrate staple foods to prefer the more expensive food such as meat and milk (Fabiosa, 2005). The projection of changes in the daily calories consumed

by the Indonesian people in 2030 will increase quite high. More specifically, the commodity of all types of meat will increase by 90%. In contrast, the daily consumption of rice will decrease by 4% (Krisnamurthi, 2016). The increasing consumption of all types of meat will enhance the high demand for meat. Further, animal foods price tend to rise in the last ten years which is illustrated in Figure 1. The growth of incremental pricing average of eggs annually is 10.94 %. Then, the annual pricing of the other animal foods such as milk, beef, chicken increments respectively by 6.94 %; 9.58%; 5.24 % (Statistik, 2015). Fulfillment of animal foods declined dramatically in 2013. Then, they increased again in 2014. While Indonesia's protein consumption was recorded at 55.01 grams/ capita/ year in 2010. In 2014, it was annually recorded as 53.91 grams/ capita (Statistik, 2015). This value was below The Standard National Protein Adequacy Rate, i.e. 57 grams of protein/capita per day. Also, it became the lowest rate in ASEAN (Fabiosa, 2005). Therefore, it is pivotal to investigate how does the effect of the price and income on the demand for animal food.

Many previous studies investigate the system of food demand in emerging economies and advanced economies. Some approaches that were utilized such as LES (Linear Expenditure System), Rotterdam model, Translog Model, and AIDS (Almost Ideal Demand System). In addition, the most popular approach is QUAIDS (Quadratic AIDS). The implementation of AIDS can be shown in the research of demand food system (Deaton, 1990). Then, (Pangaribowo and Tsegai, 2011) studied the demand food system by using a QUAIDS. However, the study of animal food was still under search. Therefore, by using a QUAIDS, this research aims to identify in detail how does the effect of income, price, and the demographic factors on the demand for animal food. Also, this research investigates deeply the income elasticity and price elasticity on animal food. Moreover, this research shed lights on how does the nature between substitute and complementary within animal food. Therefore, the objective of this research is to analyze the demand for animal food by using a QUAIDS model approach. Through this research, it will be obtained how the vulnerability and flexibility of each group of urban and rural households on the impact of price changes based on the dynamics of food demand for animal sources of protein by considering the factors of preference, substitution, complementation. This research will recommend the government to arrange the scenario of requisite policy to protect farmers, Indonesian people and related industry. The contribution of this research can be the guidance for the Indonesian government to manage the dynamics of animal product trading systems more precisely and measurably. Therefore, the role of government can be more accountable as the decision maker. More specifically, it can be more important in determining the best alternative policy for the benefit of industrial and farm development. For example, the result of this research can maximize the protective role for the farmers and the community regarding the consumption of animal food. It can stimulate the achievement of protein standard which is 57 gram/capita a day per households in Indonesia.



Source :Modified and adapted from (Agustina, 2016; Hanny P. Muliany, 2016; Roch Widaningsih, 2016; Suryani, 2016)

Figure 1: The Development of Average Retail Prices of Animal Food Protein.

Materials and methods

Data and descriptive statistics

This research used the secondary data from Susenas (Survei Sosial Ekonomi Nasional) in March 2016 which comprises thirty-four province data. The data analyzed were the consumption of animal foods data and the household expenditure on animal foods, i.e. eggs, chicken, beef, fish and powder milk. In addition, sociodemographic data (households' residence status (rural/urban)), data on the number of households' members, and households' income data were required. Then, data were analyzed by STATA 14. The number of samples is 291,414 households from the rural and urban area.

The food group expenditures in households

There are two assumptions utilized regarding the expenditure source in households. Firstly, this research used total households' expenditure for five categories of comestibles such as staple food, grain food, animal foods, fruits and vegetables and supplementary food. Secondly, we employed the total expenditures for animal foods allocated to five food groups, i.e. eggs, beef, chicken, fish and powder milk which are shown in the following Table 1.

Group	Group name	Goods/items
1	Eggs	Chicken eggs, free-range chicken eggs, duck eggs
2	Chicken	Broiler chicken meat, free-range chicken meat
3	Beef	Beef
4	Fish	Fish, shrimp, squid and shellfish
5	Milk powder	Infant milk powder, formula milk powder

Source: Modified from the National Bureau of Statistics classifications (Statistik, 2015)

Tabel 1: The items of the commodity animal foods groups.

The percentage share of food group expenditures on total food based on 2016 quantiles are shown in Table 2. The lowest quantile (Q1) of the households' group shares has the highest percentage which is the grains by 29.65%. This is in line with the research of (Tefera, et al., 2014) Grains become the highest demand for food commodity compared to the others. It also becomes the highest percentage among the other quantiles. However, the trend of grains declines within the next quartiles. The trend of grains deteriorates by 22.13%. In contrast, the trend of meat, as well as and eggs and milk expenditure increased respectively by 4.21% and 3.15%. According to (Alem, 2011; Attanasio et. al., 2013; Vu and Glewwe, 2011), the percentage of the group of protein foods such as egg and powder milk, meat

Food Group	Food group expenditure (%)							
	Income quantile in the 2016						Trend	Trend Value
	Q1 (low)	Q2	Q3	Q4	Q5 (high)	Total		
Grains	29.65	22.99	17.88	13.36	7.51	14.02	↓↓	-22.13
Tubers	1.29	1.09	1.00	1.29	0.98	1.10	↓	-0.31
Fish, shrimp, etc.	6.56	7.09	7.57	7.60	7.22	7.30	^	0.66
Meat	1.97	2.68	3.41	4.36	6.18	4.46	^	4.21
Eggs and milk	4.19	4.80	5.32	6.05	7.34	6.08	^	3.15
Vegetables	9.08	8.70	8.31	7.75	6.16	7.49	↓	-2.92
Nuts	3.19	2.77	2.43	2.27	1.75	2.25	↓	-1.44
Fruits	2.33	2.84	3.37	4.08	5.52	4.18	^	3.19
Oil and coconut	3.79	3.41	3.11	2.82	2.10	2.76	↓	-1.69
Drink material	4.64	4.16	3.89	3.53	2.75	3.48	↓	-1.89
Spices	2.48	2.33	2.23	2.04	1.62	1.99	↓	-0.86
Other consumption (noodle)	2.28	2.27	2.24	2.15	1.77	2.05	↓	-0.51
Finished food and Beverage	19.32	22.68	24.32	27.83	36.47	29.05	^^	17.15
Cigarette	12.94	15.16	16.11	15.12	11.60	13.80		

Source: own processing

Table 2: The percentage share of food group expenditures on total food 2016.

and fish is enhancing along with the increasing income. This is in line with the research of McKinsey Institute (2012) that the consumption food in Indonesia has been shifted from the low carbohydrate to the high protein. Therefore, the price and income can be the determinant of the amount of animal foods consumption by households in Indonesia.

The model estimation by Quadratic Almost Ideal Demand System (QUAIDS)

This research employs QUAIDS to identify in detail about how does the effect of income, price, and the demographic factors on the demand for animal foods. More specifically, this study investigates the price elasticity and the income. Based on the non-parametric analysis of consumer purchasing patterns, the Engel curve requires a higher order than the logarithm of expenditure. QUAIDS is the development of the AIDS model with a quadratic logarithm. According to (Banks at al., 1997), this model is implemented to catch the curvature of the Engel curve by using the households' expenses survey. In this case, QUAIDS is the development AIDS model and it fulfils the characteristics of the demand function.

The Quadratic Almost Ideal Demand System (QUAIDS), developed by Banks, Blundell, and Lewbel (1997), which was further augmented with demographic variables by Poi (2013), is used to estimate price and food expenditure elasticities in the second stage. QUAIDS has been widely applied in the literature on food demand analysis. The QUAIDS augmented with demographic and other controls will use to examine the household food demand patterns, and thus availability and access to animal source foods, across region types (urban/rural).

QUAIDS model has features which are almost similar to the AIDS model. It can catch the curvature of the Engel curve. Therefore, QUAIDS is selected as the demand model to manage the empirical estimation strategy. In addition, this research expands the QUAIDS model with socio-demographic variables to comprehend the role of non-economic variables in the demand behavior of animal foods. The implementation of QUAIDS in emerging economies is still limited (Poi, 2012). The model of QUAIDS demand for animal foods in Indonesia can be shown in the following equation.

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} ln\left(p_j\right) + \beta_i ln\left(\frac{x}{a(p)}\right) + \frac{\lambda_i}{b(p)}\left(ln\left(\frac{m}{a(p)}\right)\right)^2 \quad (1)$$

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} \ln p_j + (\beta_i + \boldsymbol{\eta}_i'\mathbf{z}) \ln\left\{\frac{m}{\overline{m}_0(\mathbf{z})a(\mathbf{p})}\right\} + \frac{\lambda_i}{b(\mathbf{p})\, c(\mathbf{p},\mathbf{z})}\left[\ln\left\{\frac{m}{\overline{m}_0(\mathbf{z})a(\mathbf{p})}\right\}\right]^2$$

$$\text{where } c(\mathbf{p},\mathbf{z}) = \prod_{j=1}^{k} p_j^{\boldsymbol{\eta}_j'\mathbf{z}} \quad (2)$$

w_i is the share expenses of eggs, chicken, beef, fish, and milk on the total expenses. m is the total expenses for animal foods. Meanwhile, $a(p)$ and $b(p)$ are the prices of animal foods which are illustrated in the following equation.

$$ln\alpha(p) = \alpha_0 + \sum_k \alpha_k ln(p_k) + \frac{1}{2}\sum_k \sum_l \gamma_{ki}\, ln(P_k)\, ln(P_1) \quad (3)$$

$$b(p) = \prod_{i-1}^{n} P_i^{\beta_i} \quad (4)$$

Not only the AIDS model requires the restriction, the QUAIDS model also need it to maintain the consistency by utilizing the utility maximization. The equation is shown as follow.

$$\text{Adding-up: } \sum_{i=1}^{n} \alpha_i = 1;\ \sum_{i=1}^{n} \beta_i = 0; \sum_{i=1}^{n} \gamma_{ij} = 0\ \forall j;\ \sum_{i=1}^{n} \lambda_i = 0 \quad (5)$$

$$\text{Homogeneity: } \sum_{j=1}^{n} \gamma_{ij} = 0\ \forall i, \text{ and} \quad (6)$$

$$\text{Symmetry: } \gamma_{ij} = \gamma_{ji}\gamma_{ij} = \gamma_{ji} \quad (7)$$

Based on the previous model, the price elasticity is:

$$\eta_{ij} = \frac{\mu_{ij}}{W_i} - \delta_{ij} \quad (8)$$

In addition, the income elasticity is:

$$\eta_i = \frac{\mu_i}{W_i} + 1 \quad (9)$$

Where δ_{ij} is the delta Kronecker, μ_{ij} and μ_i are:

$$\mu_{ij} = \frac{\partial W_i}{\partial lnp_j} = \gamma_{ij} - \mu_i\left(\alpha_j + \sum_{k=1}^{n} \gamma_{jk} lnp_k\right) - \frac{\lambda_i \beta_j}{b(p)}\left\{ln\left(\frac{x}{a(p)}\right)^2\right\} \quad (10)$$

$$lnV = \left\{\left[\frac{lnx - lna(p)}{b(p)}\right]^{-1} + \lambda(p)\right\}^{-1} \quad (11)$$

$$\mu_{ij} = \frac{\partial W_i}{\partial_x} = \beta_i + \frac{2\lambda_i}{b(p)}\left\{ln\left(\frac{x}{a(p)}\right)\right\} \quad (12)$$

$$\lambda(p) = \sum_{i=1}^{n} \lambda_i lnp_i \quad (13)$$

$$\alpha_i = \alpha_{0i} + \sum_{m=1}^{M} \alpha_{mi} Z_m \quad (14)$$

$$\sum_{i=1}^{n} \alpha_{0i} = 1;\ \sum_{i=1}^{n} \alpha_{mi} = 0, \forall_m. \quad (15)$$

Elasticity price model that was developed by Banks, Blundell and Lewbel (1997) is illustrated by the following equation:

$$w_i = \alpha_i + \sum_{j=1}^{k} \lambda_j \ln p_j + \left[\frac{m}{\bar{m}_0(z)\alpha(p)}\right] + \frac{\lambda_i}{b(p)c(p,z)}\left\{\ln\left[\frac{m}{\bar{m}_0(z)a(p)}\right]\right\}^2 + \varepsilon \quad (16)$$

$$c(\mathbf{p}, \mathbf{z}) = \prod_{j=1}^{k} p_j^{\eta_j' z} \quad (17)$$

The parameters generated from the QUAIDS model are used to calculate the own-price elasticity of both Hicksian and Marshallian, expenditure elasticity and cross price elasticity.

Marshallian price elasticity (Uncompensated) is:

$$\epsilon_{ij}^{u} = -\delta_{ij} + \frac{1}{w_i}\left(\gamma_{ij} - \left[\beta_i + \eta_j' z + \frac{2\lambda_i}{b(\mathbf{p})\, c(\mathbf{p},\mathbf{z})} \ln\left\{\frac{m}{a(\mathbf{p})\, \bar{m}_0(\mathbf{z})}\right\}\right] \times \left(\alpha_j + \sum_l \gamma_{jl} \ln p_l\right) - \frac{\left(\beta_i + \eta_j' z\right)\lambda_i}{b(\mathbf{p})\, c(\mathbf{p},\mathbf{z})}\left[\ln\left\{\frac{m}{a(\mathbf{p})\, \bar{m}_0(\mathbf{z})}\right\}\right]^2\right) \quad (18)$$

Expenditure elasticity is:

$$\mu_i = 1 + \frac{1}{w_i}\left[\beta_i + \eta_j' z + \frac{2\lambda_i}{b(\mathbf{p})c(\mathbf{p},\mathbf{z})} \ln\left\{\frac{m}{a(\mathbf{p})\bar{m}_0(\mathbf{z})}\right\}\right] \quad (19)$$

Hicksian elasticity (Compensated) is:

$$\epsilon_{ij}^{c} = \epsilon_{ij}^{u} + w_j \mu_i \quad (20)$$

Equation (1) to (15) adopted from Deaton and Muellbauer (1980), equation (16) to (20) adopted from (Poi, 2012) with reference to Banks et al. (1997).

Results and discussion

The estimation of parameter

The result of QUAIDS yields the parameter. This parameter presents the respond of households on the change of price, income, and the demographic variable of the number of household members. The parameter can analyze the elasticity of income elasticity, price, and cross price. All parameters have a significant error from 1% to 5%. The parameter of income squares for all animal foods groups is significant. It indicates that there is a nonlinear relationship between total expenditure and animal foods demand. This result aligns with the previous study such as in Indonesia (Bopape and Myers, 2007; Pangaribowo and Tsegai, 2011), and in Ethiopia (Tefera et al., 2018). The quadratic parameters of expenditure on chicken and fish are negative. It indicates that chicken and fish are a normal item. On the other hand, the parameters of eggs, beef and milk are positive. It means that the commodity is a luxury item. Further, the parameters for estimating QUAIDS of animal foods consumed by household in Indonesia (all-HH/all household) both in rural and urban areas can be seen in Table 3, 4 and 5.

Parameter (Coefficient and SEM	Eggs (1)	Chicken (2)	Beef (3)	Fish (4)	Milk Powder (5)
Constant					
α	0.199**	-0.637**	0.499**	0.090**	0.847**
Income					
β	0.008**	-0.264**	0.098**	-0.001**	0.158**
Price					
γ_1	0.429**	-0.148**	-0.058**	-0.039**	-0.183**
γ_2	-0.148**	0.305**	-0.097**	0.046**	-0.106**
γ_3	-0.058**	-0.097**	0.026**	0.022**	0.107**
γ_4	-0.039**	0.046**	0.022**	-0.052**	0.023**
γ_5	-0.183**	-0.106**	0.107**	0.023**	0.159**
Income square					
γ	0,014**	-0.021**	0.004**	-0.001**	0.004**
Demography					
η_hhm_tot	-0.003**	0.003**	0.0001**	0.0003**	-0.0004**
Demography					
ρ_hhm_tot	0.009**	0.009**	0.009**	0.009**	0.009**

Note: ** and * indicate significant at the 1% and 5% significance level, respectively
Source: research findings

Table 3: QUAIDS Parameter Estimates for all Indonesian household (all-HH) (N= 291,414).

Parameter (Coefficient and SEM	Eggs (1)	Chicken (2)	Beef (3)	Fish (4)	Milk Powder (5)
Constant	-0.048**	0.185**	0.354**	-0.184**	0.693**
α					
Income	-0.104**	-0.056**	0.092**	-0.094**	0.161**
β					
Price	0.584**	-0.254**	-0.105**	0.037**	-0.262**
γ_1	-0.254**	0.076**	0.006**	0.083**	0.089**
γ_2	-0.105**	0.006**	0.040**	-0.049**	0.107**
γ_3	0.037**	0.083**	-0.049**	0.021**	-0.092**
γ_4	-0.262**	0.089**	0.107**	-0.092**	0.158**
γ_5					
Income square	0.011**	-0.013**	0.005**	-0.007**	0.005**
γ					
Demography	-0.003**	0.003**	-0.0001**	0.001**	-0.0005**
η_hhm_tot					
Demography	-0.043**	-0.043**	-0.043**	-0.043**	-0.043**
ρ_hhm_tot					

Note: ** and * indicate significant at the 1% and 5% significance level, respectively
Source: research findings

Table 4: QUAIDS Parameter Estimates for Indonesian rural (N= 155,438).

Parameter (Coefficient and SEM	Eggs (1)	Chicken (2)	Beef (3)	Fish (4)	Milk Powder (5)
Constant	1.143*				
α		-2.312*	0.871**	0.228**	1.070**
Income	0.132**				
β		-0.474**	0.141**	0.034**	0.168**
Price	0.418**				
γ_1	-0.415**	-0.415**	0.045**	-0.016**	-0.032**
γ_2	0.045**	1.052**	-0.293**	-0.029**	-0.315**
γ_3	-0.016**	-0.293**	0.055**	0.054**	0.139**
γ_4	-0.032**	-0.029**	0.053**	-0.067**	0.058**
γ_5		-0.316**	0.139**	0.058**	0.149**
Income square	0.018**				
γ		-0.026**	0.005**	0.0002**	0.003**
Demography	0.0007**				
η_hhm_tot		-0.0005**	0.0005**	0.0001**	-0.0009**
Demography	0.146**				
ρ_hhm_tot		0.145**	0.145**	0.145**	0.145**

Note: ** and * indicate significant at the 1% and 5% significance level, respectively
Source: research findings

Table 5: The QUAIDS Parameter Estimates for Indonesian urban (N= 135,976).

The factors affecting animal foods demand in Indonesia

The finding of QUAIDS analysis shows the income, price, and socio-demographic factors significantly influence the demand for animal foods. Table 6 shows the expenditure elasticity of all animal foods which was positive. It means the more augmented income the more demand for animal foods. In other words, the households di Indonesia prefer to keep consuming protein (Shibia et al., 2017). The expenditure elasticity for eggs, chicken, beef, fish, and powder milk are 0.53%, 1.43%, 2.18%, 1.53%, and 1.96%, respectively. Eggs are inelastic and classified as normal goods. It is because it has an income elasticity of less than one (Sacli and Ozer, 2017). Beef is the most sensitive

to changes regarding the increment income. The effect of income results in animal foods in Indonesian households getting more elastic. This means that an increase in income will increase consumption of animal protein.

Eggs are the normal goods of animal foods group not only in the city but also in the rural areas. However, beef can be categorized as the luxuries goods, because it has the income elasticity that is more than one. Also, beef has the highest elasticity which is 2.78% in rural area, and 189% in urban area (Delport et al., 2017). It is followed by milk powder by 2.29% in rural area and 1.75% in urban. While fish attain 1.69% in rural area and 1.41% in urban. Chicken obtain 1.53% in rural area and 1.35% in urban area (Delport et al., 2017; Ackah and Appleton, 2007). The number of households' members (HHsize) shows the negative and significant effect on eggs and milk. It means that the growth of HHsize of individual could reduce eggs and milk by 0.0706% and 0.0708%.

Marshallian and Hicksian Own-Price Elasticities (uncompensated and compensated)

There are many previous studies investigate the estimation of demand to analyze the consumption behavior of both individuals and households. The demand system was focused on demand consumer behavior which is beneficial to arrange government policy such as the reduce poverty program (Elijah Obayelu et al., 2009; Ivanic and Martin, 2014). The elasticity shows how much does the households respond to the price or income changing (Elijah Obayelu at al., 2009). Also, the elasticity of price and income can reflect the respond of the households to the changing of animal foods price. In this case, similar previous study has been undertaken at the developing countries such as in Tanzania (Abdulai and Aubert, 2004); in Nigeria (Elijah Obayelu et al., 2009), in Vietnam (Vu and Glewwe, 2011), and in Slovakia (Cupák et al., 2015; Robles and Keefe, 2011).

Animal Foods	Indonesia	Rural	Urban
	Marshallian (uncompensated)		
Eggs	-0.824	-0.827	-0.799
	(0.003)	(0.005)	(0.005)
Chicken	**-1.574**	-1.587	-1.634
	(0.009)	(0.011)	(0.013)
Beef	**-2.475**	-1.884	-3.168
	(0.038)	(0.040)	(0.072)
Fish	**-2.198**	-1.849	-2.631
	(0.017)	(0.022)	(0.027)
Milk Powder	**-1.710**	-1.734	-1.625
	(0.014)	0.020	0.021
	Hicksian (Compensated)		
Eggs	-0.534	-0.539	-0.494
	(0.003)	(0.005)	(0.005)
Chicken	**-1.193**	-1.172	-1.290
	(0.009)	(0.012)	(0.013)
Beef	**-2.418**	-1.835	-3.103
	(0.038)	(0.040)	(0.072)
Fish	**-2.123**	-1.780	-2.552
	(.017)	(0.022)	(0.027)
Milk Powder	**-1.515**	-1.556	-1.417
	(0.014)	(0.020)	(0.021)

Note: standart error of mean is parentheses
Source: research findings

Table 7: Own-price elasticities.

The price elasticity comprises the Marshallian price elasticity (uncompensated elasticity) and Hicksian price elasticity (compensated elasticity) depicted by Table 7. The analysis of the QUAIDS model yields all of the price elasticity is negative which is similar to the expectation. In addition, Marshallian price elasticity has a bigger impact than Hicksian price elasticity in all urban-rural areas in Indonesia. It is aligned with the previous researches (Bopape and Myers, 2007; Elijah Obayelu et al., 2009; Abdulai and Aubert, 2004; Meenakshi and Ray, 1999). According to Abdulai and Aubert (2004), Marshallian price elasticity also

Animal foods	Indonesia	Rural	Urban	HHsize
Eggs	0.531**	0.568**	0.476**	-0.001**
Chicken	1.437**	1.530**	1.346**	0.001**
Beef	2.178**	2.785**	1.885**	0.0002**
Fish	1.538**	1.695**	1.411**	0.0001**
Milk powder	1.962**	2.291**	1.749**	-0.001**
N	291,414	131,975	112,512	

Note: ** and * indicate significant at the 1% and 5% significance level, respectively
Source: research findings

Table 6: The expenditure elasticity across commodities in Indonesia-rural-urban.

yields a bigger impact than Hicksian price elasticity in Nigeria. It is because beef, fish, milk and chicken have elastics nature, except eggs. In other words, the increasing prices can cause the reduction of beef consumption which is bigger than the changes of such price.

The expenditure (income) elasticity in the rural area is bigger than in the urban area in term of animal protein which is illustrated in Table 5. It can implicate the income policy to be more effective for households in the rural area. Meanwhile, in the urban area, price policy can be more effective to be implemented. Table 5 illustrated the elasticity of prices in the urban area which is bigger than the rural area. Therefore, direct cash funding could be more suitable to the households in the rural area. While price subsidy could be appropriated to households in the urban area.

Marshallian and Hicksian Cross-price elasticities

In Table 8, most of the cross-price elasticity is positive. It means that there is a substitute relationship between animal foods. On the other hand, the negative effect of animal foods is because of the complementary relationship between animal foods. For example, eggs gave a complementary nature. It means that many households can consume eggs together with the other animal foods, while other animal foods protein is substitute food. Beef can be substituted with eggs, chicken, and fish. It indicates that the more increased beef price, the more households substitute it by consuming fish (26.81%), chicken (7.63%), or eggs (3.03%). The increasing of income that is followed by the decreasing of milk price and the rising of chicken, fish, and eggs can decrease the consumption of beef by 5.83% (2.43477-2.37645). Mostly, the coefficient of the cross price elasticity of Hicksian is positive. This is aligned with the previous research of Sacli and Ozer (2017) in Turkey. According to Sacli and Ozer (2017), five groups of animal foods have a positive coefficient of the cross Hicksian elasticity coefficient. In Turkey, if the price of beef increases, households will replace the consumption of animal food with lamb, chicken and eggs which is the same as in Indonesia. It means that there are an inter-relations among animal foods in Indonesia and Turkey. In this case, the growing price of beef could impact to the substitute of other animal

Animal Foods	Eggs	Chicken	Beef	Fish	Milk Powder
			Marshallian (uncompensated)		
Eggs	-0.824	0.159	0.038	0.040	0.075
	(0.003)	(0,003)	(0.002)	(0.002)	(0.002)
Chicken	-0.210	**-1.574**	0.062	0.102	0.153
	(0.007)	(0,008)	(0.003)	(0.004)	(0.005)
Beef	-0.072	0.379	**-2.475**	0.449	-0.457
	(0.033)	(0.032)	(0.038)	(0.023)	(0.029)
Fresh Fish	-0.135	0.523	0.268	**-2.198**	-0.009
	(0.019)	(0.019)	(0.013)	(0.017)	(0.016)
Milk Powder	-0.373	0.241	-0.116	-0.030	**-1.710**
	(0.012)	(0.013)	(0.008)	(0.008)	(0.014)
			Hicksian (compensated)		
Eggs	-0.534	0.293	0.052	0.064	0.125
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Chicken	0.621	**-1.193**	0.101	0.173	0.297
	(0.007)	(0.009)	(0.003)	(0.004)	(0.005)
Beef	**1.161**	0.946	**-2.418**	0.554	-0.243
	(0.032)	(0.033)	(0.038)	(0.023)	(0.029)
Fresh Fish	0.745	0.926	0.309	**-2.123**	0.143
	(0.019)	(0.020)	(0.013)	(0.017)	(0.016)
Milk Powder	0.754	0.758	-0.063	0.066	**-1.515**
	(0.012)	(0.013)	(0.008)	(0.008)	(0.014)

Note: Standard error of mean in parentheses
Source: research findings

Table 8: Uncompensated and Compensated cross-prices elasticities: Indonesia (All HH).

foods that have lower price such as eggs, fish, and chicken.

The growth of beef prices is followed by increasing income. It can increase the consumption of chicken by 3.9% (0.06237-0.10139). Then, to enhance the consumption of beef in Indonesia, the government need to stabilize the price of beef. The government requires to establish the policy regarding the beef price to maintain stability and to increase the production of beef in Indonesia.

In Table 9, cross-price elasticity of animal food protein in Indonesian urban households is presented. Majority of the elasticity is positive. It means that there is a substitute relationship among animal food in the households of urban in Indonesia (Shibia at al., 2017; Angelucci and Attanasio, 2013). Cross-price elasticity of positively affect the price of eggs, chicken, and fish. It means that there is a substitute inter-relationship among beef, eggs, chicken, and fish. The increasing of beef price can be followed by the decreasing of milk price. Also, it can induce the households to shift the preference in consuming other animal foods such as eggs, chicken and fish. According to Elijah Obayelu et al. (2009), the increasing of beef price can rise the chicken consumption of the households by 3.5% (0.13586-0.03515).

In Table 10, the cross-price of elasticity of animal foods in the rural area in Indonesia is presented. The cross-price of Marshallian elasticity is higher than the cross-price of Hicksian elasticity (Elijah Obayelu et al., 2009). It is because the cross-price of Marshallian elasticity has an effect on the price and income. Meanwhile, the cross-price of Hicksian elasticity merely influences the price. Most of the cross-price elasticity of households in the urban area in Indonesia is positive. It means that among the various types of animal foods is a substitute or replace each other. The increasing price of animal protein augments the consumption of other animal foods (Delport et al., 2017; Nguyen and Winters, 2011). For example, in Indonesian urban households, rising prices for beef also increase the consumption of eggs, chicken and fish. The increase in beef prices is followed by the increasing consumption of chicken meat by 4.2% (0.02974-0.07222).

Animal Foods	Eggs	Chicken	Beef	Fresh Fish	Milk Powder
			Marshallian Price Elasticity (uncompensated elasticity)		
Eggs	-0.799	0.173	0.011	0.030	0.049
	(0.005)	(0.004)	(0.003)	(0.002)	(0.003)
Chicken	-0.079	-1.634	0.136	0.136	0.120
	(0.010)	(0.013)	(0.006)	(0.006)	(0.007)
Beef	-0.801	0.994	-3.168	0.766	-0.259
	(0.056)	(0.057)	(0.072)	(0.041)	(0.045)
Fresh Fish	-0.307	0.661	0.455	-2.631	0.197
	(0.029)	(0.031)	(0.023)	(0.027)	(0.024)
Milk Powder	-0.582	0.089	-0.058	0.061	-1.625
	(0.018)	(0.020)	(0.012)	(0.012)	(0.021)
			Hicksian Price Elasticity (compensated elasticity)		
Eggs	-0.494	0.312	0.025	0.056	0.101
	(0.005)	(0.004)	(0.003)	(0.002)	(0.003)
Chicken	0.669	-1.290	0.171	0.200	0.250
	(0.010)	(0.013)	(0.006)	(0.006)	(0.007)
Beef	0.598	1.636	-3.103	0.886	-0.017
	(0.055)	(0.057)	(0.072)	(0.041)	(0.045)
Fresh Fish	0.614	1.084	0.498	-2.552	0.357
	(0.028)	(0.031)	(0.023)	(0.027)	(0.024)
Milk Powder	0.616	0.639	-0.002	0.164	-1.417
	(0.017)	(0.020)	(0.012)	(0.012)	(0.021)

Note: Standard error of mean in parentheses
Source: research findings

Table 9: Uncompensated and Compensated cross-prices elasticities: Indonesian urban.

Animal Foods	Eggs	Chicken	Beef	Fish	Milk Powder
			Marshallian (uncompensated)		
Eggs	-0.827	0.169	0.035	0.028	0.087
	(0.005)	(0.004)	(0.002)	(0.002)	(0.003)
Chicken	-0.279	-1.587	0.030	0.095	0.144
	(0.010)	(0.011)	(0.004)	(0.005)	(0.007)
Beef	0.090	0.153	-1.884	0.226	-0.414
	(0.038)	(0.037)	(0.040)	(0.026)	(0.037)
Fish	-0.180	0.530	0.137	-1.849	-0.071
	(0.026)	(0.026)	(0.015)	(0.022)	(0.022)
Milk Powder	-0.195	0.279	-0.107	-0.054	-1.734
	(0.017)	(0.017)	(0.010)	(0.011)	(0.020)
			Hicksian (compensated)		
Eggs	-0.539	0.301	0.048	0.052	0.137
	(0.005)	(0.004)	(0.002)	(0.002)	(0.003)
Chicken	0.627	-1.172	0.072	0.172	0.301
	(0.009)	(0.012)	(0.004)	(0.005)	(0.007)
Beef	1.127	0.629	-1.835	0.314	-0.234
	(0.037)	(0.037)	(0.040)	(0.026)	(0.037)
Fish	0.632	0.903	0.175	-1.780	0.070
	(0.025)	(0.026)	(0.015)	(0.022)	(0.022)
Milk Powder	0.832	0.75	-0.059	0.034	-1.556
	(0.017)	(0.017)	(0.010)	(0.011)	(0.020)

Note: Standard error of mean in parentheses
Source: research findings

Table 10: Uncompensated and Compensated cross-prices elasticities: Indonesian rural.

The growth of beef consumption is higher than the consumption in urban households. This indicates that chicken meat has a high preference in rural households.

Conclusion

This paper presents a model for animal food demands system by using 2016 Susenas data. Data analysis includes the quadratic of income to test the non-linear relationship between income and share of expenditure. The results of the QUAIDS model analysis show that all animal foods in Indonesia are elastic except eggs. It indicates that the percentage change in the amount consumed by each animal food is greater than the percentage change in price. This will emerge the huge implications in fulfilling households' protein consumption in Indonesia. To date, three provinces from 34 provinces in Indonesia consume protein in accordance with national protein sufficiency rates. Beef is the most influential to changes the prices, income, and preference. The highest demands elasticity of beef, milk, fish, chicken meat and eggs are 2.19%; 1.96%; 1.53%; 1.43% and 0.53%, respectively. The increasing beef prices are followed by the increasing of chicken meat consumption in Indonesia by 3.9%. It comprises chicken meat consumption in urban areas by 3.5% and in rural areas by 4.2%. The government should apply the income policy which will be more effective in rural areas. Also, the government should implement price policy which will be more effective in the urban area. The Indonesian government should develop a strategy that motivates the household to have a more diversified diet.

HH size also has a very significant effect on animal foods consumption. This requires a policy to improve households' food security. All animal foods have high-income elasticity except eggs. The policies related to income will encourage the increasing of beef consumption. Therefore, the encouragement of beef consumption and the stabilization of beef production by increasing income can be a more effective way. Also, the short-term targeted income transfer programs such as the short-term credit programs to the poor people can be potential to activate the households' food security which was similar to Nigerian government policy.

This research applies the new development of AIDS models namely the QUAIDS model which is directed at finding a framework for animal food demand models in Indonesia. Throughout the review of the latest literature, such research is still rarely found in Indonesia. Mostly the QUAIDS model applied at province level by considering the region type only. This study only included five groups of animal food sources of protein, namely eggs, chicken, beef, fresh fish, and milk powder.

Theoretically, the QUAIDS model that has been applied in several studies can be combined with welfare analysis and poverty analysis. Related with welfare analysis, the concepts of compensating variation (CV), equivalent variation (EV) and consumer surplus (CS) developed by Araar and Verme (2016) will be used. In measuring the impact of price changes on poverty, the concept such as Price Elasticity of Poverty (PEP), and Price Index for the Poor (PIP) that developed by Son and Kakwani (2009) will be applied. Integration of all of these approaches will not only provide impact price changes on "animal source foods" demand and consumption behavior, but also insight how the impact price changes for the poor households relative to the non-poor households in order to generate pro-poor policy recommendation. This idea will be presented in the other articles.

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Design and Realization of Interconnection of Multifunctional Weighing Device with Sigfox Data Network

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Abstract

With the increasing expansion of IoT networks, people are trying to connect more and more devices to data networks. Nowadays, such devices are made possible by platforms such as Arduino and Espressif. In recent years, one of the areas of interest for IoT has been the development and maintenance of beekeeping. Although there are various commercial solutions for multifunctional hive scales (BeeSpy or Alya), they are quite expensive. In this paper, we present a hardware and software solution to this problem. From a hardware point of view, our goal was to design such a device that would be competitive, capture various data using ambient sensors, and communicate over the new SigFox data network that was introduced in Slovakia in 2018. From a software point of view, we aimed to design and implement an application for smartphones. With this application, it is possible to fully visualize all acquired sensor data. The communication between the multifunction weighing device and the user's smartphone is ensured via SMS messages.

Keywords

Arduino microcontroller, Sigfox network, LPWAN, bee multifunction weighing device.

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Introduction

The Internet of Things or IoT is a system of interconnected computational devices, machinery, objects, people or animals using a data network. The "thing" in IoT has a very general meaning. It can mean an everyday object like a car, which has a wide variety of sensors built-in; a washing machine, which reports its state on a regular schedule, etc.

IoT thus consists of intelligent devices connected to a data network. These are devices with integrated sensors gathering data, which the devices must act upon. They share their gathered data through the connection to an IoT gateway or the other nodes in the network. Shared data is sent to the cloud for analysis or are being analyzed locally. Such devices can operate without human interaction (M2M). When necessary, a human can interject and control the devices directly. This kind of interaction is labelled as M2H interaction. Sometimes the devices can act upon the data gathered from the other nodes of the network. The communication between the devices and networking is dependent on the IoT platform in use.

In this paper, we describe the design and implementation of a multifunction weighing device connected to the Sigfox data network. This data network represents a communication framework for IoT in more than 60 countries. The multifunctional weighing device has been designed and constructed for beekeepers who maintain their hives outside built-up areas (forest areas) and transmitting data from sensors via GSM signal or Wifi is not viable. Paper is divided into several sections. The related work section describes works with similar research and implementation character. This section also describes current trends in IoT networks, in development platforms, and commercial hive weighing solutions. The next section explains our procedure in designing and implementing a multifunctional weighing machine. The discussion section represents an evaluation of the results achieved by our team.

Materials and methods

The decline in young people's interest in beekeeping, greater agglomeration and the overall approach to nature conservation (over-usage of pesticides, absence of flowering areas, forest logging) have caused a rapid decline in the world bee population in recent years. Their importance is unquestionable as they not only produce honey, propolis and other products but also serve a vital pollination function. Scientists, therefore, strive to draw attention to the need to monitor beehives so that we not have only an idea of the amount of honey produced in the combs, but also receive an early warning on diseases and pests. The following works focus on the design and implementation of bee weights that send the data to the user.

Although the first researches on beehive weight scales were carried out in 1977, these studies could not make use of the possibilities of currently available sensors and neither of wireless communication due to the lack of available technology (Mclellan, 1977).

Fitzgerald (Fitzgerald et al., 2015) have addressed this issue and designed intelligent bee scales taking advantage of wireless communications technology. Using a simple strain gauge sensor to weigh the actual amount of honey in the hive, the data is sent to the base station via Zigbee. The obtained data showed that the initial platform scale has a linear output characteristic. Based on the data from the analogue-to-digital converter, they determined the accuracy of the scale to several tens of grams. In addition to weight, sensors were used to monitor temperature (MCP9700A) and humidity (808H5V5). The base station node was developed using an off-the-shelf ATmega 1281. This platform uses low power WSN and is powered by a solar panel. The firmware wakes up four times in a 24-hour cycle to send data to read from the weighing scales.

Zacepins (Zacepins et al, 2016) focused on how to help beekeepers remotely monitor bee colonies to identify the status of bee swarming. To identify this condition, they monitored 10 bee families in their hives for 4 months. They used temperature measurements to identify the condition, registering a temperature increase of 1.5-3.4 °C during the warm-up phase (last 10-20 minutes before take-off).

Edwards-Murphy (Edwards-Murphy et al., 2016) designed a monitoring system based on WSN. Data transmission from sensors (temperature, relative humidity, acceleration and measurement of gases in the atmosphere) is provided by the ZigBee 3G11 base station. The disadvantage of their proposed solution is the short range of the broadcasting station - only a few tens of meters.

Jiang (Jiang et al., 2016) also used WSN technology to detect the number of bees that flew from the alley in the morning and returned to the hive in the evening. In this way, they were able to predict the mortality rates or, conversely, the growth of the bee population in the hive. Data was transmitted via GPRS gateway to the backend platform.

Gil-Lebrero (Gil-Lebrero et al., 2017) used the IEEE 802.15.4 communication standard to retrieve data being sent from the sensors, so communication can be established via 3G/ GPRS or WiFi.

Debauche (Debauche et al., 2018) designed a technical solution based on available accurate sensors and cloud architecture. Their solution is designed not only for obtaining data from strain-gauge sensors (measuring the increasing quantity of honey) but also for monitoring the behaviour of bees. Their solution allows researchers to provide a platform to better understand and measure the various impact factors that can affect the mass extinction of bees.

Commercial solutions of selected hive scales in Slovakia

There are several different types of hive scales available on the Slovak market that communicate using different data networks. Besides weight sensors, they also use other sensors for data collection.

BeeSpy – The system for continuous monitoring of the bee condition in the hive. It is a modular system designed for all-year use. The main aim of this system is to keep the bee colony under constant surveillance. Thanks to wireless communication technologies it is possible to monitor the current state of the colony from the comfort of beekeeper's home. The weight scale is focused on measuring the weight of the beehive, from which it is possible to ascertain the stock levels in winter, and honey production in the summer. It is also possible to measure both the ambient temperature and also the temperature, relative humidity and the activity of the bees inside the hive. The scale has a metal construction and consists of a strain gauge bridge, control electronics and a connector for additional sensors. The electronic circuit is designed to allow a wireless module to be plugged in at any time. The user can choose between a Wi-Fi module and a GSM module. The scale is fitted

with a 3-digit segment display that shows the current weight. It can measure either the total weight of the hive or its relative weight. BeeSpy devices can be linked together which makes it possible to power scales from one power source and send data gathered from multiple hives to the cloud. The collected data are displayed in well-arranged graphs. The scale can weigh up to 200kg at a resolution of 50g. The price of this hive weight scale (Figure 1) is around €308 (BeeSpy, 2019).

Source: BeeSpy (2019).

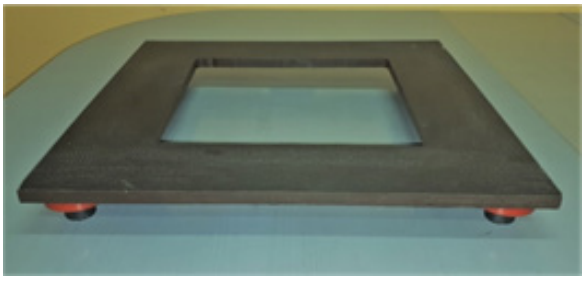
Figure 1: BeeSpy hive weight scale.

VILKO - A multifunctional device allowing hive monitoring without the beekeeper needing to visit the hive location (Figure 2). The main task of the device is to process, store and transfer data via GSM connection. Since it uses the GSM network, it is necessary to provide a SIM card to the device to enable communication. Data from the device is collected via SMS messages or a website. Similarly, the commands for the device are also sent via SMS messages. The scale has one input and one output interface. The input can be connected, for example, to a door sensor, triggering an SMS message to be sent immediately, in case of the hive door getting opened. The output can be connected to various devices such as light bulbs, heaters, sirens or other parts of the device. The device is battery-powered and uses solar panels for charging. The scale can measure the hive weight, temperature, battery condition, movement of the device, or even unexpected and unwanted visitors. Additionally, it can measure humidity and ambient temperature. Users of the device can set an interval for measuring and storing the transmitted data (2 SMS messages per day maximum), set the time of automated transmission, and set up an alarm system. It is also possible to activate and deactivate alarms used to prevent unwanted handling of hives or scales. Users can enter 5 telephone numbers for sending the data and receiving commands from. The scale can measure with an accuracy of 0.1kg, allowing you to set up the hive's base weight to calculate the weight gains up to the maximum weight of 200kg. Cloud data storage can be switched on and off. When it is switched on the data is processed and stored on a web page where it can be viewed in graphical form or tables. The current price of the complete kit is €480 (Alya, 2019a).

Source: Alya (2019a)

Figure 2: VILKO hive weight scale.

Mellisa BL - an electronic scale intended for weighing hives and colonies (Figure 3). Its main task is to weigh (up to 150kg at 0.1kg deviation), display and record the measured values.



Source: Alya (2019b)

Figure 3: Mellisa hive weight scale.

The measured values are saved in a database. The weight and temperature are displayed when the scale is activated. The user can read the current status via the iBeehive application. Measured values are automatically transmitted to the app on your phone or tablet. The scale allows the user to set up four different times for measuring and saving values. This will automatically happen without the need for a beekeeper to switch on the scale. An external temperature sensor can be connected to the balance. To transfer data to the app, the scale connects to the phone or tablet wirelessly over Bluetooth. A common smartphone charger is used for recharging the battery of the device. A power bank is used to power the electronics. Establishing a connection, displaying the values, communicating

and transferring data to the application on the phone is only possible with the scale switched on. After a specified time, the electronics automatically switches to sleep mode and communication with the application is interrupted. Basic features include displaying the current weight, temperature, and battery charge status. The material used to make the scale is highly weather-resistant. Four sensors provide accurate weight measurement even in case of an uneven load. Android 4.3 and above or iOS 5 and above are required for the app. The scale has an opening in the centre that allows hive ventilation. Its price is €184 (Alya, 2019b).

Low power network technologies suitable for IoT

LPWAN or Low-power WAN is a wireless wide area network technology that connects low-bandwidth devices. Most LPWAN-enabled devices are battery-powered for long-range transmission. LPWAN is capable of sending packets ranging from 10 bits to 1 kilobit at a transmission rate of up to 200 kilobits per second. The range of LPWAN transmission starts at 2 kilometres to an incredible thousand kilometres, depending on devices used (Saelens et al., 2019).

In 2010 in Toulouse, France, a startup named SigFox developed a network technology by the same name. SigFox is a wireless data network that uses LPWAN principles. It is typically applied in Europe for water, gas and electricity metering devices, parking sensors in garages announcing free parking spaces, safety devices and many other sensory devices (Mekki et al., 2019). Sigfox operates in unlicensed ISM bands with frequencies lower than one gigahertz. The ISM band uses 915 MHz in the US and Canada, 868 MHz in Europe and 433 MHz in Asia. The network is built on a star topology, like all LPWAN-related technologies. Terminals connected to the base station use Binary Phase Shift Modulation (BPSK) in the ultra narrow band (100Hz). Thanks to this modulation, the interference is very low, which also decreases the power consumption, increases the sensitivity of the receiver and reduces the manufacturing cost of the antenna. This modulation also allows communication over very long distances to run smoothly compared to competing technologies. SigFox promises a signal range of up to ten kilometres in urban areas and up to forty kilometres in rural areas (Mekki et al., 2018).

Communication in the SigFox network could initially only transmit it's data, as the device was only allowed to send data to the base station - uplink. Later, however, the devices were also allowed to receive data from the base station - downlink. Downlink communication can take place only after receiving the sending message, which means the network does not support full-duplex communication, only half-duplex. SigFox also allows you to send an acknowledgement for downlink communication. Communication is limited to 140 messages with a maximum message size of 12 bytes in the uplink direction and 4 messages with 8 bytes size limit in downlink direction per day. Of course, these messages can be smaller, or even empty. However, the communication speed is limited to 100 bits per second. Since it is only possible to receive four downlink messages per day, it cannot be reliably confirmed whether each uplink message was successfully received at the base station. To mitigate this issue, SigFox uses frequency and data diversity and devices send duplicate messages, usually three at a time, to the base station. Because of this, the band is divided into 400 different channels, each 100Hz wide. There are about 40 of these channels that are not in use. The base station can receive messages from all 400 channels at once. The leaf node chooses the channel completely randomly (Razza et al., 2017).

A vital part of the network is a so-called SigFox Backend, which represents a kind of inter-point for processing data sent from the terminal. Here you can track message statistics, set up events, give privileges to other users, and set up callbacks. With callbacks, it is possible to set where the received data will be forwarded to. However, this is only possible after registering the device with ID and PAC numbers (Mekki et al., 2018).

SigFox data network currently covers half of Europe. It is being built up in the US, South America, Australia, Japan and parts of the world, representing the total of60 countries and 5 million square kilometres. In Slovakia, this LPWAN network is provided by SigFox operator, Simplecell Slovakia. Simple cell covered 87% of the territory and 92% of the population of Slovakia (www.simplecell.sk). In Slovakia, SigFox also has competition in LoRaWan (coverage of only 16 built-up urban areas) and NB-IoT (coverage of the capital only).

LoRaWan was designed to improve battery life, network capacity and communication costs. The range of the signal depends very much on the environment, but usually, the LoRaWAN

data network covers the entire city in which the base station is located (Sinha et al., 2017), (Centenaro et al., 2016), (Hossain et al., 2018).

It is not always necessary for devices to communicate over long distances. Sometimes they only need to be able to communicate within a PAN or BAN network. ZigBee and Bluetooth Low Energy data networks are most common for this use-case.

ZigBee operates in unlicensed 915MHz bands in the US, 868MHz in Europe and 2.4GHz worldwide. It is based on the IEEE 802.15.4 standard. for PAN networks. The baud rate is 250 kbps. The range is from 30m in confined spaces to 100m in areas with direct visibility (Payne et al., 2019).

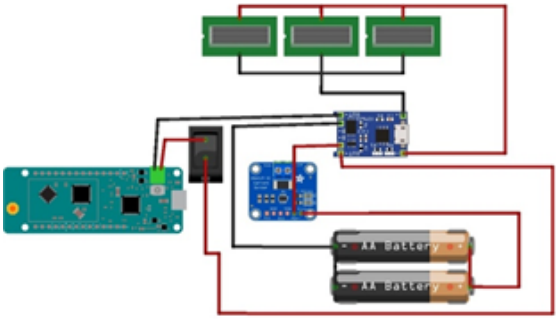
Bluetooth Low Energy (BLE) is an energy-efficient version of Bluetooth that uses other devices as base stations. These devices tend to be connected to a larger network. BLE uses FHSS modulations in the unlicensed ISM band at 2.4GHz. The maximum speed is 1Mbps, which is approximately one-third of the speed of classic Bluetooth. During transmission at this rate, it consumes about half of the Bluetooth 4.0 electrical power, which brings it to the range from 10mW to 500mW, making the BLE an excellent candidate for integration into various smart devices (Bulić et al., 2019).

Hardware design of our solution

At the heart of the system is the Arduino MKR FOX 1200 microcontroller. The following sensors are used to collect data on its environment:

1. Real-time clock,
2. vibration sensor,
3. electric current measurement sensor,
4. 2 temperature sensors,
5. strain gauge sensors for measuring weight,
6. rain gauge.

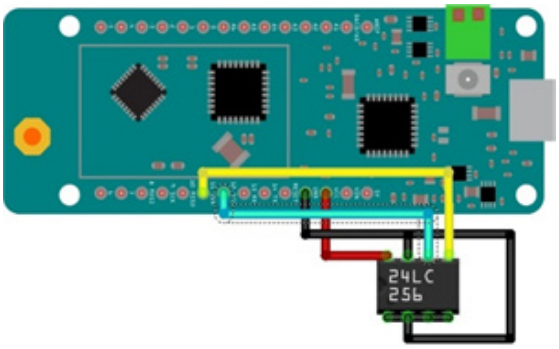
Both Arduino and the sensors are connected to the mainboard. All sensors, except the vibration sensor and rain gauge, have their ground outputs connected to the collector of the NPN transistor (to reduce energy consumption). The transistor is designed to disconnect the sensors from the power whenever they are not in use. The system is powered by a combination of two lithium-ion batteries that are connected to the charging module. The charging module (Figure 4) consists of three single crystal photovoltaic solar panels of 1.25W (to achieve energy independence during the days of sunshine).



Source: own creation

Figure 4: Connection of the power system.

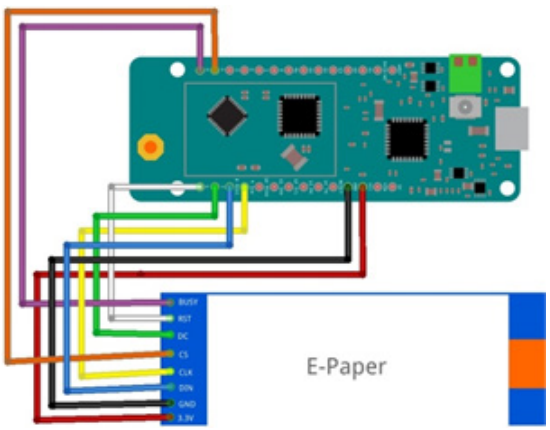
The external EEPROM memory 24LC256 is used to save the settings (Arduino MKR FOX 1200 does not contain EEPROM memory). The EEPROM (Figure 5) stores the settings such as the selected mode and weight calibration. The external memory was selected because the data still needs to be backed up even after the device loses access to electricity. The settings in the EEPROM can be changed using two buttons.



Source: own creation

Figure 5: EEPROM Connection Schema.

Waking up the device from standby and triggering the screen update procedure is done by a pressing down a dedicated button. An e-ink screen was used as a display part of the device to reduce energy consumption (Figure 6).



Source: own creation

Figure 6: E-Ink (E-Paper) Screen Connection Schema.

It is a monochrome electronic paper display with a 2.9-inch screen, displaying in black and white. The active area has a resolution of 296x128 pixels. When using the display, we decided to use both the full and partial image updates depending on the situation.

The casing and some other components were printed using a 3D printer for storage and protection from external (weather) influences. All parts were sealed to meet IP64 requirements. For data visualization we used an IoT platform ThingSpeak, where the obtained data are displayed in the form of graphs and data can be exported and sent through a Twilio SMS gate if necessary. The original 2dB gain antenna was changed to a 5dB gain antenna.

Selection and implementation of sensors

The proposed system is equipped with various sensors that any beekeeper will certainly make use of. The most important is a strain gauge sensor for weight measurement. Temperature and humidity information both inside and outside the hive is also of vital importance for maintaining the beehive. Another important data for the beekeeper is the amount of rainfall, for which we've added a rain gauge. If someone attempts to steal a hive or hive weight scale, we have equipped the system with a vibration sensor to give the owner a movement report of either hive or a weight scale. Last but not least the real-time clock and current measurement sensor also provide the device with important data.

Weight scale sensor - the weight scale sensor was created by assembling four separate strain gauges connected to the Wheatstone Bridge. The strain gauges are connected to a 24-bit HX711 analogue-to-digital converter with amplifier. One strain gauge can measure weight up to 50kg. Thus, in a four-sensor configuration, we can achieve weight measurements up to 200kg (Figure 7).

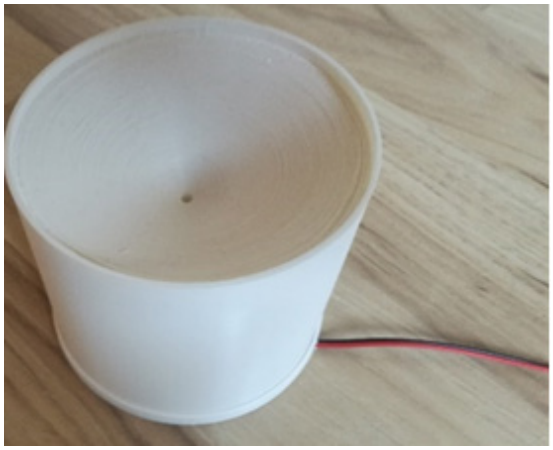
Source: own creation

Figure 7: Weight scale sensor.

When the pressure (force) is applied to the strain gauge, its electrical resistance changes. The HX711 can record and amplify these changes so that Arduino can measure the value. The HX711 divides this weight into 224 (16777216) voltage levels.

Temperature and humidity sensor - DHT22 is a sensor that allows temperature measurement with accuracy to one decimal place and much more accurate relative humidity measurements than the standard DHT11. It can measure temperatures between -40 ° C and 80 ° C. It measures relative humidity from 0% to 100%. The sensors are connected to unused UART lines. An external sensor located on the side of the 3d printed case box is connected to pin 14 (TX). The sensor on the inside of the hive was connected by a 1.5m cable to the RX line, which is located on pin number 13 on the board and was led out of the box.

Rain gauge sensor - we have chosen the tipping-bucket rain gauge to be a part of our proposed multifunctional device (Figure 8).



Source: own creation

Figure 8: Rain Gauge sensor.

The rain gauge was made using 3D printing. The tipping-bucket was designed to tip over after filling up with 6 ml of water (usually tipping-bucket rain gauges tip over after filling up with 4 ml of water), thus reducing the number of wake ups of the microcontroller and slightly improving energy consumption. We placed a neodymium magnet onto the tipping-bucket that closes a switch whenever the flip occurs. The switch is connected to a pin that supports external interrupts, thus waking up the microcontroller. The microcontroller will count the tip over after each interruption. We used a formula to calculate the volume of a cylinder to know how much rain had fallen since the last message was sent. In the formula, we express the height as "v". The volume of fluid per flip is known to be 6ml, which we can substitute for the volume "V" in the formula. Our 3D model design has a radius of 5.2 cm which we use as the radius in the formula. After the calculation, we know that one flip of the tipping-buckets

represents about 0.71mm of rainfall, which means that to record a dropped 1mm, the rain gauge must flip 1.4 times. We later incorporated this knowledge into the program and we send the recalculated value in millimetres in a SigFox message.

Electric current sensor - for electric current measurement we have chosen INA219 sensor, which allows for communication with microcontroller via the I2C interface. Using I2C interface we can better ration the pins on an Arduino board. We have mounted the sensor onto the mainboard and connected a cathode of the lithium-ion battery to the Vin+ pin. To the Vin- we have connected the positive pin of the charging module so that we create a serial connection required for measuring the current. Based on which directions the electrons flow, we can determine whether the batteries are being charged or discharged. When the batteries are being charged, the electric current measurement shows negative values. Otherwise, when the batteries are being discharged, the measurement shows positive values. We show these values on the display.

Real-time clock - the board was also fitted with a DS3231 module. Although it connects to the same bus as the EEPROM memory and current measurement sensor, since it has a different address from memory and the current sensor, there is no mixing of data. The use of the module allows us to implement different kinds of modes that change time intervals for transmissions. It also plays an important role in external interrupts. With this module, we can measure time before and after the interrupt so that Arduino can switch to standby for the remaining time, during which must remain suspended.

Vibration sensor - similar devices usually contain a kind of accelerometer that communicates via the SP1 or I2C bus. In our case, however, given a large number of connected sensors, such a solution would not be ideal, as it would not be able to wake Arduino up from standby state. We could only find out the state of the situation while Arduino is active, which is a very short time. That's why we chose a vibration sensor. Not only because of its simple construction but also because of its low price. We placed the sensor on the board and connected it to the microcontroller terminal that supports interrupting the processor. The ground terminal has not been connected to the transistor collector, so the sensor can operate continuously.

Creating a User Interface

The main element of the interface is the screen. On the screen, we decided to display information on the date, power supply, microcontroller status (active mode/power saving mode), messaging mode, current hive temperature, ambient temperature and weight of the hive (Figure 9). To activate the screen, the user has to press the “WAKE” button. Upon waking up, the microcontroller changes its state from “Sleep” to “Awake”. Once awaken, the user can control the interface using two buttons to change settings. The “MODE” button, which is used to switch the device to a SigFox message transmitting mode, has been connected to the analogue terminal via a 1:1 voltage divider. We used two resistors with a resistance value of 1kΩ for the voltage divider. The “TEAR” button is directly connected from the VCC to the analogue terminal.

The system contains 8 messaging modes:

15min - the message is sent every 15 minutes,

30min - the message is sent every 30 minutes,

60min - the message is sent every 60 minutes,

ECO - During winter, in the time from 6 pm to 6 am, the report will be sent every 3 hours. Outside of this range, it will be sent every hour. In other seasons, the reports will be sent every 2 hours in the range from 10 pm to 4 am and every hour outside this time range.

ECO + - almost identical to ECO, but during winter, in the time range from 6 am to 6 pm, messages are sent every 2 hours,

DAY15 - messages are sent every 15 minutes until 10 pm; after 10 pm the system goes into standby for 8 hours,

DAY30 - messages are sent every 30 minutes until 10 pm; after 10 pm the system goes into standby for 8 hours,

DAY60 - messages are sent every 60 minutes until 10 pm; after 10 pm the system goes into standby for 8 hours.

Source: own creation

Figure 9: Front of the multifunction weighing device.

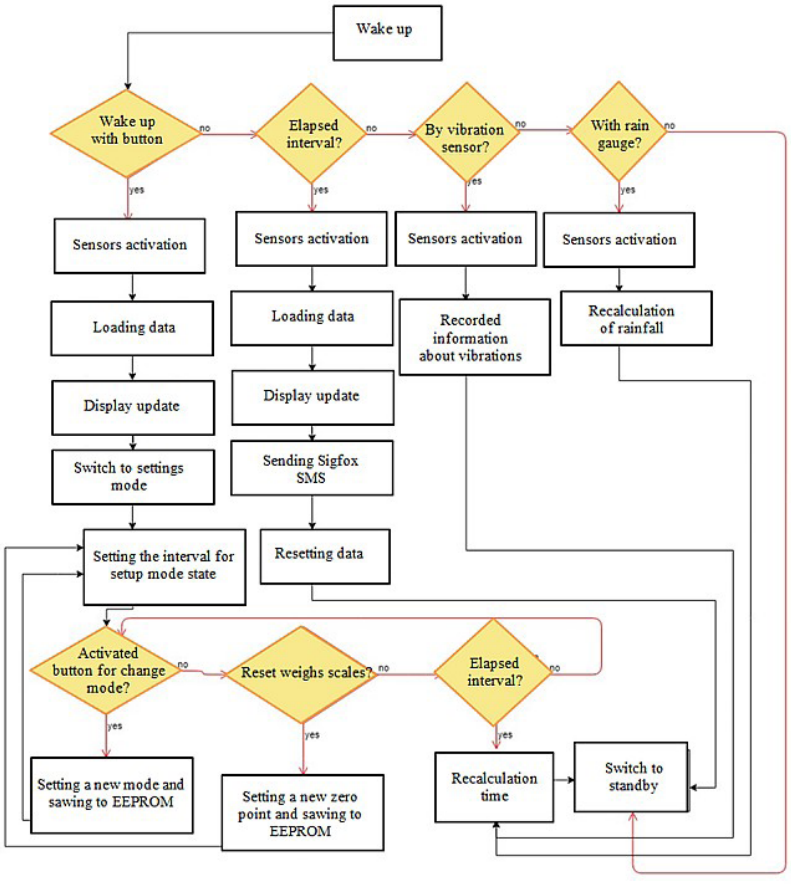
The program running on Arduino MKR FOX 1200 was written in Arduino IDE using C++ language. The program consists of a part (void setup) that happens once at boot time (the so-called

initialization part) and a part that will happen repeatedly in a loop (void loop).

The loop function (Figure 10) contains interrupt commands that are executed based on external influences (sensor data), commands to display information on the display, and commands for transmitting data to the SigFox backend. The message sent through SigFox must not exceed 12 bits. We used a float data type variable for the temperatures obtained, but we limited the sending of the temperature to sending only once in 1 hour. We have proceeded similarly for the obtained data on indoor and outdoor humidity. Both temperature and humidity are important data for a beekeeper, so they must be as accurate as possible. Even with a small change in these values, the beekeeper can predict what may be happening to the hive. For example, the elevated temperature often means the colony is infested with a disease (Varroa destructor), in which the bees are trying to rid themselves of the parasite by increasing their internal temperature. We have used the uint_8 data type for vibration and rainfall data as we do not need to measure negative values and we only need values from 0 to 255. We used the float data type for the weight measured by the weight sensor because we want the beekeeper to know as accurately as possible hive's changes in weight.

Backend setup is done using the website http://backend.sigfox.com, entering the ID and PAC of the Arduino MKR FOX 1200 microcontroller and creating a new callback (data is sent in the uplink direction). Twilio SMS gateway (providing free SMS messaging until the user overspends the prepaid credit) is used to send the current status SMS without adding any additional hardware. To avoid having to create a dedicated application, we have used the widely used ThingSpeak IoT platform (Figure 11, left). ThinkSpeak lets you visualise the following data:

1. Vibrations (first item, left panel),
2. Outdoor temperature (second item, left panel),
3. Indoor (hive) temperature (third item, left panel),



Source: own creation

Figure: 10 Initialization function flowchart .

4. The amount of rainfall (fourth item, a panel on the left).
5. Weight (first item, right panel),
6. External humidity (second item, right panel),
7. Internal (hive) humidity (second item, a panel on the right),
8. Vibration history (second item, right panel).

Source: own creation

Figure 11: Data displayed by ThingSpeak (left) and ThingView (right).

We have chosen the ThingView app for Android smartphones (Figure 11, right). The beekeeper using the multifunctional weighing device we have designed can monitor the hive status not only through the web application but also through a smartphone. All parameters that would have to be set directly through the MFP can also be set through ThingSpeak or ThingView. Using both applications, it can get a detailed overview of the hive status based on the available statistics (Figure 11, right):

1. Weight,
2. Outdoor temperature,
3. External humidity,
4. Indoor temperature,
5. Indoor humidity,
6. The amount of rainfall.

In case of adding a new sensor to the device, the platform allows the creation of dependencies and processing of statistics by comparing this parameter with other available sensory parameters or time interval.

Discussion – Comparing another DIY solution with our solution

The device we designed was created according to the requirements specification made by a beekeeper and the Department of Ecology and Environmental Sciences of the Faculty of Natural Sciences, Constantine the Philosopher University in Nitra (Figure 12).

Source: own creation

Figure 12: Our designed and implemented device.

The device is currently being actively used. Any device that has been designed, created and registered for a Sigfox data network backend must go through the registration process. Currently, there are various commercial solutions (described in the Commercial Solutions section of selected hive scales), but their cost is often prohibitively high for beekeepers. Also, the possibilities of commercial solutions are often limited by the capabilities of the used data network. For this and other reasons, the market has seen an increase in DIY (Do-It-Yourself) solutions. Thus, the Discussion section will be comparing our solution (Table 1) with the DIY solution by Nathan Seidle (hereinafter referred to as DIY-NS).

Component	DIY-NS	Price (€)	Our solution	Price (€)
Microcontroller	Arduino UNO	20.00	Arduino MKR FOX 1200	36.41
Wi-Fi module	Spark Core	35.33	X	X
Weight sensor	HX711 + personal weight	79.56	HX711 + strain gauge sensor + OSB board	10.00
Rain sensor	X	X	Printed on a 3D printer	1.16
Outdoor thermometer and humidity meter	X	X	DHT22	2.54
Internal thermometer and humidity meter	SparkFun Si7021	7.00	DHT22	2.54
Sensor of real time	X	X	DS3231	2.10
electric current sensor	X	X	INA219	1.21
Vibration sensor	X	X	SW18010P	0.36
EEPROM	X	X	24LC256	0.26
Display	X	X	E-Paper	16.18
Accumulator	6Ah Li-Po	26.50	2x3,4Ah 18650 Li-Ion	4.60
Solar panel	2.5W	34.00	3x1,25W	4.53
Case	X	X	Printed on 3D printer*	3.22
Antenna	2.4GHz	4.38	868MHz 5db	2.46
Buttons	X	X	3x waterproof buttons	0.87
Together		**206.77**		**88.44**

Note: * The print was realized with the ABS material type, filament diameter 1.75mm, consumed filament length 80m. The price of new filament 21.70€/kg. The full price of material cost 4.38€ (rain sensor + case).
Source: own creation

Table 1: Price comparison of the two solutions

DIY-NS uses Wi-Fi to transmit data from the hive. Data is gathered by the Arduino Uno microcontroller using only two sensors: weight sensor and integrated temperature and humidity sensor. The DIY-NS uses an off-the-shelf personal scale connected to the HX711 as a weight sensor. Strain gauge cells are, like in our solution, connected to the Wheats Bridge. The HTU21D sensor, which communicates with the microcontroller via I2C, is used to collect hive temperature and humidity data. The DIY-NS is powered by a 6Ah lithium polymer battery that is recharged using a 2.5W solar panel. The analog.io platform is used for data visualization, and data.sparkfun.com is used for data processing (Seidle, 2019).

DIY-NS solution is ultimately several times more expensive than our proposed solution, also contains fewer sensors and uses Wi-Fi to collect data. This means, that the device needs to be within the range of a Wi-Fi access point (Wifi has a much lower range compared to Sigfox and isn't usable in mountain areas unlike SigFox transmitters).

Conclusion

In this paper, we have presented a design and implementation of a multifunctional weighing device intended for beekeepers' needs. The designed device can communicate with the user via the IoT SigFox data network. The device periodically sends information about the condition of the hive and its surroundings. It can measure the indoor (hive) temperature and relative humidity of the hive as well as the outdoor temperature and humidity. The hive weighing is accurate to 50g (as opposed to 100g in current commercial solutions compared in this paper) at a maximum hive weight of up to 200kg. Measurement of rainfall is also possible, thanks to a tipping bucket rain gauge. The system is secured by a vibration sensor. The device is powered by two lithium-ion batteries that can maintain the system (when the system is in power saving mode of 4-7mA) for about 2 months, with a frequency of sending messages every 15 minutes. 7 additional modes are available to extend battery life, and 3 solar panels are mounted on the device for charging the batteries. Data received from the device is displayed using ThingSpeak IoT website or the ThingView Android app. Regular SMS status messages are also a feature of the system. Overall, our designed device is several times cheaper than commercial devices available on the market. Currently, several beekeepers in Slovakia are actively using the unit.

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Welfare with IoT Technology Using Fuzzy Logic

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Abstract

The article describes the concept of deploying IoT technologies within the environment of agrarian operations using a system approach with a focus on fuzzy logic. In addition to the introductory acquaintance with IoT and fuzzy theory, the paper focuses on specific possibilities of applying the fuzzy approach, especially in the case of animal husbandry. The main benefit for this field is the fulfillment of welfare principles and the achievement of economic savings based on optimization. The article also showcases a practical implementation of a demonstrative solution in the JavaScript programming language using data from IoT sensors.

Keywords

IoT, Fuzzy Logic, Welfare, Networks, Precision Agriculture, Smart Agriculture, JavaScript.

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Introduction

Technological solutions, such as the modern IoT (Internet of Things), can solve problems or bring about the optimization of existing processes, but only if they can naturally interact with the environment in which they are deployed.

This approach is best suited for implementations of continuous, i.e. analog systems, which can respond to change immediately in almost an unlimited number of levels. However, to be able to apply the available numerical methods to these systems, digitization is necessary. This allows to express reality using a discrete approach with a limited number of levels. Therefore it is necessary to focus on those principles of IoT that are based on the discrete approach, for example that the measurement takes place only a few times over a defined period (sampling) and the values are quantized to predefined levels (Rymarczyk, 2020).

IoT issues are more increasingly important and experience dramatic development in many areas. Such development brings many new technological innovations as well as generated new problems. Vast quantities of IoT devices in use or still in development need to be categorized based on their usage, type, internet connection, place of implementation etc. One of the important places of usage is agrarian sector and countryside in general. It belongs to one of the more “traditional” areas of IoT implementation, but there is still a lot of room for further development (Stočes et al., 2016).

Fuzzy logic and IoT technology were also presented as a strategy to develop an intelligent irrigation approach that fosters water conservation and better irrigation management in areas with high levels of water stress. The developed fuzzy controller, based on Mamdani fuzzification using trapezoidal and triangular membership functions, efficiently set the time and duration of irrigation for a given crop. The use of fuzzy control helped maintaining the moisture above a pre-set value with smooth variations preventing frequent system’s run-off and preserving water and energy. To monitor system in real time, a wide-range ZigBee based wireless network was also used. The system is easy to implement, and economically justifiable (Alomar and Alazzam, 2019).

The combination of IoT and fuzzy logic is also being successfully used is various non-agriculture applications. For instance, the fuzzy logic model was used to control the intensity of light emitted by lighting. Using this approach, it is possible to enlighten the environment according to the conditions and not waste energy by producing excessive lighting (Altun and Dörterler and Doğru, 2018). Another possible

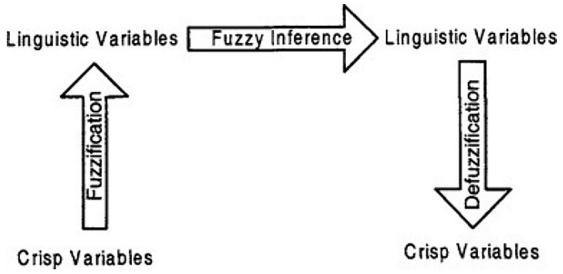
application of this approach is in fashion retail as described by (Chan, Lau and Fan, 2018).

Materials and methods

Fuzzy logic is fundamentally built upon the concept of fuzzy sets (Rezaee and Kadkhodaie-Ilkhchi and Alizadeh, 2008). Even though the gradual evolution of the expression of uncertainty using probability theory was challenged first in 1937 by Max Black (Ross, 2004), Lofi Zadeh at the University of California initiated research into fuzzy logic approach in 1965. Since then, fuzzy logic has fully come of age. Its foundations have become firmer, its applications have grown in number and variety, and its influence within the basic sciences, especially in mathematical and physical sciences, has become more visible and more substantive. Yet, there are two questions, that are still frequently raised: a) what is fuzzy logic and b) what can be done with fuzzy logic that cannot be done equally well with other methodologies, e.g., predicate logic, probability theory, neural network theory, Bayesian networks, and classical control? One suggested answer is that the main contribution of fuzzy logic is a methodology for computing with words, as no other methodology serves this specific purpose. A fuller exposition of the methodology of computing with words (CW) will appear in a forthcoming paper. Needless to say, there is more to fuzzy logic than a methodology for CW (Zadeh, 1996).

In general, the fuzzy inference system consists of four modules, the first one is the fuzzification module that transforms the system inputs which are crisp numbers, into fuzzy sets. The second module is called knowledge base, it stores the IF-THEN rules, the rules normally specified by experts. The third module is called the inference engine, it simulates human reasoning process by making fuzzy inference on the inputs and IF-THEN rules. The fourth and last one is called defuzzification module that uses inference engine to transforms the fuzzy set into a crisp value (Fayaz and Kim, 2017).

The following Figure 1 shows the above process where the second and third mudules are merged into a fuzzy inference step.

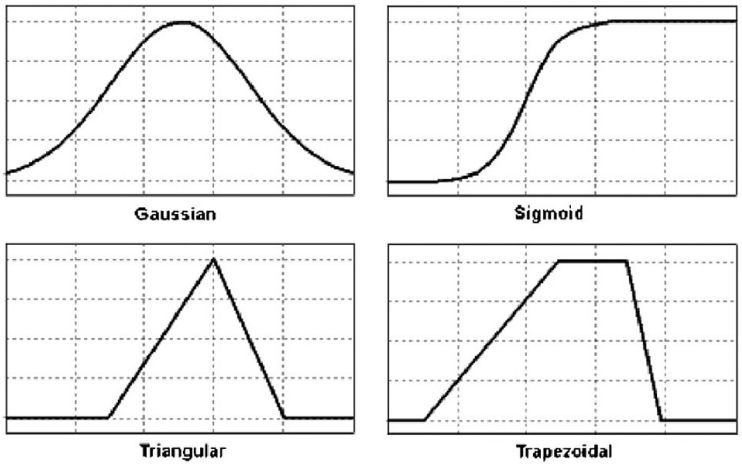


Source: Wang, 2001

Figure 1: Fuzzy logic concept.

Fuzzification

Fuzzification is a step to determine the degree to which an input data belongs to each of the appropriate fuzzy sets via the membership functions (Xu, 2010). In fuzzy logic, a fuzzy inference system is used as a procedure, in which the input is converted in to fuzzy sets with the help of membership functions like for instance: triangular, trapezoidal, gaussian, or sigmoidal (Patel and Champaneria, 2017) (see Figure 2).



Source: Rezaee and Kadkhodaie-Ilkhchi and Alizadeh, 2008

Figure 2: Four types of fuzzy membership functions: Gaussian, sigmoid, triangular and trapezoidal.

Membership functions

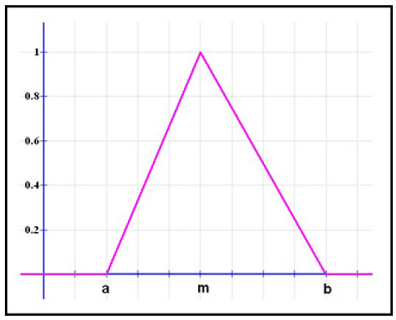
Definition: a membership function for a fuzzy set A on the universe of discourse X is defined as μA:X → [0,1], where each element of X is mapped to a value between 0 and 1. This value, called membership value or degree of membership, quantifies the grade of membership of the element in X to the fuzzy set A. Membership functions allow us to graphically represent a fuzzy set. The x axis represents the universe of discourse, whereas the y axis represents the degrees of membership in the [0,1] interval (Alonso, [no date]).

Below is the list of membership functions we will use in our experiment:

Triangular function: defined by a lower limit **a**, an upper limit **b**, and a value **m**, where

a < m < b. It is described in formula (1), and shown in Figure 3 (Alonso, [no date]).

$$\mu_A(X) = \begin{cases} 0, & x \le a \\ \dfrac{x-a}{m-a}, & a < x \le m \\ \dfrac{b-x}{b-m}, & m < x < b \\ 0, & x \ge b \end{cases} \quad (1)$$

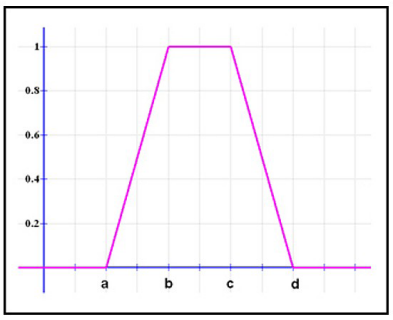


Source: Alonso, [no date]

Figure 3: Triangular function.

Trapezoidal function: defined by a lower limit **a**, an upper limit **d**, a lower support limit **b**, and an upper support limit **c**, where **a < b < c < d**. t is described in formula (2), and shown in Figure 4 (Alonso, [no date]).

$$\mu_A(X) = \begin{cases} 0, & x > d \\ \dfrac{d-x}{d-c}, & c \le x \le d \\ 1, & x < c \end{cases} \quad (2)$$

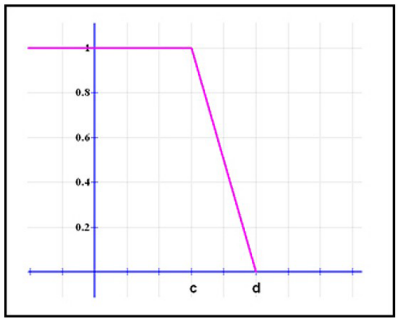


Source: Alonso, [no date]

Figure 4: Trapezoidal function.

Grade function: with parameters **a = b = -** ∞. It is described in formula (3), and shown in Figure 5 (Alonso, [no date]).

$$\mu_A(X) = \begin{cases} 0, & x < a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ 1, & x > b \end{cases} \quad (3)$$

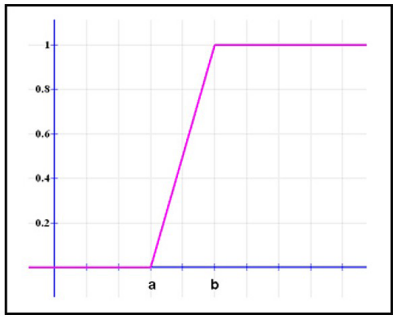


Source: Alonso, [no date]

Figure 5: Grade function.

Reverse Grade function: with parameters **c = d = + ∞.** It is described in formula (4), and shown in Figure 6 (Alonso, [no date]).

$$\mu_A(X) = \begin{cases} 0, & x < a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ 1, & x > b \end{cases} \quad (4)$$



Source: Alonso, [no date]

Figure 6: Reverse Grade function.

Knowledge Base

A system of fuzzy IF-THEN rules is considered as a knowledge-based system where inference is made on the basis of three rules of inference (Perfilieva, 2007). The 'noun' is often unimportant in the applications. Therefore, it is commonly replaced by some variable X whose values are not the objects themselves but only its features, such as height, volume, tension, size, abstract degrees of beauty, temperature, etc. This leads us to the concept of a fuzzy IF-THEN rule which is a kind of "abstracted" compound adjectival predication.

Definition: By fuzzy IF-THEN rule we understand either of the compound adjectival predications R^1 and R^A taken in the form of formulas (5) and (6), where X and Y represent features of objects (Novák and Lehmke, 2006).

$$\mathcal{R}^A \coloneqq X \; is \; \mathcal{A} \; AND \;\; Y \; is \; \mathcal{B} \tag{5}$$

$$\mathcal{R}^1 \coloneqq IF \; is \; \mathcal{A} \; THEN \;\; Y \; is \; \mathcal{B} \tag{6}$$

As an example, in practical implementation, such a rule can look like this:

IF it is hot, **THEN** ventilate a lot.

Fuzzy inference

Fuzzy inference is a method that interprets the values in the input vector and based on sets of rules, assigns values to the output vector. In fuzzy logic, the truth of any statement becomes a matter of a degree. Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping then provides a basis from which decisions can be made or patterns discerned (Kala, 2016; Kalogirou, 2014).

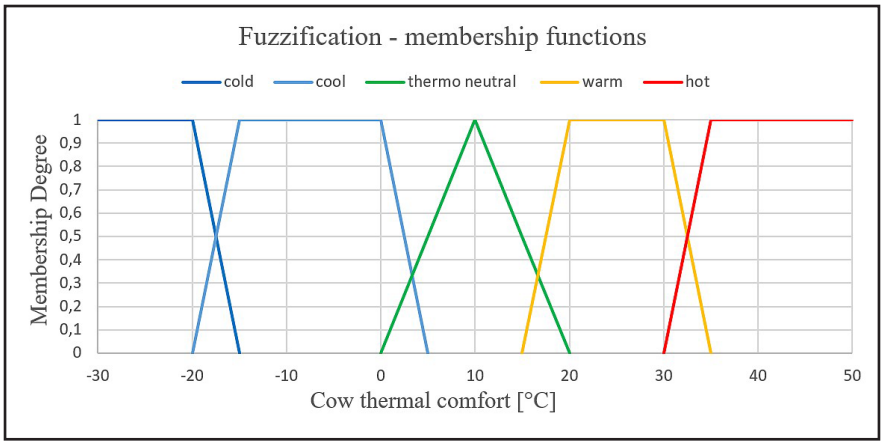
Defuzzification

Defuzzification is the process of obtaining a single number from the output of the aggregated fuzzy set. It is used to transfer fuzzy inference results into a crisp output. In other words, defuzzification is realized by a decision-making algorithm that selects the best crisp value based on a fuzzy set. There are several forms of defuzzification including center of gravity (COG), mean of maximum (MOM), and center average methods. The COG method returns the value of the center of area under the curve and the MOM approach can be regarded as the point where balance is obtained on a curve (Masoum and Fuchs, 2015; Patel and Champaneria, 2017).

Experimental Implementation

The aim of the experiment was to determine whether it is possible to apply the theory of fuzzy systems to ensure compliance with the principles of welfare in the environment of animal husbandry. The term "animal welfare" is being used increasingly by corporations, consumers, veterinarians, politicians, and others. However, the term can mean different things to different people. Understandably, in the past, veterinarians and farmers have seen animal welfare chiefly in terms of the body and the physical environment (shelter, feed, etc.). Meaning that if an animal is healthy and producing well, it is faring well. Research on aspects of animal welfare has also mainly focused on the body, using physiological measures, such as endorphins, plasma cortisol, and heart rate, to examine how the animal is coping with its environment. However, there are limitations to seeing animal welfare only in terms of the body. One limitation is that genetics and the environment can produce desirable physical outcomes, even though the animal's mental state is compromised. For example, a canine breed champion may have perfect conformation and be in perfect health, but it may be very anxious in its home environment. Another limitation is that some physical parameters (heart rate, plasma cortisol) are difficult to interpret, because they can be increased by both positive and negative experiences, such as the presence of a mate and the presence of a predator (Hewson, 2003; Broom, 1991; Blood and Studdert and Carling, 1988).

The main purpose of the experiment was to create a system that could better inform farmers about the needs of his animals. The air temperature was chosen for the experiment for clarity, as it is an important element of the stable microclimate. Together with other physical characteristics (air flow, relative humidity) it most influences the thermal state of the animal organism and its thermal well-being. In a certain temperature range, at constant values of other physical elements, the thermal state of the organism is considered optimal, as the animal has only a small expenditure of energy to maintain physiological functions and has a feeling of thermal well-being (comfort). This temperature range is the so-called "thermoneutral zone", which is much wider in cattle, as well as in other ruminants (such as sheep), than in monogastric animals. In addition to species affiliation, it is also affected by other factors, especially the overall level of metabolism (Doležal et al, 2004).



Source: own processing

Figure 7: Fuzzification – membership functions.

Based on a literature search, especially the relevant legislation, the following five fuzzy sets have been defined, which will be used for fuzzification (see Figure 7) (No. 208/2004 Coll., 2004; 98/58 / EC, 2017).

Fuzzy logic sets are implemented by the JavaScript programming language. The experiment was based on the Open Source library "es6-fuzz" (Schürmann, 2019), which was embedded into the program for the experiment. The following example program (see Figure 8) shows the creation of membership functions according to their respective graphs. The definition of the shape of individual curves is solved by including partial libraries.

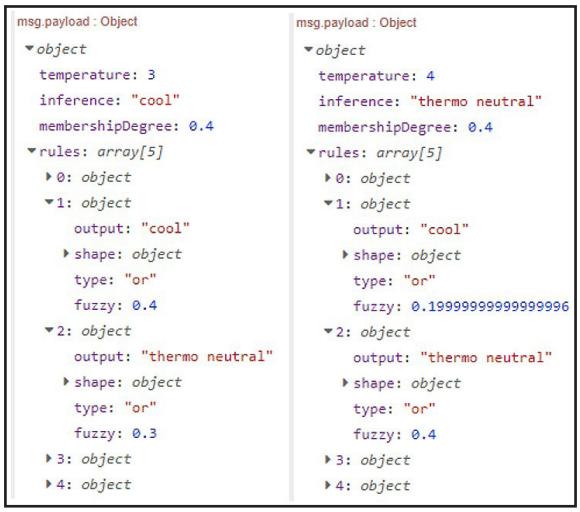
```
var Logic = require('./lib/logic')
var Trapezoid = require('./lib/curve/trapezoid');
var Triangle = require('./lib/curve/triangle');
var Grade = require('./lib/curve/grade');
var ReverseGrade= require('./lib/curve/reverse-grade');

var logic = new Logic();
var res = logic
  .init('cold', new ReverseGrade(-20, -25))
  .or('cool', new Trapezoid(-20, -15, 0, 5))
  .or('thermo neutral', new Triangle(0, 10, 20))
  .or('warm', new Trapezoid(15, 20, 30, 35))
  .or('hot', new Grade(30, 35))
  .Fuzzyinfer(20);
```

Source: own procerssing

Figure 8: Sample javascript program.

Figure 9 shows the function of the program. It is a JSON data structure, with attributes showing program variables. The office entry was at temperature of 3 ° C and 4 ° C, the inference item shows with what word the program qualified the given value and "membershipDegree" constitutes the degree of belonging to the given set.



Source: own procerssing

Figure 9: JSON data structure.

Results and discussion

It has been verified that the fuzzy approach can be used in a very simple way to pass information to the stable staff, where it is better understood by humans in a form of a verbal expression that adds contextual information in relation to the animal.

Thanks to this approach, greater optimization of operation can be achieved, which reduces the error rate of the employees and increases the production of the stable due to compliance with welfare conditions. Fuzzy approach can therefore directly lead to an economically positive effect.

For fully automated operations, it will be necessary to use the knowledge base and subsequent defuzzification for automatic intervention, which was not the goal of this experiment. It would require specialized professionals so that the control circuit can be set optimally.

Fuzzy control itself is a very widespread and standard tool. For example, the Japanese have been quickest to apply fuzzy logic in 1989. A fuzzy system developed by Hitachi was already used to control subway trains in the city of Sendai, accelerating and decelerating cars more smoothly than a human driver could (Pollack, 1989).

Conclusion

Apart from its usage in agriculture, utilization of fuzzy approach in conjunction with IoT can be for example aimed at developing an energy-saving thermometer for measuring the temperature of the human body. The results show that HI-Thermo saves energy of monitoring significantly. Using fever body temperature measurements, the proposed system consumes 15% lower than the existing traditional monitoring of body temperature, which does not implement fuzzy logic (Mandala et al, 2017).

It would be appropriate to evaluate the benefits of the use of these technologies, similar to the work assessing the benefits of precision farming technologies in sugar beet production. (Jarolímek et al, 2019)

A secondary output of this research is the finding, that fuzzy logic can be beneficial for IoT devices themselves, regardless of industry use. An important opportunity for the use of fuzzy approach, as outlined here is the implementation of algorithms directly into battery powered IoT devices, which will achieve significant aggregation of information and thus save energy in wireless communication. Alternatively, the capabilities of fuzzy logic can be used for instance in forecasting. The field of fuzzy logic still experiences very active theoretical research, so there is high possibility for new knowledge and approaches to emerge in the near future (Fayaz and Kim, 2017).

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