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Determinants of Albanian Agricultural Export: The Gravity Model Approach

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Abstract

Despite its huge agricultural potential, Albania has a sharp trade deficit with agricultural commodities. The main focus of this study is to analyse key determinants of its agricultural export. Here we employ baseline gravity model considering conventional gravity variables for Albanian export flows for the period 1996-2013. The Poisson Pseudo-Maximum Likelihood (PPML) regression is used for stepwise estimations of the augmented gravity model, including effects of Albanian Diaspora, exchange rate and price stability, trade liberalization and institutional distance. Main findings suggest that agricultural export flow increases with increasing economic size, revealing higher impact of importer's absorbing potential comparatively to Albania's productive potential. On the other hand, growth in domestic demand, resulting from increase in population, leads to reduction of agricultural export. Moreover, agricultural export flows are determined by low transportation costs (distance), adjacency proximity (sharing common border) and linguistic similarities. Presence of Albanian Diaspora residing in the importing countries facilitates export flows. Results of this study reveal that exchange rate variability has a positive impact, while bilateral institutional distance has diminishing effects on Albanian agricultural exports.

Keywords

Agricultural trade, export, gravity model, panel data, Albania.

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Introduction

Albania initiated transition into a market economy since the early 1990s. Transition from communism into free market system was unique and escorted with dramatic turbulences. Early period of market reforms endorsed radical model of the shock therapy, guiding Albania's economic system to drastic and profound structural changes. Price controls were lifted, markets were liberalized and privatization process initiated (McCarthy et al., 2009). Initial reforms, between 1993 and 1996, resulted with outstanding economic growth, marking highest growth rates compared to all transition economies. However, in 1997, flourishing financial pyramid schemes ruined both political and economic system. The country witnessed collapse of pyramid investment schemes, which were larger (relative to the size of the economy) than any previous schemes of this kind (Korovilas, 1999). Hence, Albania plunged into deep economic crisis. Rioting and civil unrest brought the country in the edge of civil war. Events from that period served to Albania as hardship lesson of market and institutional failure. Since then, fast and systematic recovery took place. Sustained economic growth of 2000s, among other factors, is a merit of integration into international markets. Improvement of trade links and injection of foreign investments into domestic economy fuelled development perspective of Albania.

Albania is an agricultural economy. Agriculture employs more than a half of the population and accounts about a quarter of output (Zahariadis, 2007; EC, 2014). Hence, it has a huge potential to become engine of economic growth and competitiveness in international markets (USAID, 2012). Despite its indisputable potential, agricultural sector in Albania faces significant challenges. Predominant constraints of agriculture include small and fragmented farms (average farm size of 1.2 ha), migration from rural areas, underdeveloped irrigation system, low

labour productivity, and limited technological level (USAID, 2012; EC, 2014). Interest for investment in agricultural sector remains low as well. Additional agricultural constraints are derived from the complex land reform (see Cungu and Swinnen, 1999; Deininger et al., 2012; Qineti et al., 2015). Majority of the small farms in Albania are subsistent and agricultural production serves to home consumption. Empirical studies (i.e. Mc Carthy et al., 2009) suggest that the farm households cultivating staple crops achieve to market only 4 to 8 percent of their production. The rest is used for self-consumption.

Studies utilizing aggregate trade flows in Albania (see Xhepa and Agolli, 2004; Asllani, 2013; Fetahu, 2014; Sejdini and Kraja, 2014) report unexploited trade potential. They suggest that main constraints of Albanian foreign trade rest on the limitations of domestic supply. Trade flows are determined by trade links with neighbouring countries, low transportation costs and cultural links. Moreover, they put emphasis on non-tariff trade barriers such as market access, border procedures, free movement, development and dissemination of information.

Albania has adopted a liberal trade regime since the very beginning of its economic transition. It was among the first steps of transition reforms. The process of trade liberalization has been intensified particularly after the accession of Albania in WTO in the year 2000 (Government of Albania, 2015). Membership in WTO induced deep reforms in legislation and trade policies in compliance with WTO guiding principles. The main objectives of Albania's trade policy are coherent with WTO principles and therefore guarantee the absence of quantitative restrictions on imports and exports, export subsidies, any kind of tax on exports and export bans (WTO, 2016). Further steps of trade liberalization followed Albania's involvement in the regional integration through a network of bilateral Free Trade Agreements (FTAs) with its regional countries. Later on, bulk of bilateral FTAs melted into the creation of Regional Trade Agreement (RTA), known as renewed Central Europe Free Trade Agreement (CEFTA 2006). This RTA incorporated group of countries from Southeast Europe (Albania, Bosnia and Herzegovina, Croatia, Kosovo, Macedonia, Montenegro, Moldova and Serbia) and entered in force in 2007. The map of liberalized trade agreements is further extended with the signature of FTA with Turkey in 2008. In 2008, Albania signed another FTA with European Free Trade Agreement Association (EFTA) countries (Norway, Switzerland, Iceland and Lichtenstein). FTA with EFTA countries entered in force in 2011. Most importantly, since 2009, Albania is implementing the Stabilization and Association Agreement (SAA) with the European Union (EU). Meanwhile the free trade agreement, which is integral part of SAA, is in force since 2006. However, early roots of trade liberalization with the EU date from 1999. Since then, Albania benefited from Autonomous Trade Preferences with the EU, granting duty-free access to EU market for nearly all products from Albania (excluding only wine, sugar, certain beef products and certain fisheries products, which enter the EU under preferential tariff quotas, as negotiated under the SAA). Summing up, Albania's trade is operating in free trade regime with EU, EFTA, Turkey, and its neighbouring CEFTA 2006 countries.

The main objective of this paper is to explain main determinants of agricultural export in Albania. The paper is organized as follows: the next section provides retrospective of previous studies employing gravity model in agricultural trade. The following section describes methodology, estimation strategy as well as variables and data used in empirical estimation. Then we present and discuss results of the estimation in the subsequent section. Lastly we summarize and draw conclusions.

To our knowledge, this paper is first attempt that employs gravity model in determining key aspects of agricultural export in the case of Albania. This study estimates implications of conventional gravity variables including wide range of other factors, such as border effects, cultural links, migration, price instability and exchange rate variability, free trade agreements, quality of institutions, on the potential of agricultural export in Albania.

Retrospective of previous studies

Gravity model has been used in agricultural trade analysis as a baseline model for estimating the effect of a variety of policy issues. Country level analysis utilizing gravity model in agricultural trade analysis are scarce. Thus, Ševela (2002) applied gravity model to explain Czech agricultural export. Except of conventional variables, the study observes effects of import tariff for agricultural products, exchange rate and membership in EU and EFTA. Results of the study are consistent with theoretical framework of the gravity model.

Previous studies analyse many different trade determinants. Studies dealing with the effects of trade liberalization (FTAs, RTAs and Preferential

Trade Agreements) suggest that these instruments serve as an attractive platform to promote agricultural trade. Typically, positive effects of trade liberalization are translated in elimination of trade restrictions and facilitating integration through liberalization of non-tariff barriers. With some exception, majority of the previous studies suggest net trade creating effects (Jayasinghe and Sarker, 2008; Grant and Lambert, 2008; Korinek and Melatos, 2009; Sun and Reed, 2010; Koo et al., 2006). Pishbahar and Huchet-Bourdon (2008) employ extended gravity model to estimate the impact of eleven RTAs on European agricultural imports. Their findings suggest that majority of European Union RTAs supports agricultural exports of developing countries to the EU market. On the other hand, two most important and unilateral (Generalized System of Preference and the agreement with Mexico) have negative effect on agricultural exports.

Studies dealing with effects of immigration links on trade date since the early 1990s. As Gould (1994) stresses out immigrant links have potential to decrease transaction costs resulting from knowledge of home-country markets, language, preferences, and personal contacts (see for example Genc et al., 2012; Head and Ries, 1998; Raulch and Trindade, 2002; Peri and Requena-Silvente, 2010). On the other hand, Parsons (2005) is interested in the effects of the stock of immigrants from the EU expansion countries residing within each EU-15 country. The results indicate that Eastern European immigrants exert a positive influence on both EU-15 imports and exports. It is predicted that a 10% rise in Eastern European immigration will increase EU-15 imports from these countries by 1.4% and EU-15 exports by 1.2%.

Effects of exchange rate volatility are frequently incorporated in analyses of price competitiveness in international markets (for example Maitah et al., 2016) but also in gravity models dealing with agricultural trade. Thus, Cho et al. (2002) employ panel data to estimate gravity models for ten developed country. They found out that real exchange rate uncertainty has had negative effect on agricultural trade. Moreover, the negative impact of uncertainty on agricultural trade has been more significant compared to other sectors. Extension to this study can be found in Kandilov (2008) and studies for specific countries include the work of Fertö and Fogarasi (2011), Sheldon et al. (2013), Kafle and Kennedy (2012), Koo et al. (1994), Frankel and Wei (1998).

Institutional effects on agricultural trade have received a great attention recently. Levchenko (2004) investigates quality of institutions (quality of contract enforcement and property rights). His paper studies consequences of trade when institutional differences are the source of comparative advantage among countries. Findings of the study imply that institutional differences are important determinant of trade flows. Moreover, results of the paper suggest that institutional differences diverge less developed countries to gains from trade. Similarly, Linders et al. (2005) found that institutional distance has a negative effect on bilateral trade, presumably because the transaction costs of trade between partners from dissimilar institutional settings are high. They stress out that institutional quality of both the importer and exporter increases the amount of bilateral trade.

Materials and methods

Gravity model specification

Gravity model has become a workhorse (Eichengreen and Irwin, 1998) in international trade analysis. Bulk of empirical studies rank the gravity model among the most accurate tools in explaining and predicting bilateral trade. Conventional theory of gravity model in international trade emerged in the early 1960s with the pioneering studies of Tinbergen (1962) and Pöyhönen (1963). Later on, empirical works utilizing gravity model were initiated by Linnemann (1966). Since then, evolution of the gravity model and diversity of its application was remarkable. Theoretical framework of the gravity model is borrowed from the gravity law of physics. Isaac Newton's gravity model assumes that attraction between two heavily bodies is proportional to the product of their masses and inversely related to the distance between them (Frankel, 1997). Translated into the international trade theory, gravity model suggests that volume of trade between two countries is proportional to their economic size (national incomes) and inversely related to the distance. Therefore, gravity model predicts that economically rich and geographically close countries trade more together than with third countries (Pokrivčák and Šindlerová, 2011). Main advantages of the gravity model lay on results of empirical work. Linders and De Groot (2006) suggest that gravity model is particularly efficient in explaining a large portion of the variation in bilateral trade.

For the last fifty years, gravity equations have

dominated empirical studies in international trade. In its basic form, the amount of trade between countries is assumed to be increasing in their sizes, as measured by their national incomes, and decreasing in the cost of transportation between them (Cheng and Wall, 2005). Therefore, the basic form of the gravity equation is expressed as follows:

$$T_{ij} = \beta_0 \frac{GDP_i^{\beta_1} GDP_j^{\beta_2}}{DIST_{ij}^{\beta_3}} \quad (1)$$

where T_{ij} is bilateral trade between country i and j; GDP_i (GDP_j) is economic size of country i (j) measured by GDP; $DIST_{ij}$ is bilateral distance between the two countries; β_0 is a constant, β_1, β_2 and β_3 are parameters often estimated in a log-linear reformulation of the model.

For the purpose of this study, we employ modified gravity model used by McCallum (1995). It is adjusted for logarithmic form and allows adding supplementary variables:

$$\ln X_{ij} = \beta_0 + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j + \beta_3 \ln DIST_{ij} + \beta_4 \delta ij + \varepsilon_{ij} \quad (2)$$

where X_{ij} is trade flow from country i to country j (in our case export), GDP_i and GDP_j is GDP of the country i and country j, $DIST_{ij}$ is distance between country i and j, δ_{ij} is dummy variable for the other factors influencing trade flows, and ε_{ij} is error term.

We adopted the above equation to fit it to the gravity model for agricultural exports in Albania. Further we adjusted the basic form of the gravity model equation (baseline model is called Model 1 in the Results section) for agricultural exports of Albania as follows:

$$\ln X_{ij} = \beta_0 + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j + \beta_3 \ln GDPpc_i + \beta_4 \ln POP_j + \beta_5 \ln POP_i + \beta_5 \ln DIST_{ij} + \varepsilon_{ij} \quad (3)$$

where X_{ij} is the value of agricultural exports from country i (Albania) to country j (importer). GDP_i and GDP_j stand for real GDP of country i and j, and measure economic size of the two economies. POP_i and POP_j are market size variables indicating population of the country i and j. $DIST_{ij}$ represents distance between country i and j. ε_{ij} is a stochastic disturbance term that is assumed to be well-behaved.

In order to estimate key determinants of agricultural export, we follow a stepwise procedure. First, we estimate the baseline gravity model to determine the coefficients of Albania's agricultural export flows (hereinafter Model 1). Subsequently, we augment the baseline model with dummy variables controlling for the income effects (Model 2), effects of adjacency, linguistic similarities and cultural links (Model 3), effects Albanian Diaspora (Model 4), effects of bilateral exchange rate and price stability of the importing country (Model 5), effects of trade liberalization with CEFTA, EU, EFTA and Turkey (Model 6), and institutional effects (Model 7). Finally, we estimate pooled effects of all variables included in the model (Model 8). For this purpose, the baseline model is modified with supplementary variables, as follows:

$$\begin{aligned}\ln X_{ij} = {} & \beta_0 + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j + \beta_3 \ln POP_i \\ & + \beta_4 \ln POP_j + \beta_5 \ln DIST_{ij} + \beta_6 GDPpc_{ij} \\ & + \beta_7 ADJ_{ij} + \beta_8 LAND_j + \beta_9 LANG_{ij} \\ & + \beta_{10} COL_{ij} + \beta_{11} \ln DIA_{ij} + \beta_{12} \ln EXR_{ij} \\ & + \beta_{13} INF_j + \beta_{14} CEFTA_{ij} + \beta_{15} SAAeu_{ij} \\ & + \beta_{16} EFTA_{ij} + \beta_{17} FTAtur_{ij} + \beta_{18} INSTdist_{ij} \\ & + \varepsilon_{ij} \quad (4)\end{aligned}$$

where $GDPpc_{ij}$ is income effect variable indicating income differential between Albania and importer. The next two variables determine transportation costs. ADJ_{ij} is a dummy indicating if country i and j share common land border. $LAND_j$ dummy shows whether importing country j is landlocked. Variables aiming to capture cultural and historical similarities, respectively transaction and information costs follow. $LANG_{ij}$ shows whether country i and j has a common primary language. COL_{ij} indicates whether importer was Albania's colonizer. DIA_{ij} is stock of Albanian Diaspora in partner countries. EXR_{ij} is real exchange rate variable measured by the units of the importing country's home currency per Albanian Lek (ALL) and INF_j represents inflation rate (annual CPI rate) in the importing country. $CEFTA_{ij}$, $SAAeu_{ij}$, $EFTA_{ij}$ and $FTAtur_{ij}$ stands for free trade agreements with CEFTA, European Union, EFTA and Turkey. $INSTdist_{ij}$ shows bilateral institutional distance between Albania and import partner (see Linders et al., 2005).

Model variables

The dependent variable used in this study is the volume of Albanian agricultural exports to its partner countries. In this paper, we utilize conventional income variables explaining bilateral trade flows. Exporter's GDP (Albania) explains country's productive potential, while GDP of importing partner reflects absorbing potential, respectively purchasing power (see Koo et al., 1994). Theoretical framework of the gravity model predicts positive relationship to trade for both variables. Population is another

conventional variable injected in the model with the aim to explain relationship between market size and Albanian agricultural export flows. There is no a priori relationship between exports and the populations of either the exporting or importing country (Martinez-Zarzoso and Nowak-Lehmann, 2003; Armstrong, 2007). An estimated coefficient of population of the exporter may have negative or positive sign depending on whether the country exports less when it is big (absorption capacity) or whether a big country exports more compared to a small country (economies of scale).

In order to investigate effects of transportation costs we embrace the variable of geographical distance between the capital city of Albania (Tirana) and capitals of importing countries. Increasing distance between trading partners proxies higher transport costs and decreases Albanian export flows. Therefore, gravity model predicts negative coefficient for this variable. Similarly, trade with landlocked countries involves higher trade costs, therefore negative coefficient is expected. On the other hand, lower transport and transaction costs are associated with neighbouring countries. Hence, we expect positive coefficient for the variable explaining exports with countries that share common border with Albania (see Anderson and Van Wincoop, 2001; Jansen and Piermartini, 2009).

Further, gravity equation is augmented with dummy variables predicting effects of cultural and historical similarities between Albania and importing countries. Here we impose dummy variables explaining whether Albania's trade partners were a former Albania's colonizer or if they share common primary language. These variables have been frequently used in the literature aiming to capture information costs. In particular, our interest is extended to the effects of Albanian migrants living in importing countries. Literature suggests that migrant ties can stimulate exports by lowering transaction costs and bringing their preferences for goods produced in home country. Hence, Albanian migrants might lower information and transaction costs through knowledge of home-country markets, language, business contracts etc. Therefore, empirical studies suggest that larger migrant stocks are associated with higher trade flows (see Gould, 1994; Bryant et al., 2004; Parsons, 2005).

The effects of trade liberalization are observed by incorporating dummy variables controlling for the impact of RTA with CEFTA 2006 countries (in force since 2007), SAA with EU (in force since 2009), FTA with EFTA (in force since 2011) and FTA with Turkey (in force since 2008).

Effects of exchange rate are frequently incorporated in gravity models dealing with agricultural trade (see Koo et al., 1994; Frankel and Wei, 1998; Hatab et al., 2010). In our case, annual exchange rate is determined by the Albania's currency units (ALL/Albanian Lek) per one unit of the importing country currency. We expect that an increase in exchange rate would devaluate Albanian currency, hence exports would be cheaper. In such a case, devaluation of the domestic currency should increase Albanian agricultural export. Therefore, as the result we expect a coefficient with positive sign. Another factor influencing trade flows is price stability. In order to capture effects of price stability here, we incorporate in the model inflation rate (annual CPI rate) of the importing partner. Therefore, we expect a negative sign for the coefficient of inflation.

There is common agreement that institutional quality has substantially positive impact on bilateral trade flows (De Groot et al., 2004) and reducing the level of uncertainty (Jansen and Nordås, 2004). Therefore, if trade is supported by an effective rule of law, and if government regulation is transparent, countries engage in more trade (Linders et al., 2005). Following De Groot et al. (2004) we measure effects of bilateral institutional distance between Albania and its trading partners. Institutional distance between country pairs is measured as follows:

$$INSTdist_{ij} = \frac{1}{6}\sum_{k-i}^{6}(I_{ki} - I_{kj})^2 / V_k \qquad (5)$$

INSTdist is institutional distance, I_{ki} indicates country i score on World Governance Indicator's k^{th} dimension and V_k is variance of this dimension across all countries.

In the last stage this paper, we estimate Albanian export potential by comparing actual and predicted export flows with individual trading partners.

Gravity model estimation technique

The choice of gravity equation estimator has been frequently debated among the scholars dealing with performance of the gravity model. Prevalence of heteroskedasticity and zero bilateral trade flows in the standard empirical methods were the focus of criticism (see Helpman et al., 2008; Westerlund and Wilhelmsson, 2009; Silva and Tenreyro, 2006). Hence, Silva and Tenreyro (2006) argue that

standard empirical methods employed in estimating gravity equations are inconsistent and lead to biased results. They suggest that the use of standard log-linear estimator suffers from the presence of heteroscedasticity, which in turn might yield biased estimates of the true elasticities. On the other hand, various approaches have been employed in dealing with zero flows. Some authors suggest dropping the zero flows from sample (Linneman, 1966) or adding a constant to all trade flows to estimate log-linear equation (Rose, 2004).

Despite controversies and existence of wide range of estimation techniques such as Heckman model (Gomez-Herrera, 2013), FGLS (Martinez-Zarzoso, 2013), Helpman model (Helpman et al., 2008), Tobit model (Martin and Pham, 2008) etc. previous studies reveal that it is difficult to advocate a sole estimation technique as the best-performing. Choice of the method should be based on both economic and econometric considerations (Linders and De Groot, 2006) including robust specification checks and tests (Martinez-Zarzoso, 2013). For the purpose of this study, we adopted econometric approach using the Poisson Pseudo-Maximum Likelihood (PPML) estimator model, as proposed by Silva and Tenreyro (2006, 2011). PPML provides a natural way to deal with zero values and is robust to different patterns of heteroskedasticity. Even the critical voices (Martin and Pham, 2008) of PPML estimator suggest that in the case of small fraction of zero values, the PPML estimator model is the best performing method for the gravity model estimation. In this study the share of zero values is relatively low (18.6 percent), which indicates that the use of PPML estimator is appropriate.

Data

Panel data used in this study comprises Albanian agricultural exports to 46 import partners, including countries from EU-28, CEFTA 2006, EFTA and BRICS, as well as USA, Japan and Turkey. Data utilized in this study cover the period 1996-2013. Trade flows observed here cover 92% of Albanian agricultural exports for the given period. Data on agricultural export flows were obtained from the UNCTAD, disaggregated according to Standard International Trade Classification (SITC, rev. 3). Data on real Gross Domestic Product (GDP), population, exchange rate and inflation were acquired from the same source. Data on distance between capital cities, together with dummies on cultural and historical links such as adjacency (sharing common land border), common primary language and Albania's former colonizer were obtained from the CEPII (Centre d'Etudes Prospectives et d'Informations Internationales) database. Data on common RTAs with trading partners were utilized from the WTO (World Trade Organization). Lastly, data for institutional distance were obtained from the World Governance Indicators (WGI) database (Kaufmann et al., 2010). Data on the stock of Albanian Diaspora residing in the importing countries were obtained from the World Bank migration database. Missing data for the given time period in the case of institutional variables and stock of Albanian migrants were interpolated. Definition of variables, expected coefficient signs and basic statistics of the employed variables are summarized in Appendix Table 1. Correlation matrix presented in the Appendix Table 2 suggests that the issues related to multicollinearity are not present in the dataset. Data processing and empirical estimations were conducted on Stata 12.

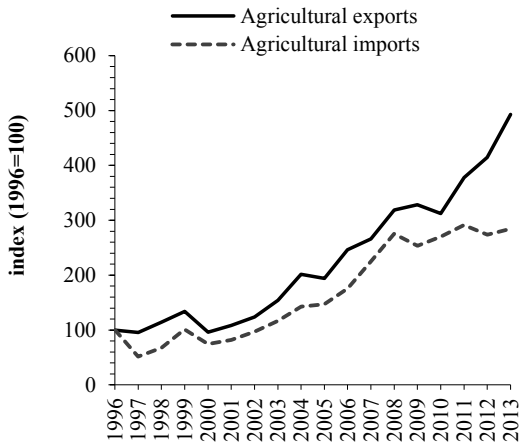
Results and discussion

Agricultural trade in Albania

Albania is endowed with natural resources, such as fertile land, and suitable climatic conditions for agricultural production. Abundance of natural resources combined with low labour costs provides good grounds for intensification of labour intensive agricultural activities. Moreover, geographical layout, proximity to the EU market, and access to sea transport, make export potential viable in terms of low transport costs. Therefore, agriculture fulfils preconditions to excel Albanian export and shrink the actual sharp trade deficit. Despite its great potential, Albania remains a country with low agricultural exports and high dependency on imports. Since the early period of transition, agricultural exports marked a significant growth. Between the period 1996 and 2013, volume of agricultural exports increased from 32.4 million USD to 171.3 million USD. Data on Albanian agricultural trade (Figure 1) reveals that since 1996 agricultural exports marked over a five-fold increase, while imports rose at slower pace (3 times). Despite such impressive growth, data from 2013 suggest that agricultural exports/ import coverage rate is only 20%, meaning that import to export ratio is as high as 5:1 (Figure 2).

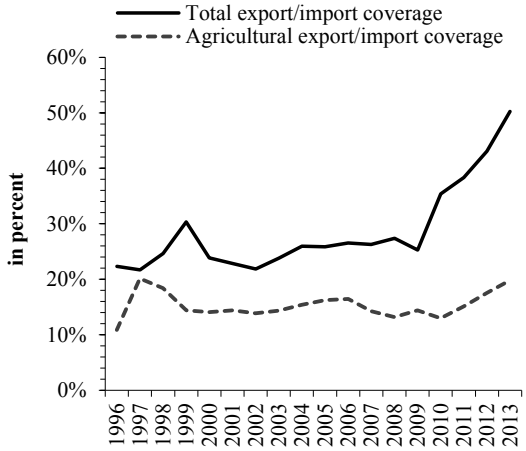
Destination of Albanian agricultural export

European Union is the main economic and trade partner for Albania since the beginning of transition process. Among others, strong trade linkages are



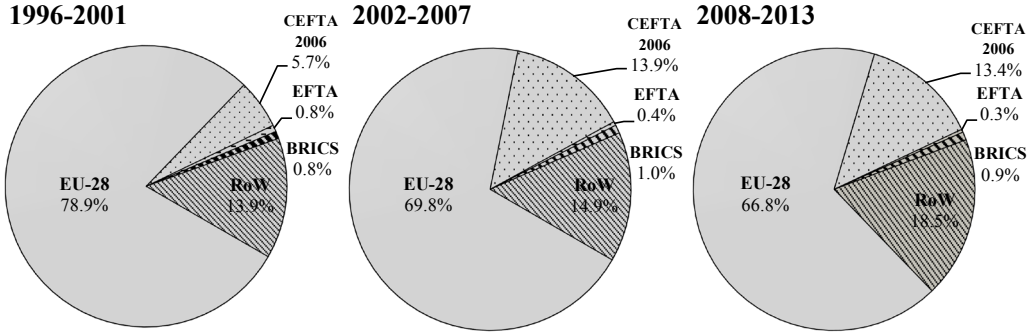
Source: UNCTAD, own elaboration

Figure 1: Growth of Albanian agricultural trade.



Source: UNCTAD, own elaboration

Figure 2: Agricult. import/export coverage.



Source: UNCTAD, own elaboration

Figure 3: Agricultural exports, by trading blocs (in percentage).

reflected in the case of Albanian agricultural export destination. The share of agricultural exports to EU-28 constitutes two thirds (66.8%) of total agricultural exports for the period 2008-2013 (Figure 3). A slight decline in the share of agricultural exports to EU is directly affected by the global crisis of 2008-2009. According to ACCIT (2013) the crisis in Italy and Greece and drastic decline of domestic demand in both neighbouring countries had a direct impact in the slowdown of Albanian exports. Moreover, our estimations confirm that this is particularly true in the case of agricultural exports. Before the crisis (2007) share of agricultural exports to Italy was 40.0% while in 2013 it dropped at 35.1%. Similar outcome took place with agricultural exports to Greece, a fall from 10.5% in 2007 to 8.7% in 2013.

On the other hand, trade links with the majority of CEFTA 2006 countries have been well established even before the free trade agreement entered in force. Share of agricultural exports to the group of neighbouring SEE (South Eastern Europe) countries is 13.4%. Despite significant increase since 1996-2001, the share of agricultural exports to CEFTA 2006 countries remained relatively constant. In addition, EC (2015) suggest that Albanian export potential to these group countries remains unexploited. Establishment of the CEFTA 2006 has particular merits in lowering technical barriers, but remains behind in releasing administrative barriers such as customs procedures, as well as dealing with barriers in the area of sanitary and phytosanitary measures. EFTA is inferior agricultural export partner to Albania. Total share of agricultural exports to EFTA countries is incremental, accounting for 0.3% of total agricultural exports. Unattractiveness of Albanian agricultural exports to this group of economies reflects high transport costs due to the large distance between EFTA members and Albania. Similarly to the trade pattern with EFTA, agricultural trade with informal trading block of BRICS countries (Brazil, Russia, India, China and South Africa)

is very low. Total agricultural exports to BRICS during the period 1996-2013 were statistically insignificant (less than 1%) or 13.7 million USD.

Empirical results

Baseline model estimations reported in the Table 1 (Model 1) reveal that obtained results are persistent with theoretical framework. The coefficients of importer's economic size (GDP) and market size (POP) are positive and statistically significant. Importer's economic size is positive and significant in all estimated models, while the significance of the importer's market size varies over the estimated models. Results suggest that Albanian agricultural export will increase proportionally with an increase of importer's economic size. On the other hand, Albania's economic size is found to be positive but statistically insignificant, whilst the domestic market size has a robust significant negative coefficient. Ceteris paribus, increase in Albanian population enables domestic market to absorb a greater portion of agricultural production and reduces surpluses dedicated for export. This outcome is particularly relevant in the low income countries where agricultural and food commodities are perceived as normal goods. As expected, our results illustrate that distance has negative impact on agricultural exports in all estimated models. Such an outcome is typical for conventional gravity model analysis, since the distance is expected to affect export flows negatively. Increasing geographical distance between the capital city of Albania (Tirana) and capitals of importing countries proxies higher transport costs and decreases therefore agricultural export flows.

In addition to the traditional variables, we adjust the baseline model with the variable of bilateral income differential aiming to test for the relative strength of the Linder hypothesis vis-à-vis the Heckscher-Ohlin (HO) hypothesis. Yielded result (Model 2) implies that estimated coefficient of this variable is negative, but statistically insignificant. However, the estimates of the pooled model (Model 8) find the variable statistically significant at 5 percent. Such result implies that income disparities tend to decrease agricultural export flows, emphasizing income convergence as relevant factor in promoting export. Therefore, findings of this study support the Linder hypothesis in the case of Albania.

Results of the model augmented with effects of adjacency (sharing common border), linguistic similarities and colonial links (Model 3) confirm the common validity with theoretical foundations of the gravity model. Positive and significant coefficients obtained for these variables depict that Albanian agricultural export is strongly influenced by the transportation and transaction costs. Indeed, results predict higher agricultural export flow with countries that share common border with Albania. Similarly, common primary language and colonial links with the importing country tend to foster agricultural export flows. On the other hand, effect of landlocked importing country, despite the expected negative coefficient sign, is found statistically insignificant.

Once we extended the baseline model with the effects of Diaspora (Model 4), results revealed a strong impact of the Albanian immigrants residing in the importing country. Presence of a larger Albanian immigrant stock in the importing countries is associated with lower transaction and information costs and higher agricultural export flows. Moreover, relevance of the Albanian Diaspora, as it can be seen in the pooled model estimates (Model 8), prevails on its significance over the transaction costs (adjacency) and linguistic similarities (common language). Therefore, any trade enhancing policy aiming to promote agricultural export in the case of Albania should perceive Diaspora as irreplaceable platform for export promotion and growth.

Results of the effects of the bilateral exchange rate and price stability in the importing country are presented in Model 5. As expected, exchange rate has a significant positive coefficient, indicating that depreciation in Albanian Lek (ALL) against the currencies of importing partners facilitates agricultural exports. By contrary, coefficient of price stability (inflation) is found statistically insignificant, despite the expected negative coefficient sign.

Findings of this study yield relatively ambiguous results related to the effects of trade liberalization (Model 6). Results show that RTA with CEFTA 2006 countries had positive and significant impact on agricultural export creation, while export diversion effects prevail from the FTA with EFTA members. Accordingly, results induce negative coefficients for SAA with EU and FTA with Turkey, but statistically insignificant. This outcome should be interpreted with cautions, for at least two particular reasons. Firstly, impact of the free trade agreements in agriculture tends to produce delayed effects because

AGR_exp	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
ln_GDP_imp	0.855***	0.927***	1.011***	0.367***	0.579***	0.967***	1.134***	0.781***
	-0.058	-0.087	-0.07	-0.066	-0.102	-0.069	-0.1	-0.135
ln_GDP_exp	0.135	0.15	0.068***	0.045	0.303**	-0.005	-0.292	-0.471***
	-0.14	-0.137	-0.134	-0.113	-0.144	-0.176	-0.182	-0.166
ln_POP_imp	0.303***	0.209**	0.337***	0.464***	0.554***	0.228***	-0.129	0.037
	-0.059	-0.094	-0.064	-0.069	-0.091	-0.072	-0.118	-0.116
ln_POP_exp	-5.595**	-5.597**	-5.476**	-8.953***	-4.993**	-9.579**	-5.784***	-14.680***
	-2.345	-2.334	-2.456	-1.883	-2.284	-4.801	-2.197	-2.915
ln_DIST	-2.462***	-2.426***	-2.293***	-1.330***	-2.371***	-2.434***	-2.135***	-1.146***
	-0.1	-0.097	-0.107	-0.097	-0.108	-0.095	-0.135	-0.113
GDPpc_dist		-0.047						-0.065**
		-0.029						-0.032
ADJ			1.098***					0.016
			-0.152					-0.202
LANG			0.933**					-0.640**
			-0.363					-0.251
LAND			-0.043					0.766***
			-0.196					-0.21
COL			0.394***					0.764***
			-0.135					-0.175
ln_DIA				0.303***				0.275***
				-0.022				-0.034
ln_EXR					0.276***			0.144***
					-0.072			-0.052
INF					-0.009			-0.014***
					-0.006			-0.005
CEFTA						0.561*		0.688**
						-0.311		-0.272
SAA_eu						-0.291		-0.396***
						-0.206		-0.139
FTA_efta						-1.875***		-1.105**
						-0.37		-0.454
FTA_tur						-0.005		-0.671***
						-0.224		-0.218
INST_dist							-0.152***	-0.146***
							-0.037	-0.027
cons	47.137**	46.869**	42.975**	68.938***	40.106**	79.437**	51.457***	117.275***
	-19.777	-19.641	-20.504	-15.83	-19.218	-39.713	-18.65	-24.271
R2	0.884	0.886	0.877	0.933	0.889	0.878	0.891	0.949
Observations	792	792	792	747	792	792	783	738

Source: Own elaboration
Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 1: PPML regression results of the gravity model: Agricultural export of Albania.

of the asymmetric nature of FTAs. Actually, this outcome is persistent with previous studies indicating that it may take a several years or even longer until actual export creation effects in agriculture occur. And secondly, it might signal weak competitiveness of the Albanian farmers and their inferior position towards heavily subsidized farmers of the importing countries.

The effects of institutional environment in agricultural export are observed in Model 7. Results of the baseline model extended

with bilateral institutional distance derive significant negative coefficient indicating that costs of agricultural export increase with institutional distance. Performance of Albanian agricultural export diminishes with higher institutional quality disparities between trading partners. Indeed, institutional heterogeneity induces higher transaction costs and restrictive effects on Albanian agricultural export. Therefore, the greater is the institutional quality gap with the importing country the lower are Albanian agricultural export flows.

Potential of agricultural export

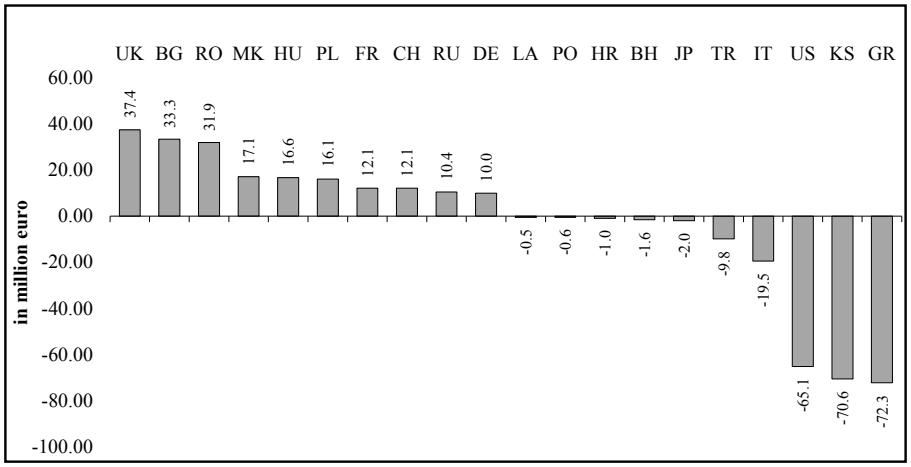
In the last section of this study we estimate Albania's export potential by comparing actual agricultural exports with predicted exports. Results presented in this section show the absolute difference between the actual and predicted level of agricultural export (A – P). A positive value implies the possibility of agricultural export expansion while a negative value indicates that Albania has exceeded its export potential with a trading partner. For the sake of simplicity, results of the export potential are presented in the aggregate format for the period 1996-2013.

As it is revealed in the Figure 4, Albania overexploits its agricultural export potential with its traditional EU neighbouring markets (Greece and Italy), culturally proximate trade partners (Kosovo, Turkey, Croatia, Bosnia and Herzegovina) as well as geographically distant countries (USA and Japan). On the other hand, Albania has unused agricultural export potential particularly with the Central and Eastern European Countries (CEECs) such as Bulgaria, Romania, Hungary and Poland. With this group of new EU member countries, Albania has institutional similarities and comparatively lower transport and transaction costs. Therefore, market access into these markets is significantly easier compared to the EU developed countries. Additional advantage to the market expansion in such markets is related to similarities in consumer preferences and the common status of transitional economies, such as it is the case of Albania.

On the other hand, results of this study identify untapped export potential of the Albanian agricultural exports in the group of developed European countries. This is particularly true for the Western European markets such as UK, France, Switzerland and Germany. As it is noted from the results of previous section (particularly in the case of Italy and Greece) primary advantage to market expansion in this group of countries is large presence of Albanian Diaspora. Migrant links, among other factors, might serve as a solid platform for intensification towards these export markets. On the other hand, the main barriers in exploiting export potential in these countries are related to higher transport and transaction costs, institutional dissimilarities and higher quality standards.

Discussion and remarks

Our gravity analysis for Albanian agricultural export leads to comparable results as models for other countries. For example, a study of determinants of Turkish agricultural exports to the European Union (Erdem and Nazlioglu, 2008) found that Turkish agricultural exports to the EU are positively correlated with the size of the economy, the importer population, the Turkish population living in the EU countries, the non-Mediterranean climatic environment, and the membership



Source: UNCTAD, own elaboration

Figure 4: Potential agricultural export 1996-2013 (actual export - predicted export).

to the EU-Turkey Customs Union Agreement while they are negatively correlated with agricultural arable land of the EU countries and geographical distance between Turkey and the EU countries. Results from Albania also confirm importance of traditional gravity variables and importance of exporter's Diaspora for export of agricultural products.

Transformation of the agricultural sector is a very sensitive aspect. In many Central and Eastern European Countries it was connected to the transition process and later also with adoption of common EU rules. Experience from Central and Eastern European Countries (see Svatos and Smutka, 2010; Svatos et al., 2010) revealed, that the process of EU accession reflected positively in results of agricultural trade. Moreover, EU accession resulted in agricultural export concentration in the common internal market (Svatos and Smutka, 2010). On the other side, trade creating effect of RTAs was confirmed by Korinek and Melatos (2009). Their gravity model for members of three regional trade agreements suggests that the creation of AFTA (ASEAN Free Trade Agreement), COMESA (Common Market for Eastern and Southern Africa) and MERCOSUR (Southern Cone Common Market) has increased trade in agricultural products between the RTAs countries. They also found that in some cases, lack of transport and communications infrastructure, in addition to supply constraints, lessens the effect of the RTAs on trade flows. Besides RTAs, preferential trade policies can also help to support international trade (Cipollina et al., 2010). Most developing countries can export to the European Union and the United States with preferential market access. The results show (Cipollina et al., 2010) that preferential schemes have a significant impact on trade in terms of margins and intensity, and such effect seems to be stronger in the case of EU preferences, although with significant differences across products. In the case of Albania not all RTAs and FTAs have the same effect on agricultural trade, in our study export creating affect was confirmed for RTA with CEFTA 2006 countries and export diversion effect for FTA with EFTA countries.

According to gravity model for Egypt's agricultural exports (Hatab et al., 2010) 1% increase in Egypt's GDP generates more than 5% increase in its agricultural export flows. In contrast, the increase in Egypt's GDP per capita causes exports to decrease, similarly as in our model. Authors argue on such outcome emphasizing that economic growth increases per capita demand for all normal goods. Moreover, the exchange volatility has positive coefficient (depreciation in Egyptian Pound stimulates agricultural exports) and transportation costs have a negative influence on Egyptian agricultural exports. The same outcome of exchange rate volatility can be observed in the case of Hungarian agricultural exports (Fogarasi, 2011). Other variables, such as population and income (GDP) of export destination countries have positive sign, while distance from Hungary has a negative one.

Effects of the institutional determinants in agricultural trade were investigated by Bojnec and Fertö (2015). They focus on effects of quality of institutions and similarity of institutions in explaining variation in bilateral agricultural and food exports among OECD countries. Study finds out that good quality of institutions reduces the effects of distance. Factors influencing bilateral trade among the Western Balkan countries were identified in the work of Trivic and Klimczak (2015). They considered geographical, economic or political determinants as well as factors constituting cultural, communicational and historical proximity between countries. Their results differ from traditional results gained from gravity analysis in the way that the strongest influence on trade values were exhibited by variables representing ease of a direct communication and similarity of religious structures. In addition, war and one-year-post-war effect showed a strong and statistically important influence. The authors therefore conclude that non-economic factors in the region of the Western Balkans play the most important role in determining trade values between countries. Our analysis for the case of Albania confirms these results to the extent that Albanian immigrants in importing countries represent a significant factor for export growth, even if the countries are geographical neighbours or have similar language. Furthermore our results indicate that more similar institutional environment of the trade partner to Albanian one has positive effect on its agricultural export.

Conclusion

The paper employs gravity model approach to analyse main determinants of agricultural export in Albania. The study utilizes econometric approach using Poisson Pseudo-Maximum Likelihood (PPML) estimation for Albanian agricultural export flows with major trading partners for the period 1996-2013. Main results of the baseline model

suggest that agricultural export flow increase with increasing economic size (GDP), revealing higher impact of importer's absorbing potential comparatively to Albania's productive potential. On the other hand, increase of Albanian market size (population) has diminishing effects on agricultural export flows. Ceteris paribus, growth in domestic demand, resulting from population growth, leads to reduction of agricultural export. As expected, findings of this study suggest that increasing distance between trading partners is associated with reduction of Albanian agricultural export.

Albanian agricultural export is highly concentrated in a limited number of importing partners, respectively in neighbouring countries (such as Italy and Greece). It indicates that geographical proximity, low transport and transaction costs are key drivers of agricultural export. Such an outcome is supported by the results of the augmented gravity model conducted in this study. Namely, results reveal that higher agricultural export flows are associated with neighbouring countries sharing common border. Moreover, stronger linguistic similarities and cultural links with importing partners (such as Kosovo and Macedonia) tend to accelerate Albanian agricultural export. Influence of Albanian Diaspora residing in the importing partner countries is found to have robust effect on the promotion of agricultural export. Interestingly, findings of this study suggest that effects of Diaspora prevail on their importance over the transport and transaction costs.

On the other hand, devaluation of the Albanian currency has significantly positive impact on Albanian agricultural export flow, prevailing on its relevance over the price stability (inflation) in the importing countries. Concerning the effects of trade liberalization on the performance of agricultural export, our findings depict that RTA with CEFTA 2006 countries had trade creating, while FTA and EFTA trade diverse effect. Effects of SAA with EU and FTA with Turkey are found statistically insignificant. Actually, these findings should be perceived with caution due to asymmetric nature and short time lap since these trade agreements entered into force.

Lastly, bilateral institutional distance tends to diminish Albanian agricultural exports. Therefore, institutional convergence with the EU standards, based on the principles of well functioning market economy, would influence the extension of Albanian exports in those European markets (in which breakthrough of Albanian agricultural exports is limited due to institutional barriers). Moreover, improvement of institutional quality would have influence on interim institutional stability for domestic farmers, including better credit access, fight against corruption and sustainable political stability.

Findings of this study are important for trade and agricultural policy makers. From the trade policy perspective, one should assume that the platform of agricultural export promotion should aim market diversification in those countries (other than neighbouring countries) in which Albanian farmers can exploit their comparative advantage. Indeed, Albania is a small and open economy operating in the liberalized trade regime therefore any trade restrictive efforts might produce negative effects. On the other hand, from the agricultural policy perspective, special attention should be paid to measures that lead to improvement of the competitiveness of local farmers. Public investments in the rural infrastructure and irrigation system should be accompanied with direct farmer support. Notably, Albania has huge potential to become competitive actor in international markets if supportive measures are directed in increasing productivity of labour intensive agricultural sectors, such as fruits, vegetables, medical plants and fishery. Further specialisation in these sectors is supported by the present factor market endowments, natural resources and climate conditions in Albania.

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Appendix

Variable	Code	Definition	Source	Period	Expected sign	Summary statistics				
						Obs.	Mean	STD.	Min	Max
Agricultural export	AGR_exp	Agricultural exports of Albania (in million USD)	UNCTAD	1996-2013		792	1.628	5.435	0.000	60.215
GDP importer	ln_GDP_imp	Log of real GDP of importing country (in million USD)	UNCTAD	1996-2013	+	792	11.89	2.096	7.066	16.641
GDP exporter	ln_GDP_exp	Log of real GDP of Albania (in million USD)	UNCTAD	1996-2013	+	792	8.804	0.598	7.743	9.465
Population importer	ln_POP_imp	Log of population of importing country (in thousands)	UNCTAD	1996-2013	+/–	792	9.365	1.942	5.599	14.125
Population exporter	ln_POP_exp	Log of population of exporting country (in thousands)	UNCTAD	1996-2013	+/–	792	8.016	0.031	7.966	8.047
Distance	ln_DIST	Log of Distance between capitals of Albania and importer	CEPII	1996-2013	–	792	7.233	0.962	5.050	9.159
GDP pc distance	GDPpc_dist	GDP per capita distance between Albania and importer	UNCTAD	1996-2014	+/–	792	1.869	3.554	0.000	27.698
Adjacency	ADJ	= 1 if Albania and importer share common border	CEPII	1996-2013	+	792	0.068	0.252	0.000	1.000
Language	LANG	= 1 if Albania and importer share common language	CEPII	1996-2014	+	792	0.034	0.182	0.000	1.000
Landlocked	LAND	= 1 if importer is landlocked, dummy	CEPII	1996-2015	–	792	0.182	0.386	0.000	1.000
Colony	COL	= 1 if importer was Albania's colonizer, dummy	CEPII	1996-2016	+	792	0.023	0.149	0.000	1.000
Albanian Diaspora	ln_DIA	Log of Albanian migrant stock in importing country	World Bank	1996-2016	+	747	5.904	2.934	0.000	13.425
Exchange rate	ln_EXR	Log of exchange rate between ALL/currency of importer	UNCTAD	1996-2013	+	792	3.665	1.661	-0.76	7.157
Inflation	INF	Inflation rate of the importer (CPI annual rate)	UNCTAD	1996-2013	–	792	7.086	39.37	-4.48	1058.3
CEFTA 2006	CEFTA	= 1 if RTA with CEFTA 2006 countries, in force	WTO	Since 2007	+	792	0.061	0.239	0.000	1.000
SAA with EU	SAA_eu	= 1 if SAA with EU, in force	WTO	Since 2009	+	792	0.172	0.377	0.000	1.000
EFTA	FTA_efta	= 1 if FTA with EFTA countries, in force	WTO	Since 2011	+	792	0.011	0.106	0.000	1.000
FTA Turkey	FTA_tur	= 1 if FTA with Turkey, in force	WTO	Since 2012	+	792	0.008	0.087	0.000	1.000
Institutional distance	INST_dist	Institutional distance between Albania and importer	WGI	1996-2016	+/–	783	3.662	3.228	0.000	11.938

Note: RTA (Regional Trade Agreement). FTA (Free Trade Agreement), SAA (Stabilization and Association Agreement), ALL (Albanian Lek), CPI (Consumer Price Index)
Source: Own elaboration

Appendix Table 1: Definition, expected sing and basic statistics of the model variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
(1) AGR_exp	**1.000**																		
(2) ln_GDP_imp	0.259	**1.000**																	
(3) ln_GDP_exp	0.128	0.171	**1.000**																
(4) ln_POP_imp	0.182	0.825	-0.009	**1.000**															
(5) ln_POP_exp	-0.137	-0.151	-0.827	0.008	**1.000**														
(6) ln_DIST	-0.171	0.563	-0.041	0.473	0.037	**1.000**													
(7) GDPpc_diff	-0.008	0.177	0.252	-0.182	-0.235	0.165	**1.000**												
(8) ADJ	0.130	-0.249	0.040	-0.169	-0.037	-0.475	-0.118	**1.000**											
(9) LANG	0.003	-0.258	-0.004	-0.141	0.003	-0.375	-0.087	0.621	**1.000**										
(10) LAND	-0.079	-0.197	0.018	-0.224	-0.017	-0.344	0.187	0.143	0.334	**1.000**									
(11) COL	0.038	0.075	-0.004	0.144	0.003	-0.038	-0.085	-0.040	-0.025	-0.075	**1.000**								
(12) ln_DIA	0.527	0.315	0.119	0.164	-0.088	-0.376	0.114	0.450	0.212	0.067	0.108	**1.000**							
(13) ln_EXR	0.154	0.010	-0.083	-0.148	0.046	-0.147	0.090	-0.065	-0.271	-0.250	0.108	0.233	**1.000**						
(14) INF	-0.024	-0.074	-0.117	0.023	0.059	-0.081	-0.061	-0.022	-0.016	-0.032	0.099	-0.013	0.028	**1.000**					
(15) CEFTA	0.006	-0.246	0.222	-0.162	-0.249	-0.386	-0.118	0.322	0.259	0.130	-0.035	0.104	-0.142	-0.012	**1.000**				
(16) SAA_eu	0.135	0.068	0.495	-0.090	-0.683	-0.072	0.131	-0.048	-0.075	0.001	-0.075	0.073	0.159	-0.052	-0.105	**1.000**			
(17) EFTA	-0.029	0.054	0.120	-0.040	-0.175	0.033	0.368	-0.028	-0.018	0.043	-0.018	0.035	0.033	-0.016	-0.024	0.043	**1.000**		
(18) FTA_Tur	0.051	0.068	0.095	0.086	-0.118	-0.022	-0.048	-0.023	-0.014	-0.043	0.573	0.075	0.023	0.003	-0.020	-0.043	-0.010	**1.000**	
(19) INST_dist	-0.126	0.176	-0.311	-0.234	0.280	0.276	0.431	-0.233	-0.190	0.048	-0.183	0.022	0.210	-0.105	-0.254	-0.104	0.076	-0.108	**1.000**

Source: Own elaboration

Appendix Table 2: Correlation matrix.

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Trade Dynamics in the Italian Floriculture Sector within EU Borders: A Gravity Model Analysis

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Abstract

Despite its economic magnitude worldwide, the scientific attention to the floriculture sector remains scarce within the borders of the European Union. Focusing on Italy, the aim of this paper is to provide an insight into the floriculture trade for the first time. More specifically, in addition to describing trade dynamics of the floriculture sector both in Italy and in the European Union in recent years, this paper applies a gravity model to investigate and evaluate the role of some major economic and geographical variables as determinants of Italian trade flows of cut flowers and live plants within the European Union, from 2001 to 2013. Among these, findings prove that the most important are the GDP per capita of the European trade partners, as well as their production and consumption volumes.

Keywords

Floriculture sector, Italian trade, gravity model, panel data, Europe.

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Introduction

Flowers are goods with a recognized social value, enhancing life quality and influencing human feelings and their increased use makes the marketing of flowers a lucrative business (Belwal and Chala, 2008). Nevertheless, there is a generalized lack of both data (mostly related to trade) and scientific contributions in the literature on this specific sector. The floriculture sector can be defined as a segment of horticulture concerned with production, marketing and sale of a wide variety of plants and planting materials (Getu, 2009) that can be divided into cut flowers, foliage, plants and bulbs (Gebreeyesus, 2015; Van Rijswick, 2015).

The European Union (EU-28) represents both the largest producer and consumer of cut flowers and live plants worldwide (ITC, 2016) and Italy plays a quite important role in this market. In 2014, supported by the single Common Market Organization (CMO - EU Regulation No 1308/2013) within the new Common Agricultural Policy (CAP) 2014-2020, floriculture sector moved a consistent amount of money within the EU-28 both in terms of imports (about € 9 billion) and exports (about € 6 billion), and the Italian contribution was far from negligible with € 439 million of imports and € 639 million of exports (Eurostat, 2015).

Despite the economic magnitude of this agricultural sector worldwide, EU trade patterns and dynamics have received very little attention in the scientific debate on floriculture sector. Accordingly, there is a clear scarcity of academic literature concerning the breadth and the determinants of floriculture trade.

Hence, the aim of this paper is twofold as, in addition to describing trade dynamics related to the floriculture sector both in Italy and in the European Union in recent years (as the reader can find into the next paragraph), it also provides a better understanding of the dynamics of Italian trade flows applying a gravity model, in order to investigate and evaluate the potential influence of some important economic and geographical variables on Italian trade patterns and volumes of cut flowers and live plants within the EU.

An overview of the floriculture sector

Among the categories considered within the floriculture sector, this study focuses on cut flowers and live plants, firstly because their trade flows (considering both import and export) are more consistent than those of foliage and bulbs (Table 1), and secondly because these two latter categories register a scarce or incomplete availability of information. Due to the complete availability of data from Eurostat database, 2014 was the most recent year that could be considered to describe the Italian trade and the main EU importers and exporters.

According to The Swedish Chambers of Commerce (2011), floriculture consumption is strongly related to income levels, thus clarifying why markets with high purchasing power also have high consumption levels. In addition, although consumers buy flowers even for own use, cut flowers consumption in EU peaks around holidays or festive days (e.g., Mother's Day and Valentine's Day) and other special occasions as weddings and funerals. However, percentage and quantities vary greatly by country; in Italy, over 35% of the total flowers consumption is due to cemetery use followed by special occasions (34%), while only 12% is for private own use (Lauricella, 2013).

Global consumption of cut flowers is estimated at about € 30 billion per year with North America and Europe being the leading markets (Rikken, 2010). Within Europe, Germany (about € 4 billion), Italy (€ 2.7 billion), France (€ 2.7 billion) and the UK (€ 2.2 billion) are the biggest markets in terms of consumption value (CBI, 2016a).

The EU also represents the largest producer of flowers and plants worldwide (ITC, 2016): in 2012, it was leader of flowers and plants market with a share of 42.6% of the global production, followed by China (15.5%), USA (11.1%) and Japan (9.5%) (EC, 2013). Over the last 10 years, this sector has faced an almost steady increase in the production trend in EU-28. In 2014, the European production of flowers and plants amounted to € 20.2 billion. The Netherlands represented by far the largest producer, accounting for 33% of production value, followed by Germany (13%), Italy (12%) and France (12%) (Eurostat, 2015). Italy is one of the leading producers of plants in the EU, boasting a strong tradition in cut flowers especially in specific regions (i.e., Liguria, Toscana, Lazio, Campania, Puglia, Sicilia): here the production is concentrated in the north, where smaller growers are disappearing while scales of production are increasing (Rikken, 2010). However, since the last two decades flowers and plants production has started to shift from countries in the northern hemisphere towards developing countries, as Colombia, Kenya, Ecuador and Ethiopia. As suggested by many authors (Korovkin, 2003; Raynolds, 2012; Staelens, et al., 2014), in such countries the spreading of this sector represents a catalyst for rural employment and new job opportunities especially for women. These relatively new producing countries have advantageous production conditions as lower labour costs, availability of land, good climatic conditions, and fiscal incentives (Van Rijswick, 2015). It is worth noting that the increase of flowers' production in such developing countries is a result of specific investments by local and foreign businessmen and migrating European growers. These latter, in addition to relocating their production abroad (Rikken, 2010), have also contributed to consolidate the large-scale production at the expense of smallholders (Gebreeyesus, 2015).

This trend has altered global trade routes and flows, leading to an increasing share of EU's imports coming outside the EU-28. Table 2 shows that cut flowers and plants' imports from outside the EU (Extra-EU imports) amounted to € 1,327 million in 2014. The Netherlands is the main actor when

Italy	Import			Export		
	from extra EU-28 partners	from intra EU-28 partners	Tot. import	to extra EU-28 partners	to intra EU-28 partners	Tot. export
Live plants	16.8	210.4	227.1	99.1	404.8	503.8
Cut flowers	15.3	135.2	150.4	9.2	56	65.2
Foliage	2.4	15.6	18	8.5	59.5	68
Bulbs	0.2	46	46.2	1.9	3.1	4.9
Tot.	34.7	407.2	441.7	118.7	523.4	641.9

Source: own elaboration on Eurostat data (2015) - http://ec.europa.eu/eurostat/data/database

Table 1: Italian trade (intra and extra EU-28) of floriculture sector in 2014 (million €).

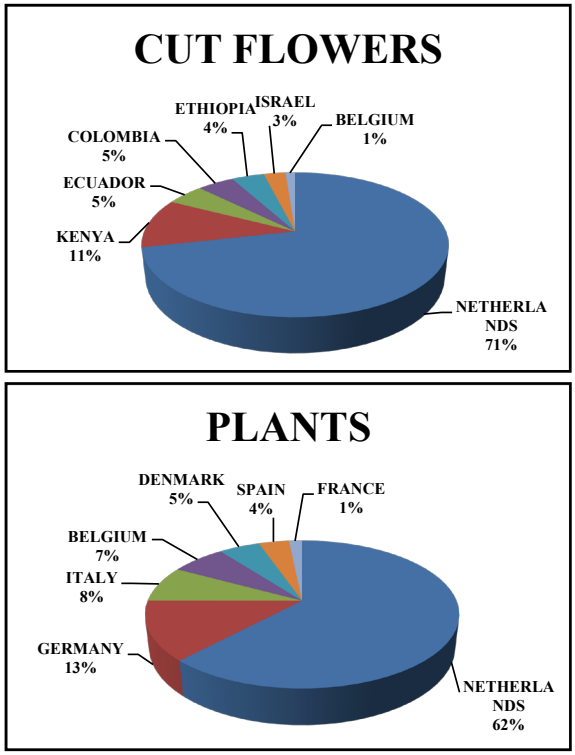
Main European importers (value, in million €, of total import: from EU-28 extra + EU-28 intra partners)			Main European importers only from EU-28 extra partners		
	2014	(%)		2014	(%)
Germany	2,094	27%	The Netherlands	751	57%
The Netherlands	1,166	15%	Belgium	171	13%
United Kingdom	1,007	13%	United Kingdom	163	12%
France	832	11%	Germany	93	7%
Belgium	460	6%	Spain	62	5%
Italy	378	5%	Italy	32	2%
Austria	313	4%	France	15	1%
Poland	233	3%	Sweden	13	1%
EU-28	**7,867**		**EU-28**	**1,327**	

Source: own elaboration on Eurostat data (2015) - http://ec.europa.eu/eurostat/data/database

Table 2: Main EU importers of cut flowers and plants (value of import in million €) and main European importers only from EU-28 extra partners (value of import in million €) in 2014.

it comes to import volumes from outside the EU, with a share of 57% of the total, followed from afar by Belgium (13%) and United Kingdom (12%). Italy lies in the sixth place in this ranking, with only 2% of the total extra EU imports. Despite the increase in the EU flowers' import from non-EU countries, most of the supply keeps coming from the internal market (83% of the total), suggesting a certain degree of self-sufficiency in this sector. Out of the € 6.5 billion worth (i.e., the difference between EU total import in 2014, € 7.8 billion, and the imports from EU-28 extra partners in the same year, € 1.3 billion) of flowers and plants imported in 2014 by EU countries from other partners belonging to EU-28, Italy is the fifth largest importer (5%), preceded by Germany (31%), UK (13%), France (12%) and the Netherlands (6%), respectively.

The Netherlands plays a key role in the international trade, being the main supplier of both cut flowers (71%) and plants (62%) to EU countries (Figure 1). After The Netherlands, the main suppliers for cut flowers are mainly EU-28 extra countries as Kenya (11%), Ecuador and Colombia (both accounting for 5%), Ethiopia (4%), Israel (3%) and Belgium (1%). On the contrary, European countries as Germany (13%), Italy (8%), Belgium (7%), Denmark (5%), Spain (4%) and France (1%) represent the main suppliers for plants, after the Netherlands (62%).



Source: own elaboration on Eurostat data (2015) - http://ec.europa.eu/eurostat/data/database

Figure 1: Main suppliers of cut flowers and plants to the EU in 2014.

According to Eurostat (2015) (Table 3), the value of EU total export for cut flowers and plants amounted to € 8,462 million in 2014. The EU main exporters are The Netherlands (64%), Germany (8%), Belgium (7%) and Italy (7%). Taking into account only the exports towards EU-28 extra countries (that amounted to 16% of total EU exports in 2014), Italy represents the third country (8%), after the Netherlands (59%) and Germany (8%).

Main European importers (value, in million €, of total import: from EU-28 extra + EU-28 intra partners)			Main European importers only from EU-28 extra partners		
	2014	(%)		2014	(%)
Germany	5,439	64%	The Netherlands	838	59%
The Netherlands	680	8%	Germany	114	8%
United Kingdom	609	7%	Italy	108	8%
France	569	7%	Spain	63	4%
Belgium	295	3%	Denmark	45	3%
Italy	292	3%	France	33	2%
Austria	118	1%	Poland	30	2%
Poland	100	1%	Belgium	30	2%
EU-28	**8,462**		**EU28**	**1,412**	

Source: own elaboration on Eurostat data (2015) - http://ec.europa.eu/eurostat/data/database

Table 3: Main EU exporters of cut flowers and plants (value of import in million €) and main European exporters only in EU-28 extra partners (value of import in million €) in 2014.

Materials and methods

Gravity model represents a kind of spatial interaction model and can be used to calculate the number of interactions between two countries. The fundamental idea underlying spatial interaction models is that the degree of interaction between two countries is a function of the degrees of concentration of people or things in the two countries and a measure of the distance separating these countries. This fundamental idea originally derives from Newton's gravity law (Linnemann, 1966; Niedercorn and Bechdolt Jr., 1969). The gravity equation is found to be very successful in explaining the international trade empirically (Sá Porto, 2000). When analyzing the international trade, the gravity equation for more than two countries can be used adding more variables beyond the original ones as production, consumption, price, territorial boundaries, common languages, exchange rates, common participation in trade agreements, and others (Cochrane, 1975; Anderson, 1979; Frankel, 1997).

A panel gravity model has been used to analyse floriculture trade dynamics between Italy and other EU-28 Members States over the period from 2001 to 2013, considering only data related to plants and cut flowers categories. In particular, we used the following codes available on Eurostat: 0602 for plants and 0603 for cut flowers. The availability of complete data between 2001 and 2013 related to both cut flowers and live plants categories and to all the variables of interest determined the choice to consider such a range, in order to have the widest amount of years possible and, thus, of observations; indeed, 2013 was the most recent available year.

In addition, the Hausman test (1983) has been applied to choose between fixed and random effect to estimate the gravity model. The main difference between both effects is basically on the correlation between the error term and the variables. The fixed effects model eliminates the error term, which is correlated with the variables, through a transformation of fixed effects, called the within transformation because it estimates the estimators by the method of Ordinary Least Squares (OLS) and this method uses the time variation in y and x within each unit of cross-sectional (within variation). There is also variation between units cross-sectional (between variation) that is only used in the estimation in which the intercept is present. In this case, the use of random effects model is the most suitable. The random effects model considers that the error term is not correlated with the variables. Thus, it enables the coefficients to be estimated as a single cross section, that is, the panel data structure is not required for the estimation of the model (Wooldridge, 2002; Baltagi, 2005). Moreover, the Wooldridge test was applied and all the estimates were performed using STATA version 12.

The estimated gravity model to analyze the Italian trade dynamics has the following form:

$$Trade_{ij} = \alpha_0 GDPit\_pc_i^{\alpha_1} GDPc\_pc_j^{\alpha_2} Prod\_pc_j^{\alpha_3} Consump\_pc_j^{\alpha_4} Dist2_{ij}^{\alpha_5} e^{\alpha_6 ADJ_{ij} + u_{ij}} \quad (1)$$

This equation can be reformulated as:

$$lTrade_{ij} = \alpha_0 + \alpha_1 lGDPit_{pc_i} + \alpha_2 lGDPc_{pc_j} + \alpha_3 lProd_j + \alpha_4 lConsump_{pc_i} + \alpha_5 lDIST2_{ij} + \alpha_6 ADJ_{ij} + u_{ij} \quad (2)$$

where:

i = Italy

j = EU-28 Member States except Croatia, Cyprus, Estonia, Ireland and Malta

$lTrade_{ij}$ = floriculture trade flow between Italy and EU considered Member States

$lGDPit\_pc_i$ = Italian Gross Domestic Production (GDP) per capita

$lGDPc\_pc_j$ = Gross Domestic Production (GDP) of EU Member States per capita

$lProd\_pc_j$ = floriculture production of EU Member States per capita

$lConsump\_pc_j$ = floriculture consumption of EU Member States per capita

$lDist2_{ij}$ = distance-squared between the Italian Capital town and those of the EU Member States

ADJ_{ij} = dummy representing territorial boundary (adjacency)

u_{ij} = error term

Among EU-28 Member States, Croatia, Cyprus and Ireland were dropped because of the lack of production data in the time span considered, whereas Estonia and Malta were dropped because they showed negative consumption values.

Trade, production and consumption variables are derived from Eurostat (2015) (in values in €); GDP (in US $ at constant prices 2005) and population have been collected from United Nations Statistics Division (UNSD, 2015); the distance (in kilometers) has been collected from the Centre d'Études Prospectives et d'Informations Internationales (CEPII, 2015). Trade variable is the sum of imports plus exports (Pietrzak and Łapińska, 2015). In order to obtain data related to EU member states' domestic consumption, firstly we summed up import and production and then we subtracted exports. Finally, all the variables have been divided by the country specific population in order to obtain each variable per capita.

It was expected that GDP of EU Member States per capita had a direct relation (positive sign) with the Italian trade as the general idea behind the inclusion of this variable is that the higher the GDP, the higher the trade between countries in general (Cieślik, 2009). It was also expected that the production variable had a positive sign as it represents the production capacity of each country and the higher it is, the higher the ability to trade for the country. On the other hand, the consumption indicates the market potential for sales (Starck, 2012). In relation to the distance, it can be considered as a proxy of transport costs and it was expected to be negatively correlated (negative sign) to trade (Agostino et al., 2007). Hence, the higher the geographical distance between the capital cities of two trade partners, the higher the trade impediment between them (Simwaka, 2006). Finally, the presence of a common board, that is the adjacency, represents lower transport limitations (Anderson, 1979; Egger, 2002) and promotes trade flows reducing transaction costs (Sánchez-Robles Rute et al., 2012).

Results and discussion

To decide which model was the most suitable to analyze the Italian floriculture trade, this study applied the Hausman test. Results showed that the fixed effect was the better solution to estimate this gravity model [$\chi^2(4) = 12.90$; *p-value* = 0.012]. In addition, the Wooldridge test showed the presence of the first order autocorrelation [$F(1, 21) = 6.763$; *p-value* = 0.017]. This problem was solved considering the robust standard errors and the results are in Table 4.

The F statistic tests the hypothesis that all the slope coefficients are simultaneously zero; that is, all the explanatory values jointly have no impact on the regression. Since the computed F value

Dependent variable = *lTrade*	**Coefficient**	**Standard error**	***t***	**p-value**
lGDPit_pc	-1.467	1.01	-1.45	0.147
lGDPc_pc	3.62	0.488	7.41	0
lProd_pc	3.493	0.674	5.18	0
lConsump_pc	-3.12	0.621	-5.02	0
Constant	-2.801	3.238	-0.87	0.388
R^2 (overall) = 0.201	id = 22	temp = 13	n = 286	
R^2 (between) = 0.194				
R^2 (within) = 0.378		$F(21, 238) = 77.15$	Prob>F = 0.000	

Source: own processing, 2015

Table 4: Gravity model results.

of about 77.15 is highly significant (Prob>*F* = 0.000), it means that the variation in the dependent variable can be explained by the explanatory variables, being the coefficients in the model different from zero. The determinant variables explained up to 20% of the variation in the model, being the variation among the years explained up to 38% and the considered countries up to 19%. The apparently low value of R2 can be explained by the fact that the Italian trade also depends on some other variables that are not included in this analysis and that influence the domestic demand, as consumer purchasing preferences and consumption habits which are different in each country. In addition, according to Gujarati (2004, p. 544) "low R^2 values are typically observed in cross-sectional data with a large number of observations".

Among the explanatory variables considered by the panel gravity model, the Italian GDP per capita, representing the population's purchasing power, is found to be not significant for the Italian floriculture trade. One possible reason could be the existence of a relatively large home-market effect; accordingly, McCallum (1995) and Sohn (2005) argue that a home-bias effect, such as local distribution networks, can play a greater role in trade compared to the GDP.

Conversely, the GDP per capita of EU partners, being a proxy of richness magnitude, represents a significant variable. In particular, if partners' GDP increased by 1%, the trade between each country and Italy increased by 3.62%. According to this, it is expected that the higher the GDP of the exporter countries, the greater their capacity to supply the importing countries' consumption needs, representing the base of the trade (Cardoso et al., 2016). In addition to this, such GDP per capita effect can be also supported by the fact that, being the exotic varieties commonly superior goods in consumption, low-GDP countries are often dominated by subsistence farming that does not consider specialized and diversified production (Sohn, 2005).

Moreover, results show that the higher the floriculture production of each country, the higher the trade between this and Italy: in particular, a 1% increase in a EU partner's production is associated with about a 3.49% increase of the Italian trade with this country. It is worth highlighting that trade is stimulated mainly by production diversification in each country (Sohn, 2005), whereas production specialization is due to the specific factor endowment and proper climatic conditions of each country.

In relation to the consumption variable, representing the potential market of flowers in each country, it showed an indirect relation with the trade (negative sign). Results indicate that for every 1% increased in EU Member States' consumption, the trade between them and Italy is decreased by 3.12%. One possible reason is that specific flower varieties produced in Italy may not be those mostly consumed in other EU Member States. Because of this, the trade of the flowers varieties produced in Italy not increases when consumption in other EU countries increases, probably because it does not address specific consumers' interests and needs at all. Indeed, consumers have become more refined in demanding new products nowadays (ITC, 2016), as shown by many authors (Özzambak et al., 2009; Rihn et al., 2015; CBI, 2016b). To meet this growing and changing demand, production has continued to move from countries that have traditionally been consumers and growers, such as The Netherlands, to other relatively new producers such as Colombia, Ecuador, Kenya and Ethiopia. In such developing countries, the increased production contributes to food security, mainly by increasing the income and purchasing power of farmers (Van Den Broeck and Maertens, 2016).

Finally, the distance and the adjacency variables are the fixed effects, i.e. they do not vary over the time, and because of this such variables were omitted in the model.

Conclusion

In order to fill a void in the scientific literature, this paper provides a first evaluation of Italian floriculture trade using a gravity model, while generating new questions which need to be answered further. Despite the crisis that has weakened companies of the floriculture sector in recent years, nowadays the Italian floriculture sector still manages to maintain a position of prestige in most European and international markets. This is mainly due to the entrepreneurial capacity of producers and the high quality of production. Although the floriculture production is characterized by farms with small size, that notoriously reveal a little bargaining power, Italy represents the third major producer within the European borders, after The Netherlands and Germany. This research showed that the Italian floriculture trade is positively influenced by European trade partners' both GDP and production volumes, whereas it is negatively influenced by their consumption. Accordingly, high GDP and production volumes of a country suggest

a high capacity to buy and to supply the needs of other trade partners and this evidence supports the idea that current bilateral trade flows between Member States will last in the future, whereas it is not easy to forecast future trade relationships between Italy and new emerging producers as developing countries. In relation to flower consumption, the comprehension of its negative influence on Italian trade needs some further investigation, as by means of mixed-method approaches as commonly used for food analysis (Giampietri et al., 2016a, 2016b), and represents a limitation of this study. Since flowers are not primary goods, it is plausible that their consumption is both linked to GDP per capita and specific consumer preferences and habits. It is worth noting that there is still a lack of an extensive assessment of consumer preferences related to flower purchase and their influence on Italian trade, thus requiring further investigations. In addition, the analysis of each plant variety separately could represent an alternative to improve the explanation capacity of this model. Finally, other variables could be investigated further for each country as: the language (Lombardi et al., 2016), the average annual spot price of the investigated categories (cut flowers and live plants), the labour cost, the presence of trade public incentives, the presence of public direct investments in floriculture sector and, by expanding the sample of trade partners, also the EU membership.

In order to boost the floriculture sector's development and trade, nowadays new policy strategies are required to overcome many sector specific problems. First of all, the lack of infrastructure and logistical centers able to concentrate the production of small scale Italian farms, in order to compete with the main producers all over Europe and abroad. Furthermore, in order to encourage the sustainability of this sector, new alternative means to road transport should be implemented to reach other destinations (new emerging countries) than historical trade partners as EU northern countries. Finally, more innovation is required, related to both quality production and processing, as well as more tailored marketing strategies, in order to address specific segments of consumers according to the seasonal consumption of floriculture products.

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Author Contributions

This paper derives from a full authors' collaboration. In particular: E. Giampietri (E.G.), M. Rasetti (M.R.) and B.F. Cardoso (B.F.C.) designed and performed the research; E.G. and M.R. wrote the introduction and analyzed the data related to the floriculture trade; B.F.C. wrote the methodology; E.G. and B.F.C. discussed and wrote results and conclusion; A. Finco and P.F.A. Shikida provided general supervision and guidance.

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Socio-economic Assessment of the Philippine Agrarian Reform

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Abstract

This paper, using qualitative research methods, aims to assess the challenges faced by the Philippine Comprehensive Agrarian Reform Program and its extension on the selected cases from five Philippine provinces. In 27 years of its implementation, the agrarian reform has achieved land redistribution of around 7.7 million hectares despite the periodical lack of political will and opposition from landlords, sometimes violent or through protracted legal battles. Support services focus almost exclusively on Agrarian Reform Communities, in which such services are funded mostly through the official development assistance from abroad rather than government's budget. Limited availability of support services to those agrarian reform beneficiaries located outside of Agrarian Reform Communities prevents them from becoming economically viable producers and seriously taints whatever land distribution may have accomplished. Some reform beneficiaries may have been awarded their land on paper but were not able to take possession of the land or must have abdicated control of it.

Keywords

Comprehensive Agrarian Reform Program (CARP), land reform, land redistribution, landlordism, land conflict, agriculture support services.

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Introduction

Agrarian reform in the Philippines is a not an easy task compacted by the challenges it has to face – "opposition from landlords, criticism by civil society, suspicion by the private sector, cynicism by legislators, lack of financial and material resources as well as general public apathy" (Guardian, 2003). However, it is widely recognized that the agrarian reform has contributed to the improvement of lives of a substantial number of Philippine peasants, though the actual impact of the reform on the rural poor "may not have been as large as its proponents would have liked to see" (World Bank, 2009). Pessimistic predictions and sweeping dismissal by some critics of the land reform accomplishments have not materialized and sizeable land redistribution has been achieved with around 7.7 million hectares of land, or one quarter of total Philippine land area or 80% of of all agriculture land (De Los Reyes et al., 2017), distributed in the 27 years of the implementation of the Comprehensive Agrarian Reform Program (CARP) and its extension. As GTZ (2006) wrote then and is still true today, it is evident that the agrarian reform is far from being completed, especially in terms of compulsory acquisition of large private landholdings and their redistribution to the mass of landless peasants. The remaining lands are the most contentious landholdings, most tedious and difficult to acquire and distribute (Focus on Global South, 2013). Moreover, in some cases, agrarian reform beneficiaries may have been awarded their land on paper, but have not been able to take actual possession of the land or have abdicated the control of it. Many others have been left without meaningful support that would enable them to become economically viable producers.

The current Philippine president Rodrigo Duterte called the agrarian reform implementation a 'farce' and a 'total failure' during his election campaign. After assuming the office, he made support services alongside land distribution one of his policy priorities, reversed the "long-standing presidential pattern of ignoring agrarian reform's social justice principles" (Tadem, 2016) and appointed Rafael Mariano, a former activist of peasant class origins, as Department of Agrarian Reform (DAR) Secretary. Mariano immediately initiated a review

of 'anti-farmer decisions' sparking a policy discussion on the future of the agrarian reform. While the former pro-reform elements in the civil society and bureaucracy advocate for another CARP extension, the Secretary would prefer to roll out much more radical Genuine Agrarian Reform that would go as far as free distribution of land to farmers. This paper is an attempt to contribute to the current policy discussion as well as to the literature on the land reform in the Philippines in particular and in developing countries in general by highlighting the successes and failures of CARP and its extension at micro-level and challenges in its implementation.

1. Concepts of land/agrarian reform

Agrarian reforms worldwide have been attempting to "correct historical injustice committed against landless peasants" and have been conceived based on a political-economic perspective of agrarian structure, where "power and power relations between different social classes within the state and in society are at the center of a more egalitarian distribution of property rights over land resources" (Borras, 2007). According to Borras (2006) redistribution of wealth and power from the landed elite to landless and near landless people is the essence of land reform. Fuwa (2000) counters that the ultimate achievement of land reform should not be land redistribution as such but rather enabling reform beneficiaries to become competitive in the context of liberalized markets and reduced role of the state. Land reform entails equitable and rational change in agrarian structure by "compulsory, drastic and rapid means" resulting in increased access to land by the rural poor and secured tenure for those who actually work the land (Ghimire, 2001; Tai, 1974) which gives small cultivators "greater control over the use of land and greater leverage in their relationships with the rest of society" (Jacobs, 2013).

The terms 'land reform' and 'agrarian reform' are often used interchangeably, even in this text, but are actually not precisely the same. Banerjee (1999), Jacobs (2013), Tai (1974) and others limit the 'land reform' to its narrow definition of redistributing land to rural poor, while 'agrarian reform' is considered to have a wider meaning embracing improvements in both land tenure and agricultural organization, including provision of infrastructure, services and, sometimes, a whole program of redistributive and democratic reforms. Adams (1995) sees 'agrarian reform' as a construct of the Cold War to counter the concept of 'communist' land reform. Cohen (1978) defines 'agrarian reform' as "a multi-disciplined set of interrelated aims and means capable of combating the ills" of the "feudal and quasi-feudal institutional agrarian structure." None the less, advocates of land reform agree that simply redistributing land to the landless poor would not achieve equity nor efficiency of land reform; real reform should be accompanied by agricultural extension and emergency income support programs (Banerjee, 1999) or a mix of technical support and access to credit, markets and inputs (Cotula et al., 2006). Most advocates of agrarian reform have explicitly maintained no illusion that land redistribution is a "magic panacea to rural poverty and underdevelopment" (Borras, 2006); land redistribution is a necessary but insufficient condition for rural development and poverty eradication and must not be seen in isolation from broader support to the agricultural sector (Borras, 2006; Cotula et al., 2006).

Whilst the pursuit of land reform in 20th century was reinforced with the view that agriculture should be in the center of development agenda by the national governments, more prominent reason for adopting land reform was often to prevent rural unrest and struggle for social justice; land redistribution happened more likely when the rural poor formed a credible threat of revolt (Albertus, 2015; Fuwa, 2000). Other reasons for agrarian reform according to Cox et al. (2003) included existence of large tracks of land with low farming intensity, exploitative labor relations on large estates, land conflicts, collapse of large state, collective or cooperative farms. According to Cotula et al. (2006) redistributive land reforms have been motivated by three inter-related objectives: i) to reduce poverty and landlessness in rural areas through more equitable access to land, ii) to improve social justice by shifting the balance between different groups in the ownership and control of land, and by restoring alienated land rights and iii) to promote rural development by raising agricultural productivity and creating a class of productive smallholder farmers.

Platteau (1992) and Borras (2007) sum up that redistributive land reform was highly popular in official development agendas during the past century when it was generally accepted that large landed estates were economically inefficient because the land was underused - the creation of small family farms should maximize use of relatively scarce land resources by applying abundant rural labor to it. The decolonization struggle, post-conflict democratic reconstruction and consolidation,

and the end of authoritarian regimes and subsequent transitions have also provided significant bases and imperatives for land reform. Deininger and Binswanger (1999) show their skepticism about land reforms relying on expropriation because they "have been more successful in creating bureaucratic behemoths… than in redistributing land from large to small farmers" and because of their supply-driven nature such reforms lead to economic inefficiency, when productive farms are expropriated and subdivided into smaller, less productive farm units, when environmentally fragile, public lands are distributed, or when peasants unfit to become beneficiaries are given land. According to Jacobs (2013), the great majority of agrarian reforms have been incomplete, either redistributing little land or else allowing landlords or large commercial farmers to exert continued power. Land-redistribution-before-development approach has led to land redistribution–centered reforms where in most cases the state has failed to deliver support services to beneficiaries (Deininger 1999).

2. Rolling out land reform in the Philippines

The history of the colonial rule in the Philippines by the Spanish and Americans led to the process of land acquisition by the elite, land-grabbing and privileged access to legal formalities creating a system of property rights that tends to appear arbitrary to peasants (Putzel, 1992). For centuries, agricultural lands have been in the possession of a few powerful landlords and corporations, the majority of people remained as tenants, farm workers and landless agricultural laborers, a reality that has contributed to the widespread rural poverty (Elvinia, 2011). Prior to the initiation of land reform in the Philippines, almost 50% of the rural population was landless (Elauria, 2015). Since World War II, consecutive Philippine governments have used land reform in various forms and intensity as a key element of their poverty reduction strategies, as well as a tool to address social unrest and insurgency in the rural areas (Balisacan, 2007). Land reform in the Philippines has had a long and dubious history marked by cycles of intense popular assertion that put the idea of land reform firmly on the national political agenda "in between long periods of government inertia" (Borras and Franco, 2007). The political reality of land reform implementation in the Philippines has seen contestation by different social forces with differing interests and levels of bargaining power (Cruz and Manahan, 2014).

CARP, enacted in 1988, aimed to redistribute 10.3 million hectares of land to more or less 5 million landless peasant-families or 30 million individuals (Bejeno, 2010). CARP and its 2009 extension, the Comprehensive Agrarian Reform Program Extension with Reforms (CARPER), was quite distinct from previous Philippine land reform initiatives because it went beyond land transfers to provision of basic support services, including access to credit and marketing assistance, with the aim to transform the beneficiaries into efficient agricultural producers and entrepreneurs (Velesco, 2011). CARP was an improvement over previous land reforms also in that it covered all agricultural lands and the entire rural landless labor force, including previously excluded seasonal farm workers and occupants of public lands (Velesco, 2011). However, CARP was a compromise law, accommodating demands from the landowning classes and agribusiness, and as such it contained legal loopholes that allowed mere regulation of existing tenancy forms, including the nefarious stock distribution option and leaseback agreements, provided for an ample list of exemptions for acquisition, established 'fair market value' for landowner compensation, created a payment amortization scheme that was unfavorable for beneficiaries and set a high retention limit that could reach 14 hectares (Borras, 2007; Tadem, 2015).

Landowners have been resistant, sometimes violently, to CARP. In some cases, beneficiaries have been unable to take actual possession of formally awarded lands due to strong, violent opposition from a landlord, or protracted legal battles launched by landlords (Borras, 2006). Numerous reports have surfaced of agrarian reform beneficiaries being harassed, intimidated, raped, evicted, robbed or killed by landlords, their paramilitaries or hired goons (Guardian, 2003; Villanueva, 2011; Bejeno, 2010). While Binswanger and Deininger (1996) argue that the main reason for landlords' resistance to land reforms is a payment often below the market price, the Philippine landowners were compensated generously receiving on average 133% of the market value of their land under the Aquino administration (Riedinger, 1995). One possible explanation for this overpricing made by Putzel (1992) is corruption of Land Bank officials in charge of land valuation. The other possible explanation is daily pressure and harassment of DAR officials by landlords, some of whom might hold high positions within the local administrations (Borras and Franco, 2007).

CARP is further hampered by rampant land conversions and displacements of peasant

communities, incursions of property developers, other rent-seekers and special economic zones and the expansion of urban areas into the countryside as well as an ineffectual bureaucracy (Tadem 2015; Elvinia, 2011). DAR is a huge and diverse state bureaucracy composed of an army of 15,000 personnel scattered nationwide who, like other government employees, are not well paid and moreover as with other Philippine government agencies 'political patrons' play a role in their appointments and recruitment (Borras and Franco, 2007).

3. CARP's objectives and achievements

The goal of the land reform in the Philippines was initially to break up large farms and redistribute the land into small plots to be cultivated by landless small family farmers (Borras and Franco, 2006). Subject of compulsory land acquisitions under CARP were private agricultural land holdings larger than 5 hectares, regardless of crops or fruits produced, with some notable exceptions. While the average farm size in the Philippines is two hectares, CARP award ceiling to landless farmers and regular farmworkers was fixed at three hectares (Government of the Philippines, 1988). CARP's objectives of improving equity and productivity in the agriculture sector by distributing agricultural lands to landless farmers, farm workers and tenants were geared towards achieving the constitutional obligation of promoting social justice and rural development (Senate, 2008). CARP basically consists of three key components (Elvinia, 2011): i) land tenure improvement that deals with the acquisition and distribution of lands, ii) support services which involve the provision of extension services, credit, and infrastructure support to agrarian reform beneficiaries and iii) settlement of cases relating to landlord-tenant relationship and cases pertaining to land valuation and disputes.

The CARP implementation recorded significant delays and thus it had to be extended through promulgation of CARPER which also contained new provisions that favored beneficiaries in terms of land acquisition and distribution such as the indefeasibility of awarded beneficiary lands, recognition of usufruct rights, a grace period for amortization payments, speeding up the process of awarding lands, removal of the stock-distribution option, outlawing the conversion of irrigable and irrigated lands, automatic coverage of lands targeted for conversion pending for five years, reintroduction of compulsory acquisition and voluntary-offers-of-sale as main redistribution modes, as well as recognition of women as beneficiaries (Tadem, 2015; Bejeno, 2010; Cruz and Manahan, 2015).

Much has been written elsewhere on CARP/CARPER's accomplishments and failures. Low budget allocation, since it is the Congress, the bastion of landowning classes and their allies, that makes yearly decisions on budget allocations to the various CARP components, as well as low budget utilization have been a major constraint for the agrarian reform (Fuwa, 2000; Tadem 2015; Borras and Franco, 2007). Because of these limited funds, in 1993 the government launched the Agrarian Reform Community approach to beneficiary development, which focuses the delivery of support services to selected areas, rather than dispersing the delivery to all areas covered by CARP (World Bank, 2009). The Agrarian Reform Communities have become the 'show-window of the agrarian reform' and when officially assessing the CARP impact, the focus is always on these (Guardian, 2013), even if only 27% agrarian reform beneficiaries are actually located in one of the Agrarian Reform Communities (Tadem, 2016).

What made CARP moderately successful during the period of 1992 – 2000, was the way in which pro-reform forces in society linked up with pockets of pro-reformists within the agrarian reform bureaucracy to convert less-than-ideal openings for agrarian reform into actual redistribution of land (Borras et al., 2007). "Various studies found that benefits such as improvements in tenure security, higher income of farmer-beneficiaries and higher yields brought about by increased inputs and investments on land were derived from the CARP implementation" (Senate, 2008). According to the study using panel data of 1,800 households by Reyes (2002), CARP has led to higher real per capita incomes and reduced poverty incidence between 1990 and 2000; real per capita incomes of agrarian reform beneficiaries increased by 12.2% between 1990 and 2000 and the difference in the poverty incidence between agrarian beneficiaries and non-beneficiaries has widened to 11.2 percentage points in 2000. However, Adamopoulos and Restuccia (2014) used a quantitative model and micro-level data to imply that CARP in fact reduced agricultural productivity by 17% and according to World Bank (2009) the "progress in CARP implementation in the past two decades has been extremely slow" and only mildly successful at reducing rural poverty.

According to Tadem (2015), DAR and other

government agencies have been negligent in the provision of timely and adequate support services to agrarian reform beneficiaries, preventing them from becoming economically viable producers and seriously tainting whatever land distribution may have accomplished; as of December 2013, only 44% all agrarian reform beneficiaries had access to support services, with 27% of them living in Agrarian Reform Communities, which are mostly funded by foreign aid. Agrarian reform beneficiaries lack access to financial services and thus majority of their credit comes from loan sharks or aryendadors and traders who charge usurious interest rates (Tadem, 2015). Unable to shell out the money, the farmers are forced to lease their land to the aryendandor to pay for their debt. Most CARP beneficiaries "either lack the entrepreneurial skills required to efficiently manage their land or factor prices are too high that it becomes too costly for the farmer to enter into the market" and thus s/he turns to leasing or selling the land (Elauria, 2015). Adam (2013) shows on a case study from Mindanao that a majority of the coconut farmers there is trapped in new forms of debt-bondage and is forced to transfer the rights over their land. Among CARP strategies were leaseback, joint ventures and contract growing schemes, which have been heavily criticized as inimical to the rights and interests of small farmers because of low rent and unfulfilled promises of employment and other benefits; "many of the farmers who entered into such schemes remain impoverished while having abdicated their access to and control of their lands" (Villanueva, 2011). While CARP/CARPER prohibits the sale of lands awarded under the program, the law allows agrarian reform beneficiaries to enter into business contracts involving the lease of their lands for up to 50 years. This is virtually equivalent to selling away their lands and giving the lessor unlimited access, management and use of land resources. As Adam (2013) shows on a case study from Mindanao, business elites have managed to obtain control over lands redistributed by CARP through all sorts of informal arrangements.

Among rather failed approaches to agrarian reform in the Philippines was the voluntary land transfers scheme. In 2002, President Arroyo administration adopted the voluntary land transfer scheme as the main strategy for land reform with the aim to cut down government spending on land acquisition (Borras, 2005). As it turned out later, the voluntary land transfers usually faked redistribution via paper sales and use of the on paper beneficiaries who are either family members, "dummies, coerced tenants and farm workers or people completely unaware of the transaction" (Borras, 2007).

Materials and methods

Despite the relatively large literature on the land reform in the Philippines, which we attempted to review in the previous section of this paper, and official quantitative statistics on land redistribution, which offer an important but insufficient means of assessment of CARP/CARPER success, little has been systematically documented on the impact and prospects of land reform implementation at the micro level. There are also significant regional differences and variations in CARP/CARPER implementation, which call for a more qualitative analysis and comparative research methods to add another layer to the official 'big-picture' data and information. In line with this, the main objective of this research is thus to highlight the challenges in CARP/CARPER implementation in five Philippine provinces. For this purpose, the following research questions were formulated:

- What are the challenges in successful implementation of CARP/CARPER and how are they addressed or confronted?
- What are the causes preventing implementation of the land redistribution component?
- What is the availability of support services to agrarian reform beneficiaries?

While responding to these questions in order to avoid repetition and to follow interrelation between some aspects, the results/discussion section is divided into four sub-sections dealing with opposition by landlords, DAR, availability of support services and other causes of land conflicts. The rationale behind the province selection was that Leyte and Negros Occidental provinces rank among the provinces with lowest accomplishments in land acquisition and distribution. Bataan province was added because of the infamous land dispute of Sumalo farmers in Hermosa municipality, going back to 1989. Misamis Oriental and Bukidnon provinces could illustrate the specific issues related to the armed conflict on Mindanao and to indigenous peoples.

This paper uses mainly qualitative analysis based on fieldwork and observation, personal account, related publicly available documents and secondary data to analyze the complex social, economic and political issues related to the agrarian reform in the Philippines. Because of the qualitative rather

than quantitative nature of the research, the primary methodological approach of the field data collection was a combination of 20 focus group discussions and 39 in-depth interviews to generate stakeholder information and perspectives about the impact, challenges and prospects of CARP/CARPER implementation. The field data were collected in May and July 2016 and January - February 2017 with the July 2016 experience helping to further fine-tune the design of the questioning and formulation of questions. The following semi-structured focus group discussions and key informant interviews were conducted:

- 16 focus group discussions with agrarian reform beneficiaries from Negros Occidental, Bukidnon, Misamis Oriental, Bataan and Leyte provinces, with minimum 7 and maximum 17 participants per group; 12 in-depth interviews with leaders of agrarian reform beneficiaries' groups or federations of these in Leyte and Bukidnon provinces
- 8 key informant interviews with DAR representatives in Misamis Oriental, Negros Occidental and Leyte provinces; 3 key informant interviews with Commission for Human Rights (CHR) employees at national level and in Misamis Oriental province and 1 key informant interview with police officer in Leyte province
- 4 focus group discussions with local NGO workers with minimum 5 and maximum 13 participants per group; 15 in-depth interviews with local NGO workers active in agrarian reform issues – 2 in Leyte, 3 in Misamis Oriental and 2 in Negros Occidental provinces as well as 8 at national level. The NGOs included KAISAHAN, established by one of the former DAR Secretaries in 1990, and ANGOC, active in land reform monitoring since 2010.

The semi-structured discussion between focus group discussion participants provided us with an opportunity to hear issues that may have not emerged from participants' individual interaction with us. The interaction among the participants led to increased emphasis on the participants' rather than our perspectives and permitted discovery of aspects of understanding that often remain hidden in the more conventional in-depth interviewing methods. Data were analyzed using content analysis where recurring themes were identified and coded to reflect the emerging patterns, which were interpreted later by the authors employing phenomenological approach using abductive reasoning. The paper also relies on dozens of semi-structured interviews with key Philippine and expatriate NGO workers and Philippine government representatives at various levels that were conducted by the first and second authors between November 2013 and February 2017 and helped to inform our understanding of CARP and land tenure issues in the Philippines as well as their dynamics.

We see the main limitation of this paper in the fact that agrarian reform is a multi-objective process involving ethical, political, social, economic and productive objectives among others. While such process necessitates complex, long-term evaluation, our constraints in terms of time and resources allowed us for just a rapid field appraisal. Moreover, in terms of sources of information we had to rely largely on peasants and local NGO workers and to smaller extent on DAR and CHR employees, all of which could contain several potential sources of bias, but were not able to conduct interviews with any of the landlords or local government representatives to triangulate the data and confront the reported information.

Results and discussion

1. Opposition to CARP/CARPER from landlords

During the focus group discussions and in-depth interviews across all studied provinces, opposition by landlords, either violent or through legal actions, was identified as a major setback in the completion of land redistribution. Agrarian reform beneficiaries reported to experience threats and harassment and in many cases physical harm. Negros DAR Regional Director recalled a daughter of an agrarian reform beneficiaries' leader having been raped, six assassinations of agrarian reform beneficiaries or prospective beneficiaries in 2016 only and many agrarian reform related harassment cases. Municipal Agrarian Reform Officer (MARO) in Ormoc municipality of Leyte province proclaimed the "resistance of landlords as the main challenge" for the land redistribution whereas landlords have the "access to state machinery and it is easier for them to mobilize trucks [full] of army [personnel] to protect their lands" than for agrarian reform beneficiaries to get police protection. According to DAR Regional Director, a landowner in Negros Occidental province engaged security guards to harass DAR land surveyors in order to delay coverage of his land by the agrarian reform.

Based on the anecdotal evidence collected by the authors during this research, a popular tactic by landlords is to pay a group of people to claim the very same plot of land that has already been or is about to be allocated to other peasants under the agrarian reform. During our research, we came to know at least four such cases in Leyte and two in Negros Occidental. In at least two of these Leyte cases, farmers disqualified by DAR were paid by the landlord to prevent those who received land ownership certificate from taking the actual possession of the land.

DAR informant in Misamis Oriental province reported that the "opposition from land owners to installation is very common. Sometimes it is because they claim that the Land Bank valuated their lands less than market rate." To make sure that the agrarian reform beneficiaries are able to take possession of the awarded land, DAR has to "schedule dialogue with local government units and police…" and make sure that police are present during the actual installation process.

In Cauayan municipality of Negros Occidental province, the 'blue guards' hired by the landlord used threats, intimidation and harassment to farmers and forced people to leave their homes and even closed down the church. In Cagayan de Oro municipality of Misamis Oriental province, a group of farmers claiming 18 hectares under CARP reported "harassment by hired goons who sprayed bullets" at them and destroyed at least 400 of their banana 'trees'. In Sugbongcogo municipality of Misamis Oriental province, a group of peasants who were awarded land ownership certificates for a 13.5-hectare coconut plantation were threatened and physically assaulted by the landlord's security guards until they gave up their efforts to take possession of the land. It was only few years later that an NGO and DAR under police protection helped them to finally take possession of the land. Even after that, the first harvest was taken by the people sent by the landlord, second time the farmers were able to harvest but the trucks with the harvest were confiscated by the landlord-hired good; this was confirmed by several DAR informants.

Landlords resort systematically to legal arguments as a way of delaying and thwarting the implementation of the agrarian reform and to de-legitimize farmers' stakes and claims to the land. The Sugbongcogo case has reached all the way to the Supreme Court where it has been pending for more than one year now. In a separate case of Sugbongcogo, the landlord filed motions for reconsideration to demand exclusion of several agrarian reform beneficiaries on the ground that they were either owning land or residing elsewhere. Such petitions of exclusion are also common in Negros Occidental according to DAR Regional Director and KAISAHAN. In Kabankalan municipality of Negros Occidental, the landowner representative is using a legal catch that the notification of coverage was supposedly not delivered properly to and received by the landowner in 2014 and with the CARPER expiration, DAR is not legally able to reissue the notification of coverage anymore.

In some cases, landowners have filed cases of qualified theft and trespassing when tenants entered fields they had been farming for years or when they tried to harvest crops they had planted. Protest actions of agrarian reform beneficiaries or prospective beneficiaries are being criminalized as was the case of Sumalo farmers in Bataan province where our CHR informant, who used to be their legal defender, "unarmed farmers, including women, are prosecuted for threatening and coercing heavily armed guards." Often security guards are filing these cases rather than landowners directly. In Cauayan municipality of Negros Occidental province there is a standing warrant of arrest against three peasants for supposed arson; they have been in hiding for seven years and could not attend hearings of the civil court cases related to their land. Interestingly, this particular group of agrarian reform beneficiaries adopted the tactics of counter-claims and there has already been 21 cases in total filed by either of the sides included coercion, harassment, ejection, serious physical injury; most of these have already been decided in favor of the farmers.

Another delaying tactics employed by landowners according to Negros DAR Regional Director are so-called 'chop chop titles' where the land ownership is transferred to dummies or distant family members. DAR can "still cover these lands but it takes quite a long time" to prove that the land division was only virtual or artificial in order to avoid compulsory acquisition.

Negros DAR Regional Director shared one of the strategies to overcome the opposition of landlords: "Landlords sometimes change their stance after they are visited by the Church representatives because you cannot say no to the Bishop." DAR informants in Misamis Oriental province explained how the mayor is instrumental in overcoming the landlord opposition: "Last time when the landowner was evicting

the agrarian reform beneficiaries from the CARP land, the mayor went with the police to help them back; the peasants are his voters." However, this cannot be expected when the political leaders come from landowning family clans like Llarazabals-Locsins in Ormoc or Bantugs-Benitezes, Starkes and Guanzons of Negros Occidental.

In concluding this subchapter, let us quote Negros DAR Regional Director: "CARP has been experiencing strong resistance from landowners even if due process has been observed. Would their resistance to a more radical Genuine Agrarian Reform not be much stronger?"

2. DAR capacities, performance and perceptions

The peasant focus group discussion participants mostly agreed that DAR despite 'being slow at times' is 'on their side'. Participants of one focus group discussion claimed: "DAR staff has become interested in the peasants' plight only after Mariano became the Secretary." At the same time, during several focus group discussions in Misamis Oriental and Negros Occidental, agrarian reform beneficiaries and prospective beneficiaries shared several anecdotes of collusion between DAR officials, at municipal and barangay (the lowest administrative unit) levels, with landowners and real estate developers in order to evade the land acquisition. Participants of one of the Negros Occidental focus group discussions agreed among themselves: "DAR and Department of Agriculture are very supportive, but the problem lies with the officials of local government units who are in pay of landlords." Interestingly, there is a large variability in barangay captains' attitude to farmers – from barangay captains who are actually agrarian reform beneficiaries themselves and are criminalized for their leadership efforts as in Sumalo of Bataan province, over barangay captains who are sympathetic or at least indifferent to peasants' plight to barangay captains who are likely corrupt or loyal to their landholding political patrons as our focus group discussion and interviews indicated.

One of the reasons why some agrarian reform beneficiaries in at least three sites in Negros Occidental were not able to get possession of their lands was the fact that the land boundaries according GPS coordinates on issued land ownership certificates were located in the ocean. While during the focus group discussion, the farmers were convinced that this indicates to corruption of DAR or Land Bank officials, DAR Regional Director had a different explanation: "We rushed in order to meet the July 2014 deadline for land acquisition by CARPER, so some mistakes during land survey have been made." In Sagay municipality, the area of CARPER lands in the sea is as large as 500 hectares. DAR can correct some of these obviously erroneous land redistributions, especially if the notice of coverage has been published, however, the Regional Director expects that "landowners will use [such errors] to file cases [disputing] the land redistributions. For notices with major problems and not published yet, the farmers have no choice but to wait for a promulgation of the new [agrarian reform] law which would warrant DAR" to continue with land acquisition. In Kabankalan municipality, the focus group discussion participants reported that a one-time MARO threated them with a gun during their non-violent protest and that later their 1995 file was supposedly lost by another MARO and thus they needed to restart the application process from the beginning. In Bago municipality of Negros Occidental province, Calumangan farmers have not hesitated to file a legal case against DAR for delaying CARP implementation in their case.

While there is a widespread assumption that CARP/CARPER faces lack of financial resources given the landlords' influence on the Senate, the key informant interviews conducted as a part of this research largely contradicted it. Provincial Agrarian Reform Officer (PARO) of Misamis Oriental reported that the office has "more than enough funds" for CARPER implementation and the problem is rather in recurrent underspending of these funds. This contrasted with the situation in Leyte province, where MARO in Ormoc reported lack of financial resources in the past few years while stressing the recent positive change under the new Duterte's administration. The difference in funding levels between these two provinces could probably be explained by the fact that, lying on the conflict-affected island of Mindanao, Misamis Oriental province is a primary target for foreign development assistance and most of the funds come from donors and lenders such as the European Union, Japan International Cooperation Agency (JICA), International Fund for Agricultural Development (IFAD), World Bank and Asian Development Bank (ADB) rather than through the government's annual budget allocation. The relative availability of foreign originated funds to support CARP was also reported in Negros Occidental by interviewed DAR and NGO employees.

3. Availability of support services to agrarian reform beneficiaries

The lack of support services and access to credit is a common problem reported by all the agrarian reform beneficiaries and NGO informants during the focus group discussions and in-depth interviews. Out of the 12 installed agrarian reform beneficiaries groups in Leyte, none has received any support services or had access to credit and finance from the government with the exception of one group of agrarian reform beneficiaries receiving a two-wheel tractor for paddy cultivation from the Department of Agriculture. Where limited support services were provided, these came rather from NGOs such as KAISAHAN rather than from the government; local government unit included some of the agrarian reform beneficiaries into their training program and seeds distribution program but they did not provide any machinery. MARO reported not to have had any funds for support services in 2016.

PARO in Cagayan de Oro stressed the fact that support services extended through Agrarian Reform Communities are available to all peasants regardless whether they obtained land through CARP/CARPER or not. At the same time, agrarian reform beneficiaries, who are not organized and living in an Agrarian Reform Community, do not receive any support in Misamis Oriental province. The largely foreign funded projects to Agrarian Reform Communities focus on high value crops such turmeric and cocoa as well as post-harvest facilities and value chain development for coco sugar or abaca fiber. The support also includes Farmer Business School, social entrepreneurship, sanitation in rural barangays and even biofuel production. Negros DAR Regional Director confirmed that in Negros Occidental, provision of support services is limited only to those who are organized. In creating necessary economy of scale for sugar cane cultivation, DAR has a real success story to report: "64 sugar block farms pulled their small landholdings to create larger farms which were then provided with technical assistance and establishment of nurseries with new crop varieties. The complete package included institutional development, shredders, farm equipment, cane loaders, organic fertilizers, tractors… They were also able to access agrarian credit program through the Land Bank." According to an informant from PAKISAMA, a national peasant confederation: "There are special show-case projects in three municipalities of Bukidnon province which receive a lot of support. These are especially resettlement areas [of the surrendered Huk rebel from 1950s]. In contrast to this, there are Agrarian Reform Communities, like Sumilao, that receive only limited support and even that takes too long. For example, mechanical dryer approved in 2013 by Department of Agriculture, has not been received yet. At the beginning DAR has provided us with 2 million pesos [approximately 40,000 USD] of seed funds and Department of Agriculture post-harvest facilities, but more is needed to bring about value addition."

An interesting opinion agreed among one focus group discussion participants in Negros Occidental was that "if DAR favors you, you get more" in terms of support services. In Escalante municipality of Negros Occidental, interviewed agrarian reform beneficiaries received financial support through the Land Bank and DAR, as well as training from DAR in accounting, financial management, strategic planning and leadership. One focus group discussion participants in Kabankalan municipality of Negros Occidental claimed that "DAR does not provide any support services here. We only know about one association around South Carlos which has received one tractor." Focus group discussion participants in Sugbongcogo municipality told us about planned Department of Agriculture distribution of cacao and coffee seedlings that was stopped by DAR because their "case was pending at the Supreme Court." Unlike in Leyte province, where NGOs are virtually the only provider of support services, Negros DAR Regional Director was critical about the fact that "NGOs focus just on farmers getting the land, but they lack the attention to what happens after that."

According to the NGO informants different DAR offices approach support services differently. In Negros Occidental "DAR is more effective compared to Negros Oriental where farmers can't get anything. In Negros Occidental farmers receive land ownership certificate in the morning and paycheck in the afternoon while elsewhere, farmers have to borrow from a loan shark using land ownership certificate as [collateral] security." During the focus group discussions and in-depth interviews farmers in Leyte and Negros Occidental often mentioned problematic access to credit. In both provinces, aryendo is reported to be rampant; in Leyte farmers reported that they take 3-month loans from rice traders with the usurious 30% interest rate per month, while in Negros Occidental the interest rate was supposedly 20% per month. Leyte farmers told us of a group of agrarian reform beneficiaries who lost effective

control of their lands because of a failed harvest and consequently their inability to repay the loan. Improvements in credit access will thus continue to be an important condition for achieving sustainable outcome of the agrarian reform.

The agrarian reform involves transition of peasants from mere dependent farmworkers to new farmer-owners. According to Negros DAR Regional Director, "attitude of farmers in the former sugar plantations and their feudal mindset from hacienda represent another challenge for the agrarian reform implementation and this needs to be addressed. As farmworkers, they are used to believe and obey whatever their landlord tells them. They are not able of critical, independent thinking." This important component of social transformation is left out by the agrarian reform and thus should be complemented by the civil society. According to Negros DAR Regional Director "in order to sustain the gains of the agrarian reform this needs to be done already by the time of the land distribution," so that the beneficiaries are ready to become viable entrepreneurs.

4. Other causes of land conflicts

Other causes for exacerbation of land conflicts and significant obstacles in successful agrarian reform implementation are premature land conversion, land grabbing, voluntary-offer-to-sell and conflicts with ancestral domain scheme under the Indigenous Peoples Rights Act as will be illustrated by following eight cases. In Kabankalan municipality of Negros Occidental province, three months after a 1,703-hectare sugar cane plantation was included in CARP coverage, MARO informed the farmers according to their narrative "that the land will be converted to housing estate and that municipality will make corresponding zoning ordinance." Such conversion is illegal without prior DAR approval, which has not been given in this case as Negros DAR Regional Director confirmed. In the meantime, the housing construction has been ongoing. Similarly in Cagayan de Oro municipality of Misamis Oriental province, 18 hectares of land has been put under the notification of coverage by DAR in January 2008 but before DAR managed to issue land ownership certificates, the application for land conversion from agriculture land to a housing project has been approved by the municipality. Informant from a group of agrarian reform beneficiaries from Hinoba-an municipality, Negros Occidental province who have been farming the lands acquired through CARP since 1999 told us about their concerns of a "possible eviction by the provincial government and local government unit because of a large-scale Japanese investment consisting of ecotourism project, airport and seaport."

In 1989 Sumalo farmers in Bataan province were offered 124 hectares of land through voluntary-offer-to-sell mechanism but before this had been processed, the landowner applied for land conversion. The farmers thus filed a petition to the Office of the President and succeeded in stopping the conversion. However, with the Supreme Court reversed the decision based on a technicality in 2006. After five years, during which farmers experienced harassment, staged several rallies, including one in front of DAR national office that lasted 1 year, 8 months and 6 days, DAR revoked the conversion because the land had not developed by the landowner in line with the approved conversion as prescribed by the law. However, the farmers have not obtained the control of the land yet. Another infamous case are Sumilao farmers of Bukidnon province who were struggling for 21 years to get land under CARP. In the last years of this struggle, their efforts were directed against the planned land conversion for the establishment of a hog farm by the San Miguel Foods Inc. Their efforts included hunger strike and a two-month 1,700-kilometre walk from Mindanao to Manila DAR national offices in 2007. Three years after this walk, the farmers have been awarded land ownership certificates for 144 hectares of land.

An NGO informant described how in Negros Occidental province Cuanco corporation supposedly used voluntary-offer-to-sell scheme to keep control of the land through lease back mechanism. After the voluntary-offer-to-sell was made, Cuanco built irrigation scheme and established orchards for pili nut, rambutan, durian and green tambis that led to very high valuation of the land which the farmers were not possibly able to pay. As a part of the leaseback package, Cuanco promised to pay rent of 10,000 to 15,000 pesos (200 to 300 USD) per hectare per year, provide jobs and payment of the annual amortization. However, reportedly, no jobs have been extended so far and amortization is yet to be paid.

We wrote elsewhere on the land tenure issues faced by indigenous peoples in Mindanao. One of the interviewed DAR representatives in Misamis Oriental cited as another reason for slow CARP/CARPER implementation that "almost all Mindanao is claimed by indigenous peoples as their ancestral domains. We have to issue our land titles within the ancestral domains if we

are to implement the agrarian reform at all." This informant also added that some indigenous people actually prefer to obtain the land titles through CARP rather than as ancestral domain based on the Indigenous Peoples Rights Act because under CARP "it comes together with support services." Several government informants, including CHR representative in Manila, referred to a recent violent conflict resulting in several deaths within one tribal community in Bukidnon province between a group of indigenous peoples who claimed ancestral domain titles and another indigenous group who received the land ownership certificates under CARP and leased it to an agribusiness for a large-scale pineapple plantation. A case from Malaybalay municipality of Bukidnon province shows that land redistribution may not only be delayed because of landlords, developers or agribusiness. A particular plot of land here had to be surveyed already five times by DAR, as the focus group discussion participants reported, because boundary stones were removed by other peasants from the same barangay who claimed to be legitimate beneficiaries as well.

Conclusion

It is difficult to define success or failure of an agrarian reform. The land redistribution achieved by CARP together with support services and infrastructure provided to Agrarian Reform Communities are undisputable success. However, as we showed on the cases from five provinces, the agrarian reform faces a range of significant challenges. We conclude in line with Cox et al. (2003), that also in the Philippines the implementation of agrarian reform encounters many critical constraints such as slow bureaucracy, lack of support services and landowning classes with the political and administrative connections to protect their vested interests leading to inadequate implementation of the reform laws. We showed how landlords resort systematically to legal arguments as a way of delaying the implementation of the agrarian reform and to de-legitimize farmers' claims to the land. In DAR's perspective, it is not cost-effective to provide a package of support services to a handful of agrarian reform beneficiaries and support services are thus largely limited only to the Agrarian Reform Communities. In most cases, the lack of adequate and appropriate support services, access to credit, farm implements, seeds, etc. remains a problem. As a result of weak managerial capacities of agrarian reform beneficiaries and limited access to credit not all beneficiaries become viable entrepreneurs and some may be forced to sell their newly acquired land because of their inability to generate sustainable income from it, inability to pay their amortization or ending in a debt-trap.

When discussing land reform, its political aspects are no less important than its economic aspects. The landowner class tends to be well represented in the ruling elites of most developing countries, which gives "them enormous political power that they can use to block, stall, or undermine efforts to carry out land reforms" (Banerjee, 1999). As shows the experience of "Taiwan and South Korea, where successful land redistribution took place after the end of a major war and under the 'communist' threat, and… Indian states of Kerala and West Bengal, where land reforms were key elements in egalitarian social change," the success of a land reform "ultimately depends upon strong political power allied to land reform challenging resistance by landed interests" (Cotula et al. 2006). We are reaching the same conclusion as Lavelle (2013) formulated in connection with the land reform in Venezuela that rather than confronting power structures the agrarian reform in the Philippines left landowners in dominant economic positions.

Many questions for further multidisciplinary research unfold from our work both in terms of land/agrarian reform in general or CARP/CARPER in particular. Is there a correlation between left-wing insurgency and extreme inequity in the land distribution in rural areas? What is the relationship between the land inequality and the poverty reduction potential of agricultural growth? What is the impact of CARP/CARPER on competitiveness or economic welfare of the agrarian reform beneficiaries? How has the relevance of land distribution to small farmers been changing over the almost three decades of the agrarian reform implementation given the rural-urban migration, aging farmer population and decrease in the relative importance of agriculture in the Philippine gross domestic product? Is the assumption that land reform may help keep people in rural areas instead of them moving to cities correct? Since there is not enough land available to provide to all the prospective agrarian reform beneficiaries, what are the alternatives? For cultivation of certain crops, such as sugar cane, economy of scale is critical, what are the best effective ways to consolidate the distributed lands?

The authors are aware that a complex

and progressing program like the agrarian reform in the Philippines is difficult to capture in its entirety, hence this study does not claim to cover fully all the relevant aspects. However, we believe that our results will provide useful information and guidance for policy makers as well as for other researchers.

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Measurement and Statistical Analysis of End User Satisfaction with Mobile Network Coverage in Afghanistan

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Abstract

Network coverage is one of the fundamental requirements of any business of a service provider. Mobile operators are expected to deploy base stations in an effective way in order to cover most of the residential areas of a particular country. Improved network coverage leads to increase total revenue, provide end users with enhanced Quality of Services (QoS) anytime anywhere, and play vital role in the development of telecom sector. In this paper, we measure and statistically analyze network coverage of mobile operators in Afghanistan. Our study is based on primary data collected on random basis from 1,515 mobile phone users of cellular operators. The relationship between "No Network Coverage" in some residential areas and "Satisfaction of Mobile Phone Users" is also investigated. We furthermore propose realistic, feasible and cost-efficient solutions to mobile operators and policy makers in order to expand network coverage to non-covered residential areas as well as enhance the performance of networks in existing covered areas of the country.

Keywords

Mobile network, network coverage, measurement, statistical analysis, end user, quality of service, end user satisfaction, Afghanistan.

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Introduction

Mobile network coverage is considered one of the fundamental requirements of cellular networks. In order for an operator to provide coverage for a desired area needs to install base stations in appropriate locations and furthermore optimize network from time to time. The more an operator expands coverage area the better it builds a strong brand, which leads to inspire customer loyalty and grows market share. However, it takes most operators six to seven years to build a network with nation-wide coverage when introducing new technologies. For example, a mobile operator in Germany (Telefonica – which uses the O2 brand) began deploying Long Term Evolution (LTE) in 2011, and it took seven years (2017) to cover more than 95 % of the population. In reality, this operator achieved nation-wide Global System for Mobile Communication (GSM) coverage by using 900 MHz several years ago. They could not however deploy LTE on this frequency as the spectrum was occupied by GSM (HUAWEI, 2017).

Providing of network coverage in urban areas is a challenging task due to high-rise buildings, trees, massive number of end users, etc. Dense located buildings in urban areas do not only attenuate the received signal power but also weaken the undesired signal, i.e., the interference. On the other hand, low-density population in rural areas are not cost-efficient for operators to provide services. However, every residential area is required to be covered and people need to be provided with telecom services equally without considering their locations. Therefore, each area needs its own specific scheme to be covered considering

demographic data, QoS, Capital Expenditures (CAPEX), and Operational Expenditures (OPEX).

Recent statistics provided by ITU shows that globally cellular networks cover 95 % of residential areas in the world (i.e. around seven billion people) (ITU, 2016). Mobile broadband networks (3G or above) reach 84 % of the global population but only 67 % of the rural population. By the end of 2016, 3.9 billion people – 53 % of the world's population – was not using the Internet, it specifically means that one out of two people (47 %) in the world are using the Internet. Based on these facts, there are still more residential areas (both rural and urban) in the world, which are required to be covered and people need access to enhanced telecom and internet services as a basic human right (ITU, 2016).

On the other hand, according to (Cisco, 2017), there will be 11.5 billion mobile devices by 2019. Mobile data traffic is globally expected to grow up to 24.3 Exabytes (EB) per month by 2019 – nearly a tenfold increase in comparison to 2014. The ever-increasing amount of mobile data traffic moves technical experts forward to seek various techniques and schemes in order to handle challenges in different parts of mobile networks.

The Afghanistan Telecom Regulatory Authority (ATRA) and Ministry of Communication and Information Technology (MCIT) claim that 89 % of residential areas in the country is covered by network coverage (ATRA, 2016). However, no detailed report has been published to prove and verify the accuracy of this claim. Subsequently, no study has been conducted so far to measure the quality and satisfaction of end user with network coverage. Therefore, in this study we are going to measure and furthermore statistically analyze end user satisfaction with mobile network coverage in Afghanistan. We will also focus on how to improve existing network coverage and furthermore expand it to non-covered residential areas. It is worth noting that, we are only dealing with expansion of network coverage to non-covered areas and improving of outdoor coverage, thus, the optimization of in-door coverage is not in the scope of our study.

There are couple of studies, which empirically analyze end user satisfaction of mobile operators with employing of different methodologies and various variables. A study has found in Turkey that satisfaction of mobile phone user is associated with wide and improved network coverage, efficient customer service, enhanced QoS, and fulfilling the expectations of end users (Aydin and Ozer, 2005).

Three more empirical research studies in Hong Kong (Woo and Fock, 1999), China (Wang and Lo, 2002) and South Korea (Kim and Jeong, 2004) have found many factors i.e. wide and improved network coverage, reasonable pricing policies, enhanced QoS (both voice and data), value added services and customer support which influence end user satisfaction.

A study has recently been conducted in Pakistan discovered that service quality, price rate, brand image, sale promotion and improved network coverage have significant impact on end user satisfaction (Iqbal, 2016). While, (Khan, 2010) has found that tangibles, reliability, responsiveness, convenience, assurance, empathy, and network quality have statistical significance relationship with end users satisfaction.

Moreover, a comprehensive survey based research has recently been conducted to measure and analyze satisfaction of end users with QoS of mobile operators in Afghanistan (Habibi et al., 2016). This study analyzes the relationship between various variables and end user satisfaction through hypotheses testing and furthermore proposes adequate technical solutions for operators in order to overcome existing challenges in the area of QoS. Most of the above studies and in particular (Habibi et al., 2016) measure and furthermore statistically analyze satisfaction of end users with QoS of mobile networks. But a detailed study in order to measure and analyze end user satisfaction toward network coverage, and the most unwanted situations which mobile phone users experience are missing in the literature. In order to fulfil this gap, we have taken this initiative by conducting a survey-based research in Afghanistan. We have thoroughly analyzed and furthermore tested the relationship between "End User Satisfaction" and "Network Coverage". Despite that, we have proposed adequate and realistic recommendations in order to address existing challenges in the area of network coverage in the country.

Mobile networks in Afghanistan

A modern, secure, effective and nationwide telecom infrastructure in the country helps to stimulate economic growth, raise living standards of ordinary Afghans and restore the traditional sense of community and common purpose that unites the Afghan people. It furthermore enhances the effectiveness, efficiency and transparency of public sector, improves delivery of social

services, and builds a peaceful and unified society. Considering geographic feature of the country, mobile networks play vital role in narrowing of the physical distances that separate Afghan villages and towns and furthermore dramatically improve access to educational opportunities, humanitarian relief efforts, and even e-health and e-business services.

Considering geographical feature of Afghanistan, a telecom sector with above characteristics does not only play vital role in the transformation of country but can also bridge South-Asia with Central-Asia and China with Middle East. The country has the opportunity to take advantage of its unique geographical positon, and to become a hub for regional connectivity and economic exchange. One of the most important drivers for regional connectivity and cooperation in telecom sector is the political commitment of the region. To achieve this, the region requires robust institutional frameworks in order to plan and furthermore implement regional connectivity agenda.

The Afghan government has been putting many efforts in the telecom sector since 2002. For the time being, there are in total five mobile (four private and one stated-owned) and one landline state-owned operators in the country. The Afghan Wireless Communication Company (AWCC), Etisalat – Afghanistan (ETA), Mobile Telecommunication Network – Afghanistan (MTNA), Telecommunication Development Company Afghanistan (TDCA or Roshan) are the private and Salam is the state-owned mobile operators. The state has its own public landline operator namely the Afghan Telecom (AFTEL). A detailed history of telecom sector and deep insight to each of the operators can be found in (Hamdard, 2012), (UN-ESCAP, 2015), (Baharustani, 2013) and (infoDev, 2013). All operators have built their own broadband microwave backbones. A nationwide 3,100 kilometers of optical fiber network has also been established by AFTEL throughout the country (Habibi et al., 2016). So far 7,155 base stations are installed which cover 89 % of the residential areas (ATRA, 2016). The MCIT has purchased the first ever satellite in the history of the country (AfghanSat One) in 2014. China and Afghanistan have signed an agreement on April 20, 2017 to launch the second satellite (AfghanSat Two) to the space and furthermore lay direct 480 kilometers of optical fiber to connect both neighboring countries (3GCA, 2017).

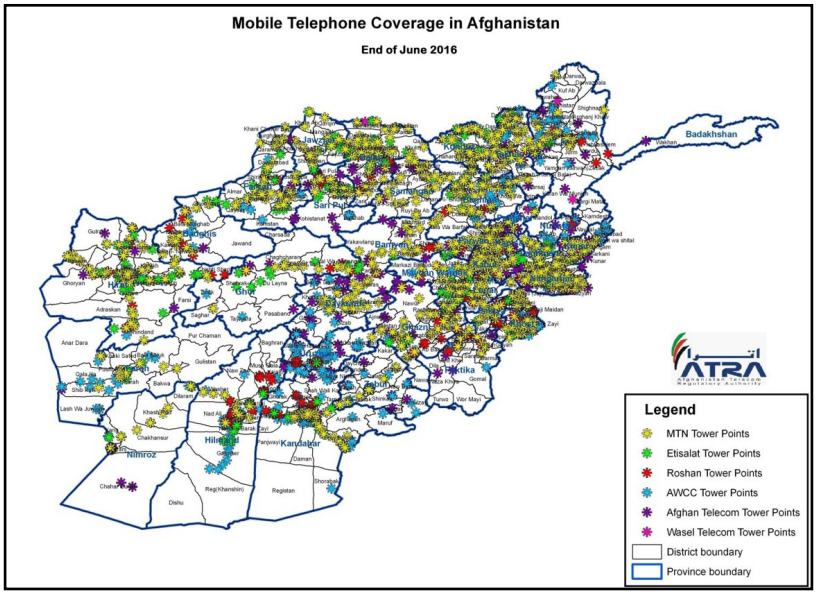
Alongside all these positive changes and development, there are still some challenges within the telecom sector requiring more effort to be overcome. It can be derived from the previous paragraph that mobile operators do not cover 11 % of the residential areas and Afghan citizens living in those areas still do not have access to telephony and internet services. According to (Habibi et al., 2016), 16 % of end users are unsatisfied, 28 % are neutral, and 3 % are very unsatisfied with the QoS of mobile telephony service. The study has found that 32 % of end users were complaining from low signal intensity, 18 % from blocked calls, 17 % from dropped calls, 11 % from echo, and 14 % from noise during usage of mobile telephony (Habibi et al., 2016). The authors in (Habibi et al., 2016) have further discovered that 32 % of end users are unsatisfied and 12 % are very unsatisfied with mobile internet service.

There are still more efforts needed to be put by policy makers and public and private sector in order to overcome the abovementioned challenges, provide fully nationwide telecom services, enhance the QoS and increase end users' satisfaction, and build a modern and secure telecom infrastructure. The ATRA/MCIT should first provide solutions to existing challenges in the sector, and then take a step forward to work on regional connectivity in order for the country to act as a digital bridge within the region.

Network coverage footprint

A cellular network is distributed over small areas called cells; each cell is served by at least one fixed-location transceiver known as a cell site or base station. The cell site can further be divided into sectors. The combination of cells is called a cluster, which is served by a Base Station Controller (BSC) or Radio Network Controller (RNC). A cellular network can be made of thousands of cells, hundreds of clusters and tens of RNCs.

These sectors, cells, and clusters are joined together in order to provide network coverage over a large geographic area. When a cellular network provides coverage, it enables a large number of UEs to communicate with each other and with fixed landline telephones anywhere and anytime. The base stations provide mobility facility to both low speed and high speed UEs during telephony and data services. The size, shape, and capacity of a cell and network coverage depend on demographic data and natural factors such as mountains, desserts, highway etc. The quality of coverage is measured in terms of location probability. Therefore, the radio propagation conditions have to be predicted



Source: (ATRA, 2016)

Figure 1: Network coverage footprint in Afghanistan.

as accurately as possible for that specific region.

A detailed view of network coverage in Afghanistan provided by 7,155 base stations is shown in Figure 1. The ATRA/MCIT do not publish number of passive and active base stations in the country, so in order for us to predict the accuracy of the network coverage penetration. According to the information we have obtained from some of the engineers workingwith different operators, there are many base stations in different provinces, which are currently switched off by operators due to various reasons. According to their decade of experience, they doubted that mobile networks would cover 89 % of the country. ATRA/MCIT should provide a detailed report of the entire telecom sector every quarter of the year to move operators forward in order to improve network coverage and QoS.

Existing challenges

Despite all positive developments mentioned in previous section, there are still some challenges on the road to future growth of telecom sector in Afghanistan. Some of these challenges have complex relationship with other sectors i.e. education, security, reconstruction, etc. In this subsection, we will only focus on the existing challenges related to network coverage of mobile operators.

- According to ATRA, cellular networks do not cover 11 % of the residential areas in the country. It means that massive number of Afghans still do not have access to mobile phone and internet services (ATRA, 2016).
- Referring to (Habibi et al, 2016) and the result of our research in this paper, majority of Afghans are not satisfied with the quality of existing 89 % of network coverage. It specifically means that satisfaction of end users has been rarely considered by operators. The quality of existing service and the performance of networks should be improved.
- The continued security threats in some parts of the country present a high level of risk and uncertainty for operators to expand network coverage. The telecom sector itself has become a target from non-state elements. Since February 2008, mobile networks have regularly shut down their base stations at night to avoid attacks from criminal elements, six towers were attacked and five workers have been killed (infoDev, 2013).
- The telecom infrastructure cannot currently support high capacity networks and advanced technology approaches. The optical fiber ring and microwave backbones are not installed according to international norms and standards in some places, the sector is still facing lack of skilled labors, and of course, corruption which is impacting it at certain levels. All of these challenges have direct influence on performance and expansion of network coverage.

In order to overcome abovementioned challenges, the MCIT/ATRA have to come first with modern

and strategic solutions to solve these fundamental and infrastructural problems and then move forward to the regional connectivity and implementation of next generation technologies.

Materials and methods

It is vital to choose an appropriate strategy for measurement of network coverage in order for the operators to have a detailed view of their services and networks across a specific geographic area. Vendors, operators, regulatory bodies, and researchers around the world have been trying to propose different strategies in order to measure network coverage from various perspectives and at different stages of network deployment. Measurements should be chosen corresponding to the needs in the stages of planning, development, installation, and maintenance of network coverage.

There are different ways to measure network coverage i.e. operators measure a specific geographic area using Radio Frequency (RF) test such as drive tests (Aydin and Ozer, 2005) in order to figure out signal strength of propagated RF by their base stations' antennas, regulatory bodies conduct survey for public to find out end users' satisfaction degree from operators' services, and so on.

In this paper, we analyze mobile network coverage from the end user perspective in Afghanistan. We conducted a survey in order to figure out end users' satisfaction with network coverage. The survey of this research was originally conducted to study both network coverage and QoS of mobile networks in Afghanistan, but primary data only related to network coverage is measured and analyzed in this paper. We prepared questionnaire (containing 15 questions) in English, Pashto and Dari languages. All technical terms in the questionnaire were explained in such a way, which were easily understandable for ordinary mobile phone users. The survey only covered end user practices, therefore, we use an effective evaluation method of multiple-choice questionnaire.

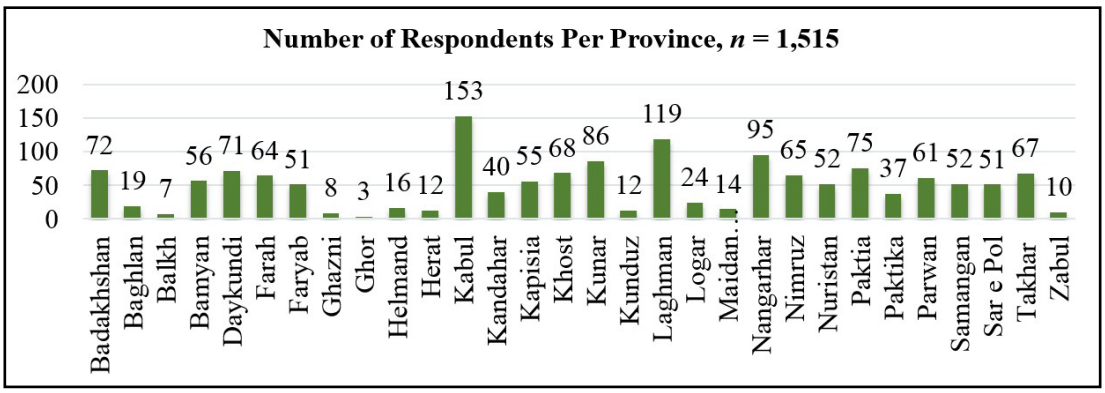
Results and discussion

In the beginning, we conducted a pilot survey on a small group of mobile phone users through in person interviews in Kabul in order to test questionnaire. Based on feedbacks from the target group of respondents, necessary changes have been brought in the strategy as well as confirmed in the final draft of the survey. We have subsequently employed the mix-mode technique of data collection from 1,515 mobile phone users during (August – December) 2015. In practice, we collected 812 respondents over the internet using Google Docs from 30 provinces and volunteer surveyors interviewed 703 respondents in person whithin 14 specific provinces. The total number of respondents who attended the survey from all 30 provinces is shown in Figure 2. The average number of respondents per province (mean) is 50.5.

All respondents have answered about their age, gender, level of education, favorite mobile operator, the time each of them has spent with their favorite mobile operator, and the purpose of mobile phone usage. The result of all these variables are shown in Table 1.

The measured data related to the ages of mobile phone users is shown in Table 1. The result illustrates that more than half of the mobile users are between 18 – 30 years old, which clearly declares generational divide in access and usage of mobile phone service in Afghanistan.

The result of data furthermore finds gender inequality in access to mobile phone service



Source: Own processing

Figure 2: Number of respondents per province.

No.	Variable	Attribute	Outcome (%)	No.	Variable	Attribute	Outcome (%)
1	Age (Year)	< 18	11	4	Operator	AWCC	14
		18 – 30	59			ETA	30
		31 – 45	24			MTN	23
		> 45	6			Roshan	19
2	Gender	Male	75			Salam	14
		Female	25	5	Time with Operator (Years)	< 2	28
3	Education	Illiterate	8			2 – 5	52
		Primary	13			6 – 10	17
		Intermediate	10			> 10	3
		High School	28	6	Purpose of using of Mobile Phone	Telephony	48
		Bachelor	33			Internet	4
		Masters	8			Both	48

Source: Own processing

Table 1: General variables of the survey.

in Afghanistan. As shown, three out of four of mobile phone users are males while only 25 % are females. There are couple of reasons of gender inequality in access and usage of mobile phones in a developing country such as Afghanistan. Many research scholars have pointed out that high illiteracy rate of females, patriarchal societies, limited access to telecom services, structural and cultural barriers within the society are main reasons, which led to gender inequality in developing world (Primo, 2003).

Education has significant role in removing barriers on the way to use mobile phone as well as its service (Primo, 2003). Therefore, level of education of end users has been asked in the survey in order to specifically find out that how does significant is it in access and usage of mobile phone service. Based on the results shown in Table 1, only 8 % of end users who use mobile phones are illiterate while the rest of the end users are having various level of education. It is concluded that massive number of mobile phone users in the country are literate while a small amount is illiterate.

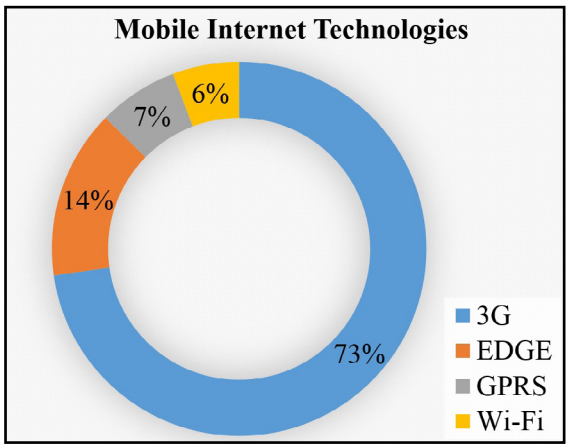
The end users were asked about their favorite operator in order to find which one of the operators is leading the market. It can be concluded from the result of the survey shown in Table 1, that ETA is the leading telecom operator in Afghanistan from end user perspective while the state-owned GSM operator Salam is at the end of the list (see the Table 1).

The respondents were further asked about the time they have been using their current SIM card in order to measure end user loyalty. The results in Table 1 shows that roughly half of the end users have been using their favorite network operator from two to five years, while only 3 % stay with their network operator more than ten years. The loyalty of end user depends on various factors, but most important are wider area of network coverage, enhanced QoS, reasonable price for the service, and various types of services offered by the operator.

Mobile phone users use a cellular phone in order to send/receive message, access to internet, send/ receive email, download apps, get directions, recommendations or other location – based information, participate in a video call or video chat, “Check in” or share location, and so on. In the questionnaire, all of the mentioned applications of mobile are divided into 3 categories, mobile for internet purposes, mobile for telephony purposes and mobile for both internet and telephony purposes. The Table 1 furthermore shows, that usage of mobile phone for telephony and internet purposes are roughly same, while only 4 % of mobile phone users in Afghanistan use mobile phone only for internet purposes.

For the time being, the most advanced mobile technology, which is provided by all operators in the country, is UMTS. However, the MCIT has recently announced to launch Fourth Generation (4G) services across the country (Kabultribune, 2017). There are still some areas which are covered by EDGE, GPRS, and in some cases, the end users use Wi-Fi in their homes or small offices. The result of the survey in Figure 3 shows that roughly three out of four of end users use 3G (UMTS) service, 14 % EDGE, 7 % GPRS, and 6 % use mobile

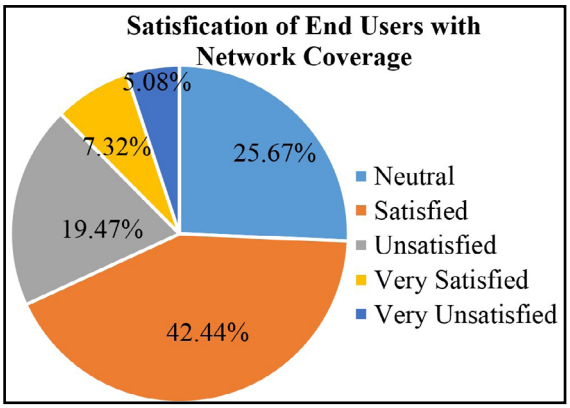
internet technologies for Wi-Fi purposes.



Source: Own processing

Figure 3: Mobile internet technologies.

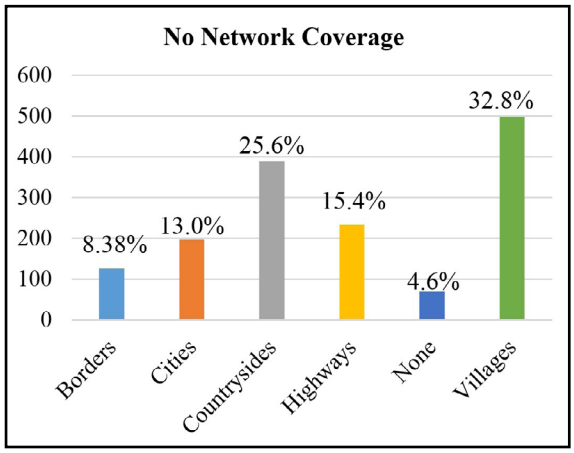
The survey explores satisfaction degree of end users with mobile network coverage in the country. According to Figure 4, 42.44 % of end users are satisfied with the network coverage of mobile operators in the country, 19.47 % are unsatisfied, 7.32 % are very satisfied, 5.08 % very unsatisfied, and 25.67 % neutral.



Source: Own processing

Figure 4: Satisfaction of end users with Network Coverage.

The survey furthermore indicates the areas where end users mostly experience "No Network Coverage". The result in Figure 5 shows that most of the end users are experiencing "No Network Coverage" in villages (32.8 %), 8.38 % in the areas, which are closed to country's borders, 13 % in the cities, 25.6 % in the countryside, 15.4 % on highways, the rest 4.6 % of end users are satisfied with network coverage and do not experience "*No Network Coverage*" at any of the above places.



Source: Own processing

Figure 5: Areas where end user experience No Network Coverage.

Statistical analysis and hypothesis testing

There are in total two categorical variables which create one hypothesis based on the data related to the network coverage of mobile networks in Afghanistan. Associations between these two variables should be tested. Hence, *Goodness-of- Fit (Chi-Square)* test has been chosen to deploy on the hypothesis in order to find dependency.

Before conducting the chi-square test, it is necessary to set up significance level. We have considered 95 % significance level (α = 0.05). As shown in Equation 1, it is determined by multiplying of "number of rows minus one" by "number of columns minus one".

$$DF = (r - 1) * (c - 1) \quad (1)$$

r = No. of rows, c = No. of columns

In next step, the below given formula (Equation 2) is used to perform chi – square test.

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i} \quad (2)$$

k = No. of categories, χ^2 = Chi-square

i = No. of parameters being estimated

O_i = Observed frequency, E_i = Expected frequency

As mentioned earlier, after obtaining the χ^2 value, it should be compared with critical value from the distribution table considering DF. The final decision is made based on this comparison. If the "chi-square value > table value", the hypothesis is rejected, otherwise, it is impossible to reject.

Out tested hypothesis is stated as follows:

Is there any dependency between categorical variables of 'No Network Coverage in a Geographic Area' and 'Satisfaction of End Users with Network Coverage' of mobile operator in Afghanistan?

The first step is to state the null hypothesis (H_0) and alternative hypothesis (H_1).

- H_0 = There is no association between *'No Network Coverage'* and '*Satisfaction of End Users'*.
- H_1 = There is an association between '*Not Network Coverage'* and *'Satisfaction of End Users'*.

The Statistical Application System (SAS) software is used in order to conduct chi-square test, create contingency table and calculate *DF*. Based on the results obtained from SAS, the *DF* and χ^2 values are given below:

$\chi^2 = 307.4957$, $DF = 20$

The contribution table value considering 20 *DF* and $\alpha = 0.05$ is 31.410. As calculated, contribution table value is less than comparing to chi-square test value (307.4957 > 31.410), therefore, the null hypothesis is rejected.

307.4957 > 31.410 > Reject H_0.

To conclude, there is statistically significant evidence at $\alpha = 0.05$ that H_0 is false. Thus, it can be claimed that, there is dependency between categorical variables of '*No Network Coverage*' and '*Satisfaction of End Users*' of mobile networks in Afghanistan. It specifically means that, *No Network Coverage* in a geographic area has significant impact on the *Satisfaction of End Users* of mobile operators in Afghanistan.

The power of dependency calculated by SAS and shown by *Phi Coefficient (φ)* value is 0.4505, therefore, it can be claimed that there is a high dependency between two categorical variables.

Proposed solutions and recommendations

There has been considerable research on providing, expanding and optimization of network coverage in all types of areas. However, in real world, the deployment areas of wireless networks are always geographically bounded. It is a much more challenging and significant task to find optimal solutions to cover a specific geographic area. In order to expand network coverage to non-covered residential areas and to improve the quality of existing network coverage in Afghanistan, we propose the following recommendations.

Inter-operator infrastructure sharing

Afghanistan is made up of rugged mountain terrains, deep valleys and large pieces of deserts. It is very uneconomical and inefficient for a single operator to expand and provide its services for the people who are living in the deserts of Helmand and Kandahar as well as in the mountains of Badakhshan and Kunar. The traditional model of single ownership of all the physical network elements and network layers by mobile network operators has mostly changed in developed countries. Most operators around the world share their infrastructure with others in order to decrease both CAPEX and OPEX. It further results in the expansion of network coverage and improving of QoS, whilst having a very positive environmental impact and optimizing national scarce resources.

In mobile networks, sharing can occur at various levels and different stages. There could be various combinations including the base station site, radio equipment, RAN, Core Network (CN), roaming, power, wireless/wireline backhauls, cooling equipment, antenna cables, antennas, tower masts, and so on. However, all these various kinds of sharing are categorized into three types, passive sharing, active sharing, and roaming-based sharing (Meddour et al., 2011).

The sharing of space or physical supporting infrastructure, which does not require active operational co-ordination between mobile operators' interconnection, is called passive sharing i.e. space or tower sharing. The sharing, which requires operators to share the nodes of active network layers and coordinate with each other during operation, is called active sharing i.e. radio equipment, wireless backhauls and so on. Roaming-based sharing refers to the context of network sharing where an operator relies on the network coverage of another operator and define footprint on either permanent or temporarily basis.

Worldwide, there are many experiences of network infrastructure sharing. At the beginning of 2013, four largest European mobile operators (Deutsche Telecom, France Telecom, Telecom Italia and Telefonica) discussed the possibilities of sharing their resources. The European Commission actively forwarded this cooperation. The occurrence of the new Pan-European operator acting upon network sharing model is possible in the very nearest future due to the efforts of the executive bodies of the European Union (EU)

(Thomas and Barker, 2013). Studies have found 90 % cost efficiency between shared and non-shared networks for real dense deployments with both homogenous and heterogeneous infrastructure sharing in Poland (Kibiłda and DaSilva, 2013). Middle Eastern and North African countries i.e. Jordan, Morocco, Oman, Saudi Arabia and the United Arab Emirates mostly have roaming-based sharing infrastructures (Meddour and et al., 2011).

In the light of global experience and considering both cost efficiency and coverage optimization, we strongly recommend to both private and public sectors as well as policy makers in Afghanistan to deploy inter-operator infrastructure sharing in order to expand network coverage for the rest of 11 % of uncovered residential areas, which is going to further result in enhancing of QoS. We encourage the ATRA to take this initiative by extensively studying the experience of some of abovementioned countries/operators and form regulations, which include legal, technical and commercial aspects of inter-operator infrastructure sharing scheme.

Regular network optimization

Network optimization can help operators to assess and audit the performance of their networks using the full range of available data, and identify various aspects of the design and operation that can be improved. There is certain number of tests and tools which are used to perform network optimization within a specific period of time. The audit will typically result in a series of recommendations and an action plan for network design and performance improvement, along with a process for ongoing performance review and analysis, which is going to reduce outages, improve the customer experience, and simplify network control and operations.

We recommend telecom operators to be strongly committed to the regularity of network optimizations in order to improve network coverage and enhance QoS. We furthermore propose to the ATRA to monitor the regular optimization process of telecom operators and to share the performance report of the entire telecom sector quarterly or at least once a year. These reports are going to move operators forward to enhance the QoS and improve network coverage. Meanwhile, the civil society and mobile phone users will have access to update information and current status of this sector.

Telecom Development Fund

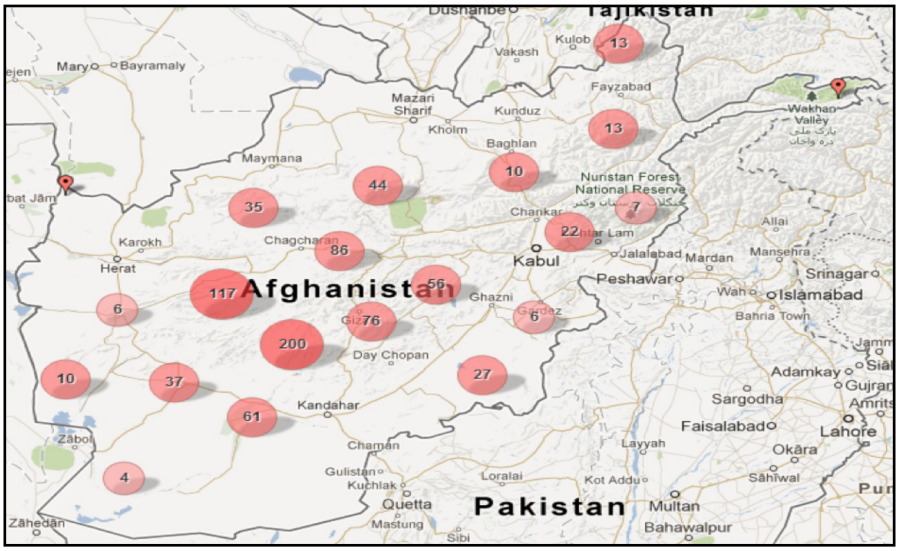
The MCIT/ATRA have a certain amount of fund namely Telecommunication Development Fund (TDF) under the Universal Access Program (UAP). The main purpose of this fund is to promote rural access to telecom services. In this program, a specific residential area is targeted to be covered by mobile networks, the project is announced and the construction of base stations are awarded to mobile operators on a competitive basis and will be operated and maintained by these operators upon completion. Despite having this fund, the MCIT/ATRA still is not able to expand the coverage to non-covered residential areas or improve the quality of existing network coverage.

We strongly recommend to the policy makers, the MCIT and the ATRA to use this fund efficiently, effectively, and furthermore encourage mobile operators to provide telecom services to non-covered areas.

Low orbit satellite

Due to the aim to offer mobile and data services in rural residential areas with very low density of end users, some operators developed a solution consisting to use low orbital satellites. However, this approach is not easy to be operated. The main drawback of this solution is the high level of sophistication needed to build, launch and operate a satellite as well as high CAPEX.

In the light of low orbit satellite experience, we also recommend to operators particularly to the state-owned ones to use low orbit satellite in order to provide services for rural areas in some districts such as Bamyan, Daykundi, Badakhsham, Noristan, and other provinces. However, the AFTEL has established a satellite-based network in 800 villages to provide access to the telephony and internet services in rural areas and countryside. This program is called Village Communications Network (VCN). A terminal covers each village in a specific area and the terminal is subsequently connected to the satellite. The MCIT claims that over a million of Afghans have benefited from VCN project (infoDev, 2013). The numbers in Figure 6 represents the locations and the density of terminals in the corresponding area. However, there are still more villages and districts that are not covered and the MCIT/ATRA are expected to do more using this scheme.



Source: (infoDev, 2013)

Figure 6: Village communication network in Afghanistan.

Implementation of telecom standardization

Despite above recommendations, one of the most vital factors which increasingly enhance quality of network coverage is the implementation of technical schemes such as deployment of small cells, high order sectorization, infrastructure sharing, beamforming, etc. according to ITU standardization. There is no study to prove that mobile operators and the ATRA mostly or rarely do not follow those unified global standards, but based on field observations of authors from the field, it can be claimed that standardizations are not followed from time to time in the telecom sector of Afghanistan. For example, while deployment of national optical fiber ring, the contractors used to put the cable in depth of few centimeters, which are not according to international standardization. Therefore, we strongly recommend to the MCIT/ATRA to monitor the deployment of global unified standardization in telecom sector in order to enhance the performance of mobile networks, which furthermore result to improve end users' satisfaction.

Conclusion

In this paper, we measured and statistically analyzed end user satisfaction with network coverage of mobile operators in Afghanistan. We thoroughly studied the current status of network coverage along with existing challenges. We have also tested the relationship between *Satisfaction of Mobile Phone Users* and *No Network Coverage* in some residential areas. In order to expand mobile services to non-covered residential areas and to enhance the quality of network coverage, we have recommended infrastructure sharing, regular network optimization, efficient and effective use of TDF, low orbit satellite and consideration of unified global standards during network deployment as adequate solutions for telecom sector of Afghanistan. In future, we are interested to work on each of the proposed solutions and recommendations of this paper individually.

Acknowledgements

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Creating a Database of Peonies and Its Use for Teaching IT Courses

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Abstract

The aim of this paper is to describe one of the possible ways of making IT courses more interesting through collecting practical field data and a subsequent creation of databases. Since the establishment of a specialized peony garden near Prague in 2008, details of the origin of acquired plants and of their cultivation under local conditions have been continuously recorded. The data resulting from the peony research are used as support for our IT courses. They are used in practical modelling of a relational database and in creating student projects focused on responsive web designs. The peonies data make the IT courses more attractive and stimulating for students.

Literature survey of the peony research publications and our own data obtained from the peony garden revealed some of the main problems in cultivating and identification of peonies. Herbaceous peonies are widespread perennials. Mostly "historical" varieties of Paeonia lactiflora are cultivated. However, these plants have long and weak stems, which are bent down by heavy flowers and must therefore be mechanically held up by stakes or support rings. By contrast, the new cultivars have solid stems, such as the hybrid herbaceous peonies and intersectional hybrids (Itoh hybrids) and do not require as much labour but are not commonly cultivated. Our research has discovered that most peony cultivars in home gardens have not been properly identified. Great emphasis has, therefore, been placed on the correct identification of peony cultivars.

Keywords

IT, peony, Paeonia, cultivar identification, database, responsive web design.

Havlíček, Z., Lohr, V., Junek, P. and Rajtr, J. (2017) "Creating a Database of Peonies and Its Use for Teaching IT Courses", *AGRIS on-line Papers in Economics and Informatics*, Vol. 9, No. 2, pp. 59 - 66. ISSN 1804-1930. DOI 10.7160/aol.2017.090205.

Introduction

Information technology (IT) requires suitable teaching materials and examples to explain how new applications operate in different work environments. The authors of this paper have selected peonies as one of the primary sources of raw data for teaching IT courses since they are all involved in IT research at the Czech University of Life Sciences Prague in the vicinity of peony garden. Below they are presenting a data model for the creation of a specialized database of peonies.

Peonies (lat. *Paeonia spp*.) are one of the most versatile perennial garden plants in many countries. Peonies are wonderful, fully hardy and long living herbaceous or tree plants. Their flowers have different colours and shapes and are often sweet smelling. Cut peonies are very popular, especially for weddings. The Netherlands is the main producer of cut peonies with approximately 55 million stems annually (Kamenetsky and Dole, 2012).

There are thousands of cultivars of peonies. Some gardeners occasionally sell peonies under names, which are not correct. We often get peonies from our neighbours or find them in the garden inherited from the parents and have no idea what cultivar they are. On the other hand, there are gardening shops or farms specialised in breeding peonies where the cultivar origin is more certain. Rogers (1995) gives an example of how the Brand Nursery Company sold the 'Edulis Superba' cultivar under 22 different names at the beginning of the 20th century. Therefore, in 1903 the American Peony Society (APS) was founded in order to maintain an official register of the cultivars origin. The key purpose of the plant registration is to give a unique label to a plant within a genus, or to place cultivated plants in an appropriate denomination class (Jakubowski, 2016). At present, the APS Registry of Peony Cultivars contains 6455 items.

The wide use of Internet technology now provides

access to information, which was previously difficult to obtain and was processed only by specialists. Rogers (1995) in his respected book "Peonies" describes more than 600 cultivated and commercially available cultivars of peonies. He had obtained details of the cultivars from the nurseries catalogues published in North America, Europe, New Zealand, Japan and China. The use of the search engines makes it now possible to find web sites of companies specialized in cultivating and breeding peonies easily, and to instantly compare cultivars in online catalogues (Hollingsworth, 2016), (Klehm, 2016) and (Warmerdam, 2016).

When creating a web site we usually use a three-layer architecture client server (browser, web server and database server). An accurate content of the web site is ensured by a properly designed database. The majority of current databases are based on the relational data model. Entity Relationship Diagram usually designs a conceptual scheme of a database.

Modern web architecture depends on a high number of web technologies such as Hypertext Markup Language (HTML), scripting languages (PHP, JavaScript) and protocols such as HTTP or TCP/IP. Thanks to these technologies students are able to develop their knowledge in life-long education (Lagakos, 2010). All of these technologies rely on deep knowledge and can be difficult to learn for some students. With the ability to connect these technologies to the real world it is believed that students may understand better the purpose and reason why they should learn them.

The main purpose of this paper is to give an example of how use the data obtained through the creation of a specialized peony garden to provide field data support for teaching IT courses.

Materials and methods

In 2007, a dedicated Peony garden was established near Prague on a field of 2000 m^2. By the end of 2016 the garden contained more than 600 cultivars and nearly 1500 peony plants.

Vegetative reproduction by roots only is used for peony propagation. The roots were obtained from various sources (78), which included suppliers from the Czech Republic, and specialist growers of peonies from the EU (Holland, France, Belgium and Austria).

From the very beginning, details of every plant, its purchase, cultivation and flowering were recorded. The plants were photographed several times during the flowering stage. Approximately 5000 photos per year were taken. The data and photographs of flowers were compared with catalogues to verify the authenticity of cultivars and to ensure accuracy of the records in database.

The background of the records is outlined below. Few plants have such a long and rich history as peonies. The roots of herbaceous peonies were (and are) used in medicine. The earliest mention of the therapeutic use of the peonies comes from China Xia dynasty (2000 – 1500 BC).

For practical purposes Page (2005) divided peonies into seven main categories:

1. The species
2. Cultivars of *Paeonia lactiflora*
3. Hybrid Herbaceous Peonies
4. Chinese Tree Peonies
5. Japanese Tree Peonies
6. Hybrid Tree Peonies
7. Intersectional hybrid or "Itoh" Peonies.

Each of these categories is discussed briefly below.

The species

The genus Paeonia is very complex taxonomically. Sekerka (2004) provides a detailed overview on the Subgenus, Sections and Subsections. Only some species have practical significance as garden plants or the source for hybridization. Wild peonies were cultivated in Europe from the Middle Ages in monastery gardens originally for medical purposes, therefore referred to as Paeonia officinalis. Peony plants are sometimes small rockery, ie. Paeonia tenuifolia, which blooms first, has a height of just 30 cm.

Cultivars of *Paeonia lactiflora*

Most commonly grown cultivars of herbaceous peonies originate from Paeonia lactiflora, which was brought to Europe in 18th century from China. These cultivars are often called the Chinese peonies. Some of these classical 19th century cultivars without specific names are present in many gardens. They are offered cheaply to attracts buyers, but according to some authors (Hodgson, 2011) they should no longer appear in gardens, because require too much care. New cultivars are primarily produced in USA. Plants have strong stems and don't need to be supported by a ring.

Hybrid herbaceous peonies

Great progress in breeding peonies in the 20th century was carried out in the USA. Breeders like A. P. Saunders, E. Auten, L. Glasscock and others crossed wild species to create new cultivars, which will gradually come to our gardens. These cultivars grow more upright and the flowers do not need support. Some have new colour as 'Coral Charm'. Some red cultivars are very popular as 'Red Charm'.

Chinese Tree Peony

Tree peony has a long tradition among the "sacred symbols" in China. Over the centuries Chinese people have learned to admire her, especially in paintings. In 1903, peony has been declared the national flower of China. The white cultivar 'Feng Dan Bai' is used in Chinese herbal medicine.

Japanese Tree Peony

Tree peonies from the 8th century have similar popularity in Japan. Peony seeds where brought into the country from China by monks. While the Chinese prefer plants with large flowers, Japanese breeders have focused on simple flowers, i.e. to the detail and beauty of individual flowers. Very impressive cultivars are 'Yachiotsubaki' and 'Shima Nishiki'.

Tree peony hybrids

They were produced by crossing cultivars of the Japanese tree peonies and wild species. These tree peonies are shrubs that grow well and after flowering they create beautiful solitaires. Cultivars as 'High Noon', 'Souvenir de Maxime Cornu' or 'Gauguin' are very good ornamental plants in the garden.

Intersectional hybrids

In 1948, Japanese breeder Tochi Itoh successfully crossed tree peony with herbaceous peony for the first time and thus provided the basis for a new group of cultivars, the so called Itoh hybrids (also known as intersectional hybrids). The plants grow luxuriantly to a height of around one metre. They are woody at the ground level while the upper parts are herbaceous. Itoh hybrid cultivars such as 'Bartzella', 'Cora Louise' and others are currently fashionable.

Flowers

Peony flowers are pentamerous, which means that the various parts of the flower are in groups of five, or multiples of five. The flower has a classical structure and consists of four parts: sepals, coloured petals, stamens and the carpel. It is possible to distinguish five shapes of peony flowers as follows: single, Japanese, semi-double, double and bomb. These basic shapes of flowers have many different transient variations, even on the same plant the flowers can vary.

The colour ranges from white blossoms through pink to dark red, but there are peony blossoms of yellow or orange colour too. The size of flowers usually varies from 5 cm to 25 cm.

Results and discussion

Database for the peony garden

The first purchases of peonies were made in 2007 from mail-order businesses in the Czech Republic. Purchases from specialized peony producers in the EU started in 2011. Since the establishment of the garden, detailed records of individual plants have been kept. Collected and processed data were stored in a specialized relational database "My Peony" which was developed specially for this purpose.

The obtained data were processed using MySQL database system (later MariaDB) with the help of the phpMyAdmin user interface. The visual editor of MySQL Workbench was used to create the conceptual scheme of a new database. Table 1 describes the structure of "My Peony" database.

The central entity of the database is called Cultivar and it describes attributes of cultivated peony varieties. Entities Bloom_Time, Fragrance, Colour, Flower_Type, Genus, Country and Hybridizer are in hierarchical relationships (one to many type) with Cultivar entity. Entity Relationship (ER) Diagram is shown in Figure 1.

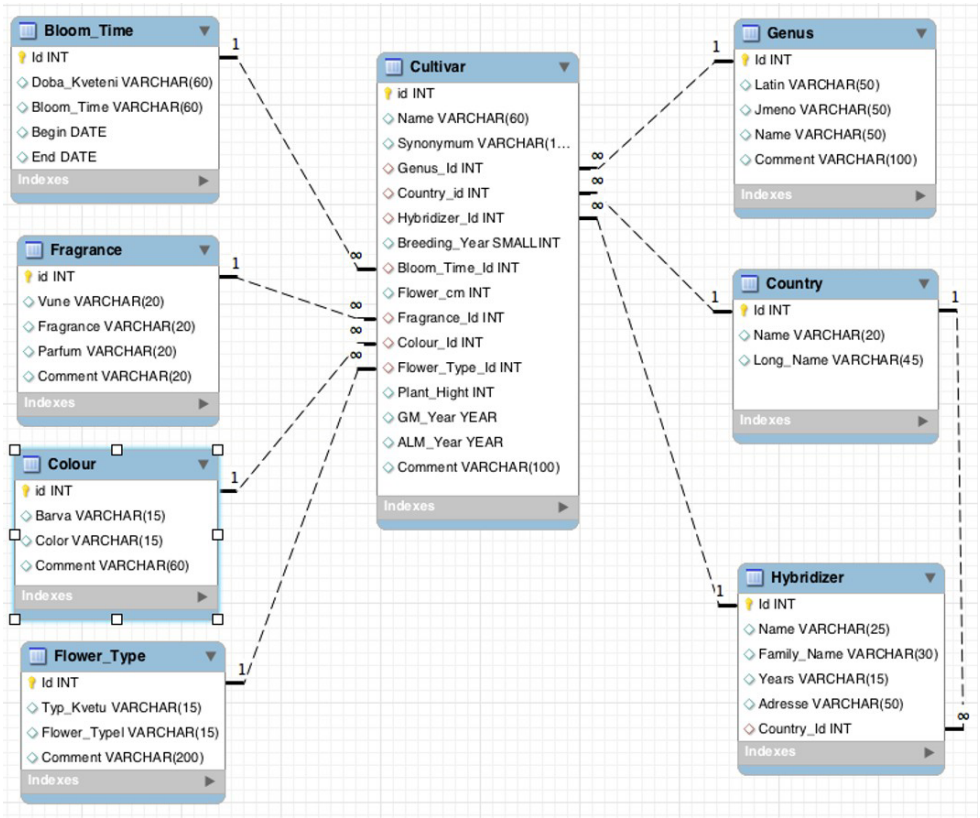
The relationship between the entities Cultivar and Place is of a many to many type and it is described by inserting a new entity Plant that contains data about individual plants. The entity Plant is in a hierarchical relationship with entity Acquisition as shown in Figure 2.

The proposed conceptual scheme is fully functional and is used to teach database technologies and Internet technologies courses. The scheme is prepared basically in English, but text items are also in Czech, eg. the entity Colour contains two items for colour name – Colour and Barva.

Entity	Content	Primary key	Number of attributes	Foreign key	Number of records in DB "My peony"
Acquisition	List of purchases	Id	8	Country_Id	78
Bloom_Time	List of bloom periods (1= very early, 2=early,…)	Id	5		7
Colour	List of peony colours (1=white, 2=red, …)	Id	5		10
Country	List of countries (1=France, 2=GB, …)	Id	3		18
Cultivar	List of cultivars	Id	21	Genus_Id, Country_Id, Hybridizer_Id, Bloom_ Time_Id, Fragrance_Id, Color_Id, Flower_Type_Id	614
Flower_type	List of flower types (1=Single, 2=Japanese, …)	Id	5		5
Fragrance	List of fragrances (0=no fragrance, 1=very light, …	Id	5		6
Genus	List of peonies categories as defined by Page (2005)	Id	5		8
Hybridizer	List of peony breeders (1=Auten, 2=Bigger, …)	Id	6	Country_Id	113
Place	List of flower beds in the field	Id	11		97
Plant	List of cultivated plants	Id	16	Cultivar_Id, Place_Id, Acquisition_Id	1500

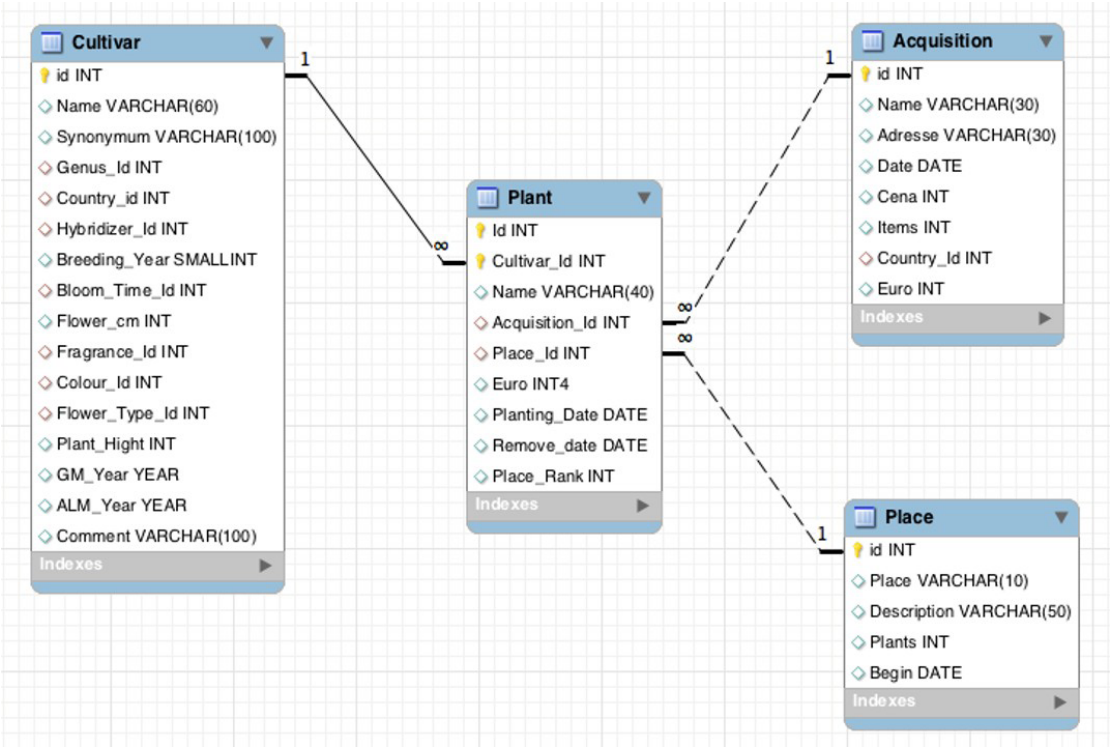
Source: own processing

Table 1: Structure of database "My Peony".



Source: own processing

Figure 1: ER Diagram – Data modelling by MySQL Workbench.



Source: own processing

Figure 2: ER Diagram – Data modelling by MySQL Workbench

Using the peonies topic in education of web technologies

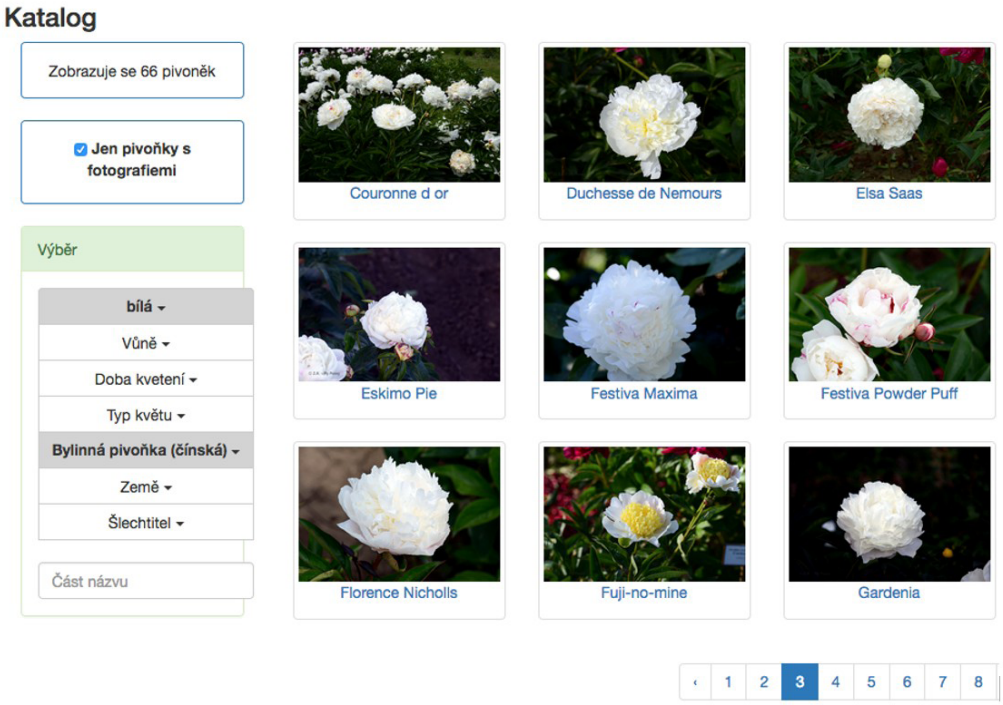
During the years from 2006 to 2016, we supervised student teams which were developing web sites with use of different approaches and technologies. There were projects based on Joomla, Prestashop, Moodle and Wordpress conducted on our departments' server kitlab.pef.czu.cz. Every year, there were hundreds of projects, for example 149 website projects in 2015 and 172 in 2016. One of the education and research results was the design of a new agritourism portal in 2010. It enabled the entrepreneurs in agritourism to present themselves on the web easily and with minimum cost using the Web Content Management System (WCMS) (Havlíček, 2010).

Every website should perform as a responsive and dynamic heap of web pages (Šimek et al., 2015). To enhance the learning process in the web development course at CULS the students were offered to create websites about peonies. Students who chose this topic worked mostly with HTML, CSS and JavaScript and they were able to create modern responsive websites. This idea was based on other studies with similar approach (Örtegren, 2012). Proper formatting in students' project respects CSS3 specifications, and students also implemented plugins like weather widget of meteorology station at CULS Prague.

It was discovered that the integration of peony photos (which were taken during the flowering period) in the website is not easy. Most of image data came from DSLR in 36MPx JPG files. This size was unacceptable for the responsive web site because of the limits in the data transfers and memory capacity especially for mobile devices. This means that image data must be compressed to suitable size and dimensions. It was also taken into account that JPEG algorithm is not ideal for web based presentations due to its compression limits. This fact leads to an other research, which attempts to provide better compression algorithms (Mehrabi, 2016).

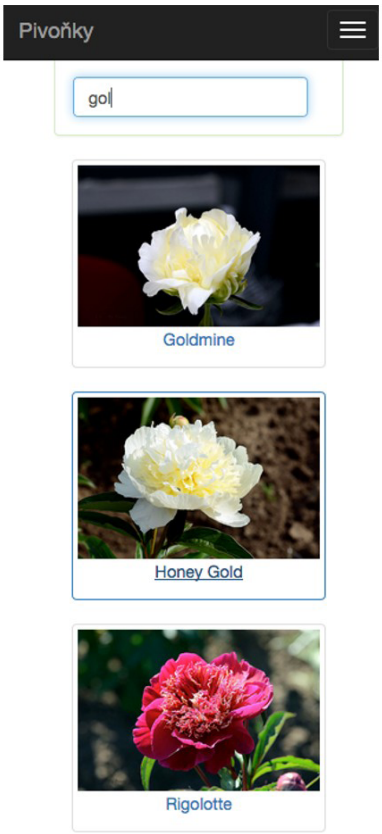
All of these findings point to the conclusion that integration of real world topics – in this case the world of peonies – might be helpful. What seems interesting is that the whole problem of designing a suitable database with interface is not as simple as it might look. Structural and biological complexity of peonies leads to a complex database and interface, which must reflect all data requirements.

Screenshots (Figure 3 and 4) of student´s project based is on Peony database URL: **http://kitlab.pef.czu.cz/1516zs/ete89e/08/**.



Source: own processing

Fig. 3: Peony Catalogue prepared by students.



Source: own processing

Figure 4: Peony Catalogue – responsive design for mobile devices.

Peony cultivar identification

Identifying varieties of peonies is quite difficult. When planting the roots of peonies one needs to rely on the quality and reliability of the supplier. The plant blossoms usually appear in the second or third year after planting. At the end of 2016 the peony garden described above had properly determined only 415 cultivars from a total of 614 cultivars recorded in the peony database. Verification of purchased cultivars was confirmed by comparison with the specialized books (Page, 2005); (Rivière, 1992); (Rivière, 2009). The correctness of the cultivar name was determined by comparing our own photos with the internet peony catalogues of specialized companies.

Visual identification of peony cultivars is only possible through the flower. For more than 200 years of horticultural cultivation, many cultivars have had two or three names. For example, the ‘Souvenir de M. Cornu’ tree peony bred in France is called ‘Kinkaku’ in Japan. Conversely, the herbaceous peony with yellow flower called ‘Goldmine’ or sometimes ‘Golden Wheel’ originally had a Chinese name ‘Huang Jin Lun’.

The problem with the exact specification of cultivars can be solved only through the study of DNA, as reported by Hao et al (2008), Gilmore et al. (2013). However the DNA determination

of cultivars is beyond the scope of this paper.

Peony cultivation is not very demanding for labour. Herbaceous peonies can be planted during dormancy (autumn or early spring). Tree peonies from the container can be planted throughout the year. Peonies do not suffer too much from diseases or pests. Peony blight is caused by Botrytis paeoniae and can seriously damage tree peonies. Due to the severity of this disease, a set of Internet sensors measuring the conditions of the plants is being prepared. The measured data will be used to predict the spread of the disease.

Conclusion

The peony database has already been used a number of times in IT courses at CULS Prague for explaining the principles of databases. The use of complex peonies data has made teaching of IT more interesting for students. It has proved that data and especially photos of plant flowers can be successfully used for identification of species and cultivars as well as for the creation of catalogues. This paper describes an example of the database use in students' web sites projects. Students were able to create web applications with responsive web design.

Analysis of research publications and their comparison with data from new peony garden showed the following practical problems in peony identification:

1. Exact identification of the different cultivars of peonies is only possible in flowering period or through DNA analysis.
2. Correct identification of cultivars is an essential prerequisite for their inclusion in the database.

In sum, the peony database proved to be successful in identification of peony cultivars. More research is needed to create an application, which would make an automatic identification of peony cultivars possible.

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Creating the Knowledge-structured Texts in Agriculture Companies: A Cost Modeling Approach

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Abstract

Agriculture is one of the most regulated sectors. Council regulations, national legal acts, subsidies, nature protection, market regulations and many other directives induce the necessity to work with a lot of text documents and to manage the knowledge in them. Thus, it is worth considering the creation of specifically designed internal documents to represent knowledge explicitly in so-called "knowledge-structured texts". However, it is a costly process to create the knowledge texts. The objective of this paper is to create a model that is capable of showing what time point the successive costs of the two types of text are equal at. Linking the methods of knowledge engineering and management is carried out with the help of an integrating element, i.e. general systems theory, through system dynamics. Despite an initial investment in the knowledge texts, the results show their potential for lowering the costs in the middle- and long-term horizons.

Keywords

Agribusiness company, costs, knowledge-structured text, management documentation, normal text, system dynamics.

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Introduction

Today is no exception; in the context of an interdisciplinary collaboration between related disciplines that deal with recruiting and working with knowledge, it is the beginning of using the knowledge in the field of "knowledge engineering" not only in educational and teaching disciplines but also on the corporate level (Koczinsky and Somosi, 2016). Knowledge engineering provides a formal model for the representation of explicit knowledge, which is subject to the transfer and sharing in the classroom or during expert consultations, or as a part of management control by means of managing the documentation at the enterprise level.

Several authors, e.g. Jokonya (2016) or Brožová et al. (2011), highlight the importance of a general system theory and system approach for this purpose. System approach has also been used to derive new knowledge representation called "knowledge unit" (Dömeová et al., 2008). Houška and Rauchová (2013) indicate that the benefit of this representation is the ability to express a formal model of knowledge in natural language, which is more comfortable for a human user. The model of knowledge unit also allows to create educational texts, instructions or procedures that include knowledge in an explicit form (knowledge-structured texts).

Dalihod (2014) or Jokonya (2016) criticize the lack of the system approach and system thinking in business management and problem-solving within the managerial communication; they also state that nowadays, the situations are occurring more frequently where managers solving communication problems are limited to solving context without using the system approach and system thinking, which is absolutely necessary for system troubleshooting. System dynamics is based on the system approach, which is very useful in addressing the social-economical and managerial problems (Fowler, 2003). Furthermore, models of system dynamics describe systems not only in the context of knowledge transfer but also from the point of view of their derivation in particular, as expressed e.g. by Vennix et al. (1990) or Ford and Sterman (1998).

Dalihod (2014) uses system dynamics for modeling the problems of internal management communications. Sonea (2014) states that verbal communication management includes both verbal communication and writing, and in the case of written communication, it mainly deals

with the creation of text documents for general corporate communications (emails, reports, newsletters etc.). In the company, as a part of the process management, we still encounter other types of documents, called "management documents", e.g. the documentation for process control, management and information standards, operational documentation, basic organizational norms, or legislative and legal standards (Carbonell et al., 2016). Using the complexity of the individual documents, we can define three basic layers in a hierarchy of data-information-knowledge (Koczinsky and Somosi, 2016).

The aforementioned knowledge-structured texts, based on the system approach, can be used, as stated by Rauchová and Houška (2013), not only for the educational level as a replacement for textbooks but they can also be used in the context of corporate management documents for medium-sized businesses, large enterprises or corporations. The question is what their effectiveness and efficiency is, i.e. whether people who solve tasks according to instructions, directives and other documents are working with lower error rate and whether this advantage brings more savings than the costs of creating knowledge-structured texts as compared to the costs of classical works directives (Rauchová and Houška, 2013b). The system approach is also suitable for creating metric-based evaluation of the efficiency and effectiveness of knowledge transfer (Rosales et al., 2012). The issue of evaluating the effectiveness of different models of training and transfer of knowledge is discussed by a number of authors (Tudor, 2012, Singer and Moscovici, 2008).

The contribution of the use of system dynamics for modeling the costs when creating texts (management documentation) for the Human Resources division for a company working in an agribusiness sector is evaluated.

In this paper, the authors will try (using modeling approaches and the system dynamics) to clarify when and under what conditions it will be advantageous to use the knowledge-structured texts over normal texts. It means that the aim of the paper is to identify the differences in the costs of the company if the company working in an agribusiness sector had used documentation in the form of knowledge-structured texts as compared to conventional structure texts. Moreover, authors will try to determine from what point of time it is worthwhile, cost-wise, for the company to invest in the creation of guidelines in the form of knowledge-structured texts.

Materials and methods

The source of data

The model has been prepared for an unnamed company working in the sector of agriculture. The company is characterized as a medium-sized enterprise (MSE). The number of employees in last 5 years was between 172 and 237, the annual turnover of the company was about 300 million Czech crowns (CZK).

Data was used in the context of modeling the costs of creating guidelines, and only in the field of human resources (HR), especially in the areas of personnel processes of the back office, as this segment is responsible for the creation of the largest amounts of text documents (management documents) with powers not only for the Human Resources division, but also in other sections of the company, its sections and divisions. The directive that occurs in the HR back-office processes does not relate to each of the employees, i.e. it deals with the appropriate management of relevant sections, divisions etc. Then, it moves forward in the hierarchy within the organizational structure. For modeling the creation of guidelines and learning according to them, it is necessary to study the structure of employees, i.e. for which employee is the directive instruction manual intended. Data that has been obtained for the model (i.e. the value of external variables e.g. in terms of the number of employees, payroll, time allocated for the creation of texts, creation of reserves etc.) was provided for the purpose of the simulation by the director of the back-office section. About 70% of external variables and coefficients have real value, 30% of the variables were determined by an expert estimate, since these were the variables and factors that were not directly observed within the section and normally are monitored under a different aggregate variable, or some parameters were derived from experiments by Rauchová et al. (2013) Horáková and Houška (2014b), Rauchová and Houška (2013), Rauchová et al. (2014). The director of the section also provided expert consultations when drawing up the model in order to explain the relationships between variables in the process of making guidelines in a company focusing on agribusiness.

The knowledge unit and knowledge-structured texts

Knowledge-structured texts and normal texts as terms are distinguished in this paper. Houška and Rauchová (2013) proposed the methodology for creating the knowledge-structured text from a normal text, where the knowledge-structured text can also contain additional information on top of knowledge units (Dömeová et al., 2008) and standard production rules. At the same time, it was discovered that not all texts can be rewritten in the knowledge form. Knowledge-structured texts have been tested in the education process (Horáková and Rydval, 2015) as a possible tool for transferring the knowledge as compared to normal educational texts (Rauchová and Houška 2013a, Horáková and Houška 2014a), their efficiency of creation has been measured (Rauchová and Houška 2013b), and the quantitative profile of knowledge-structured text and its difference from text that is normal from the linguistic point of view has been determined statistically, too (Rauchová et al. 2014b, Horáková et al. 2015).

Knowledge-structured texts were tested in the educational process as a possible tool for knowledge transfer as compared to conventional educational texts (Rauchová and Houška, 2013). The efficiency of the production of knowledge-structured texts was measured as compared to normal texts (Rauchová and Houška 2013b), and time-consuming codification of knowledge-structured text creation was measured as well (Rauchová et al., 2013). Moreover, the quantitative profile of the knowledge-structured text and its difference from the normal text in terms of linguistics was observed as well (Rauchová et al., 2014b; Horáková and Houška, 2014b).

Utilization of knowledge in the agribusiness company for the management documents is the content of this paper that uses system dynamics for modeling the costs in the segment of the human resources section of the HR back-office processes during the development of guidelines in the common and knowledge-structured text form. The lifetime of texts depends on the number of organizational changes in the company and other changes related to the operation of the business. The results of the survey set the lifetime identically for both types of texts to 36 months (3 years). After reaching the end of the lifetime, new texts need to be created. The company covers the consequences arising from risks in the form of costs (contributing to the total cost). Consequences arising from risks can be prevented through well-processed texts and their subsequent use. Well-processed texts reduce costs needed to cover the results of risks, including the total cost.

Brief characteristic of system dynamics

System dynamics is a discipline that can be used to describe the modeling, simulation and analysis of dynamic complex problems (Forrester, 1999; Pruyt, 2013). The underlying idea is that the behavior of the system is significantly determined by its own structure, individual elements and relationships among them. System dynamics is currently applied in a wide range of so-called soft systems in the fields of economics, sociology, ecology, risk analysis, resource management and many other areas (Forrester, 1999; Sterman, 2000; Meadows, 2008; Mildeová and Vojtko, 2003; Mildeová, 2012).

The essence of understanding the system dynamics is that it works with dynamic systems whose behavior is directed by quantities varying in time (Meadows, 2008); the system must be understood as a deliberately defined set of elements and relationships among them, where bonds usually have informational character. Therefore, systems are designed for investigation in terms of system dynamics characterized by: 1/ dynamic complexity, 2/ feedback arrangement, 3/ time delay, 4/ adaptability, 5/ nonlinearity, 6/ interdependence.

System dynamics is used to improve the study and better understanding of complex systems. It may lead to creation of computer simulation models, managerial simulators, it helps to understand the complexity of the dynamics and, in particular, it helps to understand the implications of applied policies and serves for designing effective policies (Sterman, 2000). Politics, according to Forrester (1987), must be understood as a rule under which various decisions are made.

We define the system initially using a Casual Loop Diagram – CLD, and subsequently a Stock-Flow Diagram – SFD is created. CLD is an important tool for defining and representing the structure of feedback systems. CLD according to Sterman (2000) allows to: 1/ quickly record hypotheses about the causes of dynamics, 2/ obtain a mental model for individuals or groups, 3/ discuss important feedback that seems to be causing a problem. CLD consists of variables that are connected with oriented bonds which represent the influences of the variables. Polarity-oriented linkages show how the independent variable affects the dependent variable. Feedback loops are important for the behavior of systems. Feedback

can be either positive (self-intensifying, labeled with the "+" sign or the letter R that stands for Reinforcing), or negative (balancing, labeled with the "-" sign or the letter B that stands for Balancing). For larger loops, the feedback will be positive in the case of an even number of negative signs in the loop and negative in the case of an odd number of negative signs in the loop. CLD does not enable mathematical modeling of the system, but SFD does. More about CLD and SFD can be found in Sterman (1989, 2000) or Meadows (2008).

Results and discussion

The basic idea of reporting a problem

The model describes two alternatives, i.e. it monitors costs for the text documentation – company guidelines and directives. The first one describes the knowledge-structured text creation. The second one describes the same situation but with standard text creation. The costs are absolutely identical in some areas but they are different in other monitored areas. That is caused by the nature of the different structures of knowledge-structured texts and their different time consumption during the text creation (Rauchová et al., 2013) and also by a different difficulty of reading. On the other hand, people solving problems according to these specially-processed knowledge texts are able to solve tasks with higher accuracy as compared to normal text (Rauchová and Houška, 2013).

The model depicts costs for both types of texts – the costs of producing the text (in the knowledge-structured text form we have to describe costs of the knowledge engineer who helps codify the knowledge in the structure). The model also includes the costs of updating, i.e. modifications which occur when the average lifetime of text documents ends. The costs of the upgrade are also influenced by the experience with texts of that particular employee. Moreover, the model includes the learning curve coefficients. Furthermore, we are watching for example the average monthly number of pages (of directive documents) that are created, the intensity of changes in the text at the data, information and knowledge levels etc. Other parts of the model are the costs of learning using these texts, i.e. variables that influence learning are for example the average number of people who are learning the text directives, average time spent by reading the texts (with a higher coefficient of knowledge), the hourly wage of these employees etc. Again, these are utilized for the learning curve.

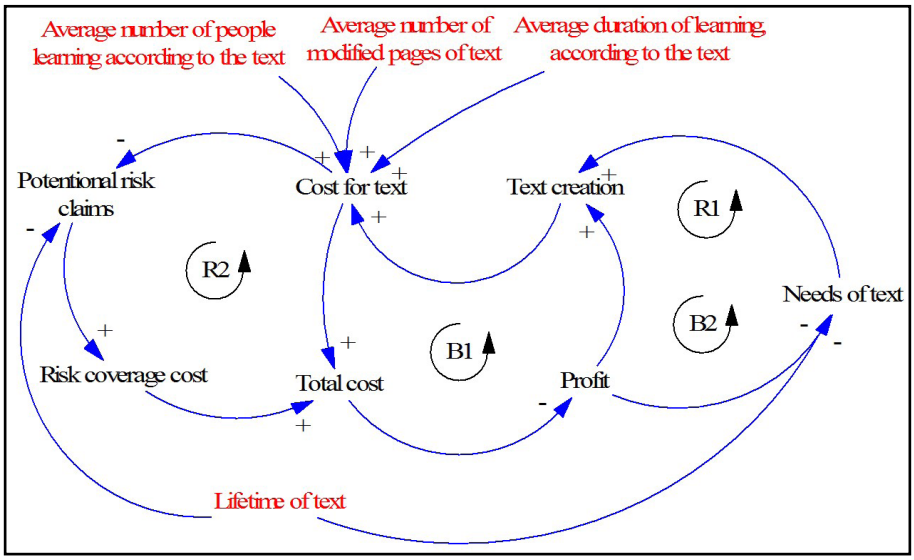
The company makes provisions each month to cover risks in the form of lawsuit court proceedings, fines and loss of business opportunities. From this point of view, it happens that a company using knowledge-structured texts faces a lower risk than with alternative conventional texts (Rauchová and Houška, 2013). At the same time, this risk decreases with the comprehensive restoration of the texts as a result of the end of lifetime of the management documents, and it increases when the documents are older. This relationship was linear for both alternative text forms created with graphics capabilities. It is also necessary to say that in the knowledge-structured texts, the reduction of the risk does not occur immediately but only after a certain delay when most employees are fully adapted to the change (Ross and Hulin, 1995).

In the model, there is also a variable which tracks the difference between these two alternatives. Other expenses (operation, overhead etc.) of the company are not included in the model, as it would be for the two alternatives that coincide. The goal is to model just their differences. The model also affects different delays in time, influence of experience (learning curve coefficients), non-linear relationship (plotted using graphical functions), feedback loop, polarity of relationships and more. The model is described using the first causal loop diagram (CLD) that reveals fundamental variables, feedback dishwasher and polarity of arrows, as well as the assembled diagram of stocks and flows, which can be used for monitoring flows, stocks (accumulation) and constants and also for watching purely external variables. The model was created in Vensim PLE (Ventana Systems Vensim Reference Manual, 2010).

CLD – Causal Loop Diagram

The CLD diagram in Figure 1 is composed of eleven variables; four variables (shown in red) are external variables that will be subject to the simulation, since they are tracking the costs and lifetime (service life) of important texts. The diagram consists of four feedback loops (R1, R2, B1, B2); two of them are reinforcing, denoted R1 and R2, and two are balancing, denoted B1 and B2. The graph also shows the polarity of relationships between different variables.

The feedback balancing loop **B1** shows the relationship between the costs and the creation of texts. ***Text creation*** influences the ***Cost for text***, which increases the ***Total cost*** that brings out lower ***Profit*** of the company. For lowering the costs, lower Profit causes lower ***Text creation***, resulting



Source: authors' own processing in Vensim

Figure 1: Causal loop diagram

in the decrease of the ***Cost for text*** and lower ***Total cost***.

Reinforcing feedback loop ***R1*** shows the following relationships between costs and needs of text. The more text is created, the higher the ***Cost for text*** and ***Total cost*** (including costs to cover the risk of lawsuits, legal proceedings and fines) are; this results in lower ***Profit of the company***. There are two ways to increase ***Profit***. Using the way of lowering the costs (displayed in balancing loop B1), the company can decrease the ***Text creation***, resulting in decreasing the ***Cost for text*** and, finally, ***Total cost***. The second way to decrease the ***Total cost*** is to try to improve the use of text and to increase ***Profit*** through the benefits of the use of text. Therefore, the lower the ***Profit*** is, the higher the ***Needs of text*** and ***Text creation*** are, resulting in lower potential risk of lawsuits, legal proceedings or fines and in more business opportunities, and therefore achieving higher ***Profit*** of the company.

The next feedback loops show the relationship between the creation of text and the potential risk claims. When a number of ***Potential risk claims*** is placed on the company, the ***Risk coverage cost*** increases, which results in higher ***Total cost*** of the company followed by the decrease of ***Profit of the company***. Then the company is at the same point with the same question: how to increase its ***Profit***. One way is to lower the costs (displayed in reinforcing loop ***R2***); the company can decrease the ***Text creation***, resulting in decreasing the ***Cost for text*** and, finally, the ***Potential risk claims*** are increased. This may be not so favorable for the company. The second way to increase ***Profit*** is to try to improve the use of the text and to decrease the ***Cost*** and achieve higher ***Profit*** through the benefits of the use of the text (lower potential risk of lawsuits, legal proceedings or fines, and more business opportunities). Therefore, the lower the ***Profit*** is, the higher the ***Needs of text*** and ***Text creation*** are, followed by an increase of the ***Cost for text*** and resulting in lower ***Potential risk claims***.

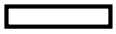
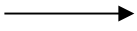
SFD – Stock and Flow Diagram

The above-mentioned model is also depicted in the stock and flow diagram in Figure 2.

Basic building blocks used in system dynamics and in the SFD model with icons are shown in the table below, adapted from Fowler (2003), Meadows (2008), Mildeová (2011).

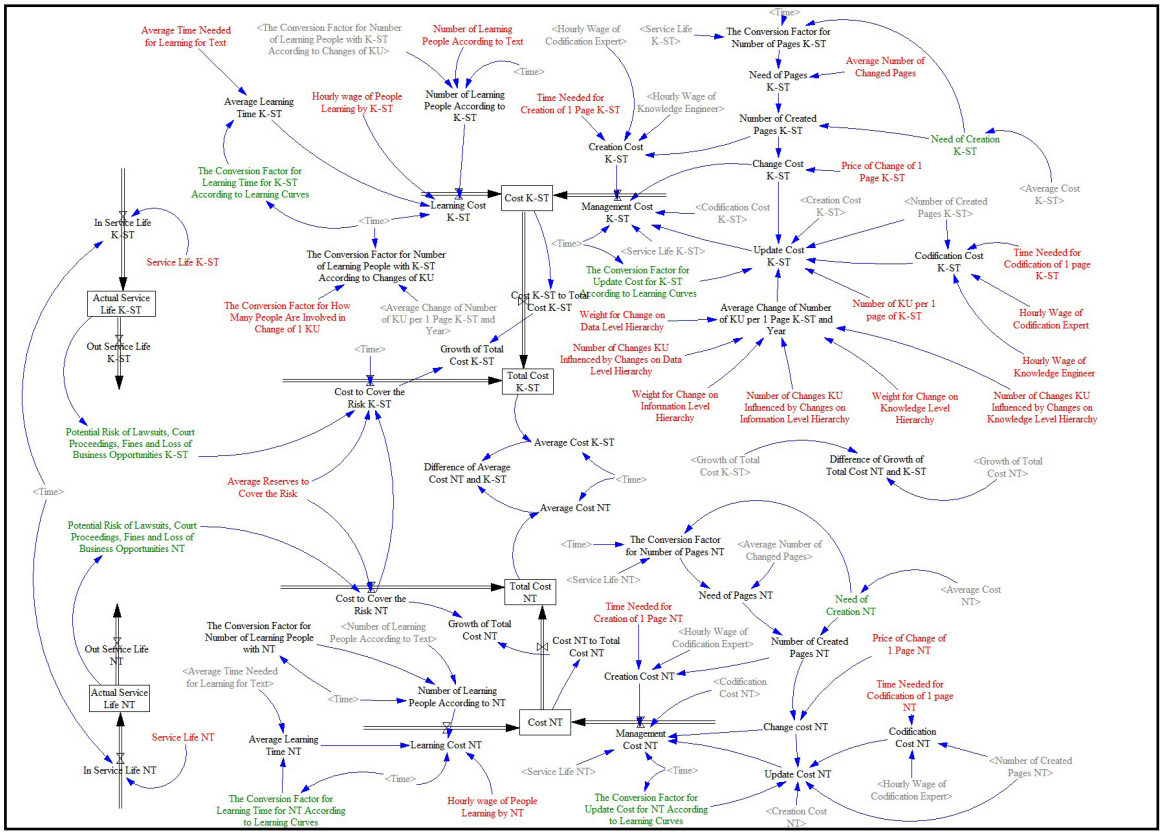
The model of creating management documents displayed in the stock and flow diagram (Figure 2) can be divided into three main parts. The left part shows the lifetime of texts. The ***Lifetime of text*** (in the SDF model as *Service Life NT* and *Service Life K-ST*) is a very important variable because it influences the level of the ***Cost to Cover the Risk***. We can suppose that with high actuality and long lifetime of the texts, we can prevent the ***Potential risk claim***s, and therefore decrease the ***Cost to Cover the Risk*** included in ***Total cost***.

The model of creating management documents displayed in the stock and flow diagram (Figure 2) can be divided into three main parts. The left part shows the lifetime of texts. ***Lifetime of text***

Building block	Symbol	Description
Stock (level)		Shows an accumulation of any variable.
Flow (rate)		Attached to a stock. Alters stock level by an inflow or an outflow.
Auxiliary (convertor)	Without symbol	Connects a stock and a flow in a complex setting. Used for intermediate calculations.
Connector (arrow)		Links different building blocks, showing the causality.

Source: authors' own processing

Table 1: Basic building blocks.



Source: authors' own processing in Vensim

Figure 2: Stock and flow diagram.

(in the SDF model as *Service Life NT* and *Service Life K-ST*) is a very important variable because it influences the level of the ***Cost to Cover the Risk***. We can suppose that with high actuality and long lifetime of the texts, we can prevent the ***Potential risk claims***, and therefore decrease the ***Cost to Cover the Risk*** included in ***Total cost***.

The top part of the model displays the process and variables affecting the knowledge-structured text creation. There are many variables representing the variable costs occurring by the text creation, such as ***Creation Cost K-ST, Change Cost K-ST, Update Cost K-ST, Codification Cost KS-T, Management Cost K-ST,*** and other variables, for example ***Number of Created Pages K-ST, Need of Creation KS-T, Learning Cost K-ST***.

The bottom part of the model displays the process and variables occurring in relation to normal text creation. In this part of the model, there are variables, such as ***Creation Cost NT, Change Cost NT, Update Cost NT, Codification Cost NT, Management Cost NT,*** and other variables, ***for example Number of Created Pages NT, Need of Creation NT, Learning Cost NT.***

The top and bottom parts (the part of the knowledge-structured and normal text) are very similar but they differ in variables that occur resulting from different text creation processes. In the knowledge-structured text creation process, the knowledge engineer who helps codify the knowledge-structured text in the structure is needed. Therefore, in this process the new variable, for example ***Hourly Wage***

of Knowledge Engineer, occurs.

In the middle part of the model, the output variable is created, i.e. ***Average Cost K-ST, Average Cost NT, Difference of Average Cost NT*** and ***K-ST***.

Research questions

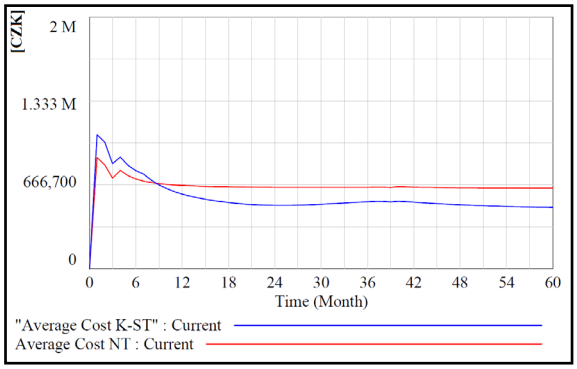
The following is a list of research questions that we will answer using model outputs after simulation.

- From what point in time is the average total cost of the company (i.e. its selected section) using the knowledge-structured texts in the management documents lower than for companies using regular texts (for equally long test period)?
- What is the evolution of the average total cost of the company (i.e. selected section of the company) using the knowledge-structured and normal text in the management documents?
- Are the knowledge-structured texts worth introducing in a small- or medium-sized company working in the sector of agriculture?

The important variables influencing management and data, information and knowledge processing at the company level are:

- Average number of modified pages [number of pages / month]
- Average number of people learning using the text [number of people / month]
- Average time of learning based on the text [hour / month]
- Average costs to cover risks [CZK]
- Lifetime (service life) of normal text [month]
- Lifetime (service life) of knowledge-structured text [month]

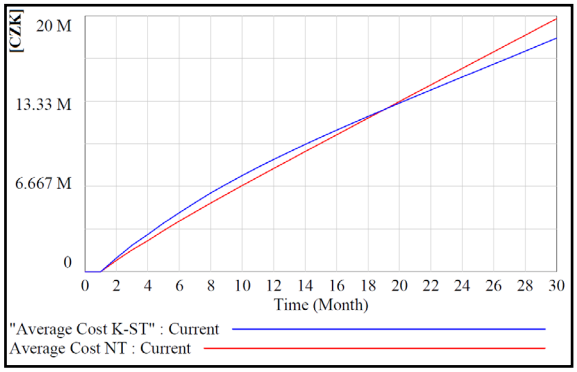
The answer to the first question of the research is given by the graph in Figure 3, which shows the average total cost in the sector of companies working with management documentation in normal form (i.e. using normal/common texts - NT) with the red curve, and the expense of the section of the company that is processing management documentation using models knowledge units (i.e. using knowledge-structured texts – K-ST) with the blue curve. If we project the intersection of the two curves to the x-axis (showing the time in months), it is clear that from the 9th month, the costs of NT are higher than those of K-ST; this is caused by a decrease of the average total cost for the segment using NT. That was caused by the adaptation of workers to change the structure of the management documentation and a decrease in the risk of lawsuits, causing a significant reduction in the costs of the risk coverage (as reserves).



Source: authors' own processing in Vensim

Figure 3: Average Cost of K-ST and NT.

The graph below (Figure 4) shows the accumulation of monthly costs and it is apparent that the cumulative amount of monthly costs for a company using NT will begin exceeding the cumulative amount of the monthly expenses of the company using K-ST in the 19th month. This means that after 19 months, the company using K-ST under otherwise identical conditions will become more profitable as compared to a company using NT. From the 9th month to the 19th month, the company using K-ST offsets the loss caused by introducing K-ST and employee training as compared to companies using NT.



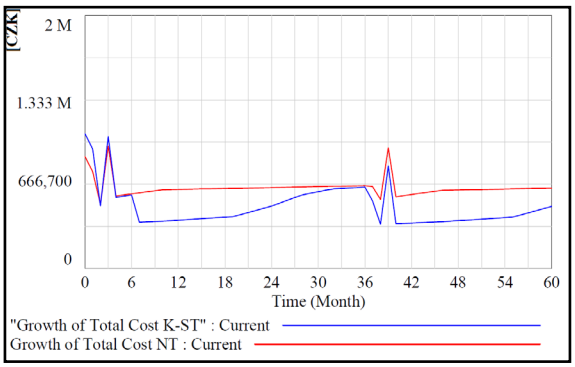
Source: authors' own processing in Vensim

Figure 4: Cumulative average cost of K-ST and NT.

Figure 5 shows the increase in total costs, which are (in order to simplify the model, as shown above), generated only by costs arising from the need to cover potential risks and by costs resulting from the use of texts. As the graph shows, the costs of the company using K-ST increase in the first months after the introduction of K-ST faster than the monthly costs of companies using NT. This is caused by the fact that the company using K-ST in the first months after the introduction of K-ST is also using NT at the same time, and it

ceases to use NT and uses only K-ST as late as after the development of K-ST and training of personnel. In this case study, monthly costs begin to decrease not sooner than after 6 months, mainly because of lower costs of the risk coverage, which is the most significant benefit arising from K-ST.

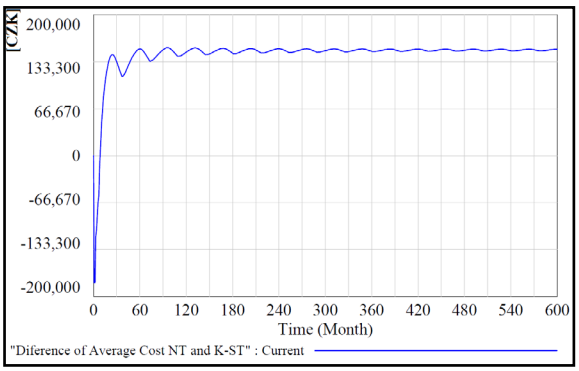
The increase of the monthly costs is mainly influenced by the service life of the texts. Texts have a lifetime of about 3 years (36 months). After they reach the end of their lifetime, it is necessary to create new texts in the extent required by the company.



Source: authors' own processing in Vensim

Figure 5: Increase of total costs of K-ST and NT.

The following graph (Figure 6) shows the difference in average monthly costs of companies using normal texts (NT) and the one using the knowledge-structured texts (ST-K). The resulting difference is calculated by subtracting the average monthly costs of companies using K-ST from average monthly costs of the company using NT.



Source: authors' own processing in Vensim

Figure 6: Difference of average costs K-ST and NT.

It is evident that in the long run, the company using NT has higher average monthly costs (the difference shifts to positive values). Therefore, it can be stated that although the costs of the initial introduction of K-ST are higher than NT, due to the benefits derived from K-ST (e.g. reducing costs to cover risks as shown above) the reduction of the monthly expenses is achieved.

The conclusions mentioned above indicate that this case study has demonstrated that the introduction and use of corporate documentation in the form of structured knowledge is beneficial for the company in the sector of agriculture in terms of monitored economic indicators.

Conclusion

The results show that the investment needed to adapt management documents in the form of knowledge-structured texts is worthwhile for a mid-size company focused on agribusiness, and especially for large companies and corporations with an extensive organizational structure, i.e. companies with a high number of management documents. However, the question is how the various parameters are to be set. Furthermore, it has to be assumed that an important role is played by the regular development of the company and that extensive organizational changes, which were (at a simulated section of the company) set for 3 years, referred to as the life directives, in the intervals between thorough editing only occur in order to update the guidelines, with varying intensity and weight changes at the level of the texts in the hierarchy of data, information and knowledge. For the simulation, a range of Human Resource Management processes of the back office of the selected agribusiness company was chosen. It is involved in the development of guidelines that are used to control the entire organizational structure of the company and cover only 10% of all employees (executives) as well as other employees in the typical positions of specialists, experts etc., and ultimately affect (directly or indirectly) the activities of people working in the operation of the selected organization. For existing parameters set by the above-mentioned section in any investment in knowledge management documents, the costs fall below the level of the current costs between the 15th month (optimistic estimate) and the 20th month (pessimistic estimate).

There are other variables that have an impact on costs, for example the ability of workers to adapt to change (not only from the point of view of the content of the text) as well as to get used to a different structure of the text, employee turnover and the number of reserves that the company generates in order to cover risks arising from non-observance or violation of the transcripts of the management documentation. There is especially a risk in the form of lawsuits, legal proceedings, fines and loss of business opportunities.

In future, the effort of authors is to generalize the above-mentioned model. It could be used for other businesses or extended, for example, in the area of yields and monitoring of economic efficiency of investment management documentation in the form of knowledge of texts. It can be also used to support the possible emergence of a new business offering outsourcing services for editing the management documentation (for larger companies), or offering courses of text editing in the knowledge form (for smaller companies).

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A Low Cost Irrigation System with Raspberry Pi – Own Design and Statistical Evaluation of Efficiency

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Abstract

Nowadays is automation a permanent part of ordinary households and subject to constant evolution. Standard of home automation is a smart (intelligent) home that meets the requirements of the owner and gives him considerable comfort. To the offer of solutions, the intelligent home includes, are control of lighting and temperature, camera system or irrigation system. Technologies of an irrigation system are being developed with an emphasis on smart management of water, advanced features and remote control of the irrigation system. The aim of this paper is to point out the new trends in irrigation systems. In this paper, we describe our own design, implementation and statistical evaluation of low-cost solutions for a smart irrigation system. This is a higher level of automation through intelligent devices with the requirements for user experience and quality of life. This device is according to our design and subsequent testing able to autonomously control three independent irrigation areas and the user experience is ensured by using the web interface (application runs on smartphones with system Android)..

Keywords

Smart irrigation system, raspberry, smartphone, statistical analyze.

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Introduction

From the mid-20th century onwards, the concept of agriculture has changed substantially. It has become an economic activity and it is no longer a subsistence activity that produces food for the family who works the land. Between 1960 and 1995, the global use of nitrogen fertilizer increased and agriculture became an activity intended to maximize profit (Pereira & Marques, 2017). Agriculture is one of the most crucial factors in sustaining human life on Earth. Also, it is a source of occupation for most people in many countries (Kathpal et al., 2017). However, in these current climate conditions is an acute shortage of agricultural water and food demand is increasing because of growing number of population and economic growth (Gheysari et al., 2015).

The growing demand for food and fiber production along with the limited freshwater resources and the intrinsic uncertainty in rainfall patterns, due to climate variability and change, has focused a great attention on agricultural water management. Irrigated agriculture has the highest rate of consumption of the freshwater resources (about 70%). In arid and semiarid climates, irrigation is essential for crop production wherein a crop failure or a significant reduction in the amount of yield would most likely occur without irrigation (Haghverdi et al., 2017). In agriculture, irrigation is an essential process that influences crop production (Kumar & Behera, 2015). Since that agricultural producers want to maximize revenues by maximizing production and aim to minimize costs and inputs (or resources) to ensure maximum profit. Inputs include labour, fertilizers, pesticides, machine utilization, plants or seeds and irrigation supply (Spedding, 2003). Consequently, there is a mounting pressure on irrigation systems to apply water more efficiently to ensure water resources availability and sustainability (Sadeghi, et al., 2017).

Recently various irrigation systems were designed to improve water use efficiency. Some of these systems are such as a water-saving irrigation strategy, which imposes a certain level of water stress to a crop either during a particular period or throughout the whole growing season,

with the expectation that any yield reduction is negligible compared to the water benefits gained from the water saving (Eck et al., 1987). However, irrigation systems involve an appropriate scheduling of irrigation, because of crop sensitivity to water deficit changes with the phenological stages (Istanbulluoglu, 2009, Patanè et al, 2017).

We can say that the issue of irrigation in actual climatic conditions is not a new topic. Various experts and researchers of Agriculture in cooperation with IT experts are for a long time investigating how can be intelligent systems applied in agriculture to not only increase revenue but also to avoid damage to the surrounding landscape. In this section, we compare various systems which have been proposed recently and are related to this topic. When we created the report of available systems we found one important thing - all these low-cost solutions relate mainly to drip irrigation. Even the proposals presented by renowned experts from floodplains as is India are focused on issues of drip irrigation. This is because in these areas are abundance of water, and the sufficient amount of water (often even excessive) is only in time of the monsoon rains. In our proposal, we examined the issue of irrigation of lawns and rock gardens, which can be used as in family houses, as well as for city parks and thus additionally saving costs for water, which is especially important for big cities.

In the year 2013 Gao et al. design an intelligent irrigation system based on wireless sensor networks and fuzzy control. The system mainly consists of wireless sensor networks and the monitoring center. The core of this system is microprocessor 8051, which provides cooperation between other hardware components. All of the nodes in monitoring area use solar power, collect the information of soil moisture, together with the growth of information in different crops different periods. Soil moisture content and the deviation rate of change of deviation are taken as input variables of the fuzzy controller, fuzzy control, and the regular database is established for the fuzzy irrigation control system. The Monitoring Center receives the data transmission from wireless sensor network node, and output of information irrigation water demands to the relay via a wireless sensor network to control opening and closing time of the valve in crop areas. The experimental results show that the system has a stable and reliable data transmission, which achieve real-time monitoring of soil on crop growth, give a right amount of irrigation crops based on information growth, which has broad application prospect (Gao et al, 2013). This system is designed to irrigate large areas. This designed system does not use the system of drip irrigation but large sprinkler. Gao et al. in their paper, however, does not provide the statistical evaluation of the effectiveness of such a system.

Kumar as irrigation system used also microprocessor 8051. Kumar used the microcontroller for the realization of intelligent drip irrigation system which will allow irrigation to take place in zones where watering is required while bypassing zones where adequate soil moisture is indicated. Another feature of this prototype is pesticide sprinkling system where the mixture is prepared in required proportion deserved by the plants automatically (required ratio is preloaded), thereby preventing the human mistakes to the maximum extent (Kumar et al., 2013). The disadvantage of this system we see currently in the use of pesticides. This system is but very simple and efficient for home realization.

Galande & Agrawal design in 2013 controlled drip irrigation system. They use as a core of intelligent irrigation system the microcontroller ARM7TDMI-S with microprocessor 89C51. The present proposal is a model to modernize the agriculture industries at a mass scale with optimum expenditure. Using this system, one can save manpower, water to improve production and ultimately profit. The developed irrigation automation system can be proposed to be used in several commercial agricultural productions since it was obtained at low cost and in reliable operation. This application of sensor-based site-specific irrigation has some advantages, such as preventing moisture stress of trees, diminishing of excessive water usage, ensuring of rapid growing weeds and derogating salification. If different kinds of sensors (such as temperature, humidity, and etc.) are involved in such irrigation in future works, it can be said that an internet based remote control of irrigation automation will be possible. The developed system can also transfer fertilizer and the other agricultural chemicals (calcium, sodium, ammonium, zinc) to the field with adding new sensors and valves (Galande & Agrawal, 2013).

Jadhav & Hambarde used for control of intelligent irrigation system microcomputer Raspberry Pi. An automated irrigation system was developed to optimize water usage for agricultural crops. The system has a distributed wireless network of soil moisture, humidity and temperature sensors. Their goal was to develop a system to control the water motor automatically, monitor the plant

growth using various parameters, spray fertilizers if needed and develop an Android app. The main idea of this is to understand how data travels through a wireless medium transmission using wireless sensor network and monitoring system (Jadhav & Hambarde, 2015).

Al-Ammri & Ridah used as an intelligent core for its designed irrigation system microcontroller AT89c51. This model of irrigation system is based on wireless sensor network (WSN). The user-controller provided with information from the receiver board (master) that transmitted sensors data (as the current parameter of the plant) through the transmitter board (slave). The receiver board AT89C51 used to receive a real-time sensor data from a transmitter to a PC monitor via serial connection and forming a database for future uses. Matlab/ Simulink and Neural Network was used for the control system to improve the performance (Al-Ammri & Ridah, 2014).

Shaikh et al., in 2016 proposed an embedded system for automatic control of irrigation. The system has wireless sensor network for real-time sensing and control of an irrigation system. This system provides uniform and required level of water for the garden and it avoids water wastage. This system is intended to create an automated irrigation mechanism which turns the pumping motor ON and OFF on detecting the dampness content of the earth. In this embedded system are interfacing Arduino board ATmega328 microcontroller through the temperature sensor, soil moisture sensor and interfacing to GSM (Shaikh et al., 2016).

Adewuyi developed a model of an intelligent irrigation system with microcontroller PIC16F877A. This microcontroller was used for the control processes programmed with 'Flowcode' flowchart basics. The performance is tested, and compared with the performance of the conventional irrigation system using Proteus VSM environment which gives an improved performance over the existing conventional irrigation system and saves energy (Adewuyi & Oko-Oboh, 2016). This system is designed for large irrigated areas.

Angal (2016) designed a home automation system which is based on Raspberry Pi, Arduino microcontrollers, and zigbee and relay boards to water plants. Raspberry Pi acts as the control block in the automatic irrigation system to control the flow of motor. The commands from the Arduino are processed by Raspberry Pi. Zigbee module is used for communication between the Raspberry Pi and Arduino. This realization presents an efficient and fairly cheap automation irrigation system. By using moisture sensor can be the irrigation system made smart and automated. The system once installed has no maintenance cost and is easy to use. This solution is only the model and it was not used in real conditions.

Madli (2016) used as microcontroller unit PIC 18f4520. The main function of monitoring unit is to monitor the field parameters; soil moisture, soil pH, air temperature and humidity. The microcontroller unit is realized by using PIC16f877A, which is responsible for collecting the parameters sensed by sensors, and transfer to the server mobile phone for processing via the Bluetooth interface using HC-05 Bluetooth module. Soil moisture and pH sensors are inserted in the soil, whereas temperature and humidity sensors measure the air temperature and humidity. These sensors act in a semi-passive mode as they are powered by the battery. The monitoring unit is placed in the field to monitor the agricultural parameters. This intelligent irrigation system from Madli is drip irrigation system (without sprinklers).

In this paper, we designed and implemented smart irrigation system, which is destined for automatic irrigation of grass area. Such an automatic irrigation system can now be taken for granted for most of ornamental gardens and lawns.

The main advantages of irrigation:

1. saving time (automatic irrigation system irrigates automatically according to the program, even when the house owner is away from home),
2. saves water,
3. irrigated if it is only necessary,
4. irrigates also difficult to reach areas.

Smart irrigation tells that the whole system is controlled by autonomous mean to automatically control the whole irrigation system whether the farmer is not present on his farm field and sends messages to the farmer about the information of farm field and change in operation of the farm field. Which require no worker for operating, and also less waste of water (Kumar & Behera, 2015).

The main role of irrigation system is to provide the lawn enough amount of water for its healthy growth. It is used mainly in the summer months during dry weather. The quality irrigation system should meet several important functions. The lawn should be irrigated evenly, without dry places. The system should irrigate only when necessary.

It is useless to water the lawn when it's raining. Automatic irrigation system which is installed in gardens is a network of pipes, wiring, and sprinklers that are generally stored beneath the surface of irrigated area. This system also includes other components, which provide automatic operation without human intervention, for example, solenoid valves, control unit and various sensors of weather. An indispensable part of any irrigation system is a control unit which is connected by wires with the sensors and solenoid valves. The user can, therefore, use the control unit set the duration of irrigation, frequency of irrigation or shutdown of irrigation due to rain.

Generally, (important) factors of irrigation system:

1. Consumption of water for irrigation system (content of irrigated area we multiplied by number 35, which represents an average dose of water per square meter per week in liter). Consumption of water for the adequate irrigation of the lawn, however, depends from the season.
2. The rate of flow - optimal value is 1 liter/ at a pressure 3.5- 5.5 bar with the average of input pipe 5/4“.
3. Time of irrigation – great time for irrigation is morning, the temperature of the air is low and the water does not evaporate but soaks into the ground. Saving of water is then 30 – 40%.

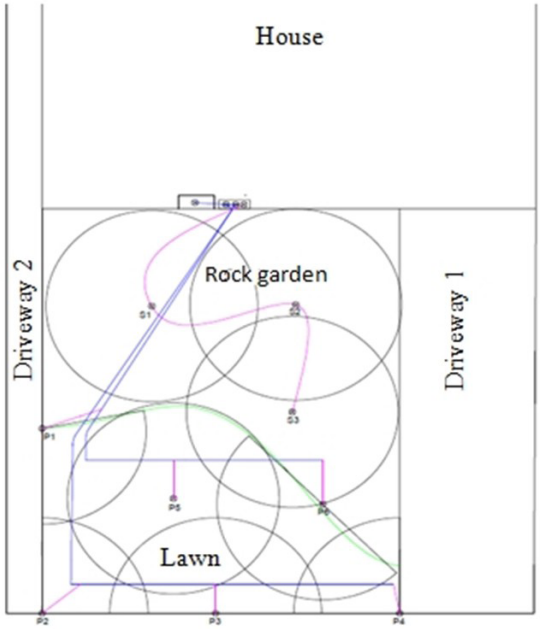
Based on these general conditions it is possible to design the automatic irrigation system. Of course, in order that the system should have success rate of at least 90%, it is necessary to also consider other factors which have the influence on the operation of smart irrigation system - such as humidity.

Each irrigation system has certain functions. For our irrigation system we require the following features:

1. Control of three independent circuits/valves,
2. Control according to ground humidity,
3. Control according to time schedule,
4. Deactivation of irrigation system due to rain,
5. Solar control, temperature, humidity and pressure of air
6. Prediction of weather,
7. Measuring the flow of used water,
8. Independent intelligent control,
9. Additional remote control via the Internet,
10. Additional manual control in case of internet failure.

Materials and methods

In our case, we decided to place the smart irrigation system so that it can irrigate an area with the size of 60 square meters in front of the family house.



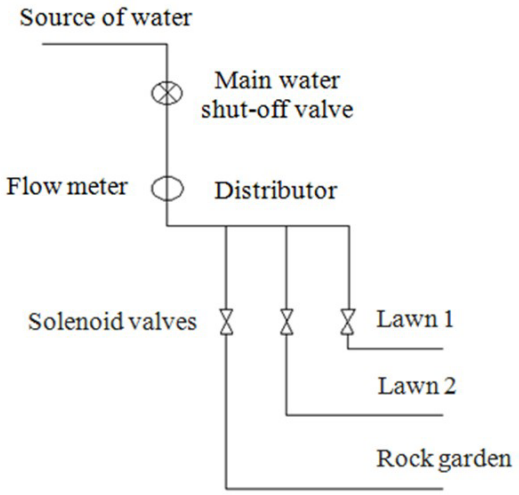
Source: Own creation

Figure 1: The layout plan of sprinklers.

This area is divided into the area with lawn and to the area with an ornamental rock garden. These areas are approximately the same, the area with ornamental rock garden (considering to the type of plants planted) has low conditions to the irrigation. For this area, we decided because of its size (need for irrigation system because of saving time) and undulation of its surface (the need for a uniform irrigation). The first step of realization is a proposal plan of irrigation for irrigation area with neighbouring objects (house, footpath, and road). We denote area for irrigation together with connection to the water source. We select suitable sprinklers on the basis of their throw distance, the range of zone and working pressure. In their location, we make sure that the entire area was covered with the sprinklers. Each of sprinklers must cover with the stream of water the area to the nearest sprinkler. For connection of the sprinklers is used a pipe, we choose the shortest distance (longer pipes can cause pressure losses). The pipe is deposited to a depth of 20-30 cm, this step solves the problem of possible freezing. For optimal conditions of pressure in the whole irrigation system, we divided the system into three branches. One branch will irrigate ornamental rock garden and the other

two are designed for the lawn. We used 9 irrigation sprinklers (range of zone 3,5 m) from the company Hunter. On the one branch, we used 3 sprinklers.

In Figure 2, there is a block diagram of designed irrigation system from the point of view of branching water.



Source: Own creation

Figure 2: Block diagram – branches of water.

This block diagram represents a low-cost solution. To ensure control of individual sections – irrigation areas, we use solenoid valve PGV - 101MM from Hunter, an operating voltage of 24V with a working pressure of 1.4 to 10 bar. We can operate solenoid valve manually, adjust of its flow, disassemble and clean. In Figure 3 is shown the real connection of solenoid valves.

Source: Own creation

Figure 3: Connection of solenoid valves.

The block diagram in Figure 2 is a low-cost solution. However, in order for the system to work as the intelligent device, it is necessary to also consider other components. In Figure 4 is block scheme of the smart irrigation system with all hardware components.

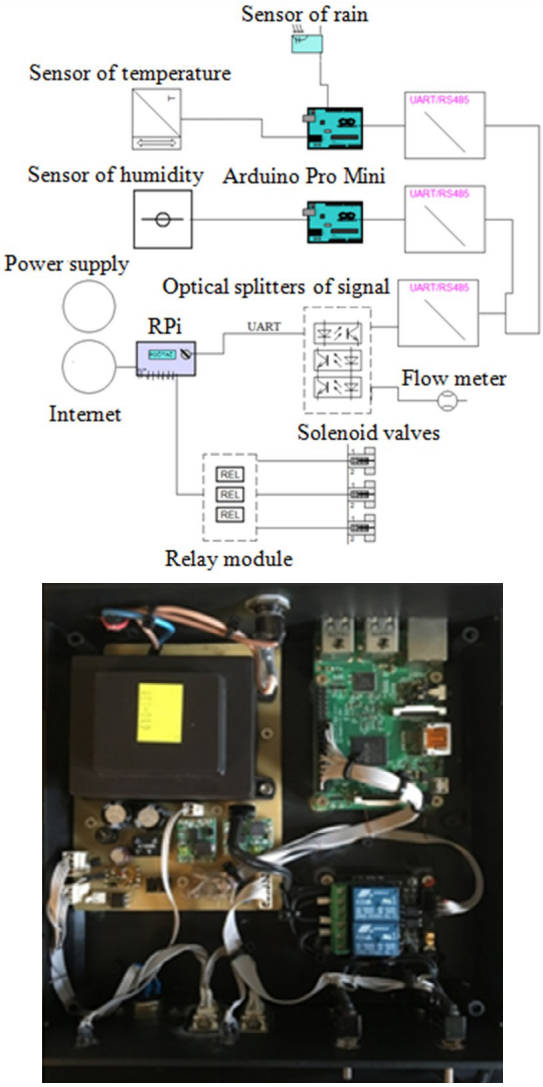


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Figure 4: Block diagram (up) and her realization of smart irrigation system with all hardware components (down).

For the realization of our irrigation system is need to dispose of these components:

1. transformer,
2. microcomputer Raspberry Pi 2 model B as control unit,
3. relay module,
4. sensor with combination to the weather (temperature, pressure, humidity and solar radiation),
5. humidity sensor,
6. flow meter,
7. sensor of rain,
8. converter UART/ RS485
9. microcontroller Arduino Pro Mini,
10. serial port RS232 Mini,

11. optical splitters of signal,
12. three-position switch,
13. appropriate cabling.

The *Control Unit Raspberry Pi* is the centre of an irrigation system. It determines when is appropriate for individual valves to open or close. The control unit opens the valves in order (always only one valve at a time). This step was made based on the optimum value of the pressure in the water pipes. In the case of low pressure the individual sprinklers would not have the required amount of water or could not even come out of the ground.

Arduino Pro Mini is a microcontroller based on the ATmega328 microchip. We used it to the conversion of signals sent from various sensors to communication signals UART (Universal asynchronous receiver/transmitter).

Relay module – because of control signals from RPi this relay module create connection between contacts with using AC24V to open/close of solenoid valves.

Optical splitters of signal for RS232 - ensures in order were not spurious signals from the outside. Significantly reducing the risk of damage input circuits RPI.

Serial port RS232 - it is used as a communication interface of computers and other electronics.

Converter UART/RS485 - communication converter of serial line UART to the interface RS485. It is designed for creation of a two-wire and multipoint join.

Transformer - allows you to effectively reduce the voltage from 230V to 24V so that we can use it to power other hardware components (controller, solenoid valves ...). For activities of other electrical circuits is the output voltage of the transformer directed through a stabilizer and adjusted for required voltage level.

Flow meter - it uses the principle of sensing mechanical speed of the magnet on turbine through the so-called Hall sensors. RPI sensing individual pulses, which can determine the water flow. Each pulse is approximately 76.6 ml water overflow.

Humidity sensor of ground - measures the volume of water which is contained in the soil based on the electrical resistance between two electrodes, which are in the sensor arm.

Sensor with combination to the weather - it consists of a humidity sensor and temperature of air (HTU21D). It can sense the temperature in the range of -40 °C to +125 °C for 24 hours. The air humidity is indicated in percentage. The last part of the module is a pressure sensor (BMP180). Value of pressure with other measurements can be produced by weather forecasts.

Sensor of rain - it contains contact field, while the presence of water on the contact field causes the conductivity sensor detects rain and irrigation system will not initiate watering.

The software of this smart irrigation system was divided into the software for control of hardware components (sensors, relay module) and software for control of Raspberry Pi. Control of hardware components was realized by using two microcontrollers Arduino Pro Mini. This microcontroller communicates using communication bus UART and is separate of optical signal splitters for the protection of control computer Rpi.

The basic part of software was created in the programming language PHP. We have created a series of subroutines which we interconnected. For function of measuring time we have created a program that collects data from all the sensors and stores them in a MySQL table. Then, using the CRON table this program can repeat the same activities every five minutes. By this we gained the essential function of measuring data on a regular basis. Switching on and off the valve is then carried out based on measured values in the database.

The next step was the proposal of the system logic. To the individual data in our database we assigned a certain weight, so we divided these data on the basis of importance. For example, the highest weight was assigned to the rain sensor, which immediately signalled a possible rain and turn off the irrigation system. The second type of weight was assigned to the humidity sensor, but we added the statement, which assesses the impact of humidity for the last eight hours. The lowest weight was assigned to sensor with combination to the weather which senses ambient air temperature, pressure and intensity of sunlight.

As the pressure that of the pump is never constant and the individual circuits does not supply the same amount of water at the same time, we cannot increase the amount of water by using the time constant. By using a flow meter, it can raise or lower the amount of water in liter, to achieve equal distribution of water on each valve. That is, in case of very high temperatures in the air during a few days in a row, we can increase the amount of water used for irrigation e.g. about 50 liter

on each valve for achieving uniform irrigation.

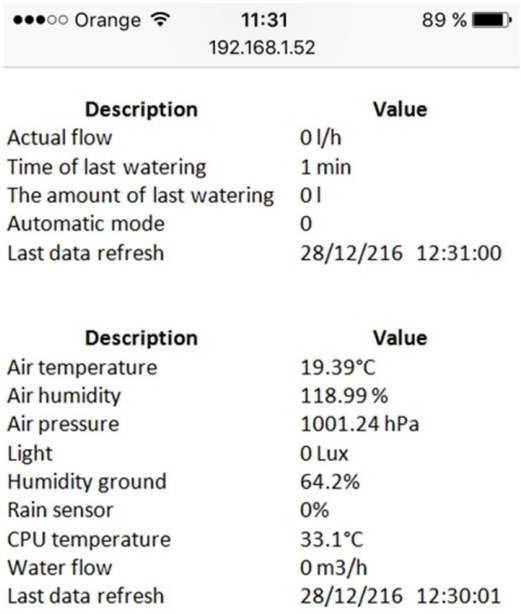
Web application – for control of intelligent (smart) irrigation system we created several options. First option is manual control of irrigation system using three switches, which are installed on device for each solenoid valve. A second option is indirect control using automatic mode and the last option is remote control using web application. The web application we created in PHP and to the work with the data we used phpMyAdmin which allows work with the MySQL database via the web interface. It allows creating, deleting, editing, filling databases or spreadsheets. After launching the web application users can see the following screen:

Source: Own creation

Figure 5: Initial screen of web application.

The initial screen consists of three buttons, intended for manual control each of solenoid valves by using web applications. When activating one valve it automatically turns off other valves and the names of buttons are changed. By the fourth button called Auto mode, we activated each valve on the basis of the measured values from the weather sensors. By activating the automatic mode, the possibility of manual activation of valves is deactivated. To check the measured values of the sensors, have their statements added to the web application (Figure 6).

Based on the measured values we can observe current flow, time and quantity of last irrigation and evaluate the costs associated with irrigation or adjust the quantity of water intended for irrigation. This web application was in the first step available only from local network but after installing VPN it is possible to use remote access to this web application. In this case, we access the web application securely using login details.



Source: Own creation

Figure 6: Web application.

The classical irrigation system is controlled using irrigation clock. This clock, however, cannot determine to what extent is the irrigation sufficient because it does not measure the value of ground humidity. We cannot determine whether the irrigation was needed in times of rain because it does not have the rain sensor. Consequently, we can say that the control of irrigation using the clock is inefficient. The control unit in conjunction with the weather sensor is an appropriate solution to control our irrigation system. As mentioned above, our irrigated area is 60 m2 and is divided into three sections and weekly water consumption of one section is 600 liter. For optimum humidity value, we divided the weekly irrigation schedule into four days. Thus, the consumption of water in one day to one section is 150 liter. Our irrigation program will begin at 6 clock in the morning because irrigation is the most effective in the early morning. At that time, the control unit retrieves the data from the sensors and evaluates them. To turn the irrigation on must be met these following conditions:

sensor of rain < 0.1,

sensor of ground humidity < 35%.

If the conditions are met, the control unit using the relay module opens valve 1 that is automatically closed after overflowing of 150 liter of water.

In the case when sensor of rain > 0.1 and sensor of ground humidity > 35%, the sensor of ground humidity indicating the need for irrigation, but the rain sensor with a greater weight of values indicates that it is raining. In the case of activating the irrigation would come to wasteful use of irrigation water, therefore the irrigation is automatically turned off. The third valve is used for the rock garden, which is less demanding for water as the lawn and irrigation does not need to be carried out in the early morning. Therefore, the amount of water which we used for irrigation of rocks was modified to 100 liter. Irrigation program for rock garden will begin when the complete irrigation of lawn by using valves 1 and 2 is done and is switched off after reaching 100 liter flow. In the case of high air temperatures, we subsequently decided to manually turn on irrigation of rocks garden in the evening, which will also serve to refresh the air around the house. In the spring and autumn months, we must adjust the lower limit of ground humidity, because for the lawn is appropriate a less intensive irrigation during these periods. Source codes of control functions are written in programming language C.

Results and discussion

The basis of irrigation system reliability is to analyze the measurement data of weather and its deviations. We focused particularly on the reality, regularity, and irregularity of measurement data, while we were looking for mistakes of measurement in the irrigation system. We can say, the mistakes of measurement = measurement of value – reference value. The mistakes of measurement were divided into three main groups:

Systematic mistakes – mistakes of measurement devices (source of the error is unknown), the mistakes that were stemming from the measurement. These mistakes can be removed with thoroughgoing devices and with the suitable method of measurement.

Random mistakes - they are caused by random external influences. They cannot be completely eliminated, but they can be determined by repeated measurements.

Personal mistakes - defects caused by poor attention from the experimenter, false readings of the devices and others. Removing is in the diligence of the work.

Our smart irrigation system has been tested on the ground area in front part of the family house. We tested correct functioning of turn off/on relay modules and correct functioning of turn off/on of solenoid valves based on the measurement data from sensors of weather and ground humidity. For testing, we chose a short period of time since 28.07.2016 to 01.08.2016. During operation of smart irrigation system may occur a sequence of different events/states. We have assigned identification code (Table 1) to these events.

Code	Event
10	Valve 1 is activated – manual control via web
11	Valve 2 is activated – manual control via web
110	Valve 1 is deactivated –manual control via web
111	Valve 2 is deactivated – manual control via web
12	Valve 3 is activated – manual control via web
112	Valve 3 is deactivated – manual control via web
20	Activated auto mode via web
120	Deactivated auto mode via web
30	Valve 1 is activated – automatic
31	Valve 2 is activated – automatic
32	Valve 3 is activated – automatic
130	Valve 1 is deactivated – automatic
131	Valve 2 is deactivated – automatic
132	Valve 3 is deactivated – automatic
21	Error in the evaluation of data

Source: Own creation

Table 1: Event codes

During the entire test period, we used the auto mode of the irrigation system. Irrigation of each section was carried out automatically under specified conditions. The measurement of data was carried each 5 minutes and these data were enrolled in the database. The data measured during the test period can be seen in Table 2.

In Table 2, we stated the measurement data of the day 29.7.2016. Irrigation system during this day was working following:

1. around 6:00 was conducted check of conditions - ground humidity was < 30%. The condition is true, the control unit using the relay module opened valve 1 and flow meter began to count impulses (1 impulse = 76.6 ml overflow of water). From the table can be seen an increase of the ground humidity.

ID	Date and Time	Air temperature	Air humidity	Air pressure	Light (lux)	Ground humidity	Rain sensor	Temperature Rpi	Overflow of water (m3/h)	Overflow of water (l/h)	Solenoid valve 1	Solenoid valve 2	Solenoid valve 3	Event code
11427	29.7.2016 4:40	16.965	88.41	98561	0	27.3	0	44.4	0	0	0	0	0	20
11428	29.7.2016 4:45	16.965	88.49	98548	0	27.3	0	45.5	0	0	0	0	0	20
11429	29.7.2016 4:50	17.025	88.38	98548	0	27.3	0	44.4	0	0	0	0	0	20
11430	29.7.2016 4:55	16.965	87.73	98555	0.42	27.3	0	44.4	0	0	0	0	0	20
11431	29.7.2016 5:00	16.835	87.89	98553	1.25	27.3	0	45.5	0	0	0	0	0	20
11432	29.7.2016 5:05	16.84	87.57	98549	3.33	27.3	0	44.9	0	0	0	0	0	20
11433	29.7.2016 5:10	16.865	86.7	98542	7.8	27.3	0	44.9	0	0	0	0	0	20
11434	29.7.2016 5:15	16.74	88.18	98555	14.17	27.2	0	44.4	0	0	0	0	0	20
11435	29.7.2016 5:20	16.75	88.17	98559	24.58	27.5	0	44.9	0	0	0	0	0	20
11436	29.7.2016 5:25	16.76	88.29	98561	40.42	27.6	0	45.5	0	0	0	0	0	20
11437	29.7.2016 5:30	16.74	87.44	98561	61.67	27.7	0	45.5	0	0	0	0	0	20
11438	29.7.2016 5:35	16.55	88.54	98559	87.08	27.8	0	44.9	0	0	0	0	0	20
11439	29.7.2016 5:40	16.76	88.86	98569	115.83	28.1	0	44.9	0	0	0	0	0	20
11440	29.7.2016 5:45	16.88	88.77	98558	143.75	28.5	0	44.4	0	0	0	0	0	20
11441	29.7.2016 5:50	16.845	89.48	98556	175.83	28.4	0	44.9	0	0	0	0	0	20
11442	29.7.2016 5:55	16.97	90,27	98558	209.58	28.4	0	44.4	0	0	0	0	0	20
11443	29.7.2016 6:00	17.185	90,84	98562	245.83	28.4	0	44.9	4.485	74.75	1	0	0	30
11444	29.7.2016 6:05	17.445	93.35	98558	287.08	32.3	0	45.5	4.6566	77.61	1	0	0	30
11445	29.7.2016 6:10	17.57	93.6	98559	333.33	34.8	0	44.9	5.049	84.15	0	1	0	130/31
11446	29.7.2016 6:15	17.675	93.59	98561	367.5	44.6	0	44.9	4.035	67.25	0	1	0	31
11447	29.7.2016 6:20	17.675	93.66	98557	395.83	45	0	44.9	3.2448	54.08	0	0	1	131/32
11448	29.7.2016 6:25	17.775	93.73	98553	448.33	44.3	0	46	2.7612	46.02	0	0	1	132
11449	29.7.2016 6:30	17.97	92.79	98556	507.5	43.7	0	44.9	0	0	0	0	0	20
11450	29.7.2016 6:35	18.145	92.61	98559	547.92	43.4	0	44.4	0	0	0	0	0	20
11451	29.7.2016 6:40	18.28	91.85	98542	625.42	42.9	0	44.9	0	0	0	0	0	20
11452	29.7.2016 6:45	18.455	92.12	98563	683.33	44.6	0	44.9	0	0	0	0	0	20
11453	29.7.2016 6:50	18.565	91.93	98551	632.08	44.6	0	44.9	0	0	0	0	0	20
11454	29.7.2016 6:55	18.68	91.33	98549	850.42	44.6	0	44.9	0	0	0	0	0	20
11455	29.7.2016 7:00	18.48	92.02	98551	682.92	45	0	44.9	0	0	0	0	0	20
11456	29.7.2016 7:05	18.75	91.25	98558	652.5	44.3	0	44.9	0	0	0	0	0	20
11457	29.7.2016 7:10	18.88	90.89	98559	767.92	43.7	0	45.5	0	0	0	0	0	20
11458	29.7.2016 7:15	18.79	91.48	98547	622.92	43.4	0	44.4	0	0	0	0	0	20
11459	29.7.2016 7:20	18.745	92.3	98525	945.42	42.9	0	44.4	0	0	0	0	0	20
11460	29.7.2016 7:25	19.095	91.73	98524	1185.83	42.6	0	44.4	0	0	0	0	0	20
11461	29.7.2016 7:30	19.565	90.23	98530	1372.92	42.4	0	44.4	0	0	0	0	0	20
11462	29.7.2016 7:35	19.905	88.42	98537	1547.92	42.2	0	45.5	0	0	0	0	0	20
11463	29.7.2016 7:40	20.095	88.03	98550	1364.17	42.1	0	49.9	0	0	0	0	0	20
11464	29.7.2016 7:45	19.995	87.51	98546	1201.67	41.9	0	44.4	0	0	0	0	0	20
11465	29.7.2016 7:50	20.31	89.28	98538	1355.83	41.8	0	44.4	0	0	0	0	0	20
11466	29.7.2016 7:55	20.29	87.57	98547	1596.67	41.6	0	44.4	0	0	0	0	0	20

Source: Own creation

Table 2: The measured data during the test period.

2. Once the value of impulses exceeds 150 liter overflow of water, the control unit closes valve 1 and opens valve 2 and re-starts counting impulses overflow of water to a value of 150 liter. This procedure is repeated for the valve 3, except flow-through of water - we set for valve 3 to value 100l

If we count the values from the flow (Table 2) at the opening of the valve 1, their sum is 152.36 liter.

It is possible that this inaccuracy was created by delay in closing the solenoid valve or inaccurate measurement of the flow meter. In the sum of the flow of water (valve 3 is open) is the value 100.1 liter. The difference in the deviations could be caused by different conditions of pressure in the pipes for irrigation. Furthermore, we focused on the reliability of measurement data from sensors of weather and proper operation of the rain sensor.

In Table 3, we stated the measurement data of the day 01.08.2016. Irrigation system during this day was working following:

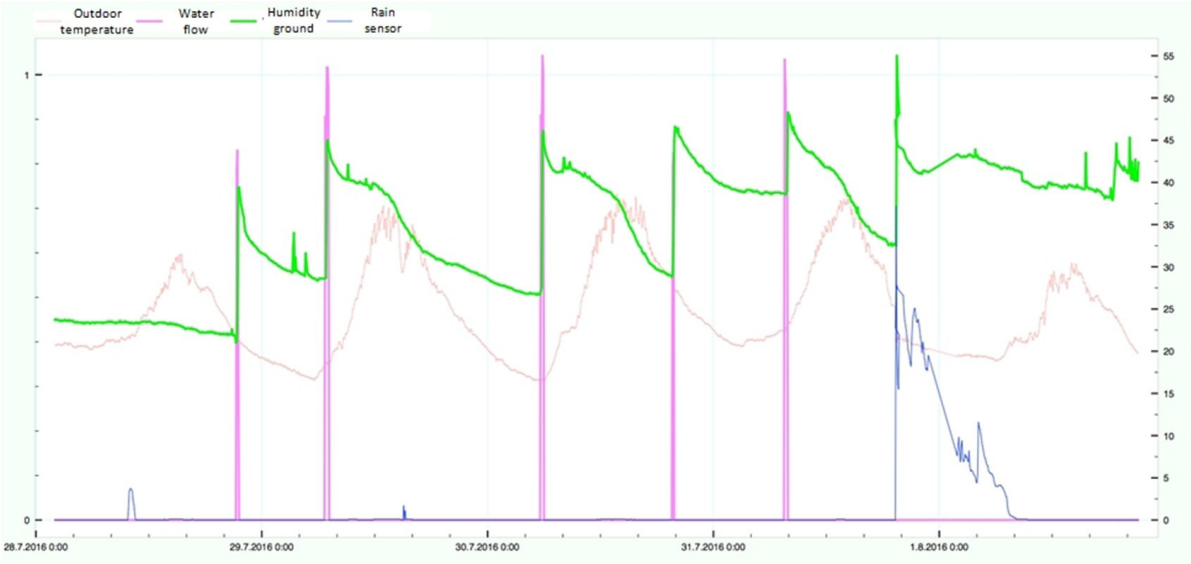
1. around 6:00 was conducted a check of conditions – sensor of rain was > 0.1. The control unit on the basis of the measured values of the rain sensor evaluated that at that time it rains and turning on irrigation is not necessary.
2. The control unit keeps all three valves closed.

The whole course of the activities of a smart irrigation system is in the following Figure 7. From Figure 7 we can deduce that during tested period the ground humidity has increased together with the flow rate of water. We can also observe the alternation of day and night based on air temperatures and fall and rise of ground humidity. In the last day of the test period, we recorded rainfall (the blue curve), which in turn caused an increased value of ground humidity.

ID	Date and Time	Air temperature	Air humidity	Air pressure	Light (lux)	Ground humidity	Rain sensor	Temperature Rpi	Overflow of water (m3/h)	Overflow of water (l/h)	Solenoid valve 1	Solenoid valve 2	Solenoid valve 3	Event code
12263	1.8.2016 5:20	19.235	95.52	98374	8.75	42.2	6.2	45.5	0	0	0	0	0	20
12264	1.8.2016 5:25	19.235	94.92	98377	13.33	42.2	5.9	45.5	0	0	0	0	0	20
12265	1.8.2016 5:30	19.145	95.68	98374	21.25	42.2	5.5	45.5	0	0	0	0	0	20
12266	1.8.2016 5:35	19.6	94.91	98375	30.83	42.1	5.5	45.5	0	0	0	0	0	20
12267	1.8.2016 5:40	19.155	94.52	98386	42.92	42.2	5.3	45.5	0	0	0	0	0	20
12268	1.8.2016 5:45	19.125	94.91	98389	66.25	42.1	5.1	46	0	0	0	0	0	20
12269	1.8.2016 5:50	19.5	96.16	98385	103.75	42.2	4.6	44.9	0	0	0	0	0	20
12270	1.8.2016 5:55	18.85	94.97	98403	130.42	42.1	4.2	45.5	0	0	0	0	0	20
12271	1.8.2016 6:00	18.955	95.83	98404	138.75	42	4	45.5	0	0	0	0	0	20
12272	1.8.2016 6:05	18.96	95.64	98419	167.92	42	4	45.5	0	0	0	0	0	20
12273	1.8.2016 6:10	18.96	95.72	98420	180	41.9	4	45.5	0	0	0	0	0	20
12274	1.8.2016 6:15	18.925	95.43	98419	213.33	42	4	44.9	0	0	0	0	0	20
12275	1.8.2016 6:20	18.97	95.12	98423	265	41.9	4.1	45.5	0	0	0	0	0	20
12276	1.8.2016 6:25	19.3	95.02	98429	365.83	41.8	4.1	46.5	0	0	0	0	0	20
12277	1.8.2016 6:30	19.045	95.72	98441	445.83	41.7	4.1	45.5	0	0	0	0	0	20
12278	1.8.2016 6:35	19.16	96.3	98441	512.92	41.6	4.1	45.5	0	0	0	0	0	20
12279	1.8.2016 6:40	19.34	95.1	98453	8´593.75	41.6	3.9	46	0	0	0	0	0	20
12280	1.8.2016 6:45	19.36	95	98449	658.75	41.7	3.8	44.9	0	0	0	0	0	20
12281	1.8.2016 6:50	19.36	96.26	98446	702.92	41.7	3.6	46	0	0	0	0	0	20
12282	1.8.2016 7:00	19.685	95.35	98454	768.75	41.8	3.2	44.4	0	0	0	0	0	20
12283	1.8.2016 7:05	19.975	93.08	98452	880.83	41.7	2.8	44.9	0	0	0	0	0	20
12284	1.8.2016 7:10	20.15	90.86	98452	892.08	41.7	2.7	45.5	0	0	0	0	0	20
12285	1.8.2016 7:15	20.49	90.02	98446	1037.08	41.6	1.7	44.9	0	0	0	0	0	20
12286	1.8.2016 7:20	20.5	89.42	98453	1216.25	41.7	1.1	44.4	0	0	0	0	0	20
12287	1.8.2016 7:25	20.795	89.04	98473	894.58	41.8	0.8	44.9	0	0	0	0	0	20
12288	1.8.2016 7:30	21.075	86.09	98493	777.5	41.7	0.6	45.5	0	0	0	0	0	20
12289	1.8.2016 7:35	20.99	86.58	98499	680.83	41.6	0.5	45.5	0	0	0	0	0	20
12290	1.8.2016 7:40	20.63	88.56	98501	953.33	41.6	0.5	45.5	0	0	0	0	0	20
12291	1.8.2016 7:45	20.68	89.15	98506	1291.25	41.6	0.4	45.5	0	0	0	0	0	20
12292	1.8.2016 7:50	21.8	87.99	98500	1235.83	41.6	0.4	46	0	0	0	0	0	20
12293	1.8.2016 7:55	21	88.3	98506	1328.33	41.6	0.3	45.5	0	0	0	0	0	20
12294	1.8.2016 8:00	21.625	83.8	98500	1692.92	41.4	0.3	45.5	0	0	0	0	0	20
12295	1.8.2016 8:05	21.22	85.96	98517	1559.58	41.4	0.2	44.4	0	0	0	0	0	20
12296	1.8.2016 8:10	21.59	83.49	98528	1343.75	41.4	0.2	45.5	0	0	0	0	0	20
12297	1.8.2016 8:15	21.46	83.46	98513	1707.08	41.4	0.1	45.5	0	0	0	0	0	20
12298	1.8.2016 8:20	21.335	82.85	98535	1796.25	41.4	0.1	45.5	0	0	0	0	0	20
12299	1.8.2016 8:25	21.195	84.59	98525	1744.17	41.3	0.1	45.5	0	0	0	0	0	20
12300	1.8.2016 8:30	21.17	85.63	98505	2265	41.3	0.1	44.9	0	0	0	0	0	20
12301	1.8.2016 8:35	21.48	83.35	98551	1327.92	41.2	0.1	44.9	0	0	0	0	0	20
12302	1.8.2016 8:40	21.59	83.45	98554	1312.5	41.2	0.1	45.5	0	0	0	0	0	20

Source: Own creation

Table 3: The measurement data of the day 01.8.2016.



Source: Own creation

Figure 7: Activities of the smart irrigation system during whole tested period.

Conclusion

The current development of intelligent irrigation systems (as well as shown in the section Related work) is focused primarily on research in the area of drip irrigation systems. It is clear that the interest of researchers is oriented in this direction. In agriculture, is the demand

of the greatest return, but as far as possible with the least waste of water. But on the other side, we must not forget about the wasting water in parks or in ornamental gardens in the cities or wasting water when we water the lawn around the house.

In this paper, we presented a draft and creation of really smart irrigation system. This smart irrigation system is currently in active usage. The statistical results showed economic running of this smart irrigation system. The resulting errors of measurement did not significantly affect its effectiveness. Currently, we removed these inaccuracies in the measurements with more accurate sensor of humidity and sensor of rain.

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Farms Productivity Developments Based on Malmquist Production Indices

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Abstract

The aim of the article was to evaluate production efficiency changes of agricultural enterprises specialized in livestock production and identify its determinants. The total factor productivity (TFP) was used to analyse the changes as determined by the DEA Malmquist index. Evaluated sample contained panel data of 440 farms (114 organic and 326 conventional) based on FADN survey in the period 2011 - 2015. The results showed very little difference in technical efficiency between groups and relatively negligible changes over the time. About 69% of organic farms reached the productivity growth with the change in TFP of 3.17%. A total of 59% of conventional farms were managed with increasing productivity and the TFP change by 1.48%. Differences between groups were given mainly by Utilized agricultural area per farm, level of Total production, Livestock output, sum of Current subsidies per hectare, and by FNVA / AWU.

Keywords

Crop and animal production, efficiency, total factor productivity, organic and conventional farming.

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Introduction

Organic farming became an integral part of current agriculture. Widespread interest in ecology, clean environment, sustainable agriculture, and healthy life style supports the expansion of this farming system. Organic farming involves a lot of non-economic factors such as higher care of environment, more favourable agronomy techniques, landscape cultivation, animal welfare, social ties, and other socio-economic factors in comparison to conventional practices focused on high production.

Productivity of organic farms is generally lower than in case of the conventional farms. Reaching economic efficiency in organic farming is more complicated due to production process and market process specificities (Brožová and Vaněk, 2013). Differences between organic and conventional productivity and farming system were detailed reviewed by Nemes (2009). Some researchers argue about the effective reasonableness of the comparison of organic and conventional farming because of so different farming procedures and principal goal of agricultural system. With respect to this, conventional farming could be considered as the most widespread production system which include a mix of agronomic techniques. Some of them are quite similar to the organic ones and therefore the result of farming could be comparable (Cisilino and Madau, 2007). The best way to minimize incorrectness in analysis is accurate selection of comparative sample. It is suggested to compare farm groups with similar characteristics as far as farm type (arable, dairy, mixed, etc.), productive system, environmental conditions (land fertility, climate, etc.), same localization (Region), equipment of productive factors, and socio-economic conditions (Cisilino and Madau, 2007). Technological and management differences are another kind of criteria (Nemes, 2009). Organic farms are able to compensate their technical disadvantage (e.g. lower productivity) due to a more reasonable use of their own inputs rather than from enhancing productivity. Although the organic farms show better efficiency than conventional ones, their overall efficiency is not completely satisfactory (Cisilino and Madau, 2007).

Effectivity of farming in selected groups of farms can be compared by different ways. Farrell (1957) developed the concept of technical efficiency (TE) of farms based on the relationship between inputs and outputs. Differences in economic

efficiency among groups of farms may result from variations in technical efficiency (larger output with equal amounts of inputs) or price efficiency (higher profits). This crucial method enabled the development of different more detailed analytic models. Data Envelopment Analysis (DEA) model is often used to evaluate results of farming productivity and calculate a value of their technical efficiency. The DEA method uses production units. Units with the highest efficiency are located on the efficient frontier. The method provides a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier (Špička, 2014). All farms involved in analysis are compared with only the "best" producers (Heidari et al., 2011). The technical efficiency score divides the sample (farms) into two groups – efficient with TE = 1.0 and inefficient with TE < 1.0. The statistical procedure tests differences of structural and economic indicators between two groups (Špička, 2014). Technical efficiency of farm is related to the subjects with the best results of analysed group, but it differs from the rate of farm profitability. Nevertheless, positive correlation between technical efficiency and profitability of production was proved (Boudný et al., 2011). The DEA method is suitable for groups of farms with similar value of inputs and outputs farming in similar productive and climatic conditions. Farms can be separated into more homogenic sub-samples according to the specialization, environment conditions and used technologies (Boudný et al., 2011). Development of farm productivity over a selected period can be evaluated by the Malquist index (Špička and Machek, 2015).

The DEA model divides evaluated sample of farms in two groups according to their technical efficiency. Several papers searched for factors describing the difference between successful and less successful subjects (Boudný et al., 2011; Davidova and Latruffe, 2003; Balcombe et al., 2005; Bravo-Ureta et al., 2007; Latruffe et al., 2008; Špička, 2014; Čechura et al., 2015; Madau, 2015; Medonos et al., 2015; Špička and Machek, 2015; and many others). The significant economic measures of production intensity in mixed type of farming are usually crop output per hectare, livestock output per livestock unit, productivity of energy and capital (Špička, 2014).

Change in total factor productivity (TFP) is significantly determined by the technological change (TCH) for all sectors of agriculture (type of farming). Čechura et al. (2015) analysed changes in TFP of Czech farms in 2007 – 2011. Sample included farms of cereal production, dairy production, and pork production. Technical/ technological change was generally speeded up by the increase in subsidies and decrease in average costs. The successful farms specialized in dairy or pork production were also characterized by a high share of the crop production. Diversification of the production can minimize the production risks and the production of its own feed can minimize costs (Čechura et al., 2015). Livestock farms generally achieve significantly higher total technical efficiency than farms specialized in crop production (Boudný et al., 2011; Bravo-Ureta et al., 2007). This could be related to relatively homogenous methods of production in livestock, which are less dependent on human error, weather or climatic conditions than crop production. The best results of total technical efficiency were found in dairy production, cattle fattening, poultry fattening, and pork production (Boudný et al., 2011). The farming intensity is another key determinant of the technical efficiency. More extensive farms and regions have a lower technical efficiency than the more intensive ones (Špička, 2014).

One of the significant sources of agricultural data is FADN (Farm Accountancy Data Network) database. It involves information from all EU member states including the Czech Republic. FADN data include heterogenous subjects of conventional and organic farming. The best solution for analysing would be to consider a constant sample of farms introduced as a panel data (Cisilino and Madau, 2007). Several papers published results calculated from this database. Davidova and Latruffe (2003) or Latruffe et al. (2008) used DEA output-orientated model to analyse the efficiency of 88 livestock and 256 crop farms of the Czech FADN database.

Balcombe et al. (2005), Bravo-Ureta et al. (2007) or Madau (2015) compared technical and scale efficiency using both Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). Empirical findings suggest that the greater portion of overall inefficiency in the sample might depend on producing below the production frontier than on operating under an inefficient scale. Estimated technical efficiency from SFA model is substantially at the same level of this estimated from DEA model, whereas the scale efficiency arisen from SFA is larger than this obtained from DEA analysis (Madau, 2015).

Czech FADN database contains farms of conventional as well as organic farming.

Moreover, it includes farms of different types of farming. Livestock production is the most important part of organic farming in our republic. Based on the published papers, the aim of our research was to evaluate production efficiency changes of agricultural enterprises in livestock production and identify its determinants. The total factor productivity (TFP) was used to analyse the changes as determined by the DEA Malmquist index.

Material and methods

The FADN CZ provides structural and economic data in standard results. The complete panel data from the period 2011-2015 were available for 440 farms: 114 organic and 326 conventional. The analysis focused on farming with livestock (general codes 4,7,8 in TF8 FADN grouping). Table 1 gives information about number of analysed organic and conventional farms according to the type of farming.

Productivity measurement is often carried out from two perspectives, Standard CRS (constant return to scale) and VRS (variable return to scale) DEA models that involve the calculation of technical and scale efficiencies (TE) and the total factor productivity (TFP) which takes into account all possible inputs and outputs of an industry (firm, process). The second deals with the use of the Malmquist index to quantify the change in a farm's efficiency over a period of time (Coelli, 1996). All indices are relative to the previous year, so the output begins with the second year. There are five indices for each farm and period: Technical efficiency change relative to a CRS technology (effch), Technological change (techch), Pure efficiency change relative to VRS technology (pech), Scale efficiency change (sech) and Total factor productivity change (tfpch). The results distinguish among the farms with productivity growth (tfpch > 1) and decline in productivity (tfpch < 1).

The standard approach to the measurement of productivity change over the time is the Malmquist TFP index (Caves et al., 1982; Fare et al., 1994). The Malmquist index is a geometric mean of two indices, evaluated with respect to period s (the base period) and period t technologies (Fare et al., 1994).

$$M_O(y_s,x_s,y_t,x_t) = \left[\frac{d_O^s\,(y_t,x_t)}{d_O^s\,(y_s,x_s)}\right] \cdot \left[\frac{d_O^t\,(y_t,x_t)}{d_O^t\,(y_s,x_s)}\right]^{½} \quad (1)$$

For output orientation: MO > 1 → Productivity growth, MO < 1 → Productivity decline

Decomposition of the index into efficiency change and technological change:

$$M_O(y_s,x_s,y_t,x_t) = \frac{d_O^t\,(y_t,x_t)}{d_O^s\,(y_s,x_s)}\left[\frac{d_O^s\,(y_t,x_t)}{d_O^t\,(y_t,x_t)}\right] \cdot \left[\frac{d_O^s\,(y_s,x_s)}{d_O^t\,(y_s,x_s)}\right]^{½} \quad (2)$$

Further decomposition of the index efficiency change into pure efficiency change

$$\text{Pure efficiency change} = \frac{d_{O\,VRS}^t\,(y_t,x_t)}{d_{O\,VRS}^s\,(y_s,x_s)} \quad (3)$$

and scale efficiency change =

$$\left[\frac{d_{O\,VRS}^t\,(y_t,x_t)/d_{O\,CRS}^t\,(y_t,x_t)}{d_{O\,VRS}^t\,(y_s,x_s)/d_{O\,CRS}^t\,(y_s,x_s)} \cdot \frac{d_{O\,VRS}^s\,(y_t,x_t)/d_{O\,CRS}^s\,(y_t,x_t)}{d_{O\,VRS}^s\,(y_s,x_s)/d_{O\,CRS}^s\,(y_s,x_s)}\right]^{½} \quad (4)$$

Four inputs and three outputs were used for the efficiency calculation in our analysis. Indicators are related to the following FADN standard results codes: Total output (SE131), Crop

Type of farming	Number of farms	(AWU/100 ha)	UUA (ha/farm)	Livestock units (LU/100 ha)
Total	**440**	**3.53**	**757.21**	**58.76**
Organic farming	**114**	**2.83**	**242.32**	**49.97**
(45) Specialist dairying	14	3.70	205.01	68.15
(46, 47) Cattle	72	2.30	317.33	49.20
(48) Sheep, goats and other grazing livestock	17	3.94	68.14	42.01
(7, 8) Mixed livestock, crops	11	3.51	67.94	44.21
Conventional farming	**326**	**3.77**	**937.26**	**61.84**
(45) Specialist dairying	92	4.65	606.46	74.60
(46, 47) Cattle	28	3.31	291.50	63.99
(48) Sheep, goats and other grazing livestock	3	2.42	66.48	60.32
(7, 8) Mixed livestock, crops	203	3.46	1189.12	55.78

Source: authors, based on Farm Accountancy Data Network (FADN CZ) (2016)

Table 1: Types of farming and number of farms represented organic and conventional groups.

output (SE135), Livestock output (SE206); Land input (SE025 - Total Utilized agricultural area), Livestock input (SE080 - Total Livestock unit), Labour input (SE010 - AWU), and Intermediate consumption (SE275 = SE281 Specific costs + SE336 Farming overheads). DEAP 2.1 program (Coelli, 1996) was used to measure the productivity indexes. The output-oriented Data Envelopment Analysis model assumed variable returns to scale. Variables were not deflated.

Statistical procedures for assessment of differences between efficient and inefficient groups were selected depending on the features of the two groups. If the two sample sizes are approximately equal, the equal-variance t-test can be used. The results of DEA indicate 169 farms with decline and 271 farms with growth, so the two-sample t-test compares the distribution between the farms with negative (group A) and positive (group B) change of efficiency. The null and alternative hypotheses were: H0: mean μ_1 = mean μ_2, HA: mean μ_1 > mean μ_2 (Diff > 0) or mean μ_1 < mean μ_2 (Diff < 0). So, the one-sided test of hypotheses is applied depending on the subjective assumptions about the efficiency determinants. The statistical analysis was processed automatically by software STATISTICA 12. Table 2 contains basic descriptive statistics of farms.

Results and discussion

Development of evaluated farms in 2011 - 2015

The results of DEA and TFP calculations are summarize in this section. We used balanced panel data for the period 2011 - 2015 with about 2,200 observations for 440 farms representing enterprises with livestock production (114 organic farms and 326 conventional farms). As the results from DEA Malmquist, we calculated measures of Efficiency change (effch), Technological change (techch), Pure efficiency change (pech), Scale efficiency change (sech), and Total factor productivity change (tfpch) for each farm. Average technical efficiency scores are presented in Table 3.

Based on DEA Malmquist analysis, overall improvement of productivity occurred in the group of complete panel data in the period from 2011 to 2015. A positive change in Total factor productivity enhanced by 1.92%. Technical efficiency in conditions of Constant returns to scale (effch) decreased by 1.07%, Technical efficiency (techch) increased by 1.66%, Technical efficiency of variable returns to scale (Pure technical efficiency; pech) lowered by 0.62%, and Scale efficiency change (sech) decreased by 0.45%. Development of Productivity change in individual years is presented in table 3. General improvement

Variable (per farm)	Mean	Standard deviation	Min	Max
Labor input	23.07	28.48	0.75	163.40
Utilized agricultural area	757.21	865.46	1.67	4 588.29
Livestock unit	398.38	465.43	4.29	2 348.29
Intermediate consumption	23 345 674	31 289 613	110 200	188 811 801
Total output (CZK)	30 832 699	42 700 716	143 000	302 363 000
Crop production (CZK)	13 899 283	21 265 079	20 000	216 540 000
Livestock output (CZK)	13 935 464	18 317 040	-491 000	90 510 000
Economic Size Class (1-14)	9	3.22	4	14

Source: authors, based on Farm Accountancy Data Network (FADN CZ) (2016)

Table 2: Basic descriptive statistics of average farms in 2011-2015 (N = 440).

	Period	effch	techch	pech	sech	tfpch
2	2012/2011	1.000	1.013	1.012	0.989	1.043
3	2013/2012	1.005	0.999	1.001	1.005	1.016
4	2014/2013	0.987	1.037	0.983	1.003	1.079
5	2015/2014	0.928	1.018	0.98	0.985	0.983
	Geometric mean	0.989	1.017	0.994	0.995	1.019
	Number of periods with decline	effch<1=2	techch<1=1	pech<1=2	sech<1=2	tfpch<1=1; 169 farms
	Number of periods with growth	effch>1=1	techch>1=3	pech>1=2	sech>1=2	tfpch>1=3; 271 farms

Source: authors, based on Farm Accountancy Data Network (FADN CZ) (2016)

Table 3: Malmquist Index summary of annual means.

was found in the period 2011 – 2014. In contrast, a decrease of 1.72% was calculated in the fifth year (2015/2014). The year 2014 was extremely successful from agricultural point with high yields of most crops. Decrease of productivity is corollary of subsequent comparison to usual agricultural production in 2015.

Productivity change by farming system categories

To compare the productivity change according to the farming system, i.e. organic and conventional, farms were separated into two groups. The Table 4 presents productivity change in groups of organic and conventional farms.

The group of organic farms (69%; 79 from 114 farms) showed running improvement of total productivity by 3.17% mainly due to Technical (technological) efficiencies with growth of 2% in the period 2011 – 2015. The highest increase was determined in comparison of 2013 and 2014 due to bumper yield in 2014. The harvest in 2015 was generally lower than in 2014, but still rather high. The favourable weather helped to gain sufficient yield which provided comparable factor of productivity in this group of farms as the previous year. A total of 59% of conventional farms (192 from sample of 326 farms) improved the efficiency and their development increased by 1.48% in the referenced period. Productivity continually increased from 2011 to 2014 and consequently decreased as was described for total set of farms due to general decrease of yield. Despite lower total value of farm production interpreted in CZK per hectare or farm unit, organic farms managed to reach higher change of technical productivity than conventional farms which testify for better adaptability of organic agriculture and ability to enhance its productivity. Farm production is limited by the farming system based on more environmental friendly practices.

Production of organic and conventional farms

Total factor productivity enabled to divide farms to separate groups based on their productivity development during the time. Farms with productivity index higher than 1 showed positive development (tfpch+). On the other hand, farms with index lower than 1 are described as subjects with negative change of efficiency (tfpch-). Table 5 presents production characteristics according to the FADN indicators of Standard results.

Organic farms showed better ability of positive improvement than conventional farms. Number of organic subjects with positive productivity index counted in our sample more than double of enterprises with negative change of efficiency. Compared to this, number of conventional farms with positive development exceeded number of farms getting worse just by 43%. Generally, there are about 20% of farms with positive technical efficiency in evaluated samples (Boudný et al., 2011; Balcombe et al., 2005; Heidari et al., 2011). The highest technical efficiency is usually reached in farms specialized in crop production (about 30%), whilst farms of livestock production or combined production improved only in 20% of analysed subjects. Combination of production types generally lower technical efficiency and variability of effectivity, as well (Boudný et al., 2011).

One of the first criteria usually used to describe farm characteristics is utilized agricultural area. Organic farms with positive index of productivity made use of larger area than farms with negative index as well as conventional farms. Utilized land area was relatively stable in organic farming, whereas conventional enterprises gradually decreased their area during the time.

Labour force in agriculture continually decreases.

Malmquist indices		effch	techch	pech	sech	tfpch	effch	techch	pech	sech	tfpch
Period		organic farming (N = 114)					conventional farming (N = 236)				
2	2012/2011	0.995	1.018	1.000	0.995	1.043	1.002	1.011	1.016	0.986	1.043
3	2013/2012	1.016	0.989	1.022	0.995	1.016	1.002	1.003	0.993	1.009	1.016
4	2014/2013	0.965	1.053	0.956	1.010	1.055	0.994	1.032	0.993	1.001	1.087
5	2015/2014	0.982	1.023	0.980	1.002	1.012	0.901	1.017	0.98	0.979	0.976
Geometric mean		0.989	1.02	0.989	1.000	1.032	0.989	1.015	0.995	0.994	1.015
the number of farms with decline		71	2	70	71	35	227	25	180	203	134
the number of farms with growth		43	112	44	43	79	99	301	146	123	192

Source: authors, based on Farm Accountancy Data Network (FADN CZ) (2016)

Table 4: Malmquist index summary of organic and conventional farming groups.

	SE010 /100 ha	SE025 (ha /farm)	SE131 (CZK /ha)	SE135 (CZK /ha)	SE206 (CZK /LU)	SE131 / SE010 (thous. CZK /AWU)	SE275 /SE025 (CZK /ha)	SE275 /SE080 (CZK /LU)	SE131 /(SE270 - SE 370) (CZK /CZK)	SE605 (CZK /ha)	SE622 (CZK /ha)	SE621 (CZK /ha)	SE415/ SE0205 (CZK /ha)	SE415 / SE010 thous. CZK/ AWU)
Total	**3.53**	**757**	**32 995**	**13 418**	**28 865**	**1 045**	**24 862**	**46 329**	**1.11**	**11 280**	**1 406**	**1 973**	**14 766**	**500**
Organic farms														
total	**2.83**	**242**	**15 535**	**4 755**	**18 305**	**596**	**13 802**	**30 107**	**1.56**	**14 667**	**2 694**	**5 083**	**11 946**	**540**
tfpch-	**2.80**	**179**	**13 679**	**4 934**	**14 771**	**551**	**13 324**	**28 961**	**1.60**	**14 458**	**2 715**	**4 986**	**10 491**	**497**
2011	2.88	180	14 408	**5 433**	15 753	585	13 299	29 000	1.46	13 653	2 749	5 120	10 331	**496**
2012	2.95	179	14 634	**5 054**	15 440	569	13 501	28 281	1.60	14 651	2 827	5 099	11 412	**539**
2013	2.81	179	14 413	**5 121**	15 277	584	13 673	29 190	1.52	14 611	2 795	5 050	11 091	**517**
2014	2.72	177	13 700	**4 930**	14 649	566	13 544	29 863	1.59	15 177	3 044	4 745	10 881	**536**
2015	2.63	183	11 240	**4 132**	12 737	451	12 601	28 472	1.84	14 198	2 159	4 914	8 739	**397**
tfpch+	**2.85**	**270**	**16 358**	**4 675**	**19 871**	**616**	**14 015**	**30 615**	**1.54**	**14 760**	**2 685**	**5 126**	**12 590**	**559**
2011	2.72	271	14 244	**4 432**	16 893	561	12 805	28 667	1.64	14 158	2 783	5 363	11 226	**528**
2012	2.74	273	14 814	**4 553**	18 256	579	13 230	30 318	1.63	14 560	2 771	5 049	11 772	**542**
2013	2.76	274	15 163	**4 490**	19 816	583	13 346	30 473	1.58	14 612	2 774	4 976	12 030	**546**
2014	2.91	273	17 456	**4 911**	21 246	649	14 591	31 461	1.48	15 423	3 023	4 934	13 763	**592**
2015	3.10	260	20 112	**4 988**	23 143	705	16 101	32 155	1.37	15 049	2 072	5 310	14 160	**586**
Conventional farms														
total	**3.77**	**937**	**39 100**	**16 447**	**32 557**	**1 203**	**28 729**	**52 002**	**0.95**	**10 096**	**956**	**885**	**15 752**	**486**
tfpch-	**3.83**	**771**	**37 539**	**15 436**	**31 380**	**1 134**	**27 592**	**47 255**	**0.96**	**10 055**	**1 092**	**1 003**	**15 389**	**470**
2011	3.87	783	36 693	**15 177**	30 386	1 089	26 089	43 868	0.91	8 916	1 054	1 072	15 302	**450**
2012	3.86	778	37 731	**15 762**	30 283	1 127	27 155	45 362	0.92	9 163	1 104	1 039	15 347	**459**
2013	3.82	774	37 587	**15 150**	32 269	1 119	27 333	46 980	0.95	10 219	1 077	1 004	15 857	**475**
2014	3.83	766	40 136	**16 468**	34 081	1 215	29 154	50 555	0.95	10 991	1 191	940	17 191	**525**
2015	3.75	756	35 549	**14 625**	29 881	1 118	28 231	49 511	1.06	10 988	1 034	961	13 251	**438**
tfpch+	**3.74**	**1 053**	**40 190**	**17 153**	**33 379**	**1 250**	**29 523**	**55 314**	**0.95**	**10 124**	**861**	**802**	**16 006**	**498**
2011	3.67	1 066	35 456	**15 931**	30 396	1 110	26 371	50 219	0.95	8 543	847	857	13 516	**427**
2012	3.77	1 066	38 262	**16 855**	31 310	1 178	28 067	53 014	0.94	8 753	869	805	14 537	**448**
2013	3.72	1 053	39 254	**16 682**	34 351	1 217	29 117	54 614	0.96	10 501	861	785	15 846	**496**
2014	3.68	1 043	44 668	**18 581**	36 922	1 411	32 008	60 592	0.92	11 377	931	766	18 990	**599**
2015	3.84	1 037	43 313	**17 716**	33 915	1 337	32 050	58 130	0.97	11 449	797	799	17 140	**522**

Note: SE010 Total labour input (Annual Working Units), SE025 Utilized Agricultural Area, SE131 Total output, SE135 Crop output, SE206 Livestock output, SE275 Total intermediate consumption, SE270-SE370 Total output excl. wages, SE360 Depreciation, SE405 Investment subsidies, SE605 Total subsidies excl. on investment, SE632 SAPS, SE622 LFA, SE621 AEO, SE415 Farm net value added (FNVA)
Source: authors, based on Farm Accountancy Data Network (FADN CZ) (2016)

Table 5: Production characteristics of organic and conventional farms in 2011 - 2015.

The analysis results confirmed faster decrease of labour input of conventional farms than of organic farming. Successful organic farms enhanced number of work force while group with negative index lowered. Labour input of organic farms was lower than conventional one.

Group of farms selected for presented analysis is focused on livestock production therefore the total production (total output) is created predominantly by livestock output. Total production and crop production are calculated in CZK per hectare, whereas livestock production is expressed in CZK per livestock unit (LU) with higher concise value in this point. Conventional farms continually increased total production in both groups of change of efficiency till 2014 with subsequent decrease. Successful organic farms gained gradually increased total output, whereas farms with negative efficiency enhanced production till 2013 followed by rapid decrease. Total output of organic farms with positive total factor productivity change (tfpch) counted in average 41% of total output of successful conventional ones. The rate changed from 40.2% in 2011 to 46.4% in 2015. Key role played difference in livestock production which changed by 13% between start and final of examined period. Based on the specialization of investigated farms, the main part of crop production are forage crops. Organic farms prefer production of own feedstuff and are less dependent on market swings. Conventional farms showed higher fluctuation in plant production among years of study resulting

from differences in yield and market prices.

Total intermediate consumption of organic farms represents in average 87% of total output per hectare. The same characteristic of conventional farms average out 73.5% which confirms narrower funds turnover inside of organic farming. Total intermediate consumption includes total specific costs (SE281) and total farming overheads (SE336).

Sum of subsidies is an integral part of farming profitability. The value of total subsidies excluding on investment, increased during the time in organic farming as well as in conventional farming. The peak was reached in 2014 followed by decrease of SAPS and LFA rates in 2015. The system of environmental subsidies was changed, as well. Table 5 shows only chosen important subsidies from the whole budget, it is obvious that conventional farms with positive TFP change had lower LFA and AEO subsidies than conventional farms with negative TFP change due to different farming conditions where most of the land is outside LFA with a smaller proportion of grassland.

Criteria of Farm net value added (FNVA) per hectare or AWU is usually used as the most comparable characteristics. This parameter of farms with positive total factor productivity change (tfpch+) copied the development of production and subsidies with general increase during the evaluated period. The peak of FNVA of conventional farming was found in 2014 as mentioned in previous parts. Organic farms with negative development varied with the lack of farming strategy. FNVA of organic farms calculated per hectare was slightly lower than the conventional one, but it was significantly higher when calculated per annual work unit (about 11% in average). Nieberg and Offermann (2008) compared FADN data from Germany and found average Income per annual work unit of organic farms about 21% higher than the profit of conventional farms. Their analysis showed that 11 % of analysed organic farms achieved only half as high a FNVA as their conventional counterparts. On the other hand, about 14% of the analysed organic farms could realize double of FNVA of their conventional comparison partners. Substitution of labour work by capital or contract work could positively affect income indicator FNVA per AWU in farms of mixed crop and livestock production (Špička, 2014).

Comparison of significance

Efficiency of farming results from input and output parameters. The importance of basic characteristics on the panel data sample was tested by statistical comparison. Results are summarized in Table 6. Utilized Agricultural Area, Total of Livestock Units, Total Intermediate Consumption per Livestock Unit, Total of Current Subsidies, and Farm Net Value Added per AWU were proved as highly statistically significant parameters ($\alpha = 0.01$). Statistically significant characteristics ($\alpha = 0.05$) Livestock Output per hectare, Total Output per AWU, Depreciation per hectare, and Farm Net Value Added per hectare were identified.

Importance of inputs and outputs related to farm efficiency of different types of production was evaluated several times. Organic as well as conventional farms analysed in our research with positive development used larger areas than farms with negative change of efficiency. Successful farms have larger arable areas with more diversified crop production and cultivate more cash-crops such as potatoes and vegetables (Balcombe et al., 2005; Nieberg and Offermann, 2008; Špička, 2014; Madau, 2015). In contrast, Boudný et al. (2011) found larger total Utilized Agricultural Area in farms with negative development of technical efficiency. Farms had larger areas of permanent grassland, lower intensity of dairy cows and poultry but higher intensity of cattle and sheep. Technical efficiency is negatively influenced by the number of plots and location in less-favoured areas (Madau, 2015).

Polish farms with an increase in productivity are more capital intensive, run by younger and most educated farmers, and more integrated in factor and product markets than farms with decreasing productivity (Balcombe et al., 2005). Positively developing farms use more hired labour and are less dependent on the family members work. Hired labour might be more qualified and more able to perform specialised tasks than family labour, as well (Balcombe et al., 2005; Latruffe et al., 2008). Conventional farms in our evaluation showed higher Labour Input per 100 ha than organic ones. Differences between positive and negative groups were very small. Contrary to our results, Špička and Machek (2015) found significantly lower Labour Input per hectare in group of successful dairy farms connected to the lower livestock intensity.

Most authors describe significant impact of Utilized Land Unit (Balcombe et al., 2005; Nieberg and Offermann, 2008; Špička, 2014; Čechura et al., 2015; Madau, 2015; Špička and Machek, 2015), Labour Input (Balcombe et al., 2005; Latruffe et al., 2008; Čechura et al., 2015; Špička

Indicator	Unit	"Group A (μ_1) tfpch < 1 N = 845"	"Group B (μ_2) tfpch >= 1 N = 1355"	H0 ($\mu_1 - \mu_2$)	T-Statistic	P-value	Sig.
Utilized agricultural area	ha/farm	648.7922	824.8142	$\mu_1 - \mu_2 > 0$	-4.66167	0.000003	++
	S_x	801.6664	896.6447				
Total livestock units	LU	61.39293	57.12306	$\mu_1 - \mu_2 > 0$	3.077915	0.00211	++
	Sx	27.58457	33.93544				
Labour input	AWU/100ha	3.613292	3.477567	$\mu_1 - \mu_2 > 0$	1.28368	0.199389	-
	S_x	2.053843	2.610631				
Total output	CZK/ha	32597.45	33242.88	$\mu_1 - \mu_2 > 0$	-0.774615	0.438651	-
	S_x	17858.79	19691.11				
Crop output	CZK/ha	13261.19	13515.47	$\mu_1 - \mu_2 > 0$	-0.681497	0.495629	-
	S_x	7669.473	8997.824				
Livestock output	CZK/ha	27940.45	29440.91	$\mu_1 - \mu_2 > 0$	-2.17631	0.029638	+
	S_x	14859.45	16246.75				
Total output per AWU	CZK/AWU	1013128	1065417	$\mu_1 - \mu_2 > 0$	-2.13175	0.033138	+
	S_x	548223.2	566532.0				
Total intermediate consumption per hectare	CZK/ha	24637.28	25001.95	$\mu_1 - \mu_2 > 0$	-0.700778	0.483516	-
	S_x	11448.03	12127.62				
Total intermediate consumption per livestock unit	CZK/LU	43466.57	48113.87	$\mu_1 - \mu_2 > 0$	-4.54182	0.000006	++
	S_x	20213.71	25096.99				
Depreciation per hectare	CZK/ha	4297.717	4494.118	$\mu_1 - \mu_2 > 0$	-1.50932	0.131362	+
	S_x	2787.781	3075.938				
Investment subsidies	CZK/ha	661.6242	736.6857	$\mu_1 - \mu_2 > 0$	-0.522505	0.601371	-
	S_x	3302.229	3261.627				
Total current subsidies	CZK/ha	10967.25	11475.76	$\mu_1 - \mu_2 > 0$	-2.96727	0.003037	++
	S_x	3694.466	4037.858				
Farm net value added (FNVA) per hectare	CZK/ha	14374.90		$\mu_1 - \mu_2 > 0$	-1.71478	0.086527	+
	S_x	8189.381	8609.347				
Farm net value added (FNVA) per AWU	CZK/AWU	475245.9	515949.3	$\mu_1 - \mu_2 > 0$	-3.26059	0.001129	++
	S_x	288020.2	282753.8				

Note:
Sx = Standard Deviation,
Significance level: - no significance, + statistically significant (α = 0.05), ++ statistically highly significant (α = 0.01)
Source: authors, based on Farm Accountancy Data Network (FADN CZ) (2016)

Table 6: Structural and production differences between groups with increasing and decreasing technical efficiency in the period 2011-2015.

and Machek, 2015), Total Livestock Unit (Špička and Machek, 2015), Crop and Livestock Production (Boudný et al., 2011; Špička, 2014; Čechura et al., 2015; Špička and Machek, 2015), Total Costs - Specific and Other Material (Boudný et al., 2011; Čechura et al., 2015; Špička and Machek, 2015), and higher income per AWU and per hectare (Špička, 2014). Total current subsidies per hectare or Farm Net Value Added per hectare did not significantly differ (Boudný et al., 2011; Špička, 2014).

Conclusion

This paper focused on the structural and production differences between groups with the positive and negative change of technical efficiency in the period 2011 – 2015. To analyse the changes, DEA Malmquist indices of total factor productivity were used. The sample of panel data of 440 farms represented enterprises with livestock production divided into 114 organic and 326 conventional ones. Based on the total factor productivity change index, the statistical description and hypothesis testing, the results revealed some important findings related to FADN organic and conventional farms.

1. The results showed very small difference in technical efficiency between compared groups of farms and the relatively insignificant changes in time. Estimated TFP did not indicate fundamentally significant

growth or significant differentiation between holdings. The analysis of technical efficiency of livestock type of farming reveals 169 farms with negative and 271 farms with positive change in the productivity efficiency. In the period 2011 - 2015, about 69% of organic enterprises (79 from 114 farms) showed the productivity growth (i.e. the change in Total factor productivity of 3.17%), mainly due to technical (technological) efficiencies with growth of 2%. A total of 59% of conventional enterprises (192 from sample of 326 farms) were managed with increasing productivity with change TFP by 1.48%.

2. The group of farms with positive change in the production efficiency had significantly higher average agricultural utilised area, livestock units (LU) per farms and total consumption related to LU than group of farms with negative change. In terms of production there are statistically significant difference in production per total labour input (AWU) and for the livestock production. Statistically significant difference in depreciation indicates higher investment activities of farms with growing TFP. Subsidies on rural development and LFA subsidies significantly determines the FNVA. The analysis proved highly significant difference in FNVA per AWU between both groups of farms.

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Reform Raises Efficiency of Tea Estates in India

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Abstract

This study compares the performance of the tea industry of Assam and West Bengal of India between two time stretches each spanning over six years; one ending in 2006-07 - the pre-reform regime - and the other beginning in the next year- the post-reform regime. The basic question addressed is whether reform policy led to improvement in technical efficiency of the tea industries of these states. The study uses stochastic frontier approach and introduces heterogeneity of tea gardens. Consideration of both Assam and West Bengal tea gardens adds unique flavour to this study. The study the study concludes that rehabilitation package of Indian government in the form of reform has paid off even within the existing framework of the tea gardens.

JEL Classification: C01, Q17, Q19

Keywords

Stochastic Production Frontier, Technical Efficiency, Tea Gardens, Panel Data, Farm-heterogeneity.

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Introduction

Tea is the most popular of all non alcoholic beverages in the world and two-third of the world population drinks '*Camellia sinensis*' (Tea). The popularity of tea has gained momentum with colonisation. Tea is commercially cultivated in the areas scattered in more than 65 countries. The major tea producing countries are India, China, Kenya, Sri Lanka, Turkey, Viet Nam, Indonesia, Bangladesh, Malawi, Uganda and Tanzania. Total tea production in the world has exceeded over 4.5 billion kgs, in 2012 where India alone contributed more than 1 billion kg of tea in 2012 and was recognised as one of the leaders in world tea production along with China (Table A1, Appendix) (Source: ITC Annual Bulletin Supplement, 2012 & MSS- March, 2013).

Tea may be placed under agriculture and also industry. It is an agricultural crop as it is grown on land and thus it is subjected to agricultural income tax. On the other hand, it is an industry in the sense that, tea is a processed commodity, and it is subjected to excise duty and cess. The tea crop involves both agricultural and industrial operations. A large amount of tea has been sold in the international markets from the very inception of this industry. As tea is placed under agriculture and industry, the concept of production efficiency is important in case of tea industry. The consequences of the presence of inefficiency in the production process can be observed in four ways, as follows:

1. It reduces the quantity of output for a given set of inputs.
2. Some of the inputs will be either under-utilized or over-utilized.
3. There will be an increase in the cost of production.
4. There will be a loss of profit.

A production frontier gives the maximum possible output from a given set of inputs or represents minimum input bundles required to produce a given level of output given the state of technology and technical efficiency relates to the producer’s behaviour relating to the production of output with a given quantity of inputs (Kumbhakar, and Lovell, 2000). Literature abounds with the application of the measurement of efficiency by the stochastic frontier approach. The pioneering contribution in this context was made by Farrell, (1957). Later on Kalirajan, (1981), Battese, and Coelli, (1988), Ferrier, and Lovell, (1990), extended the research on efficiency estimation by using a cross section time series or panel data. Kumbhakar, et al., (1991), examined the impact of technical and allocative efficiency on the level of profits of US dairy

farms. Battese, and Coelli, (1992), applied Frontier Production Function to an unbalanced panel data of paddy farmers in India. Battese, and Coelli, (1995), used a stochastic frontier production function for panel data on Indian paddy farms, in which the non-negative technical inefficiency effects were assumed to be a function of firm-specific variables and time.

Aigner, et al., (1977), considered stochastic frontier production functions and Schmidt and Lovell (1979) extended the earlier work by considering the duality between stochastic frontier production and cost functions - under the assumptions of exact cost minimization (considering technical inefficiency only) and of inexact cost minimization (technical as well as allocative inefficiency). Dutta, and Neogi, (2013), used the stochastic frontier approach to analyse heterogeneous panel data. Studies that have concentrated on the investigation of the tea gardens' efficiency in India or any other tea producing country, however, are very limited. This may be because of the non-availability of reliable panel data. Studies that merit special mention in the area of measurement of technical efficiency of tea industry are by Hazarika, and Subramanian, (1999), Mahesh, et al., (2002), Basnayake, and Gunaratne, (2002) and Ariyawardana, (2003). All these studies applied stochastic frontier analysis for investigating the efficiency status of tea gardens. The first two studies were conducted for the Indian tea industry, focusing Assam tea belt, while the last two were based on the data on tea cultivation in Sri Lanka. The stochastic frontier analysis technique was utilized also to investigate the nature of technical efficiency of organic tea small holding sector in Sri Lanka (Jayasinghe, and Toyoda, 2004). Their results indicated that efficient utilization of the existing technology and labour force itself could increase production up to 55 per cents. Baten, et al. (2009 and 2010) examined the status of technical efficiency of tea-producing industry for panel data in Bangladesh using the stochastic frontier production function, by using technical inefficiency effect model. Again, Maity, (2011), Maity, (2012), examined technical and allocative efficiency by using stochastic frontier approach for the tea gardens of West Bengal and concluded that large tea gardens were relatively more efficient than medium and small tea gardens. Maity, and Neogi, (2014), examined technical efficiency status for Indian tea gardens by using panel data. But not all tea gardens efficiency related study used a parametric approach. Rather, some studies used the non-parametric approach. For example, efficiency of the Indian tea industry, considering tea gardens of Assam and West Bengal, was investigated by using the non-parametric approach by Bhattacharjee, and Sharma, (2016).

Studies related to tea garden level efficiency measurement have generally revolved around Bangladesh, Sri Lanka and India as tea is one of the main exportable commodities from these countries. In case of India the studies have mainly focused on measuring efficiency of the tea gardens of either Assam, or West Bengal, tea belt. The present study is unique because it is based on both Assam and West Bengal tea gardens taken together. Significantly, it compares the performance of these two major tea producing states of India.

It is noted here that we have developed our model in the line of Battese, and Coelli, (1995), as well as Dutta, and Neogi, (2013). For the measurement of technical efficiency in the production of tea in Assam and West Bengal we used the stochastic production frontier approach, but we avoid using the two step procedure as it has been shown that it gives biased estimates (see Green, 2005; Fried, Lovell, and Schmidt, 2008, page 39). The methodologies used are discussed in the chapter Materials and methods.

Problem background

The present study focuses on estimating the technical efficiency for selected tea gardens of India, considering only gardens located in Assam and West Bengal. Tea is mainly grown in North India, which accounts for about 80percent of the country's total tea production. Furthermore, even though tea is commercially cultivated in 16 states in India, Assam (52.0 per cents), West Bengal (25.8 per cents), Tamil Nadu (14.5 per cents) and Kerala (5.3 per cents) together account for more than 97.6 per cents of the total tea production. Indeed, Assam and West Bengal together contribute almost 78percent of total tea production (Table A2, in Appendix). Also, the total area under tea production in Assam and West Bengal together accounts for almost 79 per cents of the total area under tea production in India.

The Indian tea industry has a 170 years old history and it has since then contributed importantly through exports to the country's national income. However, it has seen many ups and down in the last few years. The major problems of the Indian tea industry are: old age of tea bushes, limited availability of land in the traditional areas of tea cultivation for further extension and slower pace of replantation, the rate (0.4 per cent) is much lower than the desired (2 per cents) level, etc.

In view of these issues, for the reclamation of the tea gardens of Kerala, West Bengal and Assam, the Indian government announced certain rehabilitation packages in 2004. These packages gave the industry some breathing space and helped it to achieve better productivity. Encouraged by those positive results in 2006-07 the government further announced additional relief packages- focusing again mainly the tea gardens of Assam and West Bengal. The relief packages include, special purpose tea fund, Electronic Auction System, Setting up of a separate cell to look into the developmental needs of the small growers, Development of Geographic Information System through remote sensing, Energy conservation in small tea processing units, Organic Tea Development Project, etc.

The primary aim of this study is to compare the performance of the tea industry before and after the implementation of these relief packages. Since the relief packages focused tea gardens of Assam and West Bengal only and also it is true that Indian tea industry is largely dominated by Assam and West Bengal's tea gardens, this study has focused on comparing the performance of the tea industry of Assam and West Bengal, probing two stretches each spanning over six years; one ending in 2006-07 - the pre-reform regime, and the other beginning in the following year- the post-reform regime. Thus the entire study period 2001-02 to 2012-13 is divided into two regimes, the pre-reform period spanning 2001-02 to 2006-07 and the post-reform period 2007-08 to 20012-13.

Other than this research objective, another objective of this study is to test the relationship between the size of the garden, measured in terms of the land area under production, and technical efficiency. Finally, in this paper author attempts to identify the major inputs or factors that influence the production of tea.

This paper is organized so as to investigate each of these research objectives in turn. The chapter Introduction reviews the literature that covers efficiency measurement leading to the justification of conducting this study. We outline the methodologies adopted, in the chapter Materials and methods. The research objectives are investigated and discused in the chapter Results and discussion. The last chapter concludes the study and suggests the induced policy measures.

Materials and methods

Materials

This empirical study on the measurement of technical efficiency is entirely based on secondary data. The principal data source is the Tea Diary, published annually by Tea Board of India. But Tea Diary does not publish garden level panel data. Garden level panel data are collected from various garden level files maintained by Tea Board of India, Kolkata. It is to be noted here that the term "tea garden" in its present use in this paper means a collection of several individual tea farms that are producing tea under the same "garden" heading, that is, local garden names used in different areas of Assam and West Bengal. We collected data for different tea gardens from the Department of Record section of Tea Board of India, Kolkata.

The comprehensive scheme envisages the collection of reproductive data on inputs and outputs and estimation of cost of cultivation per hectare of tea for selected tea gardens of Assam and West Bengal. Garden level data were collected for the periods 2001-02 to 2012-13 and for 24 cross sections representing 24 gardens.

Methods: The Model to be estimated

We have studied technical efficiency for the tea production of selected tea gardens of India using stochastic frontier approach.

Abbreviating the production function we can write our model to be estimated as:

$$y_i = f\left(x_i, \beta\right)\exp(v_i)TE_i \qquad (1)$$

Where y is the output, x and β stand for the vector of arguments of the production function and the vector of the coefficients respectively; all the variables being expressed in logarithm. $\exp(v_i)$ is the random error term and the subscript i refers to the particular cross section.

The most commonly used forms of production functions are Trans-log and Cobb-Douglas models which are given as:

Trans-log:

$$\ln f(t, \mathbf{x}_{it}; \boldsymbol{\beta}) = \sum_{j=1}^{K} \beta_j \ln x_{ijt} + \frac{1}{2}\sum_{j=1}^{K}\sum_{k=1}^{K} \beta_{jk} \ln x_{ijt} \ln x_{ikt}$$

$$\beta_t t + \beta_t t^2 + \sum_{j=1}^{K} \beta_{jt} \ln x_{ijt} t + (v_i - u_i) \quad (2)$$

Cobb-Douglas:

$$\ln y_i = \beta_0 + \beta_1 \ln k_i + \beta_2 \ln l_i + (v_i - u_i) \quad (3)$$

Implementation of the above model requires assumption of the form of the production function. We have implemented both the flexible trans-log form and relatively simple Cobb-Douglas form using panel data on tea production of selected tea gardens of India. A study of possible superiority of the trans-log over the Cobb-Douglas model can be tested using the log-likelihood functions. The value of the generalized likelihood-ratio (L.R.) statistic for testing the null hypothesis that the coefficients of the second order terms of the Trans-log model are jointly insignificant (i.e. $\beta_{ij} = 0$) is:

$$L.R = -2\{\ln(L_{C-D}) - \ln(L_{T-L}\} \quad (4)$$

L.R. is here assumed to be asymptotically distributed as χ^2 with k degrees of freedom (Coelli et al., 1998, pp.218), where k is the number of restrictions and $L_{C\text{-}D}$, $L_{T\text{-}L}$ are maximum likelihood function for Cobb-Douglas (restricted) and Trans-log production function (unrestricted) respectively.

We once again consider equation (6). The firm specific technical efficiency (Kumbhakar, et al., 1991) which is assumed to be random variable may be written as: $TE_i = \exp(-u_i)$. Since $TE_i \leq 1$, hence $u_i \geq 0$, i.e., this error is one sided. So, we can write (6) as:

$$y_i = f(x_i, \beta)\exp(v_i)\exp(-u_i) \quad (5)$$

Here the assumptions are that $v_{it} \sim n.i.d.(0, \sigma_v^2)$ and $u_{it} \sim n.i.d.(0, \sigma_u^2)$. Further u_i and v_i are independent of each other and also independent of x_i. So, the underlying model is Normal-Truncated Normal; it was introduced by Stevenson (1980).

Our objectives are to

a) Estimate the vector β of $f(x_i, \beta)$ under a specific assumption on the form of production function, and

b) Estimate the technical efficiency of each producer.

In case of panel data technical efficiency may be assumed either to be time invariant or to be varying with time. If panel is a long one in time the assumption of time invariant may not be defensible unless specifically suggested by data. Battese and Coelli (1992) proposed a model for time varying technical efficiency for stochastic frontier approach with panel data. Technical efficiency effects for N cross-sections observed over T periods are defined by:

$$u_{it} = \left[e^{-\eta(t-T)}\right]u_i \quad i = 1,2,....N; t = 1,2,....,T \quad (6)$$

where u_i are assumed to be *IID* truncated random variables as defined above and η, which is the focus of our attention, as it measures the efficiency trend of the tea gardens, is an unknown scale to be estimated.

Maximum-likelihood estimation (MLE) of equation (10) has been obtained by using the FRONTIER-4.1 programme (Coelli, 1996). FRONTIER programme gives the estimate of vector β, as well as well as the scalar ($\gamma = \frac{\sigma_u}{\sigma}, where\ \sigma^2 = \sigma_u^2 + \sigma_v^2$),

where (γ) lies between 0 and 1 depending on the dominance of σ and σ_u respectively. One deficiency of this programme, however, is that estimates of technical efficiency for different gardens in its present application for each period is given by it by applying the same exponential trend function on the efficiency estimate for the last period; thus only the trend values are observed and garden ranking is invariant.

Specification of variables

In this section our intention is the introduction and specification of the variables used to measure the relative efficiency of the selected tea gardens in Assam and West Bengal. The specification of model is given in the previous section. We provide now the definition of the variables used as follows:

HL = Human Labour (Wage Bill)
RWW = Resources spent on Workers' Welfare
BHF = Bush Hygiene Factor
PSTCD = Pesticides
FERT = Fertilizers
IRRIG = Irrigation
RRPR = Re-Plantation Requisites
CAPST = Machineries or Capital Stock
LND = Area under production: hectare
Y = Output (revenue in Rupees per kilograms)

All the variables (including output) except land are measured in value terms, that is, in rupees lakh per hectare. The dependent variable Total Output (TOUT) is measured in terms of revenue in rupees per Kilograms to address the quality issue of tea. As tea can be of different types, the qualities and varieties can only be addressed by considering the prices paid for different types of tea and thus we consider revenue per kilogram as the output variable. The details descriptions of the variables are presented in Table 1.

Variable name	Variable description
Human Labour (wage bill) (HL)	Human Labour (wage bill) is measured in value term, that is, rs/hectare and is the total expenses on human labour in order to induce them to work in the tea-garden.
Resources spent on workers' welfare	Measured in value term, rs per hectare and is the sum of workers' welfare and security and welfare sundries
Bush hygiene factor	Measured in value term, rs per hectare and it includes cultivation expenses for matured tea bushes and the development costs of the area under which this cultivation are made.
Pesticides	Cost in Rs per hectare. It includes costs of chemical weed control and pests & blights
Fertilizers	Indicates per hectare cost of fertilizer in rupees. It includes urea, dolomite, sulphur, special foliar mixture, foliar-mop & urea spraying costs etc.
Irrigation	Indicates per hectare cost of irrigation in rupees. It includes pumping, petrol costs etc.
Re-plantation requisites	Indicates the factors required for immature cultivation, measured in rs per hectare. Immature cultivation means cultivation expenses required for immature tea bushes.
Machineries or capital stock	Indicates per hectare expenditure on machineries. It includes machineries and equipments, machineries and equipment maintenance etc.
Area under production: hectare	Indicates area in hectares under tea production.
Total output	Revenue in rupees per kilograms to address the quality issue of tea.

Source: Author's own specification

Table 1: Description of variables used in stochastic production frontier function of tea production for selected tea gardens of India.

Table A3 in the appendix gives the descriptive statistics of the dependent variables and various independent variables used in the estimation of SPF regression.

Results and discussion

In this section we discuss results related to the objectives of the study.

Area under production of tea in selected tea gardens of India during 2001-02 to 2012-13

The data on each input and output (both in physical and monetary terms) were collected by the full-time field man residing in the tea gardens selected for the study, on the basis of his day-to-day observations. We next consider the presentation of the average area under production for selected tea gardens through Figure 1.

It is clear from the above figure that Kakajan becomes the largest tea garden with an average area under production is 1559.41 hectares and Noweranuddy becomes the smallest tea garden with an average area under production is 236.81 hectares. There are only two tea gardens, namely Hattigor and Powai, whose average area under production are more than 900 hectares. There are altogether four tea gardens (Batabari, Noweranuddy, Nahorkutia, Lamabari and Teok) whose average areas under production are less than 400 hectares. Chubwa, Happy Valley, Dam Dim, Rungamuttee, Kellyden tea gardens have more than 700 hectares, but less than 900 hectares area under cultivation. All this information is graphically presented in Figure 1.

Classification of tea gardens in Assam and West Bengal

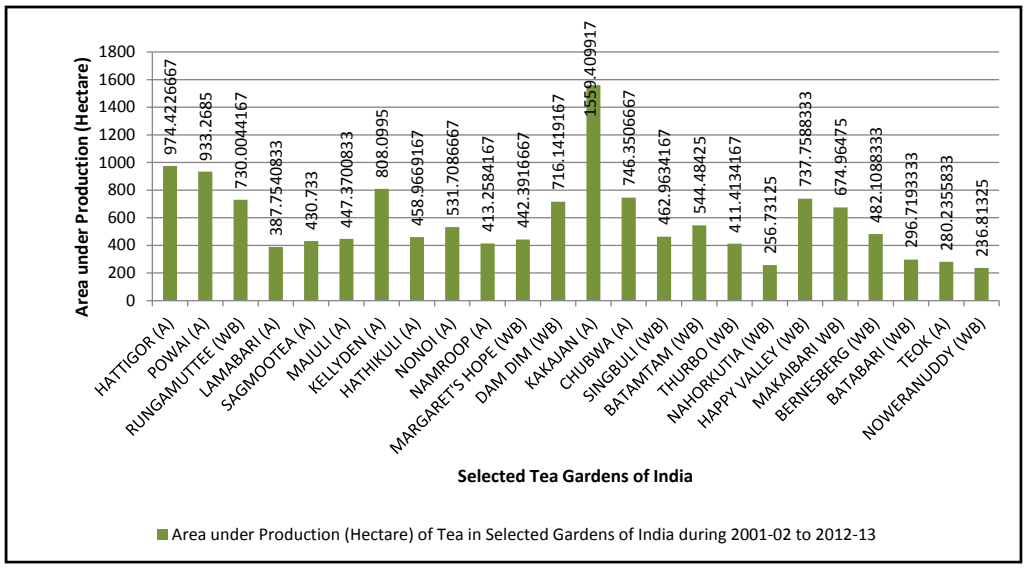
There exists a wide variation in the sizes of the gardens with respect to the area under cultivation, which gives us enough opportunity to divide the gardens into three categories, namely, small, medium and large. The gardens with less than 400 hectares area under cultivation are classified as small tea gardens. The gardens with more than 400 hectares but less than 600 hectares area under production is classified as medium tea gardens. Finally, the tea gardens whose area under cultivation is more than 600 hectares are tagged as large tea gardens. The classifications of the gardens are thus made purely on the basis of the areas under production in terms of hectares with the intention of checking the relationship between garden size and efficiency. Table 2 presents the classification of the gardens according to their sizes. Accordingly, we have five small, ten medium and nine large tea gardens - in Assam and West Bengal.

Cobb-Douglas versus Trans-log Model

A study of possible superiority of the trans-log over the Cobb-Douglas model may be made using log-likelihood functions. The log-likelihood ration test statistic is given by the relation (4)

The test results for two panels and also for entire panel were obtained STATA-11 and are presented in Table 3.

For the first panel, the test yields insignificant result; so, we cannot prefer trans-log to be in its



Source: own processing

Figure 1: Area under Production (Hectare) of Tea in Selected Gardens of India during 2001-02 to 2012-13.

Size of Tea Gardens (Hectares)	Number and Name of Tea Gardens
Tea gardens with land size below 400 hectares will be called in this study as the small tea gardens	Five tea gardens in West Bengal and Assam belong to this category. They are BATABARI (West Bengal), NOWERANUDDY (West Bengal), NAHORKUTIA (Assam), LAMABARI (Assam) and TEOK (Assam).
Tea gardens with land size above 400 hectares but below 600 hectares will be called in this study as the medium tea gardens	Ten tea gardens in West Bengal and Assam belong to this category. They are THURBO (West Bengal), BADAMTAM (West Bengal), BARNESBEG (West Bengal), MARGARET'S HOPE (West Bengal), SINGBULLI (West Bengal), HATHIKULI (Assam), MAJULI (Assam), NAMROOP (Assam), NONOI (Assam) and SAGMOOTEA (Assam).
Tea gardens with land size above 600 hectares will be called in this study as the large tea gardens	Nine tea gardens in West Bengal and Assam belong to this category. They are DAMDIM (West Bengal), HAPPY VALLEY (West Bengal), MAKAIBARI (West Bengal), RUNGAMUTTEE (West Bengal), HATTIGOR (Assam), KAKAJAN (Assam) , KELLYDEN (Assam), CHUBWA (Assam) and POWAI (Assam).

Source: Author's own division based on secondary data

Table 2: Classification of tea gardens in India (West Bengal and Assam) according to their size in hectares.

simpler form. However, this point here is only of academic interest, since both the forms yield positive and statistically significant giving us the same conclusion regarding the trend of efficiency. In all other cases the trans-log regression either fails or yields a smaller value for Log-likelihood Functions; so we reject the trans-log form and work with only Cobb-Douglas form in the subsequent steps.

Random-effects GLS regression and Fixed-effects (within) regression result analysis

As confirmed by the LR test the CD production function is applicable for two as well as whole panel. Thus our specified model may be presented by the following equations:

$$\ln Y = \alpha_0 + \alpha_{hl}\ln(HL) + \alpha_{pstcd}\ln(PSTCD) + \alpha_{fert}\ln(FERT) + \alpha_{irrig}\ln(IRRIG) + \alpha_{rrpr}\ln(RRPR) + \alpha_{capst}\ln(CAPST) + \beta_{RWW}\ln(RWW) + \beta_{BHF}\ln(BHF) + \beta_{land}\ln(LAND) + (V_{it} - U_{it}) \quad (7)$$

where, *ln* is the natural logarithm (i.e., to the base *e*).

For the purpose of estimation of the model we used FRONTIER 4.1, developed by Coelli, (1996) and STATA-11.

According to Cornwell et al (1990), for repeated observations over time, the model shall be estimated by different methods such as fixed effects 'within', or random effects 'generalized least squares' (GLS),

Panel	Natural Logarithm of LL. Function		Log-Likelihood Ratio Test = -2[ln(CD)-ln(Tr.Log)]	Prob > χ^2
	CD	Tr.Log		
Whole	-551.655	-541.827	19.66	0.8449*
First Panel (24 cross sections) (2002 to 2007)	-6.520	-4.710	3.62	0.8898*
Second Panel (24 cross sections) (2008 to 2013)	Trans-lag regression fails: so no question of comparison			

Note: *Evidence does not show any superiority of Trans-Log over Cobb-Douglas form
Source: Author's own calculation based on garden level secondary data

Table 3: Generalized Log-Likelihood Ratio Test of Significance the Trans-Log Model.

Random-effects GLS				Fixed-effects (within)		
Variable	**Coefficients**	**S.E**	**t-ratio**	**Coefficients**	**S.E**	**t-ratio**
Constant	111846.900	98585.350	1.13	1415190.000	522557.700	2.71
Human Labour	27.365***	16.003	1.71	127.699***	76.011	1.68
Pesticide	-134.030*	37.720	-3.55	-192.933***	112.826	-1.71
Fertiliser	77.632	57.229	1.36	-135.061	258.126	-0.52
Irrigation	-107.215***	56.452	-1.90	-43.477	248.822	-0.17
Replantation Requisites	-0.782	14.762	-0.05	-247.433	248.093	-1.00
Machineries	171.350*	55.140	3.11	33.068	59.362	0.56
Land	1625.000*	133.081	12.21	782.442	821.168	0.95
RWW	23.857***	14.201	1.68	42.312	130.197	0.32
BHF	53.217***	30.969	1.72	26.610	126.827	0.21
R^2 (Within)	0.006			0.028		
R^2 (Between)	0.964			0.106		
R^2 (Overall)	0.498			0.046		
Sigma u	602847.810			0.000		
Sigma e	440329.300			440329.300		
Rho	0.652			0.000		
Observations	280			280		

Note: *, **, *** significance at 1%, 5% and 10% respectively
Source: Authors' own calculation based on SRS data

Table 4: Random-effects GLS regression and Fixed-effects (within) regression coefficients of stochastic production frontier function of tea production for selected tea gardens of India for whole panel (No of observations: 280).

or random effects 'maximum likelihood estimates' (MLE), assuming a particular distribution for the one-sided error u_i in the equation.

In this study, we estimate both the fixed effects (within) and random effects GLS models. The results are presented in Table 4.

A close perusal of the reveals that the Random-effects GLS results are better than the Fixed-effects (within) regression. The variables like human labour, pesticide, irrigation, machineries, land, resources spent on workers' welfare and bush hygiene factor are turned out statistically significant at different levels for random effects GLS model. The signs of the estimated coefficients are as expected in the case of both random effects GLS and fixed effects (within) model. But the sign of the estimated coefficient fertiliser in the case of the fixed effects (within) model is puzzling. Thus, at this point of discussion, we need to identify which model will be appropriate to discuss the panel regression and the corresponding test result is discussed in the next section.

Random Effects versus Fixed Effects Model

As we are dealing with panel data, it is customary to specify the nature of the panel data and also the type of the effects model which will be applicable for the purpose of regression. Here we have utilised 24 garden level data over a 12 year period (2002-2013). For each cross section we have the relevant data covering the years 2002 to 2013. Thus, we have strongly balanced panel data. Regarding the identification of the effects

model we conducted the Hausman specification test. The result of this test is obtained by using STATA-11 and is presented in Table 5.

The null hypothesis related to Hausman test is that the Random Effects Model is appropriate. Table 4 shows that the value of χ^2 the is 19.39 with degrees of freedom 7 and the corresponding Prob > χ^2 value is 0.116. Thus, we accept null hypothesis which indicates Random Effects model will be appropriate in our case.

Analysis of efficiency levels of the teagardens

In this section discuss the results on efficiency obtained from the estimation of the model (equation 11) given in the methodology section. The results are presented in Table 6.

With the help of table-6 we will investigate our main objective- the comparison of the performance of tea estates of Assam and West Bengal in pre-reform and post-reform periods, as well as for the entire study period. This table will also help us to investigate the relationship (if any) between the size and efficiency of the tea gardens. Each pre- and post-reform period is spanning over six years; one ending in 2006-07, the pre-reform regime, and the other beginning in the following year, the post-reform regime. Twelve tea gardens from each state are considered for the purpose of comparing the performance in the post and pre-reform period. Assam consists of five large, five medium and two small tea gardens, while West Bengal comprises four large, five medium and three small tea gardens.

The mean efficiency score in the pre-reform regime is 0.847 while that in the post-reform period is 0.890. The panel mean efficiency score for the entire study period is 0.638. This mean efficiency score is considered as the benchmark of efficiency for each panel as well as for the entire study period. This means that the garden for which efficiency score is above the panel mean efficiency, we will consider that garden is technically efficient than the other and vice-versa.

In the pre-reform period (Panel-I) the lowest efficiency score is obtained for Batabari (WB) (0.716) and the highest efficiency score is obtained for Hathikuli (A) (0.943). Considering mean efficiency of panel-I as the benchmark of comparison, we find twelve tea gardens out of twenty four as efficient. Out of these twelve efficient tea gardens seven gardens are located in Assam and remaining five are located in West Bengal. The highest efficiency score in panel-I is 0.943 for tea gardens located in Assam, obtained for Hathikuli (A) and the corresponding lowest value is 0.810 - obtained for Hattigor (A). Again, the highest and the lowest efficiency score obtained for the tea gardens located in West Bengal are 0.922 and 0.716 respectively, obtained for Singbuli (WB) as well as for Makaibari (WB) and Batabari (WB) respectively. A perusal of the complete table reveals that the performance of the Assam tea gardens in the pre-reform regime (Panel-I) are relatively better than that of the West Bengal tea gardens. In fact mean efficiency score for overall Assam tea gardens is 0.865 compared to that of the West Bengal tea gardens is 0.829. In order to test the significance of such difference we conduct t-test and the test result suggests that Assam tea gardens more efficient than that of West Bengal at 5 percent level of significance (Table 7). According to our specified benchmark for Panel-I tea gardens located in Assam turned out efficient, while that of West Bengal are inefficient. Thus we conclude that reform in the form of relief packages

Variables	Coefficients		Difference (b-B)	S.E	χ_9^2	Prob > χ^2
	Fixed Effect (b)	Random Effect(B)				
Human Labour	-127.699	27.365	-155.065	83.724	22.83	0.118*
Pesticide	192.933	-134.030	326.963	139.053		
Fertiliser	135.061	77.632	57.429	251.702		
Irrigation	-43.477	-107.215	63.738	242.333		
Replantation Requisites	-247.433	-171.350	-76.083	241.888		
Machineries	33.068	0.782	32.286	57.497		
Land	-782.442	1625.000	-2407.442	810.312		
RWW	42.312	-23.857	66.170	126.375		
BHF	-26.610	53.217	-79.827	122.988		

Note: *Evidence shows Random Effects model is appropriate
Source: Author's own calculation based on garden level secondary data.

Table 5: Hausman Test to choose between Random Effects and Fixed Effects Model.

Year → / Garden Name ↓	Garden Classification	Panel-I (Pre-reform)	Panel-II (Post-reform)	Whole Panel
Hattigor (A)	Large	0.810	0.903	0.637
Powai (A)	Large	0.884	0.883	0.658
Rungamuttee (WB)	Large	0.741	0.925	0.632
Lamabari (A)	Small	0.824	0.894	0.648
Sagmootea (A)	Medium	0.832	0.910	0.646
Majuli (A)	Medium	0.876	0.887	0.640
Kellyden (A)	Large	0.894	0.938	0.646
Hathikuli (A)	Medium	0.943	0.901	0.615
Nonoi (A)	Medium	0.882	0.903	0.642
Namroop (A)	Medium	0.835	0.923	0.652
Margaret's Hope (WB)	Medium	0.811	0.931	0.644
Dam Dim (WB)	Large	0.896	0.938	0.659
Kakajan (A)	Large	0.851	0.942	0.655
Chubwa (A)	Large	0.908	0.662	0.626
Singbuli (WB)	Medium	0.922	0.895	0.629
Batamtam (WB)	Medium	0.859	0.905	0.622
Thurbo (WB)	Medium	0.825	0.920	0.636
Nahorkutia (WB)	Small	0.825	0.945	0.650
Happy Valley (WB)	Large	0.772	0.742	0.614
Makaibari (WB)	Large	0.922	0.906	0.645
Bernesberg (WB)	Medium	0.759	0.836	0.631
Batabari (WB)	Small	0.716	0.863	0.626
Teok (A)	Small	0.840	0.930	0.641
Noweranuddy (WB)	Small	0.896	0.894	0.630
Mean Efficiency (Assam)	--	**0.865**	**0.890**	**0.642**
Mean Efficiency (WB)	--	**0.829**	**0.892**	**0.635**
Mean Efficiency	--	**0.847**	**0.890**	**0.639**

Note: A stands for Assam and WB stands for West Bengal
Source: Author's own calculation on the basis of secondary tea garden level data

Table 6: Panel-wise efficiency estimates for the Tea gardens of Assam and West Bengal.

Year	Mean Difference	Standard Error	t-value	$H_a : diff < 0$	$H_a : diff \neq 0$	$H_a : diff > 0$
Panel-I (Pre-reform)	0.03625	0.023557	1.5388	0.9289	0.1421	0.0711**
Panel-II (Post-reform)	-0.002	0.026938	-0.0742	0.4708	0.9415	0.5292
Whole Panel	0.007333	0.005051	1.4519	0.9197	0.1607	0.0803***

Note: : ***significant at the 10%, ** significant at 5%, *significant at the 1% level
Source: Author's own calculation on the basis of secondary tea garden level data

Table 7: t-test for significance of the differences of mean efficiency for the Tea gardens of Assam and West Bengal with unequal variance.

was very much needed for tea gardens located in West Bengal.

The post-reform regime spans 2007-08 to 2012-13 and is identified as panel-II. A perusal of Table 6 reveals that the performances of the tea gardens, specifically those who are located in West Bengal, improved after the implementation of the relief packages. In fact, six (three from each state) sampled tea gardens out of twenty four tea gardens are identified as inefficient. The overall mean efficiency score is 0.890, higher than that during regime-I. The tea gardens located in any

state performed more efficiently in the post-reform as reflected by the overall mean efficiency score. The highest and lowest efficiency score for regime-II are 0.945 and 0.742 respectively, obtained for Nahorkutia (WB) and Happy Valley (WB) tea garden respectively. It is to be noted here that both the best and worst performer belong to West Bengal. In the post-reform era tea gardens located in West Bengal are performed more efficiently than that of the Assam. In fact the overall mean efficiency score for the tea gardens located in West Bengal is 0.892, higher than that of Assam 0.890. However, the mean difference between Assam and West Bengal tea gardens turns out statistically insignificant (Table 7). Even after this from Table 5 we infer that the reform packages influence West Bengal tea gardens more positively than that of Assam tea gardens. In the post-reform period the in term of overall efficiency score West Bengal tea gardens may be categorised not only as efficient, but also that they exceed the overall mean efficiency score of Assam tea gardens. Performance wise the efficiency level of panel-II is more impressive than panel-I and it indicates that West Bengal tea gardens became more efficient than Assam tea gardens in post-reform regime. The overall performance of the tea gardens also improved after the implementation of the governmental relief packages in the post-reform regime. Thus we would conclude that the implementation of the governmental post-reform relief packages improved the status of Indian tea industry.

Another point to be noted here is that, in panel-I twelve tea gardens out of twenty four sampled tea gardens turn out inefficient. A perusal of Table 5 reveals that considering overall mean efficiency as the benchmark of efficiency, three large, five medium and four small tea gardens turn out inefficient. Thus, in panel-I 33percent large, 50percent medium and 80 per cents small sampled tea gardens turn out inefficient.

Again, in panel-II out of twenty four tea gardens, only six gardens turn out inefficient if we consider the overall mean efficiency of that panel as the benchmark. Among these inefficient tea gardens three, two and one respectively belong to category of large, medium and small tea gardens. Therefore, 33percent large and 20percent each of medium and small tea gardens are identified as inefficient. Furthermore, it is worth mentioning here that the percentage of small and medium inefficient tea gardens reduced in post-reform period compare to pre-reform period. This means that the reform packages implemented by the government influence more positively the medium and small tea gardens than the large tea gardens. In fact the inefficiency among the small tea gardens in post-reform regime reduced to 20percent from 80percent in the pre-reform regime. The success rate is also very high in case of medium tea gardens where the inefficiency reduced from 50 per cents to 20 per cents. This again indicates that the small as well as medium tea gardens were inefficient because of structural problem which can be rectified and proper rectification can improve the level of efficiency of the concerned tea gardens.

Finally, the lowest value of efficiency is 0.614 obtained for Happy Valley (WB) and the highest value is 0.659 obtained for Dam Dim (WB) when we consider the entire study period, 2002-03 to 2012-13. Again, by considering the mean efficiency as the benchmark of efficiency, we observe that in aggregate 12 tea gardens, 8 from West Bengal and 4 from Assam turned out technically efficient. Among the technically efficient tea gardens 5, 2 and 5 gardens are classified as large, small and medium respectively. Considering the entire study period Assam tea gardens became more efficient than that of West Bengal. In fact, in terms of overall mean efficiency score, 0.635 (bench mark efficiency score is 0.638), West Bengal tea gardens turn out inefficient but Assam tea gardens remain efficient (0.640). The result of the t-test for the differences in mean efficiency of the Assam and West Bengal tea gardens are found to be significant at 10 percent level and the result is presented in table-7. Again, twelve out of twenty four tea gardens turn out inefficient if we consider entire study period. Out of twelve inefficient tea gardens four, five and three belong to large, medium and small category respectively. This means that when we consider the entire study period, 44 per cents large tea gardens while 50 per cents and 60 per cents medium and small tea gardens respectively turn out inefficient.

Thus, we may conclude that the tea gardens of Assam performed more efficiently in pre-reform period while tea gardens of West Bengal became relatively more efficient after the implementation of the reform packages in the post-reform period. However, by considering the entire study period Assam tea gardens became efficient while West Bengal tea gardens became inefficient.

After discussing the main objective of this study, we now concentrate on investigating whether our study shed light on the relationship between garden size and efficiency. For the purpose of this study, we consider in aggregate twenty-four tea gardens

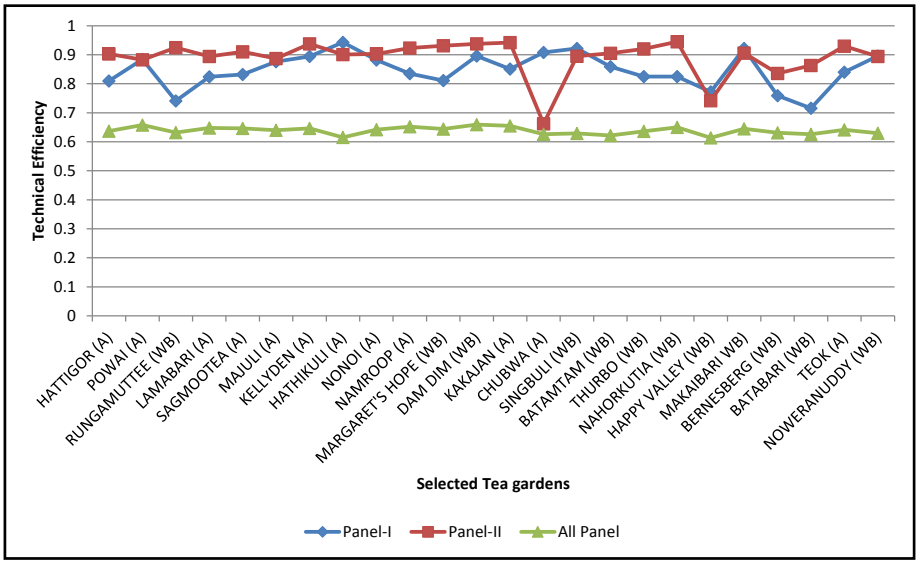
and after classifying the tea gardens into three categories, namely, large, medium and small; we have information on five small, ten medium and nine large tea gardens.

As mentioned earlier that in panel-I, 33 per cents large, 50 per cents medium and 80 per cents small sampled tea gardens turn out inefficient and in panel-II 33 percent large and 20 per cents each of medium and small tea gardens are identified as inefficient. Again, by considering the entire study period in a single jargon we get 44 per cents, 50 per cents and 40 per cents large, medium and small tea gardens respectively turn out inefficient. In other words, in panel-I 77 percent, 50 per cents and 20 per cents large, medium and small tea gardens become efficient. But in panel-II situation improved for medium and small tea gardens and in both cases efficiency increased to 80 percent while in case of large tea gardens still 77 percent gardens remain efficient. When we consider entire study period in a single jargon, 66 per cents large, 50 percent medium and only 60 per cents small tea gardens become efficient. In panel-II small and medium tea gardens appear to be performing exceptionally well. But from overall performance what we would infer that large tea gardens are relatively more efficient than that of medium and small. Again, between small and medium tea gardens, with reform, medium tea gardens become relatively more efficient than the small. Thus this study concludes a direct relation between garden size and efficiency. This result supports the earlier finding by Maity, (2011) and Maity, (2012), where author found a direct relation between garden size and efficiency by considering tea gardens of West Bengal only. The reason may be that the large gardens enjoy more specialization in terms of input utilization, managerial efficiency and at the same time large tea gardens can execute the advantage of economics of large scale production. The same result is also presented in Figure 2.

Analysis of regression result

The stochastic frontier production function in (7) can be viewed as a linearized version of the logarithm of the Cobb-Douglas production function. The inefficiency frontier model (10) accounts time-varying technical change. Maximum likelihood estimates of the parameters of the model are obtained by using a modification of the computer program, FRONTIER 4.1 (see Coelli, 1996). These estimates, together with the estimated standard errors of the Maximum-likelihood estimators, given to three significant digits, for two different panels as well as for considering entire study period are presented in Table 8.

The signs of the coefficients of the stochastic frontier are as expected, with the exception of the negative estimate of the pesticide, irrigation and replantation requisites in both pre and post reform regime as well as for the entire study period. The negative elasticities of the two variables pesticide and irrigation are quite surprising. Regarding pesticide may due to the fact that it is used more extensively as a substitute of other factors of production for getting more proper tea leave. Regarding irrigation we can say that in the tea



Source: own processing

Figure 2: Trend of efficiency of selected tea gardens of India for different panel.

Variable	Panel-I		Panel-II		Whole Panel	
	Coeff (β)	S.E.	Coeff (β)	S.E.	Coeff (β)	S.E.
Constant	5.734* (6.034)	0.950	6.625* (9.647)	0.687	8.735* (15.227)	0.574
Human Labour	1.493* (2.966)	0.503	0.214** (2.124)	0.101	0.587** (2.162)	0.271
Pesticide	-0.574* (-2.827)	0.203	-0.007 (-0.023)	0.304	-0.18 (-0.54)	0.33
Fertiliser	-0.015 (-0.059)	0.253	-0.159 (-1.010)	0.144	0.070 (0.137)	0.511
Irrigation	-0.016 (-0.899)	0.018	-0.048* (-4.170)	0.011	-0.03 (-1.06)	0.03
Replantation Requisites	-0.148* (-2.643)	0.056	-0.099* (-2.936)	0.034	-0.020 (-0.153)	0.128
Machineries	0.686** (2.453)	0.280	0.135 (1.063)	0.127	0.717** (2.162)	0.331
RWW	1.175* (10.511)	0.112	0.648** (2.508)	0.259	0.587* (3.895)	0.151
BHF	0.546 (1.084)	0.503	1.004* (11.988)	0.084	0.752** (1.983)	0.379
Land	0.446 (1.331)	0.335	0.273** (1.974)	0.138	0.868* (3.950)	0.220
Diagnostic Statistics						
Variance Parameters	**Panel-I**		**Panel-II**		**Whole Panel**	
$\hat{\sigma}_s^2$	0.061* (5.35)	0.012	0.207*** (1.671)	0.124	2.585* (6.502)	0.398
$\hat{\gamma}$	0.050 (0.752)	0.067	0.961* (33.504)	0.029	0.798** (2.328)	0.343
μ	-0.111 (-1.057)	0.105	-0.893 (-1.612)	0.554	0.489* (2.600)	0.188
η	-0.247 (-1.069)	0.231	0.243* (2.964)	0.082	0.913* (5.633)	0.162
Log(likelihood)	**-10.286**		**-69.564**		**-548.381**	
LR test	**11.799**		**2.021**		**6.102**	

Note: ***significant at the 10%, ** significant at 5%, *significant at the 1% level, t-values are in parentheses
Source: Author's own calculation on the basis of secondary tea garden level data

Table 8: Maximum likelihood estimates of the stochastic production frontier function of tea production for selected tea gardens of India (No. of observations- 280).

gardens along with plenty water, proper drainage system is also needed. Again the study areas are characterized by high rainfall area. So, for these areas, drainage system rather than irrigation plays very important role for tea plantation. That is why this estimated coefficient is not only negative, but also very low in value.

Finally, the variable Replantation Requisites (RRPR) represents the factor required for immature cultivation. It is measured in value term (Rs/hectare). Immature Cultivation means cultivation expenses required for cultivation of immature tea plants. Most of the tea gardens do not maintain their own immature tea nursery; they purchase immature tea plants from the local nursery. However, they maintain mature tea nursery alongside the garden. Perhaps because of this we get negative elasticity for this variable and the value of the estimated coefficient is low.

The estimated coefficients for the land and labour variables are 0.446 and 1.493 for panel-I, 0.273 and 0.214 for panel-II and 0.868 and 0.587 for entire study period. These coefficient estimates are highly significant, while that for costs of other inputs are relatively small though significant.

The estimate for the variance parameter, $\hat{\gamma}$, is close to one for the second regime (panel-II), which indicates that the inefficiency effects are likely to be highly significant in the analysis of the value of output of the gardens. The value of η in Table 7 suggests that in the post-reform

regime (panel-II) efficiency showed quite an increasing and statistically significant trend. For the whole period also the trend is found to be increasing and statistically significant. However what is an important observation for the question we have posed, for the first panel (panel-I), that is, in the pre-reform regime there is absolutely no trace for efficiency improvement. So, one would suspect the observed rising trend for the whole of twelve years is the handiwork of the definite rising trend of over the later half. This result gives strong support for one to conclude that the performance with regard to technical efficiency during the post-reform regime was superior to that of the earlier period.

Conclusion

The inefficiency of the tea estates can be reduced by increasing output, decreasing cost of production, increasing revenue of the tea estates, thus ultimately impacting profit. The negative values of the estimated coefficients for pesticide, irrigation and replantation requisites suggest that the tea estates have enough opportunity to improve the present condition by adopting efficient practices in these areas. Tea gardens are suggested not to use pesticide more extensively as a substitute of other factors of production for getting perfect tea leaves. Moreover, in the same line of Banerjee, and Banerji, (2008), we would like to comment that gardens are need to use organic pesticides such as turmeric, neem, etc., so that in the international arena (market) Indian tea is not criticised for using pesticides more than the recommended doses. At the same time, by using organic and locally made pesticides, tea gardens can get more production at lower costs and they will become more cost effective as well as profitable. Again, they are recommended to improve the drainage system for the gardens rather than paying more money for irrigation as these areas are characterised by heavy rain fall (Banerjee and Banerji; 2008). By doing this they will be able to utilize their funds optimally. Replantation should be done in time with new and good quality young tea plants and for that all tea gardens are suggested to maintain nurseries for mature as well as immature cultivation. Finally, tea gardens are suggested to maintain their own nurseries for immature cultivation so that they will be able to get better baby tea plants than those purchased from outside.

The high positive values of estimated coefficients of land and labour suggest that by proper utilization of the available land and by giving appropriate training and education to the garden labourer, tea gardens can increase their level of efficiency irrespective of their size.

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Appendix

Country	2012		2011		2010	
	Total Production (in m.kg)	Percentage	Total Production (in m.kg)	Percentage	Total Production (In m.kg)	Percentage
China	1761.00	38.9	1623.21	36.5	1475.06	35.2
India	1111.76	24.6	1115.72	25.1	966.40	23.1
Kenya	369.56	8.2	377.91	8.5	399.01	9.5
Sri Lanka	326.28	7.2	328.63	7.4	331.43	7.9
Vietnam	158.00	3.5	178.00	4.0	170.00	4.1
Turkey	147.00	3.2	145.00	3.3	148.00	3.5
Indonesia	130.50	2.9	142.34	3.2	151.01	3.6
Bangladesh	62.16	1.4	59.32	1.3	59.27	1.4
Malawi	42.49	0.9	47.06	1.1	51.59	1.2
Uganda	55.08	1.2	54.18	1.2	59.14	1.4
Tanzania	32.28	0.7	32.78	0.7	31.65	0.8
Others	330.87	7.3	345.16	7.8	349.45	8.3

Source: Author's own calculation based on ITC Annual Bulletin Supplement, 2012 & MSS, March, 2013

Table A.1: Major tea producers and share in world tea production.

State	Area under tea (in th. hectares)	Percentage	Production (million kg)	Percentage
Assam	304.40	54.0	629.05	52.0
West Bengal	140.44	24.9	312.1	25.8
Other North Indian States	12.29	2.2	23.92	2.0
Total North India	457.13	81.1	965.07	79.8
Tamil Nadu	69.62	12.3	174.71	14.5
Kerala	35.01	6.2	63.48	5.3
Karnataka	2.22	0.4	5.52	0.5
Total South India	106.85	18.9	243.71	20.2
India	563.98	100.0	1208.78	100.0

Note: Other North Indian States includes Tripura, Uttarakhand, Bihar, Manipur, Sikkim, Arunachal Pradesh, Himachal Pradesh, Nagaland, Meghalaya, Mizoram and Oriss.
Source: Author's own calculation based on Tea Statistics (2013-14), Tea Board of India, Kolkata

Table A.2: Area under tea production and total production of tea in tea growing states in India in 2013-14.

Variables (Rs. Lakh)	Mean	Maximum	Minimum	S.D	Skewness	Kurtosis	C.V
Human Labour (Wage Bill)	9948.71	30349.57	32.79	5710.14	-0.06	3.35	57.40
Workers Welfare (RWW)	8179.38	16903.46	28.31	4352.57	-0.57	2.83	53.21
Bush Hygiene Factor (BHF)	4836.98	16038.87	12.83	2820.97	0.12	3.92	58.32
Pesticides (PSTCD)	3039.76	10006.14	4.98	1958.91	0.38	3.37	64.44
Fertilisers (FERT)	2808.44	7372.40	5.10	1612.59	-0.15	2.95	57.42
Irrigation (IRRIG)	572.10	2979.03	0.00	735.21	1.07	3.06	128.51
Replantation Requisites (RRPR)	879.47	3960.46	2.64	762.20	0.95	4.01	86.67
Capital Stock (CAPST)	11149.16	32017.96	31.76	6480.62	-0.03	3.14	58.13
Area under Production (LAND: hectare)	581.84	1638.68	217.18	289.67	1.59	6.08	49.79
Total Output	1009189.00	2739507.00	36.72	620012.00	0.69	3.23	61.44
Yield per Hectare	2030.44	18836.00	210.00	1086.15	12.87	200.49	53.49
Number of Observations	288	288	288	288	288	288	288

Source: Author's own calculation based on secondary tea garden level data

Table A.3: Summary of inputs and output for selected tea gardens in India (2002 – 2013).

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Statistical Feature Ranking and Fuzzy Supervised Learning Approach in Modeling Regional Rainfall Prediction Systems

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Abstract

Rainfall prediction is an essential and challenging task in hydro-meteorology. Most of the existing weather dataset used for prediction consists of observatory record of several atmospheric parameters. Identifying the significant parameters from irrelevant and redundant parameter set for weather prediction is important because irrelevant parameters may decrease the prediction accuracy. The main intent of this research is to identify the influencing weather parameters for improving daily rainfall forecast efficiency. A parameter selection module identifies the significant parameter based on information gain based feature ranking. Fuzzy supervised learning module evaluates the performance of fuzzy classifiers before and after parameter selection. In the evaluation phase, learning techniques was analyzed in terms of Accuracy Rate (AcR), Root Mean Squared Error (RMSE) and Misclassification Rate (McR). Experimental results revealed that, parameter subset selection has significantly improved the performance of the learning techniques. The investigation results identified minimum temperature, relative humidity and evapotranspiration as influencing weather parameters for rainfall prediction. Empirical results revealed Fuzzy Unordered Rule Induction Algorithm (FURIA) as a suitable rainfall prediction approach. This fuzzy model achieved an enhanced accuracy rate of 84.10% after parameter selection with nominal misclassification rate of 0.1590%.

Keywords

Short-range rainfall prediction, statistical feature ranking, fuzzy rule induction and prediction accuracy.

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Introduction

Rainfall prediction plays a vital role in most of our day to day real life activities. Especially in countries like India that depends on agricultural productivity for its economic growth need reliable weather forecasting mechanism. In India about 50% of agricultural cultivation and yield are mainly influenced by the rainfall. There exists an everlasting demand for enhanced prediction models for strategic decision support. Many of our day to day activities are influenced by that day’s weather. Therefore, rainfall prediction outcomes serve as an important factor for strategic decision support in real life activities. This analysis focuses on identifying relevant parameter for enhanced rainfall forecasting using dimension reduction approach. Dimension reduction is a challenging task in data mining and knowledge representation of high dimensional data set. It is a method of reducing the high dimensional data space to minimal dimensional space by removing irrelevant and redundant data. Parameter reduction is achieved either by feature selection or feature transformation process. Parameter selection is a method of finding the most suitable subset of the complete feature vector. It is stated that selection is achieved using statistical measures such as entropy, information gain, correlation, covariance and other data mining approaches (Ishibuchi and Nakashima, 2001, 2005). Feature transformation is the other way of reducing the data space, in this technique the features are transformed as factors representing significant features. In any feature selection technique finding the most suitable subset is a tough and exhaustive. Hence, feature selection problems are considered Nondeterministic Polynomial time (NP) hard problem (Blum and Rivest, 1992). Feature selection methods are categorized as filter (Huhn

and Hullermeier, 2009), wrapper (Nikam and Meshram, 2013) and embedded approaches.

A, information gain based feature selection technique is implemented for identifying the suitable weather parameters(Novakovic, 2009). (Siedlecki and Sklansky,1988) Automatic feature selection approach and supervised learning techniques are expected to perform better than when trained with complete feature set. In a recent trend fuzzy concepts are used in a wide range of applications such as data analytics, pattern recognition, soil evaluation and meteorology from the time of its introduction (Zadeh, 1965). This proposed approach also uses the benefits of a fuzzy based learning approach for training the system to classify with less misclassification rate. As a recent trend bio inspired techniques are used in meteorology prediction nowadays (Lee et al., 2012). Genetic algorithm based feature selection is applied for heavy rain prediction at South Korea Empirical analysis conducted on rainfall data collected for a period of 20 years, genetic algorithm based feature selection performed better than the traditional feature selection method (Seo et al., 2012).

(Liu et al., 2001) introduced a novel enhanced Naive Bayes classifier technique and explored the use of genetic algorithm for feature subset selection for classification. (Dai and Xu, 2013) described the effect of fuzzy based feature reduction approach using fuzzy gain ratio for medical dataset. The feature selection method based on the fuzzy gain ratio of fuzzy rough set theory performed better than other approaches (Maqsood et al., 2014). Sudha and Valarmathi, 2013) mentioned that a feature reduction approach based on quick reduct, entropy measure and rough set approaches have wide scope of application. (Yu, 2005) described integrated feature selection approach. The rough set feature reduction techniques, computed several reduced sets than any other approaches (Sudha and Valarmathi, 2015, 2016). Dai and (Xu, 2013) and (Blum and Rivest, 1992) described a hybrid rough fuzzy neural network model for weather forecasting.

Effect of proposed fuzzy based automated weather forecasting model using temperature to predict the daily temperature is discussed in (Al-Matarneh, 2014). The experimental results of shown that the proposed fuzzy based model enhanced accuracy rate (Maqsood et al., 2004). The performance of neural network Multi-layer Perceptron (MLP), random forest, classification and regression tree, support vector machine, and k-nearest neighbor algorithms are examined in terms of accuracy (Kusiak et al., 2014). Experimental results conveyed data mining techniques as a suitable approach to construct predictive models for normal as well time series radar data. (Zadeh, 1965) proposed hybrid intelligent systems based on rough sets, neural networks, fuzzy sets and other optimization methods. It is stated that hybrid intelligent computational approach can handle uncertain, noisy and incomplete data set. Most of the hybrid intelligent systems are cost effective solutions for various scientific applications (Li and Liu, 2005) and (Zadeh, 1965). The rainfall prediction evaluation results for Mashhad meteorology stations using Adaptive Neural Fuzzy Inference System (ANFIS) outperformed other non ANFIS models. This model considered temperature, relative humidity, cloud cover total and due point as input parameters Niksaz and Latif (2014). It is stated that, hybrid intelligent computing approaches outperform than other the traditional methods (Niksaz and Latif, 2014). As stated in (Niksaz and Latif, 2014), (Seo et al., 2014) and (Liu et al., 2001) this proposed investigation on rainfall prediction uses eight atmospheric parameters in the Coimbatore region of India. This proposed approach uses an effective feature subset of the complete feature vector and fuzzy based classifier for evaluation. It is a well-known theory, that fuzzy techniques can handle complicated problems with imprecise inputs. It is suitable for many scientific and real life applications (Mc-Bratney and Moore, 1985). (Bardossy et al., 1995) stated fuzzy as a suitable technique for meteorological prediction or climate classification and described classification of various atmospheric parameters using fuzzy rules. The effect of the fuzzy logic approach based prediction model for temperature, humidity index forecasting was discussed in (Mitra et al., 2006).

(Abdul-Kader ,2009) discussed on application of Multilayer Perceptron (MLP), Radial Basis Function network (RBF) and feed forward neural networks techniques with dissimilar training sets for predictive analysis of Cairo metropolis. (Maqsood et al.,2004) discussed on neural networks based ensemble models for hourly weather forecast of the southern region around Canada using the parameters of temperature, wind speed and relative humidity. Empirical results revealed that RBF network as a suitable weather prediction model. The RBF network performed better than MLP, Elman recurrent neural network, Hop field

model and regression techniques. Kira and Rendell (1992) reported that feature selection is essential to speed up learning. The proposed model consists of parameter selection module and supervised learning (training) module. In the first module, an information gain based parameter ranking is applied for selecting the significant parameters for improving the rainfall prediction efficiency. In the next module the classifiers are trained using selected parameters and complete parameter. The feature selection techniques are effective in modeling daily rainfall prediction (Sudha and Valarmathi, 2014).

This paper is organized as follows: Section 2 discusses the study area of this scheme. In Section 3, we propose the information gain based parameter selection and fuzzy rule based classification for rainfall prediction. In Section 4, we analyze and compare the existing and proposed schemes in terms of accuracy, error rate, RMSE. Section 5 concludes this paper.

Case Study Area

Coimbatore district of Tamil Nadu State in India is selected for the assessment of rainfall prediction. Coimbatore serves as Manchester of South India; it is located in the extreme western region of Tamil Nadu. Coimbatore district's total region covers 746,800 hectares and 43% of the region is bound to agricultural cultivation. The region's climate is classified as sizzling partial dry. The major agricultural crops in this region are cotton, sugarcane, peanut sorghum, maize, rice and pulses. Rainfall received during southwest monsoon is one of the major factors for the groundwater table sauce, but rainfall source is less when compared to winter monsoon. The study region is one of the most important agricultural and industrial area in the country. Fast and uncontrolled industrial development projects have caused climatological changes in past years, hence raised necessity to conduct assessment of factors influencing the current weather prediction.

Materials and methods

Experimental analysis of rainfall record for the Coimbatore region for a period of 27 years from 1984 to 2013). The raw data set is pre-processed for outlier analysis and for removal of missing attribute values. The decision on rainfall occurrence is influenced by eight atmospheric parameters.

P1(Maximum temperature), P2(Minimum temperature), P3(Relative humidity), P4(Relative humidity2), P5(Wind speed), P6(Solar radiation), P7(Sunshine) and P8(Evapotranspiration). This rainfall dataset consists of two class variables. A class variable 'y' of decision parameter P9(Rainfall) means a rainy day else it is a no rain day.

In order to evolve suitable solution to the current challenge, this research focus on applying fuzzy rule based classification approach. The proposed prediction model is trained and validated using reduced feature input determined using information gain measure.

Stastical feature ranking techniques

Information gain measures the quantity of information in bits about the decision class variable and the related class distribution (Dai and Xu, 2013). Entropy measures the expected reduction in vagueness associated with a random feature (Novakovic, 2009). The entropy measure is considered as a measure of unpredictability. Let H (A) be the entropy measure based on the probability density function of a random parameter 'A'. The training set with observed values of 'A' is partitioned on other parameter 'B'. Then entropy measure of a parameter 'A' before partitioning and there exists a relationship between 'A' and 'B'.

Entropy of variable A before observing B is given in equation 1.

$$H(A) = -\sum_{i=1}^{n} P(A_i) \log_2 (P(A_i)) \quad (1)$$

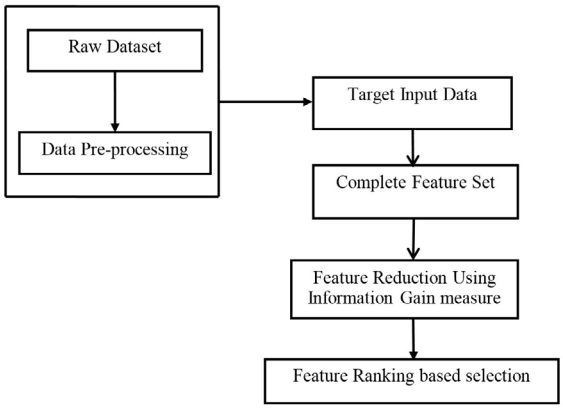
Entropy of variable A after observing B is given in equation 2.

$$H(A_i / B_i) = -\sum_{i-1}^{n} P(B_i) \sum_{i-1}^{n} P(A_i/B_i) \log_2 (P(A_i/B_i)) \quad (2)$$

The information gain measure is estimated as in equation 3.

$$\textit{Information Gain} = H(A_i) - H\left(\frac{A_i}{B_i}\right) \quad (3)$$

The proposed feature selection is an exhaustive task; it requires a suitable stopping criterion to terminate the selection process. The proposed information gain based parameter subset selection module as illustrated in Figure 1. The generation of subset of determined feature reduct is terminated based on problem specific criteria's.



Source: own processing

Figure 1: Information gain based Parameter subset selection module.

The proposed feature selection strategy terminates the subset generation based on the given criteria's:

1. Selection of a predetermined number of features in subset.
2. Achieving a pre-defined number of subsets of the power set.
3. Stopping with respect to evaluation criterion obtained.

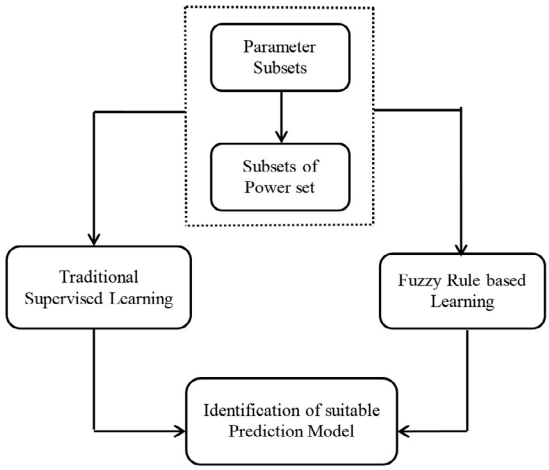
Information Gain	Ranking
0.19326	P4 - RH2
0.12675	P8 - EVP
0.10468	P7 - SS
0.09904	P3 - RH1
0.09814	P2 -MIN
0.08707	P6 -SR
0.06295	P1- MAX
0.00566	P5 - WIND

Source: own processing

Table 1: Information gain based parameter ranking.

The parameters are ranked according to the information gain value from high to low (Table 1). The parameters {P2, P3, P4, P7, P8} having information gain measure equal to or greater than the average information gain value are selected a suitable feature from the complete feature vector. Later, an exhaustive search approach based on the power set algorithm is determined to find possible combinations of subsets of selected significant parameters.

The proposed rule based supervised learning model evaluable process as represented in Figure 2 the performance of set of proposed fuzzy and non-fuzzy rule based classifiers are analyzed in terms of error rate. One of the reasons for using fuzzy logic models is that they can handle vagueness and uncertainty. It deals with arithmetical output and does not require complicated arithmetic enabling fuzzy model as a suitable technique in most of the classification.



Source: own processing

Figure 2: Fuzzy and non-fuzzy supervised learning model evaluation.

It is assumed that in this rainfall classification problem consists of 'w' training model, such that $xp = (Xm_1. \ldots.., Xm_n)$, m = 1, 2. . . W, labeled with one of two possible classes. When RF = 'n' when no rainfall otherwise RF = 'y' is rainfall occur, where Xi is the i^{th} parameter value (i = 1, 2 . . . n) of the training model.

Let R_j be a fuzzy rule represented as:

IF V_1 is P^1_j and P^2_j. . . P^n_j . Van is P^n_j => Cj (class) with (RW_j) (4)

Where Rj is the label of the j^{th} rule, $V = (V_1. . . V_n)$ is a n-dimensional sample vector, A_j is an predecessor fuzzy set, C_j is a class label and RW_j is the rule weight and Fuzzy rules for one particular class with a rule weight (RW_j) associated with this category variable are referred as consequent (Ishibuchi and Yamamoto, 2005).

Fuzzy unordered rule induction algorithm

Fuzzy unordered rule induction algorithm or FURIA is a modification and extension of the ripper rule learner algorithm (Bardossy et al., 1995). FURIA find out to separate each class from all other classes and avoids the default rule set to implement the novel rule stretch approach. Rule stretching is achieved by deleting one or more of its antecedents to generate FURIA's unordered rule set to simplify new queries. It learns

an initial rule set on whole training data and applies pruning for creating new rules for replacement of antecedents without removing all antecedents.

In FURIA, a fuzzy rule obtained by replacing crisp intervals by fuzzy intervals. FURIA implements fuzzy sets with trapezoidal membership function and rules are generated using the greedy approach (Huhn and Hullermeier, 2009). Within Fuzzy rules, traditional crisp boundaries of a rule are substituted by soft boundaries. FURIA represents a fuzzy rule as in equation (6.4).

Fuzzy rules are characterized by its core and its support. Let P be a universal set, with set of instances denoted by *p*, then a fuzzy set F_z in P is a set of ordered pairs in represented as $\{f_z\}$ where, $F_z = \{ (p, \mu_{F(x)}) \mid p$ belong to P$\}$,where $\mu_{F(p)}$ is the membership function of *p* in F which maps *p* to the membership space [0,1].

The grade of membership is assigned 'one' or '0' to those objects that completely belong to Fz and 'zero' or '1' to those that not belong to Fz at all.

The trapezoidal membership function is as below,

$$\mu_F(x, a, b, c, d) = \begin{pmatrix} [0, & \text{if } p < a] \\ [(p - a) / (b - a), & \text{if } a \le p \le b] \\ [1, & \text{if } b < p < c] \\ [(d - p) / (d - c), & \text{if } c \le p \le d] \\ [0, & \text{if } d < p] \end{pmatrix}$$

A fuzzy set P^n_j using an interval of trapezoidal membership function is specified by four parameters (IF = ($\{\emptyset^{S,L}, \emptyset^{S,U}, \emptyset^{C,L}, \emptyset^{C,U}$) Huhn and Hullermeier (2009).

$\{\emptyset^{S,L}, \emptyset^{S,U}\}$ are lower and upper bound of the support elements with membership > 0

$\{\emptyset^{C,L}, \emptyset^{C,U}\}$ are lower and upper bound of the core elements with membership 1.

Let (RH2 ≤ 52) => RF = n be a crisp rule, this rule is valid only when (RH2 ≤ 52) and invalid if (RH2 > 52) for a crisp rule the boundaries are always sharp. Fuzzy rule for the above crisp rule is: (RH2 [-inf, -inf, 52, 53]) => RF= n (CF = 0.91). Implies that the rule is valid if (RH2 ≤ 52), invalid for (RH2 > 53). It is partially valid in between [52 - 53] having soft boundaries.

Crisp rule is defined as a fuzzy rule only if each of its statistical features appears in more than one and a maximum of two predicates in its predecessor part. The FURIA rules are generated using WEKA software.

Relation: {P2, P3, P4, P7, p8}
Instances: 10000
Attributes: 6
Test mode: Ten-fold cross-validation
Classifier model (full training set): FURIA based supervised learning.

FURIA Rules:

- (RH2 in [-inf, -inf, 52, 53]) => RF=n (CF = 0.91)
- (RH2 in [-inf, -inf, 59, 60]) and (EVP in [3.4, 3.5, inf, inf]) and (MIN in [-inf, -inf, 21.5, 21.6]) and (RH1 in [-inf, -inf, 89, 90]) => RF=n (CF = 0.98)
- (RH1 in [-inf, -inf, 92, 93]) and (EVP in [5.5, 5.6, inf, inf]) and (MIN in [23.7, 23.8, inf, inf]) => RF=n (CF = 0.94)
- (EVP in [2.9, 3, inf, inf]) and (RH1 in [-inf, -inf, 92, 93]) and (SS in [4.4, 4.5, inf, inf]) => RF=n (CF = 0.91)
- (EVP in [2.7, 2.8, inf, inf]) and (RH2 in [-inf, -inf, 64, 65]) and (MIN in [-inf, -inf, 20.8, 21]) => RF=n (CF = 0.97)
- (RH2 in [-inf, -inf, 59, 60]) and (RH1 in [-inf, -inf, 92, 93]) and (RH1 in [5, 82, inf, inf]) => RF=n (CF = 0.89)
- (EVP in [2.8, 3, inf, inf]) and (RH1 in [-inf, -inf, 93, 95]) and (SS in [1.2, 1.5, inf, inf]) and (RH2 in [84, 85, inf, inf]) and (RH1 in [88, 89, inf, inf]) and (MIN in [21.4, 21.5, inf, inf]) => RF=n (CF = 0.94)
- (RH2 in [53, 54, inf, inf]) and (RH1 in [92, 93, inf, inf]) => RF=y (CF = 0.73)
- (RH2 in [54, 60, inf, inf]) and (EVP in [-inf, -inf, 1.7, 1.8]) => RF=y (CF = 0.91)
- (RH2 in [67, 68, inf, inf]) and (SS in [-inf, -inf, 4.4, 4.5]) and (RH2 in [-inf, -inf, 83, 84]) => RF=y (CF = 0.76)
- (RH2 in [56, 57, inf, inf]) and (EVP in [-inf, -inf, 6.7, 6.8]) and (MIN in [21.7, 22, inf, inf]) and (RH1 in [-inf, -inf, 82, 83]) and (SS in [-inf, -inf, 3.7, 3.8]) => RF=y (CF = 0.71)
- (RH2 in [45, 47, inf, inf]) and (EVP in [-inf, -inf, 2.9, 3]) and (MIN in [21.3, 21.4, inf, inf]) => RF=y (CF = 0.81)
- (RH2 in [47, 48, inf, inf]) and (MIN in [21.6, 21.7, inf, inf]) and (EVP in [-inf, -inf, 5.1, 5.2]) and (RH1 in [-inf, -inf, 77, 78]) => RF=y (CF = 0.69)

- (RH2 in [45, 48, inf, inf]) and (RH1 in [90, 91, inf, inf]) and (MIN in [22, 22.2, inf, inf]) and (EVP in [-inf, -inf, 3.3, 3.4]) and (EVP in [3, 3.1, inf, inf]) and (MIN in [-inf, -inf, 23.4, 23.5]) => RF=y (CF = 0.89)

Number of Rules: 14

FURIA Rule: (EVP in [2.9, 3, inf, inf]) and (RH1 in [-inf, -inf, 92, 93]) and (SS in [4.4, 4.5, inf, inf]) => RF=n (CF = 0.91).

Let us examine one of the above fuzzy rule generated by FURIA for rainfall prediction, (EVP in [2.7, 2.8, inf, inf]) and (RH2 in [-inf, -inf, 64, 65]) and (MIN (Minimum temperature) in [-inf, -inf, 20.8, 21]) => RF=n (CF = 0.97). The above fuzzy rule is a stretched fuzzy rule from the generated rule set. EVP, RH2 and MIN are attributes of rainfall prediction statistics. The parameter interval range is between 2.7 to 2.8, 64 to 65 and 20.8 to 21. Operator [inf, − inf] points to the interval that has the last valid values. CF indicates the confidence factor of the rule Huhn and Hullermeier (2009).

Results and discussion

The parameter set {P2, P3, P4, P7, P8} and its subsets having three and more of parameters are analysed. The accuracy rate; root means squared error and misclassification rate determine the performance of the classifier. WEKA tool is used for conducting the experimental analysis. It is a good open source machine learning and data mining tool for a broad range of applications Witten and Frank (2005). A detailed experimental study is conducted to evaluate the performance of simple data mining techniques and fuzzy learning algorithms before and after parameter selection. The performance of naive bayes, bayes net, radial basis function Network, sequential minimal optimization and voted perceptron was analysed. For fuzzy based classification, fuzzy rough neural network (FR-NN), fuzzy neural network (F-NN), fuzzy ownership, fuzzy discernibility classifier (F-DC) and Fuzzy unordered rule induction algorithm (FURIA) was evaluated. The accuracy rate of each classifier is determined using confusion matrix. The True positive (T_p), True negative (T_n), fake positive (F_p) and fake negative (F_n) values are represented using this confusion matrix. The accuracy rate is the percent of instances that are correctly classified by the classifier for the specified test set. The incorrectly classified instances determine the error rate or misclassification rate of the classifier. The learning models are evaluated based on the measures in equation (5 to 8).

$$\text{Accuracy Rate } (Ac^R) = \frac{Tp + Tn}{(Tp+Tn+Fp+Fn)} \quad (5)$$

$$\text{Misclassification Rate } (Mc^R) \text{ or Error Rate} = \frac{Fp + Fn}{(Tp+Tn+Fp+Fn)} \quad (6)$$

$$\text{Sensitivity True Positive Rate } (Se^R) = \frac{Tp}{(Tp+ Fn)} \quad (7)$$

$$\text{Specificity True Negative Rate } (Sp^R) = \frac{Tn}{(Tn + Fp)} \quad (8)$$

Performance evaluation pre-parameter subsets selection

The confusion matrix for traditional and fuzzy rule based learning algorithms for the complete parameter is shown in Table 2.

Classifier	TP	FN	FP	TN
FR- NN	6847	897	1026	1230
F- NN	7192	552	1151	1105
FO	6948	796	1077	1179
F- DC	7229	515	1203	1053
FURIA	7311	438	1153	1053
NB	6729	1015	796	1460
BN	6631	1113	675	1581
RBF	7022	722	1044	1212
SMO	7379	365	1319	937
VP	7400	344	1558	698

Source: own processing

Table 2: Confusion matrix before parameter selection.

Among the fuzzy techniques FURIA has acquired high prediction accuracy; the other non-fuzzy models have obtained prediction accuracy almost in analogous range. But when compared with all the models under evaluation FURIA has attained the peak prediction accuracy achieved 83.64%. The accuracy rate, misclassification rate, sensitivity and specificity rate acquired by other classification techniques and FURIA for complete parameter set is shown in Table 3. The selected techniques are trained using the reduced parameter subset obtained using the information gain (the statistical measure). The confusion matrix, accuracy rate, misclassification rate, sensitivity and specificity rate attained by other classification techniques

and FURIA for reduced parameter set is shown in Table 4 and 5.

Classifier	Ac^R(%)	RMSE	Mc^R(%)	Se^R(%)	Sp^R(%)
FR- NN	80.77	0.38	0.19	0.88	0.54
F- NN	82.97	0.41	0.17	0.92	0.48
FO	81.27	0.38	0.18	0.89	0.52
F- DC	82.82	0.32	0.17	0.93	0.46
FURIA	83.64	0.32	0.16	0.94	0.46
NB	81.89	0.36	0.18	0.86	0.64
BN	82.12	0.37	0.17	0.85	0.70
RBF	82.34	0.34	0.17	0.90	0.53
SMO	83.16	0.41	0.16	0.95	0.41
VP	80.98	0.43	0.19	0.95	0.30

Source: own processing

Table 3: Accuracy rate of classifiers before parameter selection.

Performance Evaluation Post - Parameter Subset Selection

Classifier	TP	FN	FP	TN
FR- NN	6743	1001	1072	1184
F- NN	7172	572	1073	1183
FO	6980	764	1060	1196
F- DC	7173	571	1063	1193
FURIA	7309	438	1153	1103
NB	6810	934	844	1412
BN	6779	965	722	1534
RBF	7334	410	1325	931
SMO	7392	352	1389	867
VP	7355	389	1395	861

Source: own processing

Table 4: Confusion matrix after parameter selection.

Classifier	Ac^R (%) before Parameter Selection	Ac^R (%) after Parameter Selection
F- NN	82.97	83.55
FO	81.27	81.76
F- DC	82.82	83.66
FURIA	83.66	84.10
NB	81.89	82.22
BN	82.12	83.13
RBF	82.34	82.65
VP	80.98	82.16

Source: own processing

Table 5: Accuracy rate of Classifiers after Parameter Selection.

Later, an exhaustive subset generation method is implemented to compute the possible subsets of the reduced set obtained using information gain filter. There is no improvement in prediction accuracy of the models when trained with subsets, and few have shown reduced outcomes as indicated in Table 6.

Classifier	Ac^R (%)	RMSE	Mc^R(%)	Se^R (%)	Sp^R(%)
FR- NN	79.27	0.39	0.20	0.87	0.52
F- NN	83.55	0.40	0.16	0.92	0.52
FO	81.76	0.36	0.18	0.90	0.53
F- DC	83.66	0.33	0.16	0.92	0.52
FURIA	84.10	0.37	0.15	0.94	0.49
NB	82.22	0.35	0.17	0.87	0.62
BN	83.13	0.35	0.16	0.87	0.67
RBF	82.65	0.35	0.17	0.94	0.41
SMO	82.59	0.41	0.17	0.95	0.38
VP	82.16	0.42	0.17	0.94	0.38

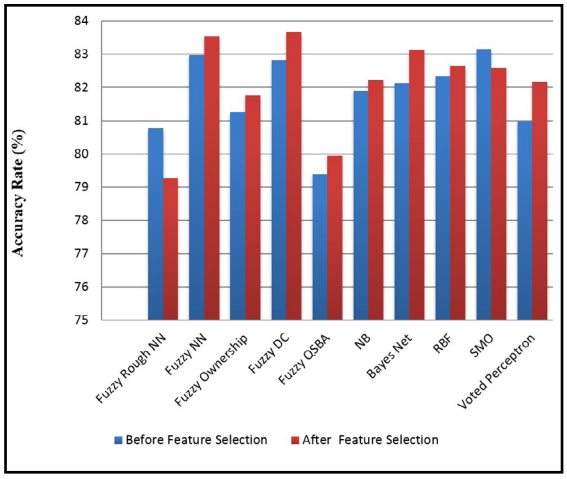
Source: own processing

Table 6: Accuracy rate after parameter selection for subset with 4 parameters.

Classifier	Parameter Subset of Power Set AcR (%)				
	{P-2347}	{P-238}	{P-2378}	{P-2478}	{P-3478}
FR- NN	78.08	79.98	78.7	78.14	77.49
F- NN	82.15	83.55	82.65	82.86	82.69
FO	80.86	82.63	81.81	81.85	81.27
F- DC	82.4	83.80	82.88	83.18	82.91
FURIA	78.67	82.86	79.82	79.33	78.22
NB	81.43	83.02	80.8	81.52	82.11
BN	82.27	83.64	82.81	82.09	82.65
RBF	81.98	82.89	81.91	81.92	82.01
SMO	81.97	82.29	77.44	82.25	82.25
VP	80.88	81.75	80.37	82.46	82.36

Source: own processing

Table 7: Classifiers with enhanced accuracy rate after parameter selection.

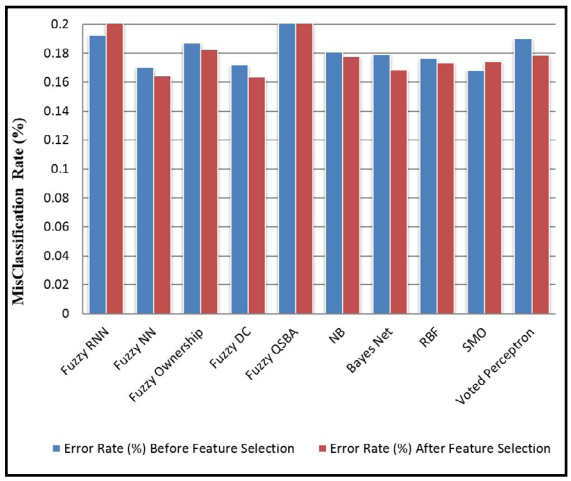


Source: own processing

Figure 3: Visualization of classifiers accuracy rate before and after parameter selection.

From the observed outcomes as shown in Figure 3 and 4, it is concluded that 80% of the learning models have shown better results. Most of the supervised learning algorithms have improved its prediction than before parameter selection. The subsets of power set evaluation notify that there is no substantial improvement in results.

The performance of the model under investigation was not satisfactory when using subsets of the optimal parameter set {P2, P3, P4, P7, P8} identified using information gain. Later, the stopping criterion for subset generation is determined by the learning algorithms accuracy rate. The process of subsets generation process for the complete feature set is terminated based on the accuracy achieved by the subsets.



Source: own processing

Figure 4: Visualization of Classifiers misclassification rate before and after parameter selection.

Conclusion

Feature selection using information gain filter has identified minimum temperature (P2), relative humidity1 (P3), relative humidity2 (P4), the sunshine (P7) and evapotranspiration (P8) as useful parameters for rainfall prediction. Experimental study and evaluations indicate that most of the classification models have shown improved prediction accuracy when trained using feature subset than when trained with a complete feature set as in Table 7. The empirical results have shown that classification algorithms have acquired no significant improvement in accuracy rate when trained with subsets of the reduct set {p2, p3, p4, p7, p8}.

Except Fuzzy Rough Neural network and SMO, other eight classification approaches achieved higher accuracy and lower misclassification rate using parameter selection using information gain measure for feature ranking. FURIA outperformed achieving 84.10% accuracy rate. Therefore fuzzy unordered rule induction is concluded as the suitable classification model for this rainfall prediction statistics.

This detailed analysis and experimental outcomes indicate that supervised learning model results after applying appropriate parameter selection can certainly improve the overall performance of proposed prediction model for optimal reduct set and not for all reduct combinations. More over the prediction accuracy achieved by this fuzzy model is not satisfactory for real time scenarios. Hence forth the necessity of identifying more suitable hybrid intelligent techniques is recommended for modeling the real-time weather prediction system.

Feature selection is a most influencing factor in data mining and decision support systems. Identifying effective inputs for achieving better outcomes will support for effective strategic decisions on various scientific applications. It is proposed to conduct detailed study of other feature selection approaches for determining the effective weather parameters. Apart from statistical measures, feature selection can be achieved using bio inspired procedures. In future we propose to achieve optimal parameter selection using particle Swarm Optimization (PSO), Ant Colony Optimization (ACO) and hybridization of evolutionary and fuzzy approach. The next objective is to propose a fusion of hybrid fuzzy, neural network and evolutionary approach to achieve better prediction accuracy.

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