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Relevance of Declining Agriculture in Economic Development of South Asian Countries: An Empirical Analysis

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Abstract

Role of agriculture has been a matter of debate among development economist. Agriculture has been a major contributor in national income and employment in South Asian economies but its share in the national GDP has been declining over time. This study examines the relevance of declining agriculture due to structural transformation in economic growth of four South Asian countries namely India, Pakistan, Sri Lanka and Bangladesh. To analyze the long-run relationship between agriculture and economic growth, an empirical model based on Augmented Neoclassical Solow-Swan model is developed. Johansen and Juselius (1990) maximum likelihood technique based on VAR model and Granger causality test has been employed to analyze long run and short run causal relations between agriculture and economic growth respectively. Results show that in all four South Asian countries, agriculture has long-run association with economic growth and it is an important driver of economic growth. Short-run analysis indicates that agriculture stimulates economic growth in all South Asian countries except Bangladesh. Neglect of agriculture and excessive focus on industrialization may retard growth both in short and long run.

Keywords

Agriculture, economic growth, South Asia.

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Introduction

Economic literature and empirical studies provide us with sufficient evidence that agricultural development is a basic pre-condition for economic development of a country. Rostow (1959) argued that “revolutionary changes in agricultural productivity are an essential condition for successful take-off.” The agricultural sector has the potentials to facilitate industrial and service sector expansion to create the takeoff environment. England, for example, relied heavily on its domestic agriculture in the early phase of its industrial revolution. In most of the western European countries such as France, Belgium, Germany, and Sweden, the takeoff rested upon a firm foundation of ‘rising agricultural productivity’. The most developed country of Asia, i.e., Japan also owes its present economic position to the development of agriculture sector in the pre-modern industrialization period. (Soni, 2013). Growth in the agricultural sector can help in overall economic growth by releasing labor as well as capital to other sectors in the economy (Yao, 2000; Gollin et al., 2002 and Humphries and Knowles, 1998). GDP growth originating in agriculture has been more successful in reduction of poverty than rest of the economy (Ravallion and Chen, 2007). Despite the historical role of agriculture in economic development, academic and donor communities have not been taking interest in the sector since mid-1980s. However, now agriculture is back on agenda because increasing agricultural productivity is the surest way to end poverty. It not only helps to increase farm incomes but also stimulates linkages to the non-farm rural economy (Timmer, 2005). On the contrary, the growth process in the manufacturing sector does not significantly impact the agricultural sector (Kanwar, 2000).

Though newspaper headlines prefer to highlight the failure of agriculture like higher food prices, rising hunger, and distress in agriculture etc. but agriculture has many success stories such as accelerating growth, poverty reduction, food security and environmental services and we need to learn from these successes in our development.

The WDR (2008) emphasized on the use of agriculture as strategic tool for development (De Janvry and Sadoulet, 2009).

South Asia is one of the densely populated areas in the world. It consists of Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. Most of these South Asian economies are based largely on agriculture and historically it has been found that it contributed positively towards overall economic development. Agriculture employs about 60 percent of the labor force in South Asia and contributes 22 percent of the regional gross domestic product (WDR, 2008). Agricultural growth in South Asia is less than 3 percent, which is far below the growth rates of other economic sectors (World Development Report, 2008). Green Revolution of the late sixties and early seventies has brought about a significant transformation in productivity of agricultural sector. However, over the last two decades, due to structural changes that have been taking place in most of the South Asian economies, the share of agriculture in gross domestic product (GDP) has started declining. Since agriculture is one of the key economic sector in South Asian countries therefore priority should be set for improvement of agriculture in the South Asian countries. Economic reforms have been undertaken in most of these countries and now they are looking for a greater role of the industrial sector in the economy.

Structural transformation is essential for economic development. In this process factor of production move across the sector which drive development process (Atiyas, Galal and Selim, 2015). Economic development generally goes parallel with declining share of agriculture in output and employment and leads to structural transformation of economy from agriculture to industrial and services sector (Hnatkovska, and Lahiri, 2013). Gollin et al., (2002) concluded that development of an economy is associated with declining role of agriculture in the economy. Dependence on agriculture may create vicious circle of low productivity and poverty. Industrialization is required to break this circle which by increasing income level leads to higher saving and investment and thereby generates self-sustaining growth (Lewis, 1954; Kaldor, 1967 and Fei and Ranis, 1964). Kuznet (1973) demonstrates that growth of an economy is accompanied with structural changes due to changes in demand and supply with rising income. Demand for agricultural products declines because of low-income elasticity of demand for agricultural product while in contrast demand for industrial goods and services as their elasticity are higher. McMillan and Rodrik (2011) found that structural change has been helpful in productivity growth in Asia but not in Africa and Latin America.

Johnston and Mellor (1961) described five major ways that agriculture can contribute in the economic development i.e (1) Provision of food (2) Raw material to industry (3) Provide domestic market to industrial sector.(4) Foreign exchange earnings (5) Transfer of labour to rest of economic sector. In a review study of agriculture and development, Dethier and Effenberger (2012) explained that agricultural growth has a capacity to overcome poverty in poor and developing countries. Improvement in agricultural productivity is essential to achieve the Sustainable Development Goals. Moreover, Agriculture could be an engine of economic growth and provide employment opportunities for the rural non-farm economy because of its linkages with small cities and rural areas. Non-agricultural sector's growth is backed by resource transfer from agriculture sector (Yao, 2010). Increase in agricultural productivity releases resources for other sectors. For developing countries, the growth in agricultural productivity and sectoral shift in employment is the key to economic growth because effective improvements in agricultural productivity give a big push to the industrialization which largely affects a country's relative income (Gollin et al., 2002; Humphries and Knowles, 1998). Evidence reveal that in all those countries which are rapidly growing at present, agriculture has been the driver for their non-agricultural sectors and overall economic growth. Economic growth through agriculture makes a strong impact in reducing poverty and hunger (Pingali, 2007). De Janvry and Sadoulet (2009) believe that the benefits from a global orientation of the agricultural sector can be pro-poor where the production and post-harvest activities continue to be labour intensive. Winters et al., (1998) argued that industrialization can be successful when solution to the problems associated with the generation, transfer and use of agricultural resources surplus has been identified.

Some other empirical studies have also been done to find the role of agriculture in economic development in different time period and different region. Results of the study by Self and Grabowski (2007) showed that growth of agricultural productivity via agricultural modernization has a positive effect on economic growth and human development. In their empirical study, Tiffin and Irz (2006) Taking data from 85 countries, provided evidence that for most of the countries, growth in agricultural value added is a major cause of GDP growth. This view is consistent with the popular paradigm among agricultural economists that agricultural productivity growth is necessary to "get the economy moving" because it releases surplus of food, labor, raw materials, capital, and foreign exchange, while simultaneously generating demand for industrial goods and services. Kanwar (2000) found that agriculture significantly affects income generation in manufacturing and construction sector in India. Ravallion and Datt (1996) analyzed the effects of sectoral pattern of economic growth on poverty in India. They found that poor people always benefitted from rural growth and rural economy and stressed that expansion and growth of primary and tertiary sector should be the central focus of policy for reduction of poverty in India. Awokuse (2009) concluded that agriculture matters for economic growth of African countries. In contrast, some arguments have also been advanced which indicate that industrial development is more necessary for economic development (Szirmai, 2015; Chakravarty and Mitra, 2009; Katuria and Raj, 2009; Cornwall, 1977; Kaldor, 1967).

Review of literature shows that most of economist believe that though relative share of agriculture has declined over time calling for rapid industralization for structural transformation but agriculture still plays an active role in economic development. It is empirically proven that without agricultural development any effort to industrialize an economy may end up in failure. Many empirical studies have been undertaken to analyze the role of agriculture in economic development but results widely vary and often are not comparable. The development economics literature is still inconclusive on how best to promote growth and prosperity in emerging and low-income countries (Cantore et al., 2014). We are undertaking a comprehensive study across the four major countries namely Bangladesh, India, Pakistan and Sri Lanka of South Asia which form together 96.3 percent of South Asia's population in 2016 (WDI, 2017) where a bulk of world population below poverty line lives. Headcount ratio for South Asia was 15.1 in 2015. The specific aims of the study are (1) to ascertain extent of declining of agricultural share in GDP, (2) analyze the compound annual growth of agriculture in these four countries and (3) examine the relationship between agricultural growth and GDP growth using Augmented Neoclassical Solow-Swan model.

Materials and methods

Conceptual framework and model specification

To analyze the long-run relationship between agriculture and economic growth, we shall use Augmented Neoclassical Solow-Swan model as suggested by Ruttan (2000), Timmer (1995), Hwa (1988), and used by researchers like Awokuse and Xie (2015), OJO et al. (2014), Samimi and Khyareh (2012) and Awokuse (2009). Our derived empirical function is as follows.

$$Y_t = K_t^{\alpha} A_t^{\beta} X_t^{\gamma} T_t^{\eta} + u_t$$

After a natural log transformation the equation is

$$\ln Y_t = \alpha \ln K_t + \beta \ln A_t + \gamma \ln X_t + \eta \ln T_t + \varepsilon_t$$

Where;

Y = Real GDP per capita, (GDP)

K = Real gross capital (GCF)

A = Agricultural value added (AGRI)

X = Real exports (EXP)

T = Terms of Trade (TOT, a proxy for other macroeconomic variable

ε = Error term (captures other variables that may influence productivity changes not explicitly included in the model)

As discussed in the literature that agriculture is engine of economic growth via support to other sector of the economy (Hwa, 1988). A number of studies have advocated for export-led economic growth. Foreign exchange earnings through export can impact the economy through multiplier effect and can be used to import manufactured and capital goods. It also increases the linkage in industry, and generates positive externalities. This accelerates economic growth. Asian economies provide ample examples of export-led economic growth (Abou-Stait, 2005; Faridi, 2012). So, we also include additional determinants of growth (exports and terms of trade [TOT]) that have been found to be robust in explaining aggregate productivity growth (Hwa, 1988; and Wunder, 2003). There is enough literature available is support of the argument that Terms of trade has relationships with economic growth (Kalumbu and Sheefeni, 2014; Blattman et al., 2004; and Mendoza, 1997). Wunder (2003) finds evidence that the increase in an economy's TOT could affect other sectors (e.g., the agricultural sector) through the expansion of exports and price booms. Mehta (2011) found empirical evidences that show long-run relationship between capital formation and economic growth. Capital formation significantly influences the economic growth (Barro, 1991; Levine and Renalt, 1992; and Beddies, 1999).

Data

Four South Asian countries are chosen for the study namely India, Pakistan, Bangladesh and Sri Lanka. The study is based on the secondary data. Annual time series data of real GDP, agricultural value added, gross capital formation is use as a proxy for real gross capital, real exports, and TOT have been collected from World Development Indicators provided by the World Bank for India, Pakistan, Bangladesh and Sri Lanka. Data of all variables have been taken in their local currency unit of the countries at constant price. For India data is taken from the period 1980 to 2013, for Pakistan from 1980 to 2014, for Bangladesh 1987 to 2014 and for Sri Lanka 1984 to 2013. Lack of uniformity in time period of study is due to non-availability of data of some variables.

Econometrics approach

Cointegration tests are most popular approach for analyzing the relationship between different variables. If cointegration is found among variables, it implies a long-run equilibrium relationship among the variables. The same approach has been used in the current study. Unit root test is the precondition of cointegration and causality analysis. Unit root test is performed using an autoregressive model to check whether a time-series variable is non-stationary or not. A series is stationary if the mean and auto covariances of the series do not depend on time. According to Nelson and Plooser (1982), most of the time series that appear in the economy will have to be differenced in order to become stationary. Univariate time-series properties were examined using two unit root tests: Augmented Dickey and Fuller (ADF) test and non-parametric Phillips-Perron (PP) approaches. The test of stationarity were carried out by estimating the following regression equation:

$$\Delta Y_t = \psi Y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-1} + \mu_t \quad (1)$$

$$\Delta Y_t = \beta_0 + \psi Y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-1} + \mu_t \quad (2)$$

$$\Delta Y_t = \beta_0 + \psi Y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-1} + \pi \mathrm{Trend} + \mu_t \quad (3)$$

whereas *i* varies from 1 to *m*

Equation (1) shows the Random walk model without drift and intercept.

Equation (2) shows the random walk model with drift.

Equation (3) shows the random walk with drift and trend.

Here the hypothesis used for inference is following

H0: $\psi = 0$ (non stationary series), H1: $\psi \neq 0$ (stationary)

Hence if the test statistic on the ψ is significant will suggest that the Y_t series is stationary.

Further, cointegration test has been done to investigate the long-run equilibrium relationship among the variables using Johansen and Juselius (1990) maximum likelihood technique based on VAR model. Johansen's multivariate cointegration modeling technique is widely accepted as an improvement on Engle and Granger (1987) modeling technique. Generalized cointegration equation is given below.

$$\Delta Y_t = \mu + \sum_{I=1}^{L-1} \Gamma_I Y_{t-k} + \Pi Y_{t-1} + \varepsilon_t \quad (4)$$

Where Y_t is an ($n \times 1$) column vector the variables *GDP, AGRI, EXP, GCF, TOT*. μ is an ($n \times 1$) vector which may include a linear trend term, an intercept term, or both. Π denote the coefficient matrices. It contains the information of long run the adjustment to change in Y_t. Δ is operator of first difference, *k* is indicating lag length determine by the Aikaike's information criterion (AIC) it is best criteria to chose lag length for small sample (Liew, 2004). ε_t is the error term. Intercept with linear deterministic trends is allowed to analyze the cointegrating equation (4). Johansen proposes two methods for determining the cointegration rank, the λmax test and the trace test.

Finally, Granger causality test has been employed to analyze causal relations between agriculture and economic growth in short run. This test predicts how much of the current value of GDP is explained by past value of agricultural value added vice-versa. GDP is said to be Granger-caused by Agricultural value added if agricultural value added helps in the prediction of GDP or equivalently if the coefficient on the lagged Agricultural value added is statistically significant. Specifically, $AGRI_t$ is causing GDP_t if some coefficient, Φ_i, is non-zero in the following equation.

$$\boldsymbol{GDP_t = \alpha_0 + \sum_{i=1}^{k} \Phi_i \; AGRI_{t-1} + \sum_{j=1}^{k} \Psi_j \; GDP_{t-j} + \varepsilon_t} \quad (5)$$

Similarly GDP_t is causing $AGRI_t$, if some coefficient, Θ_i, is non-zero in the following equation.

$$AGRI_t = \beta_0 + \sum_{i=1}^{k} \Theta_i \; GDP_{t-1} + \sum_{j=1}^{k} \delta_j \; AGRI_{t-j} + \mu_t \quad (6)$$

Some diagnostic and stability test such as Jerca Bera test for normality, Breusch-Godfrey for serial correlation, Breusch-Pagan-Godfrey for Heteroskedasticity, CUSUM test and CUSUM of square test are examined for model satisfactoriness.

Results and discussion

Structural transformation in South Asian countries

Structural transformation refers to the change in the composition of sectoral output in the economy over a period of time. Structural transformation of South Asian economies is presented in the table 1.

Table 1 shows that in 1960, agriculture contributed 57.5 percent in the economy of Bangladesh while the contribution of non-agriculture sector was 42.5 percent. But in 1990, share of agriculture sector declined to 32.7 percent and a sharp increase in industrial sector has been observed from 6.9 percent in 1960 to 20.7 percent in 1990. In 2014, agriculture share further declined to 15.8 percent, while that of industrial and service sector increased to 27.8 and 56.2 percent respectively. In India also a drastic change in the sectoral composition is found. In 1960, agricultural contributed 42.5 percent in the economy which declined to 29.0 percent in 1990, while the contribution of services sector increased to 44.4 percent from 38.14 percent and industrial sectors went up to 26.5 percent from 19.3 percent over the same period. Similar trend has been observed from 1990 onwards, when share of agricultural sector came down to 16.9 percent in 2014 and services sector reached to 52.9 percent. A noticeable trend in case of India is that the contribution of industrial sector has shown only marginal improvement from 26.4 percent to 30.0 percent during 1990 to 2014. This implies that in post-liberalization era industrial sector could not grow at the pace expected. Major cause for this has been increased inflow of foreign industrial goods from abroad especially from China due to reduction in tariffs as well as non-tariff barriers by government of India. It is the fast expansion of services sector which has caused declined in the share of agriculture. Similarly, between the periods of 1960-1990, in the economy of Pakistan, agriculture share has declined from 46.2 percent to 25.9 percent, while the contribution of industrial sector increased to 25.1 percent from 15.6 percent and services sector increased from 38.1 percent to 48.8 percent. But 1990 onwards, share of agriculture has remained stagnant at near about 25 percent and industrial sector declined to 21.2 percent and services sector increased to 53.6 percent in 2014. This clearly reflects that Pakistan economy suffered structural retrogression after 1990. Lack of infrastructure facilities and weak government policies have been major stumbling blocks in industrial expansion in Pakistan. While private domestic investment grew slowly, foreign investment shied away because of political uncertainties and growth of fundamentalist tendencies. As far as Sri Lanka is concerned, agriculture sector has marginally declined from 31.6 percent in 1960 to 26.3 percent

	Agriculture	Industry	Services		Agriculture	Industry	Services
Bangladesh				**India**			
1960	57.47	6.97	35.55		42.56	19.30	38.14
1990	32.75	20.70	46.55		29.02	26.49	44.48
2010	17.81	26.14	56.05		18.21	27.16	54.64
2014	15.89	27.87	56.24		16.96	30.05	52.99
Pakistan				**Sri Lanka**			
1960	46.22	15.60	38.18		31.66	20.40	47.95
1990	25.98	25.19	48.83		26.32	25.97	47.71
2010	24.29	20.58	55.13		12.81	29.43	57.76
2014	25.12	21.28	53.59		9.86	33.81	56.33

Source: WDI data (2015)

Table 1: Decade-wise share in GDP by economics sectors.

in 1990 and a similar marginal improvement has been observed in industrial sector from 20.4 percent to 25.9 percent, but services sector remained stagnant. After 1990, agriculture sector has declined sharply to 9.8 percent in 2014 while both industrial and service sector increased considerably.

From the above trend following conclusions about structural transformation in South Asian Countries emerge:

(1) In all economies, relative importance of agriculture sector has declined though the degree of decline has varied from country to country. Bangladesh recorded sharper decline in agriculture followed by India and Sri Lanka, in case of Pakistan process of decline has been very slow.

(2) Bangladesh has succeeded in industrializing its economy at a relatively faster pace, recording more than four-fold increase in its share. While India and Sri Lanka achieved modest industrial expansion, Pakistan has lagged behind considerably in industrial expansion.

(3) Services sector have been major sources of economic growth and structural transformation in India, Bangladesh, and Pakistan, but its role was limited in Sri Lanka as it already had a very large share.

Performance of agricultural value added and GDP in South Asian Countries

Table 2 reveals the results of correlation coefficient and decade-wise CAGR of agriculture and economic growth of major South Asian countries. Correlation between growth in agricultural value added and GDP has been strongly positive for Bangladesh and India while moderate in case of Pakistan and Sri Lanka. Decade-wise average growth shows high degree of fluctuation in agricultural growth of Bangladesh followed by Pakistan, India and Sri Lanka while in case of overall GDP growth almost similar variations are observed. This clearly demonstrate that growth in agricultural value added is crucial for sustainable economic growth in South Asian countries. Now we shall analyse the relationship between agricultural value-added and economic growth more closely by using econometric techniques.

Cointegration and long run estimates

We have found correlation between agriculture value added and agricultural growth across South Asian countries, though degree of correlation is lower in case of Pakistan and Sri Lanka. Now we shall examine the relationship between agriculture value added and GDP more closely by applying cointegration approach.

First of all we check stationarity of the series by using ADF and PP tests. ADF and PP determine the unit root test using parametric and non-parametric approaches respectively. Both tests are examined for null hypothesis of non-stationarity. Results of tests are given in the table 3. At level, time series of all four countries has unit root. However, at first difference all series are stationary. It provides sufficient condition to test Johansen and Juselius (1990) multivariate cointegration test which has been done in table 4. This test has been done to analyze whether the long run relationship exists or not.

Table 4 reveals that Trace statistics (λ_{trace}) rejects the null hypothesis (r = 0) for all four countries vis Sri Lanka, Pakistan, India and Bangladesh at 5 percent significant level. Row 2 of table 4 shows that the null hypothesis of Cointegration rank, ($r \leq 1$), is not rejected for all countries. Similarly max-eigenvalue (λ_{max}) reject the null hypothesis ($r \leq 1$) at 5 percent level of significance for Bangladesh, Pakistan and Sri Lanka but for India test value is slightly more than critical value at 5 %

	Bangladesh		India		Pakistan		Sri Lanka	
year	Agriculture	GDP	Agriculture	GDP	Agriculture	GDP	Agriculture	GDP
1960-70	2.7	3.6	2.0	3.6	4.8	6.9	2.9	4.5
1970-80	0.5	1.7	1.8	3.3	2.3	4.6	2.7	4.5
1980-90	2.0	3.7	3.1	5.3	4.0	6.1	2.1	3.9
1990-00	2.6	4.6	3.1	5.8	4.3	3.7	1.9	5.1
2000-10	4.3	5.6	3.1	7.5	3.3	4.7	3.1	5.5
2010-14	3.2	6.1	2.6	6.2	2.7	3.9	3.2	7.0
r	+0.89		+0.85		+0.54		+0.55	

Note: r denotes correlation coefficient
Source: WDI data (2015)

Table 2: Decade-wise Compound Annual Growth Rate (CAGR) of agricultural value added and GDP.

and null hypotheses is rejected at 10 percent (P-value = 0.0.057) level of significance. From the results it can be concluded that there is a cointegration among the variables and there exists long-run relationship between agriculture and economic growth.

	Sri Lanka		Pak	
At level	**ADF**	**PP**	**ADF**	**PP**
AGRI	0.40 (0.980)	0.58 (0.987)	-2.29 (0.425)	-2.20(0.475)
EXP	-1.54 (0.794)	-1.41 (0.839)	-2.01 (0.575)	-2.08(0.536)
GCF	1.55 (0.999)	3.80 (1.000)	-2.82 (0.066)	-2.82(0.066)
GDP	-0.04 (0.993)	-0.20(0.990)	-2.35(0.398)	-2.47(0.341)
TOT	-0.52 (0.484)	-0.61 (0.444)	-1.59(0.103)	-1.66(0.090)
At 1st difference				
AGRI	-6.27 (0.000)	-6.27 (0.000)	-7.27 (0.000)	-13.97(0.000)
EXP	-5.11(0.001)	-6.25 (0.000)	-6.37 (0.000)	-6.38(0.000)
GCF	-5.37 (0.000)	-5.40 (0.000)	-4.81(0.000)	-4.80(0.000)
GDP	-4.84(0.002)	-4.84(0.002)	-3.64(0.041)	-3.60(0.045)
TOT	-5.40(0.000)	-5.41(0.000)	-5.55(0.000)	-5.56(0.000)
	India		Bangladesh	
At level	**ADF**	**PP**	**ADF**	**PP**
AGRI	0.018(0.953)	0.17(0.966)	-1.77 (0.689)	-2.17 (0.486)
EXP	-2.98(0.1644)	-3.43(0.064)	-2.58 (0.296)	-2.12 (0.514)
GCF	-1.81(0.676)	-1.82(0.673)	1.77 (0.999)	1.45 (0.999)
GDP	-1.01 (0.929	-0.79 (0.957)	-0.78 (0.955)	-1.55 (0.787)
TOT	1.03 (0.917)	2.57(0.997)	0.17 (0.966)	0.58(0.987)
At 1st difference				
AGRI	-9.62(0.000)	-22.13 (0.000)	-4.01 (0.024)	-4.54(0.007)
EXP	-5.25(0.001)	-5.23 (0.001)	-4.22 (0.013)	-4.11 (0.014)
GCF	-5.74(0.000)	-5.74(0.000)	-3.98 (0.005)	-3.99 (0.005)
GDP	-5.54(0.000)	-6.87 (0.000)	-4.71 (0.004)	-4.71 (0.004)
TOT	-6.37(0.000)	-6.39 (0.000)	-6.71 (0.000)	-6.84 (0.000)

Note: Trend and intercept are included for AGRI, GCF, GDP and Intercept for TOT while for export Trend and intercept for Sri Lanka and for rest of the countries Intercept included in ADF and PP Test
Source: WDI data (2015)

Table 3: ADF and PP Test.

	Sri Lanka	Pakistan	India	Bangladesh
Cointegration rank	**Value of Trace statistics**			
r = 0	99.097*	101.58*	81.023*	99.259*
	(0.007)	(0.004)	(0.005)	(0.007)
r ≤ 1	59.961	60.05	47.656	52.738
	(0.102)	(0.101)	(0.052)	(0.301)
r ≤ 2	35.177	35.145	26.147	33.971
	(0.238)	(0.239)	(0.124)	(0.326)
r ≤ 3	16.583	18.031	12.983	16.212
	(0.447)	(0.342)	(0.115)	(0.474)
r ≤ 4	6.201	6.007	3.686	4.152
	(0.435)	(0.459)	(0.155)	(0.720)

Note: * denote 5 % level of significance, **denote 10 % levels of significance, P-value are given in parenthesis
Source: WDI data (2015)

Table 4: Johansen's cointegration test results (to be continued).

	Sri Lanka	Pakistan	India	Bangladesh
Cointegration rank	**Value of λ-max statistics**			
r = 0	39.136*	41.527*	33.367**	46.521*
	(0.040)	(0.021)	(0.057)	(0.005)
r ≤ 1	24.784	24.905	21.509	19.525
	(0.299)	(0.292)	(0.247)	(0.689)
r ≤ 2	18.594	17.113	13.164	16.978
	(0.333)	(0.448)	(0.437)	(0.459)
r ≤ 3	10.382	12.024	9.297	12.081
	(0.578)	(0.413)	(0.262)	(0.408)
r ≤ 4	6.201	6.007	3.685	4.152
	(0.435)	(0.459)	(0.155)	(0.720)

Note: * denote 5 % level of significance, **denote 10 % levels of significance, P-value are given in parenthesis
Source: WDI data (2015)

Table 4: Johansen's cointegration test results (continuation).

Coefficient and T-value of long-run regression						
Countries	**Constant**	**AGRI**	**EX**	**GCF**	**TOT**	**R-square**
Bangladesh	8.726	1.394	0.31	0.038	-0.065	0.35
		[-17.127]	[-14.344]	[1.058]	[1.667]	
India	0.229	0.482	0.063	0.494	0.012	0.49
		[-4.734]	[-1.383]	[-8.706]	[0.030]	
Pakistan	12.932	0.311	0.12	1.07	0.082	0.57
		[-1.093]	[-0.581]	[-2.683]	[-0.678]	
Sri Lanka	8.917	0.969	0.377	0.099	-0.247	0.51
		[-9.326]	[-13.349]	[-2.181]	[5.633]	

Note: T-value are given in parenthesis
Source: WDI data (2015)

Table 5: Results of long-run regression.

Table 5 indicates the Long-run estimates. Out of all four regressors our main interest is to discuss the impact of agriculture on economic growth. Results shows that agriculture makes a positive and significant impact on economic growth is south Asian countries. The effect of agriculture on economic growth is stronger for Bangladesh, India and Sri Lanka while for Pakistan though positive but not significant at 5 % percent level. This result supports the hypotheses of early development economists that agriculture is an engine of economic growth. In spite of structural transformation in economies of all four countries, policy initiatives have continuously been undertaken to improve agriculture sector in all four South Asian countries. Progress of rural electrification and the financial transformations in the mid-nineties led to the increased commercialized agriculture in Bangladesh. In India policy initiatives such as high yielding variety of seeds (HYVS), research and extension services of agriculture, the supply of inputs such as chemical fertilizers and pesticides, emphasis on the provision of agricultural credit and crop insurance has transformed agriculture from subsistence to semi-commercialized and commercialized one (Arora, 2013, Mandal and Bezbaruah, 2013; Kumar, et al.,2012). Sri Lankan government consistently emphasized on the development of agriculture through several policy packages such as land reforms and Social development programs taking agriculture as a central theme. Pakistan does not have a formal operative "Agriculture Policy" at present, instead ad-hoc policy measures are framed from time to time to strengthen agriculture (Khan, 2015).

An export is crucial for economic activity to generate foreign exchange and stimulate growth. Table 6 indicates the role of export in economy. Analysis reveal that export has strong and positive impact on economic growth for Bangladesh, India, and Sri Lanka while for Pakistan export though

	Bangladesh		India	
	F-Statistic	P- value	F-Statistic	P- value
AGRI does not Granger Cause GDP	1.535	0.240	5.16*	0.031
GDP does not Granger Cause AGRI	4.445	0.025	3.21***	0.085
	Pakistan		**Sri Lanka**	
	F-Statistic	P- value	F-Statistic	P- value
AGRI does not Granger Cause GDP	4.109**	0.032	5.747**	0.024
GDP does not Granger Cause AGRI	1.187	0.325	18.637*	0.000

Note: * Significant at 1 %, ** Significant at 5 %, *** Significant at 10 %
Source: WDI data (2015)

Table 6: Short-run estimates.

has a positive but weak impact on the growth of economy. For all four countries Coefficient of gross capital formation was found positive and highly significant which is consistent with neoclassical growth theory. South Asian economies are increasing capital formation to obtain higher economic growth. Variations in term of trade also affect economic growth of a country (Kalumbu and Sheefeni, 2014; Blattman et al., 2004; Wunder, 2003 and Mendoza, 1997). For India and Pakistan terms of trade has been positive while for Bangladesh and Sri Lanka it has been negative.

Granger causality analysis has been employed to estimates the hypothesis ALG (agricultural-led growth) and GLA (growth led agriculture) in the short- run for all four countries based on the ECM. The null hypotheses are agriculture does not Granger-cause GDP and GDP growth does not Granger-cause agricultural. Results are shown in the table 6. Mixed results are found on the contribution of agriculture to economic growth in the short-run. For India, we found bidirectional causality, both ALG and GLA is statistically significant. Agriculture is granger cause of GDP and the reverse GDP is granger cause of agriculture, but former is significant at 5 percent while later is significant at 10 percent level. In Pakistan unidirectional causality is found, agriculture stimulates GDP growth while reverse is not found significant. For Sri Lanka strong bidirectional causality is found. Null hypotheses that agriculture does not granger cause GDP is rejected at 5 percent while GDP does not granger cause agriculture is rejected at 1per cent. For Bangladesh causality has been running from GDP to agriculture. Agricultural growth is led by the overall GDP growth. These results confirm finding of similar previous studies for developing countries (Awokuse and Xie, 2015; Tiffin and Irz, 2006).

Conclusion

In the present study empirical analysis has been undertaken to examine the role of agriculture in economic growth for South Asian economies. Due to unavailability of data only four South Asian countries namely India, Pakistan, Bangladesh and Sri Lanka have been chosen for study. South Asian countries have witnessed structural transformation over time resulting in the declining share of agriculture. But agriculture sector still is crucial for their economic growth and development. Fluctuation in agriculture still leads to fluctuation in overall GDP growth in South Asian countries. Our results show that in all four South Asian countries, agriculture has long-run association with economic growth and it is an important driver of economic growth. Short-run analysis indicates that agriculture stimulates growth in all South Asian countries except Bangladesh. In addition, bidirectional relationship between agriculture and economic growth is found for India and Sri Lanka. National policymakers of these countries should recognize the role of agriculture in economic planning and formulate their economic development strategies accordingly. Neglect of agriculture and excessive focus on industrialization may retard growth both in short and long run.

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Time Series Analysis of the Behaviour of Import and Export of Agricultural and Non-Agricultural Goods in West Africa: A Case Study of Nigeria

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Abstract

This study examines the time series properties of co-integration and causal relationship between oil (non-agricultural) and non-oil (agricultural) import and export in Africa's largest economy. We employed Granger causality and Johansen and Juselius's co-integration methods to investigate causal relationships among the variables Naira-US dollars exchange rate (USD), Naira-Pounds exchange rates (GBP), Oil Import (OI), Non-Oil import (NO), Oil Export (OE) and Non-Oil export (NE). We found empirical evidence for co-integration between oil and non-oil import. Our result reveals the existence of long run equilibrium between exchange rates, oil import and export, and non-oil import (agriculture) and export. Non-oil import and export involves those of agricultural products like Cocoa, Timber, Cassava and Groundnut. We show that there is bidirectional Granger causality from import and export of both agricultural (non-oil) and non-agricultural (oil) goods and vice-versa. This empirical relationship followed closely to what economic theory have suggested. The study recommends amongst others, that government should adopt appropriate monetary and fiscal policies that will ensure realistic and stable exchange rates and foster economic growth through import and export of agricultural products.

Keywords

Causality, import, export, Nigeria, exchange rate.

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Introduction

The importance of import and export to a nation's economic growth and development cannot be over-emphasized because they are necessary catalysts to the overall development of an economy. Over the years, the African continent, specifically, West African countries have been predominantly involved in the import and export of primary goods which are highly susceptible to the vagaries of unstable price movements in the world market. Some of the products that constitute the continent's export volume include crude oil, petroleum products, and agricultural products like Cocoa, Timber, Cashew, Cotton, among others. The implication of this is that, African continents' macroeconomic performance is highly correlated with the success of these products in the world market.

However, using Nigeria as a case study for the continent, Africa has experienced periods of instability in the barrel price of oil in the world market which, given the inelastic state of the products, resulted in low income for the economy with its indirect effect on employment, inflation rate, interest rate, and balance of payments. A prominent feature of Nigeria's export has remained basically the same since 1960. In the 1960s, and 1970s the Nigerian economy was dominated by agricultural commodity exports such as cocoa, groundnut, cotton and palm products. From the mid-1970s, crude oil became the main export product of the Nigerian economy. The export of crude oil now constitutes about 96% of total exports. According to Ayinde et.al.,2015, the performance of agriculture in Nigeria since 1970 clearly showed that it contributes more than

40% of its annual Gross Domestic Product

(GDP) and accounts for over 70% of the non-oil exports. The agricultural sector was the second largest export earner after crude oil and the largest employer of rural labor in Nigeria; therefore, it ranks as a key contributor to wealth creation, poverty reduction and food security in Nigeria.

Unfortunately, this position has fallen consistently to date due to, the appalling fluctuation in the non-oil export promotion, the world prices of agriculture and manufacturing products and the emergence of oil have helped in no small measure in diverging the role of agriculture in the nation's development. This situation is worsened by the almost total neglect of the agricultural sector; hence the performance of the non-oil exports in the past two decades leaves little or nothing to be desired. The major policy concern of the Nigerian government over the years has been to expand non-oil (which involves mainly agricultural products) export in a bid to diversify the nation's export base. Moreover, since the 2005 economic reform, the Nigerian government has continued to diversify its international trade market to include agricultural import and export.

Time series methodologies have been applied to analyze agricultural data in recent times (see for instance, Emokaro and Ayantoyinbo, 2014; Aloui, 2015; Hloušková et al., 2018; Kharin, 2018 and Ayinde et al., 2015). For instance, Syed et al. (2015) analysed the impact of agricultural exports on macroeconomic performance of Pakistan. Their Johansen co-integration technique result revealed that agricultural exports have a negative relationship with economic growth of Pakistan while non-agricultural exports have positive relation with economic growth. In a similar paper, Eke et al. (2015) applied co-integration test to examine exchange rate behaviour and trade balance in Nigeria. Their results also confirmed the presence of long-run relationship between trade balance and exchange rates; showing that the latter has a negative influence on trade balance in Nigeria. Uduakobong and Williams (2017) recently analyzed the relationship between exchange rate volatility and agricultural imports in Nigeria using annual data covering the period of 1970 to 2015. Their co-integration and Granger Causality test revealed the presence of a long run relationship between exchange rate volatility and agricultural import and that exchange rate does not Granger cause the movements in agricultural imports. However, time series studies on the behavior of exchange rates and agricultural (and non-agricultural) imports and exports in West African countries are non-extant.

The main objective of this study, therefore, is to examine the nature of causal relationship between the Nigerian exchange rate and agricultural and non-agricultural trade using time series methodologies. Studying the nature of the relationship between the Nigerian naira exchange rates and agricultural and non-agricultural trade is imperative in finding stability measure for the Nigerian currency which depicts economic growth, therefore, it is imperative to investigate the behaviour of the correlation and time series relationship between foreign trade (agricultural and non-agricultural) and foreign exchanges rates (USD and GBP) in Nigeria. The scope of this study examines the behavior of import and export of agricultural and non-agricultural goods using pre-recession (1960-2010) data on the Nigerian economy. The findings from this study would contribute to the existing evidences of co-integration and causality in the Nigerian foreign trade and exchange rates. Also, the results from this study would be useful for the policy makers and decision makers in the agriculture and economic sector.

Materials and methods

Annual time-series figures from 1960 to 2010 (pre-recession period) of naira-dollar exchange rate, naira-pounds exchange rate, imports (oil and non-oil), and exports (oil and non-oil) were used in this study. The data were obtained from the Central Bank of Nigeria Bulletin, 2010 edition, covering periods of 1960-2010. The unit of measurement for the import and export data is in USD Billions. The analytical techniques employed in this study for time series analysis include unit root test, Pearson correlation and Granger causality models.

Unit root test was conducted to test for the stationarity of the series while the Pearson's correlation coefficient and Granger causality test were used to examine the relationship between the six variables: Naira-US dollars exchange rate (USD), Naira-Pounds exchange rate (GBP), Oil Import (OI), Non-Oil import (NO), Oil Export (OE) and Non-Oil Export (NE). The methods and models used in this work were adapted from the works of Emakoro and Ayantoyinbo (2014), and Ayinde et al. (2015).

It is an established fact that most macroeconomic series appear to be non-stationary at their levels

(Nelson and Plosser, 1982) and the use of such series in regression analyses lead to spurious regression estimates (Granger and Newbold, 1974). Thus, before examining integration relationships between or among financial variables, it is essential to test for unit root, and identify the order of stationarity. Test of the stationarity of financial series is paramount in other to avoid spurious results. There are several methods for testing the presence of unit roots; however, the most widely used method is the Augmented Dickey Fuller (ADF) test.

The ADF test corrects any serial correlation that might exist in the series by including lagged changes of the residual in the regression. It is defined as the regression of the first difference of the time series against the series lagged once of a constant and a time trend. It is expressed as;

$$\Delta y_t = a_0 + a_1 y_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta y_{t-i} + \varepsilon_t \qquad (1)$$

where y_t represent each time series considered in this work; USD, GBP, OI, NO, OE and NE. Δ is the first difference operator, ε_t is the error term with zero mean and constant variance, $a_0, a_1, \varphi(i = 1,\ldots,p)$ are the parameters to be estimated and i is the included number of lag of each series. The non-rejection of the null hypothesis: H_0: $a_1 = 0$ implies that, the series is nonstationary. Thus, differencing of the series is necessary to reach stationarity.

Next, the Pearson correlation was used to examine the strength of the relationships among the variables considered. That is, to observe the pairwise-relationships between foreign trades including agricultural and non-agricultural products (import and export) and exchange rates (naira-dollars and naira-pounds). Given the price of each series at time *t*, X_t and Y_t, the degree of linear association between the variables were measured by the sign and magnitude of the correlation coefficient, *r*. The model is given as:

$$r = \frac{\sum_{i=1}^{n}\left((X_i-\bar{X})(Y_i-\bar{Y})\right)}{\sqrt{\sum_{i=1}^{n}(X_i-\bar{X})^2 \sum_{i=1}^{n}(Y_i-\bar{Y})^2}} \qquad (2)$$

Where:

r = Pearson correlation coefficient

X_i and Y_i = pairwise variables at time t

$\bar{X}$ and $\bar{Y}$ = mean of the variables.

After observing the inter-relationships between the variables considered in this work, it is needful for us to validate the linear combinations and co-integrations that exist between the variables. Moreover, according to Granger (1988), causality tests are valid only in the presence of co-integration among the variables involved. Consequently, a necessary precondition to causality testing is to check the co-integration properties of the variables of interest. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary. If such a linear combination exists, the non-stationary (with a unit root), time series are said to be co-integrated. The stationary linear combination is called the co-integrating equation and may be interpreted as a long-run equilibrium relationship between the variables. This study further investigated whether or not the variables are co-integrated using Johansen and Juselius (1991) maximum likelihood method.

This test relies on two test statistics; the trace and maximum eigenvalue tests. The trace test statistics; $\lambda_{trace} = T \sum_{i=r+1,n} \ln(1-\lambda_i)$ tests the null hypothesis that, there are at most *r* number of co-integration against the alternative of no co-integrating vectors. In the equation above, *T* represents the sample size and *λ* represents the largest canonical correlation under trace. The maximum eigenvalue test uses the relationship; $\lambda_{\max} = -T \ln(1-\lambda_{r+1})$ with the null hypothesis same as that of trace value above against the alternative hypothesis of $r + 1$.

Finally, the Granger causality test was employed to further examine the relationships between the variables. That is, to provide additional evidence as to whether and in which direction cost of foreign trade influence exchange rates and vice-versa. The Granger causality analysis was proposed by Granger (1969) to examine the causal relationship between variables. This concept introduced by Granger, has turned out to be extremely important to economist and financial analyst in testing plausible economic relationships between non-stationary economic time series. It uses a one-sided distributive lag whereby the incremental forecasting value of past and present history of one variable on another variable is used as the yard stick. Consequently, it stated that, "Y_t is causing X_t if the former is better able to predict the latter using all available information". In Granger (1969)'s bi-variate framework, variable *X* is said to cause *Y* if the past and current values of *X* facilitates the forecasting of *Y* when employed in conjunction with the past value of *Y* as compared with when only past values of *Y* are employed.

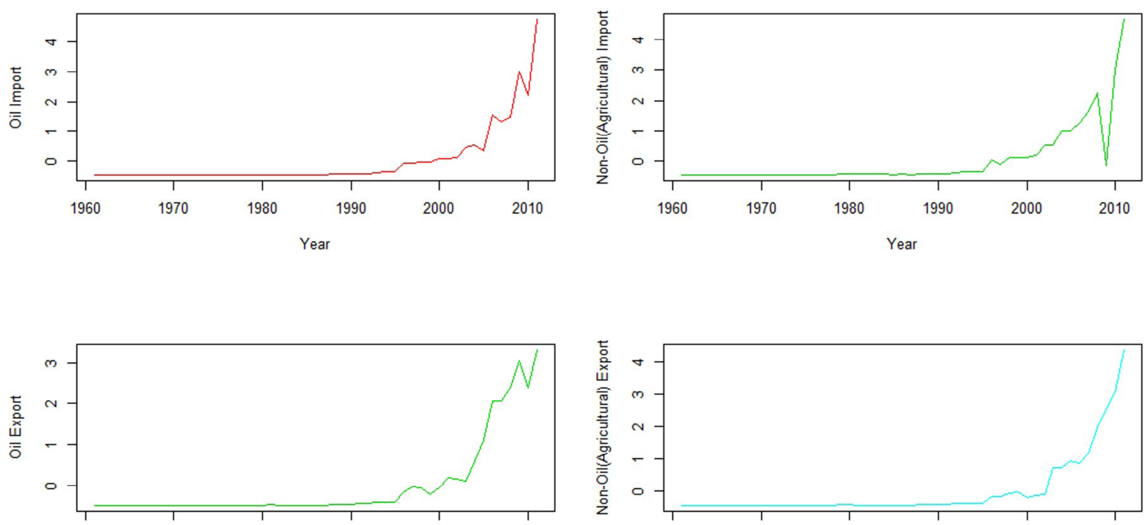
Results and discussion

The study uses figures (graphs) and tables to present the results for easy understanding. Figure 1 is the graph of each series (import and export) before any stationarity test was performed on them. It clearly shows the non-stationarity properties of the series. The lowest and highest prices of each variable were observed for the duration of the data. Considering the trend of these data, we observed from Figure 1 that all the series increased sharply in the mid-1990 except non-oil (agricultural) export which started increasing in early 2000, probably during the democratic regime of 2003. We also noticed that there was a sharp drop in the value of non-oil (agricultural) import around the year 2007 during the end of another democratic regime in Nigeria, while the change in cost of non-oil export was negligible from 1960-1995.

Table 1 shows the minimum, maximum, mean and standard deviation of the six variables. The study shows that, oil export has the highest standard deviation, followed by non-oil import. The implication of this is that both variables experienced high level of volatility during the sample period. This means that the price of oil export and non-oil imports change often over the periods under study. Persistence change in the movement of oil export data could be due to constant fluctuations in the depreciation of the naira exchange rates while that of non-oil (agricultural) imports could be due to high rate of importation among the Nigerian citizens.

With respect to the econometric methodology presented previously, it is expedient that all variables in this study are tested for stationarity using Augmented Dickey-Fuller (ADF) test. The ADF test reveals that the exchange rate variables are non-stationary and integrated of order 1, while the remaining variables are integrated of order two 2 (see Table 2). This is an indication of co-integration between the variables considered.

Next, the Johansen and Juselius (1991) testing procedure was applied on the differenced series



Source: Author´s processing

Figure 1: Time series trend of agricultural and non-agricultural import/export.

Variables	Minimum	Maximum	Mean	Std Deviation
USD	0.5464	148.455	34.3192	52.4815
GBP	1.077	249.993	57.91	89.3748
OI	22	2073579	183155.3	400706.7363
NO	346	5931795	547506	1154799.581
OE	9	10639417	1379064	2803497.872
NE	203.2	396377.2	37216.2	81985.82829

Source: Author's computation

Table 1: Descriptive statistics of the variables.

Variables	Form	P-value	ADF test	Critical-Value		Lag order
				1%	5%	
US Dollar	Level	0.9959	0.9869	-3.5683	-2.9212	10
	First Difference	0.0203	-3.3007	-3.5744	-2.9238	10
	Second Difference	0.0006	-4.6083	-3.6105	-2.9389	10
Pounds	Level	1	2.4356	-3.6056	-2.9369	10
	First Difference	0.0066	-3.7304	-3.5744	-2.9238	10
	Second Difference	0.0001	-5.3015	-3.5847	-2.9281	3
Oil Import (OI)	Level	1	3.6923	-3.5885	-2.9297	6
	First Difference	1	3.6381	-3.5811	-2.9266	3
	Second Difference	0.0482	-2.9442	-3.5847	-2.9281	3
Non-Oil Import	Level	0.9977	1.2019	-3.5885	-2.9297	6
	First Difference	0.6614	-1.2121	-3.5811	-2.9266	3
	Second Difference	0	-5.6242	-3.5847	-2.9281	3
Oil Export (OE)	Level	0.9999	2.3037	-3.6055	-2.9369	10
	First Difference	1	5.8796	-3.6105	-2.9389	10
	Second Difference	0	-6.7108	-3.5847	-2.9281	3
Non-Oil Export	Level	1	5.3183	-3.5885	-2.9297	3
	First Difference	1	6.7055	-3.6056	-2.9369	6
	Second Difference	0.0018	-4.1978	-3.5847	-2.9281	3

Source: Author's computation

Table 2: Unit root test on the variables.

to test whether they are co-integrated or not. The co-integration test reported in Table 3 shows the presence of five co-integrating vectors in the model. The implication of this result is that, variables considered share the same stochastic trend. That is, there is a long-run relationship between them (Enders and Lee, 2004).

Furthermore, the correlations between the six variables considered in this work were estimated and reported in Table 4 to determine the level of the linear relationships. The Pearson correlation coefficients among the variables signal positive correlation between the variables. It suggests co-movements between the variables. All the bi-variate correlations computed between oil and non-oil import and export and exchange rates (USD and GBP) reveal that there was no correlation coefficients lower than 0.5. The high correlations of the variables pairs are consistent with the high degree of integration between import, export and naira exchange rate; showing that a shock in each variable may have an influence on any of the variables considered in this study. For instance, a shock in non-oil export will have an impact on oil import.

Lastly, the Granger causality test was carried out in order to assert the statement that, any two co-integrated variables have either unidirectional or bi-directional causality between them (Awe, 2012, Awe et al., 2016). The decision rule for this test states that, if the coefficients of both cases in a pair are not significant, there is no causality between them, otherwise, there is bi-directional causality between them. However, if one of the coefficients is significant and the other is not, then the former Granger-causes the later and it is termed unidirectional. The pairwise comparison tests results on all the pairs of variables are presented in Table 4. These results confirm that, any two co-integrated variables have either unidirectional or bi-directional causality between them.

The results in Table 5 suggest that, in the fifteen linear combination, the direction of causality is unidirectional in 6 cases, bidirectional in 4 cases and absence of causality in the remaining 5 cases. Specifically, there is no causality between the following pairs of variables: OI and USD, NO and USD, NE and USD, NO and GBP and NE and GBP. This finding supports the evidence found in Uduakobong and Williams (2017). More so, the study reveals that; naira-US dollars (USD) Granger-causes naira-pounds and oil export while naira-pounds (GBP) granger-cause oil import and oil export. Moreover, according to international trade policies, when price of an export rises, it produces a demand, thereby

	λ_{trace}			λ_{max}		
No of CE	**Test stat.**	**C.values**	**p-values**	**Test stat.**	**C.values**	**p-values**
$r = 0$	732.0864	95.7537	0.0001	278.4324	40.0776	0.0001
$r \leq 1$	453.654	69.8188	0.0001	199.9524	33.8769	0.0001
$r \leq 2$	253.7016	47.85613	0.0001	141.916	27.5843	0
$r \leq 3$	111.7856	29.79707	0	92.08442	21.1316	0
$r \leq 4$	19.70119	15.49471	0.0109	19.16648	14.2646	0.0077
$r \leq 5$	0.534701	3.841466	0.4646	0.534701	3.8415	0.4646

Source: Author's computation

Table 3: Johansen-Juselius co-integration test results.

Variables	USD	GBP	OI	NO	OE	NE
USD	1	0.9931	0.7909	0.8098	0.8444	0.8004
GBP	0.9931	1	0.7842	0.7997	0.8622	0.8007
OI	0.7909	0.7842	1	0.8782	0.9538	0.9748
NO	0.8098	0.7997	0.8782	1	0.8598	0.913
OE	0.8444	0.8622	0.9538	0.8598	1	0.9442
NE	0.8004	0.8007	0.9748	0.913	0.9442	1

Source: Author's computation

Table 4: Pearson correlation coefficints results.

Pairs	Pairs (H_o)	F-stat	P-value	Decision	Types of Causality
1	GBP to USD	2.1699	0.1262	DNR H_o	Unidirectional
	USD to GBP	8.4845	0.0008*	Reject H_o	
2	OI to USD	1.2135	0.3069	DNR H_o	No Causality
	USD to OI	0.7597	0.4738	DNR H_o	
3	NO to USD	1.0091	0.3728	DNR H_o	No Causality
	USD to NO	3.0092	0.0596	DNR H_o	
4	OE to USD	0.0277	0.9727	DNR H_o	Unidirectional
	USD to OE	12.4798	5.E-05*	Reject H_o	
5	NE to USD	0.0436	0.9573	DNR H_o	No Causality
	USD to NE	0.6330	0.5357	DNR H_o	
6	OI to GBP	1.5871	0.216	DNR H_o	Unidirectional
	GBP to OI	4.5554	0.0159*	Reject H_o	
7	NO to GBP	1.2519	0.2959	DNR H_o	No causality
	GBP to NO	2.0901	0.1358	DNR H_o	
8	OE to GBP	1.8949	0.1624	DNR H_o	Unidirectional
	GBP to OE	15.1594	1.E-05*	Reject H_o	
9	NE to GBP	1.0262	0.3668	DNR H_o	No Causality
	GBP to NE	0.7507	0.478	DNR H_o	
10	NO to OI	7.4791	0.0016*	Reject H_o	Bidirectional
	OI to NO	50.7303	4.E-12*	Reject H_o	
11	OE to OI	2.7699	0.0736	DNR H_o	Unidirectional
	OI to OE	34.7268	9.E-10*	Reject H_o	
12	NE to OI	10.9912	0.0001*	Reject H_o	Bidirectional
	OI to NE	19.0855	1.E-06*	Reject H_o	

Source: Author's computation

Table 5: Pair-wise Granger causality test results (to be continued).

Pairs	Pairs (H_o)	F-stat	P-value	Decision	Types of Causality
13	OE to NO	17.2806	3.E-06*	Reject H_o	Bidirectional
	NO to OE	47.4544	1.E-11*	Reject H_o	
14	NE to NO	31.3377	3.E-09*	Reject H_o	Unidirectional
	NO to NE	5.9267	0.0053	DNR H_o	
15	NE to OE	3.4364	0.0410*	Reject H_o	Bidirectional
	OE to NE	23.4456	1.E-07*	Reject H_o	

Source: Author's computation

Table 5: Pair-wise Granger causality test results (continuation).

driving up the value of a nation's currency. From this study, we also note that unidirectional causality runs from oil import to oil export and non-oil export to non-oil import. Furthermore, bi-directional causality was found in oil import and non-oil import, non-oil (agricultural) export and oil import; oil export and non-oil import; and non-oil export and oil export.

Conclusion

This paper has examined the co-integration and causal relationship of import and export of agricultural and non-agricultural goods in Nigeria. The Pearson correlation coefficient result shows that agricultural and non-agricultural trade and the Nigerian exchange rates variables were positively linearly correlated. These results are significant because the co-integration test results reveal the presence of a long-run relationship between the Nigerian exchange rates and agricultural and non-agricultural import.

The time series method of Granger causality test on the six variables revealed that, the naira-dollar and naira-pounds do not influence the movement in non-oil (agricultural) import. More so, the test shows the presence of bi-directional causality between foreign trades in Nigeria. That is, it confirms the inter-relationship that exist between agricultural and non-agricultural import and export in Nigeria. This study has also revealed the critical role that exchange rate plays in a country's economy given its long run relationship with agricultural and non-agricultural imports and exports. Evidence from this study revealed that agricultural trade, just like non-agricultural trade also influenced Nigerian exchange rates movement.

We therefore recommend that, the reform agenda of governments in West African countries should be systematic and sustainable such that government strategies can be channeled to improve the competitiveness of their agricultural products in the international market. Also, policy makers in Nigeria should take bold steps to improve productivity in agriculture on a larger scale so that non-oil (agricultural) export can considerably compete with oil export in the economy in order to forestall recurring recessions.

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Is the Halloween Effect Present on the Markets for Agricultural Commodities?

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Abstract

Seasonal anomalies play an important role in the global economic system. One of the most frequently empirically observed anomalies is the Halloween effect. Halloween effect describes the anomaly on the financial markets, which is that the returns of different assets in the summer period are generally lower than the returns in the winter period. This study tests the Halloween effect on the agricultural commodities' markets over the period from 1980 to 2016. The sample includes price series of 27 major agricultural commodities. The data show that 20 out of the 27 commodities recorded a higher average winter period than summer period returns and in 15 cases, the differences are statistically significant. The data also show that out of the 7 commodities with higher summer period returns (the "reverse Halloween effect") only in cases of poultry and tea the differences are of statistically significant nature.

Keywords

Halloween effect, financial market, agriculture, commodity, seasonal anomaly.

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Introduction

1. Seasonal anomalies: problem statement

Financial markets are in constant evolution. Markets are constantly developing new methods of risk analysis. There are new products and technologies that contribute to increasing information asymmetry. But even against the desire of market players to reduce market uncertainty, force of habit as a manifestation of bounded rationality continues to exist. Among the manifestations of bounded rationality in the prevailing habits and traditions are seasonal or calendar anomalies. Calendar anomaly is a cyclic pattern of behavior of players of different markets, characterized by cyclical oscillations in returns in the financial markets. The most common seasonal anomalies are day of the week effect, January effect, the month effect and the Halloween effect. Studies show that not all the calendar anomalies occur in each market. Among the most common cases, the calendar effect is found in equity markets (Lakonishok and Smidt, 1988; Haggard et al., 2015), however some authors found that seasonal anomalies can be present on the markets of different goods (Milonas, 1991; Borowski, 2015).

Since seasonal and calendar anomalies represent irrational form of habits, it is logical to assume that the Halloween effect is in contradiction with the full rationality assumption of the neoclassical school of economic thought. In the case of financial markets, this contradiction is manifested in the inability to describe this seasonal anomaly with the efficient markets hypothesis (Fama, 1965). As follows from the main provisions of the efficient markets hypothesis, the current price of an asset incorporates and reflects all the available information about the asset, respectively, arbitrage opportunities or generating income above the norm on the market simply do not exist when using fundamental or technical analysis.

However, empirical observations and studies of many authors, described below, show the existence of data anomalies and confirm the possibility of obtaining abnormal returns, even taking into account transaction costs and adaptive expectations of market players.

2. Literature review

Halloween effect was first identified on the securities market. The basis of this seasonal anomaly is the assumption, according to which stock returns in the May-October period are significantly lower than in the second half of the year. For example, a study by Bouman et al. (2002) has shown that the Halloween effect is present in the securities markets of 36 developed and developing countries. Other studies confirmed the results of Bouman et al. (2002) and have shown that the Halloween effect exists for various stocks and for various segments of the market. For example, a study of Lean (2011) showed the presence of the Halloween effect in the stock markets of several Asian countries (Malaysia, China, India, Japan, Singapore). Jacobsen and Nuttawat (2009) found that 48 out of 49 U.S. sectors of the stock market showed better result in the winter period rather than in the summer period. For 2/3 of the sectors, the difference was statistically significant. The study is based on time series sample from 1926 to 2006. Andrade et. al (2013) came to the conclusion that the Halloween effect not only affects the value of assets, but also on the credit risk premium and volatility. Zhang and Jacobson (2013) examined data on the securities market of Great Britain for a period of more than 300 years. As a result, the authors came to conclusion that calendar and seasonal effects took place, although their scope and importance has changed significantly. The Halloween effect was present constantly regardless of the applied methods.

Commodity markets and commodity prices are under close attention of researchers all over the world. Most of papers pay attention to either food price crisis (Etienne et al.. 2014; Hochman et al., 2014) or various factors affecting commodities' prices (Liu, 2014; Ott, 2013; Hamilton and Wu, 2015; Čermák et. al., 2017). Much attention is paid to the relation between agricultural commodities' prices and oil prices (Mensi et al., 2014; Wang et al., 2014; Burakov, 2017). Nevertheless, little attention is paid to the Halloween effect and different seasonal patterns concerning commodities markets, particularly markets for agricultural goods (Arendas, 2017).

Markets for agricultural commodities are specific not only due to the necessity of providing food security, but also due to high volatility on demand and supply sides. A sharp rise in demand for particular agricultural commodity may lead to a strong increase in market prices. And contrary – a sharp decline in supply (due to poor harvest or natural disaster/weather anomalies) would also lead to a strong rise in prices in the short run. Specifics of agricultural markets are strongly connected with production cycles, which may give birth to seasonal patterns in the market prices' dynamics. Agricultural markets may also be a subject to price volatility due to speculations on financial markets, which could lead to occurrence of some seasonal effects.

E.g., Arendas (2015) show that soybean market demonstrates strong seasonality: soybean prices tend to rise during May-July period and fall during October. This can be a signal of the Halloween effect's presence. The same may be true for tea market as well. For example, Induruwage et al. (2016) test black tea auction prices for seasonality in order to develop a better forecasting model. Results of econometric estimation show that there exist two month seasonal cycles between sampled tea auction prices.

Unlike previous studies of the Halloween effect on agricultural markets, we use up to date price series and the sample includes 27 major agricultural commodities. Also the "reverse Halloween effect" hypothesis is tested for sampled markets.

The purpose of this paper is to investigate the presence of the Halloween effect on sampled markets for agricultural commodities. In the case of confirmation of the hypothesis, the results obtained can be useful both to professional market players and regulators as well as to agribusiness subjects in part of risk hedging. Also, in case of confirmation of the hypothesis, we get additional confirmation of the weakness of the neoclassical efficient markets hypothesis.

Materials and methods

In this paper we investigate the presence of the Halloween effect on different markets for agricultural commodities for the period from 1980 to 2016. For the study we use monthly closing prices for bananas, barley, beef, coarse wool, cocoa, coffee Arabic, coffee Robusta, corn, cotton, fine wool, fish meal, hides, lamb, olive oil, oranges, palm oil, pork, poultry, rice, rubber, soybean, soybean meal, soybean oil, sugar, sunflower oil, tea and wheat. Data were provided by the International Monetary Fund (IMF) database.

To study the Halloween effect, following Arendas (2017), we divide each calendar year consisting of 12 months into two periods - winter and summer. In case of presence of the Halloween effect, the returns of the winter period should be significantly higher in comparison with the returns of the summer period. The end of summer and the beginning of the winter period will be around Halloween. In this study, a turning point from one period to another is the closing price of the last trading day in October.

Thus, definition of the turning point from the winter period to the summer period is ambivalent. In professional circles it is believed that it is necessary to "sell in May and go away". So, in most papers studying the Halloween effect, the turning point is determined as the last trading day of April. In this paper we use two alternative turning points: closing price of the last trading day in April and the closing price of the last trading day in May. This allows us to study several variations of the Halloween effect.

Such formulation of the problem allows us to propose and test the following hypotheses:

H1: The Halloween effect is present in the energy market.

H2: The observed cases of the Halloween effect are statistically significant.

H3: The returns in the sampled markets follow the similar patterns.

According to the Hypothesis H1, the Halloween effect can be observed on agricultural commodities markets. If the assumption of this hypothesis is correct, then the returns of the winter period (October-April or October-May) must be higher than the returns of the summer period (May-October or June-October). It is logical to assume that for the selected observation period (36 years) we can certainly find the years in which this assumption is incorrect. However, if the Halloween effect is present on the particular market for agricultural commodities, the number of years of its presence must be more than the number of years of its absence. The same is true for comparisons of average returns of summer and winter periods on 36 years' time span - average returns of summer period should be lower in comparison with the average returns of the winter period.

Hypothesis H2 assumes that the observed cases of the presence of the Halloween effect are statistically significant. Since the average results may be greatly skewed due to the years in which the markets showed abnormal levels of return, the difference between the returns of summer and winter period should be statistically significant to prove the presence of the Halloween effect on the market. Otherwise, this pattern can be considered as a random disturbance on the market caused by an exogenous shock.

Hypothesis H3 introduces the assumption under which the related markets should behave in a similar way. We assume that related markets are influenced by similar factors. And this leads to what should trigger the substitution effect, which in turn should generate similar anomalies on related markets. We expect to see similar patterns of behavior on the sampled markets. Out of 27 commodities, similar pattern may occur in following subgroups:

- Meats: beef, pork, poultry, lamb;
- Oils: palm oil, soybean oil/olive oil, sunflower oil;
- Soybean and soybean products: soybean, soybean oil, soybean meal;
- Coffees: coffee Arabica, coffee Robusta;
- Wools: coarse wool, fine wool;
- Cereals: barley, corn, rice, wheat

If the Halloween effect is present on a particular market, the average returns of the winter period should be considerably higher in comparison with the average summer returns. To test the hypotheses presented in this paper, we use parametric (Two-sample t-test) and nonparametric (Wilcoxon rank sum test) statistical tests to assess the statistical significance of the difference between the returns of summer and winter period for selected markets.

The Shapiro-Wilk test is used to determine which type of test, parametric or nonparametric, is more suitable to test a particular data. In our case, the Shapiro-Wilk test should show whether the returns come from a normally distributed population. Despite the fact that there is a large number of tests to determine the normality of distribution, Shapiro-Wilk test is considered to be one of the most accurate (Razali and Wah, 2011). A study conducted by Arendas (2017) also shows the possibility of its application to the study of the Halloween effect on selected markets. If returns come from a normally distributed population, it is more appropriate to use the Two-sample t-test. If the returns do not come from a normally distributed population, Wilcoxon rank sum test is more suitable. The use of this test allows to assess the statistical significance of the difference between returns of summer and winter periods.

Two-sample F-test is used to determine the identity of the variances for the returns of summer and winter periods. Depending on the result of the study, we will use Two-sample t-test for equal variances or Two-sample t-test for unequal variances.

The algorithm of the research includes the following steps:

1. We calculate the return for particular markets on a certain time period. Each calendar year is divided into two periods: winter and summer. Given the differences in the definition of turning points, in the first case the calendar year is divided into periods from the last trading day of October to the last trading day of April of the following year (winter) and from the last trading day of April to the last trading day of October (summer period). In the second case, the summer period lasts from the last trading day of May to the last trading day in October and the winter period - from the last trading day of October through the last trading day of May. Monthly closing agricultural commodities prices from the database of the IMF are used.

The return is calculated by the following formulas:

$$r_{s_n} = \frac{P_{O_n} - P_{A_n}}{P_{A_n}} \quad (1)$$

$$r_{w_n} = \frac{P_{A_{n+1}} - P_{O_n}}{P_{O_n}} \quad (2)$$

where: r_{s_n} the return for the summer period, r_{w_n} is the return for the winter period, *n* represents the calendar year, P_{O_n} is the October closing price for year n and P_{A_n} is the April closing price for year n. For the second case, P_{M_n} (May closing price for year n) and $P_{M_{n+1}}$are used instead of P_{A_n} and $P_{A_{n+1}}$ respectively.

2. We calculate descriptive statistics. The descriptive statistics include the average returns for a specific time period, minimum and maximum returns, as well as the level of the presence of the Halloween effect (the number of years that the Halloween effect has emerged during the 36-year period).

3. To test whether the returns of a given period come from a normally distributed population, we use the Shapiro-Wilk test. Based on the obtained results, we decide whether to use Two-sample t-test or Wilcoxon rank sum test.

4. The Two-sample F-test for variances is used to determine whether the returns of winter and summer periods have equal variances. The result will determine the type of test most appropriate for the study: two sample t-test for equal variances or Two-sample t-test for unequal variances.

5. The Two-sample t-test is used to determine whether the difference between the returns of summer and winter periods for a particular commodity are statistically significant.

6. We use Wilcoxon rank sum test, due to its advantages over the Two-sample t-test for data that is not characterized by normal distribution.

7. We evaluate the validity of the hypotheses

Results and discussion

The results of the study show that the differences in returns in winter and summer periods in selected markets vary significantly. The same is true for the minimum and maximum returns on the markets. Strong difference may be found when comparing two different alternatives of the Halloween effect. If we turn to the percent of the presence of the Halloween effect, we could see that depending on the turning point and on the particular market, the percentage of its presence also varies significantly.

For the first alternative, where the summer period lasts from May to October and winter period - from November to April, most markets showed returns in winter period significantly higher than in the summer period (Table 1). In the first alternative, 20 out of the 27 sampled agricultural commodities show higher returns in the winter period that in the summer period. The largest differences (more than 12%) are recorded for coffee Arabica, cotton, palm oil and soybean oil. The significant differences (more than 10%) are also recorded for coarse wool, corn, oranges, rubber and soybean. At the same time beef, fish meal, hides, poultry, sugar, tea and wheat show higher average returns in summer periods than in winter periods. Out of these seven agricultural commodities, the largest difference is in cases of sugar and tea, where the average summer period returns are higher by more than 10%.

As we have pointed out before, the level of presence of the Halloween effect varies significantly from one market to another. The Halloween effect can be mostly often observed on the markets for bananas, corn, cotton, olive oil, palm oil, soybean and soybean (more than 75% of cases). On the other hand, beef, coffee Robusta, fish meal, hides, poultry, sugar, tea and wheat experienced the Halloween effect in less than 50% of cases.

Regarding the second alternative, where the turning point is May, results are generally similar to the previous one. As in the first alternative, in most cases, the Halloween effect is present on 20 out of the 27 sampled markets, where average winter returns are higher than in the summer period.

Halloween effect (time span 1)									
	Summer returns (May-October)			Winter returns (November-April)			Resulting statistics		
	min, %	max, %	average, %	min, %	max, %	average, %	Halloween effect present, years	Halloween effect absent, years	Halloween effect, %
Bananas	-25.41	31.98	1.29	-18.34	48.93	6.67	28	8	78
Barley	-41.25	32.15	-1.13	-23.16	31.59	4.82	21	15	58
Beef	-21.92	42.58	1.63	-19.99	36.53	1.39	15	21	42
Coarse wool	-38.49	44.91	-2.74	-17.89	63.21	7.87	25	11	69
Cocoa	-25.42	43.74	0.88	-29.12	46.72	1.91	19	17	53
Coffee Arabica	-51.87	124.32	-3.01	-40.38	78.44	9.14	23	13	64
Coffee Robusta	-43.26	131.49	-0.57	-32.97	70.19	6.28	14	22	39
Corn	-36.65	51.12	-2.89	-15.74	52.78	8.27	27	9	75
Cotton	-49.67	44.98	-5.03	-16.72	73.49	8.83	27	9	75
Fine wool	-42.84	38.65	-3.65	-35.97	64.91	10.35	22	14	61
Fish meal	-18.32	95.68	7.84	-38.61	41.22	1.34	9	27	25
Hides	-35.61	86.25	4.67	-59.65	36.81	1.79	17	19	47
Lamb	-45.87	78.39	3.34	-23.49	95.12	6.72	23	13	64
Olive oil	-38.14	51.14	-1.03	-17.24	64.83	5.37	28	8	78
Oranges	-11.89	47.19	-2.03	-9.74	75.38	8.41	26	10	72
Palm oil	-57.38	61.42	-4.49	-34.50	56.29	9.97	28	8	78
Pork	-45.83	112.86	1.19	-42.87	53.94	4.92	19	17	53
Poultry	-8.15	25.18	4.71	-17.92	15.91	-0.78	12	24	33
Rice	-41.19	34.13	-1.23	-32.38	189.64	4.64	19	17	53
Rubber	-33.05	47.24	-2.86	-20.24	69.13	7.16	23	13	64
Soybean	-48.13	45.82	-4.28	-13.11	34.18	6.73	27	9	75
Soybean meal	-60.81	58.08	0.84	-28.19	41.14	4.72	20	16	56
Soybean oil	-42.71	60.13	-4.16	-24.39	48.85	8.70	27	9	75
Sugar	-43.56	94.57	8.83	-57.04	67.93	-2.16	15	21	42
Sunflower oil	-56.93	112.34	-1.98	-32.83	88.49	5.22	24	12	67
Tea	-78.94	43.12	9.25	-27.78	93.56	1.17	12	24	33
Wheat	-35.98	72.44	5.84	-29.05	25.82	0.82	19	17	53

Source: own calculations

Table 1: Halloween effect statistics (alternative 1).

(Table 2) The largest differences are recorded for pork, coffee Arabica, fine wool and palm oil (more than 17%). Out of 7 agricultural commodities with higher returns in the summer period than in winter, the largest difference is shown by tea, sugar and fish meal (more than 10%).

The biggest success rate of the Halloween effect in alternative 2 (more than 70%) can be seen in cases of bananas, olive oil, corn, palm oil, pork, soybean and soybean oil. The highest success rate is recorded for soybean (83%). On the other hand, cocoa, fish meal, sugar and tea experienced the Halloween effect in less than 50% of cases.

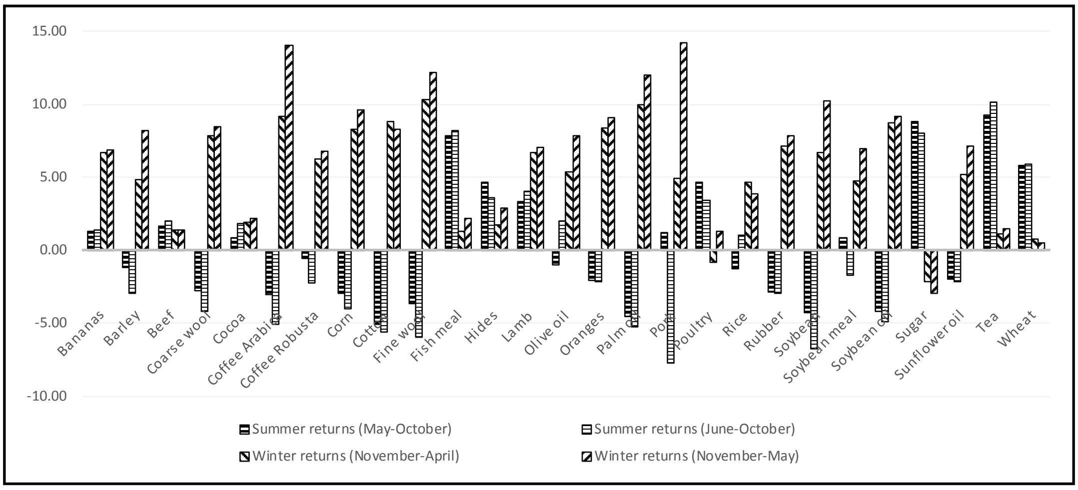
If we compare the average level of the presence of the Halloween effect in the first and second alternatives, the first alternative average level of the Halloween effect presence is 59%, and in the second alternative - 62%.

Also, the difference between the average winter period and summer period returns is bigger in the second alternative than in the first one for most cases (Figure 1).

Halloween effect (time span 2)									
	Summer returns (June-October)			Winter returns (November-May)			Resulting statistics		
	min, %	max, %	average, %	min, %	max, %	average, %	Halloween effect present, years	Halloween effect absent, years	Halloween effect, %
Bananas	-28.19	33.17	1.44	-20.95	50.61	6.92	27	9	75
Barley	-14.87	40.80	-2.95	-12.48	34.58	8.18	23	13	64
Beef	-36.79	39.02	2.04	-27.73	32.17	1.44	20	16	56
Coarse wool	-35.43	28.87	-4.15	-20.15	59.31	8.46	23	13	64
Cocoa	-24.28	39.73	1.86	-37.61	49.84	2.23	16	20	44
Coffee Arabica	-58.72	64.97	-5.03	-35.07	107.45	14.01	21	15	58
Coffee Robusta	-43.96	81.20	-2.21	-29.84	86.09	6.82	20	16	56
Corn	-39.18	45.62	-3.99	-11.05	51.32	9.64	26	10	72
Cotton	-35.24	43.15	-5.58	-21.35	58.69	8.26	24	12	67
Fine wool	-41.99	26.83	-5.93	-27.01	69.03	12.19	25	11	69
Fish meal	-25.68	69.93	8.19	-45.68	21.36	2.16	10	26	28
Hides	-32.46	77.04	3.65	-57.38	39.06	2.94	20	16	56
Lamb	-29.09	82.47	4.08	-31.14	54.10	7.03	22	14	61
Olive oil	-35.40	53.99	1.98	-19.35	75.93	7.82	29	7	81
Oranges	-24.38	45.11	-2.14	12.97	93.01	9.09	25	11	69
Palm oil	-57.88	56.81	-5.26	-37.04	81.14	12.04	27	9	75
Pork	-45.10	99.04	-7.67	-26.18	61.09	14.18	29	7	81
Poultry	-8.94	26.90	3.46	-15.08	24.30	1.28	19	17	53
Rice	-40.52	41.18	1.02	-36.41	203.48	3.90	19	17	53
Rubber	-38.87	40.36	-2.94	-19.77	53.08	7.83	25	11	69
Soybean	-46.05	37.14	-6.72	-16.70	38.06	10.24	30	6	83
Soybean meal	-49.84	51.22	-1.67	-31.42	44.57	6.98	25	11	69
Soybean oil	-37.51	57.84	-4.84	-28.05	61.32	9.16	27	9	75
Sugar	-37.14	81.25	8.03	-66.70	59.03	-2.92	14	22	39
Sunflower oil	-45.86	98.74	-2.17	-41.08	92.36	7.15	25	11	69
Tea	-62.41	32.18	10.16	-31.05	103.25	1.49	13	23	36
Wheat	-32.99	75.39	5.93	-26.12	34.58	0.48	21	15	58

Source: own calculations

Table 2: Halloween effect statistics (alternative 2).



Source: own calculations

Figure 1: Average returns for sampled commodities.

Table 3 presents the results of Two-sample t-test and Wilcoxon rank sum test. The cases in which the difference between returns in the summer and winter periods is statistically significant (at the significance level of 0.05) are highlighted. The cases in which a reverse Halloween effect manifested itself (when the returns of the summer periods are higher than returns in winter) are written in italics. Based on the results of Shapiro-Wilk test, we determined which test would be better suited for particular data sets: parametric Two-sample t-test or nonparametric Wilcoxon rank sum test. The results of a more appropriate test are in bold (Table 3).

As can be seen from Table 3, both test statistics are in agreement in all sampled markets for agricultural commodities, except coffee Arabica (alternative 1). In case of coffee Arabica, Two-sample t-test shows that the differences in returns between summer and winter periods are not statistically significant. In the same time, Wilcoxon rank sum test shows that the differences are statistically significant. Given that, the data sets are not normally distributed, the Wilcoxon rank sum test may be seen as a more appropriate test in this case. This allows us to assume that the Halloween effect is present on the market and statistically significant.

The results of the carried out research show that in case of both alternatives, the Halloween effect is present and statistically significant on the markets for bananas, coarse wool, coffee Arabica, corn, cotton, fine wool, lamb, olive oil, oranges, palm oil, soybean, soybean oil and sunflower oil. Only in the second alternative we can assume that the Halloween effect on the markets for barley and pork is statistically significant. The "reverse Halloween effect" is found on the markets for beef, fishmeal, hides, poultry, tea and wheat. Out of these

Commodity	Halloween effect (time span 1)		Halloween effect (time span 2)	
	two-sample *t*-test	Wilcoxon rank sum test	two-sample *t*-test	Wilcoxon rank sum test
Bananas	0.04562	**0.00102**	0.04359	**0.00059**
Barley	**0.08129**	0.26804	**0.01274**	0.04641
Beef	*0.96204*	***0.91753***	*0.65302*	***0.89007***
Coarse wool	0.01035	**0.01007**	0.00328	**0.00681**
Cocoa	**0.65730**	0.72406	**0.93116**	0.91305
Coffee Arabica	0.12306	**0.01994**	0.02795	**0.05603**
Coffee Robusta	0.47504	**0.19502**	0.09266	**0.28509**
Corn	0.00396	**0.00148**	0.00743	**0.00108**
Cotton	0.00701	**0.01379**	0.00312	**0.01967**
Fine wool	0.00147	**0.01486**	0.00043	**0.00214**
Fish meal	*0.74908*	***0.64521***	*0.32159*	***0.25128***
Hides	*0.90236*	***0.75306***	*0.64130*	***0.31117***
Lamb	0.00295	**0.00172**	0.00218	**0.00113**
Olive oil	**0.02274**	0.03854	**0.02135**	0.03467
Oranges	**0.04582**	0.03215	**0.00249**	0.00146
Palm oil	**0.00539**	0.00413	**0.00391**	0.00056
Pork	0.58402	**0.29321**	0.00107	**0.00009**
Poultry	*0.00184*	***0.00115***	*0.29539*	***0.35928***
Rice	0.45807	**0.85403**	0.71098	**0.78051**
Rubber	0.06352	**0.07297**	0.04314	**0.02173**
Soybean	**0.00479**	0.00218	**0.00021**	0.00024
Soybean meal	**0.52304**	0.39506	**0.08483**	0.03480
Soybean oil	**0.01943**	0.00512	**0.00179**	0.00054
Sugar	***0.24916***	*0.38627*	***0.23402***	*0.11396*
Sunflower oil	0.00941	0.03158	**0.00489**	0.02317
Tea	*0.96075*	***0.87142***	*0.59072*	***0.31134***
Wheat	***0.52043***	*0.67421*	*0.78101*	*0.82773*

Source: own calculations

Table 3: Statistical tests results (two-paired *p*-values).

markets only for poultry and tea market, the "reverse Halloween effect" is statistically significant.

Hypothesis H1, which suggests that the Halloween effect is present on the markets of the sampled agricultural commodities, can be accepted. Halloween effect is present on 20 out of the 27 markets for agricultural commodities. In these cases, average winter returns are higher than the returns in the summer periods. The results are true for both alternatives of the Halloween effect's sample. In case of 20 commodities (alternative 1) and 23 commodities (alternative 2), the success rate of the Halloween effect is more than 50% during the 36-year period. Based on these results we can conclude that the Halloween effect is present on the sampled markets for agricultural commodities for the period of 1980-2016.

Hypothesis H2, according to which the observed cases of the Halloween effect are statistically significant in nature, can be partially accepted. Even if not in all cases, the Halloween effect is statistically significant in nature (in some cases, the excess returns of the summer period over the winter period can be the consequence of an exogenous shock that produced the abnormal return). Nevertheless, for 12 commodities (alternative 1) and 15 commodities (alternative 2), the Halloween effect is present and is statistically significant. We were also able to identify two statistically significant cases of the reverse Halloween effect (for markets of poultry and tea).

Hypothesis H3 (Returns of the related commodities follow similar patterns) can be partially accepted. Although there are some exceptions, the related commodities tend to follow similar patterns in most of the cases. The "oils" subgroup (palm oil, soybean oil, olive oil, sunflower oil) and "wools" subgroup (coarse wool, fine wool) have similar patterns of behavior consistent with the Halloween effect, which are statistically significant. The "soybean and soybean products" subgroup as well as "coffees" subgroup also show the Halloween effect pattern. The "cereals" subgroup, which includes barley, corn, rice and wheat, show the following results: in cases of barley, corn and rice, the average winter periods returns are higher than the average summer period returns. The opposite is true for the wheat market. The "meats" subgroup show ambiguous results: cases of beef and poultry show higher average summer period returns, while pork and lamb show higher average winter period returns. As the data show, the related commodities behave similarly in most of the cases. Exceptions may be attributed to specifics of the production cycles or natural events, exogenous in nature.

Therefore, it is able to conclude that the Halloween effect is present on the markets for agricultural commodities. Its strength differs market to market, but in most cases it is strong enough to become a shibboleth for profitable strategies, which could generate abnormal returns even after taking the transaction costs into account.

Even given the fact that there is extensive research on the Halloween effect, consensus on the nature and sources of the Halloween effect doesn't exist. Hong and Yu (2009) attribute the Halloween effect to the summer holidays, when investors go on vacation and trading volumes on the exchanges are significantly reduced. Some authors consider that the Halloween effect's source lies in changes of weather, because the colds and decreasing temperature leads to an increase in aggression, and apathy (Cao and Wei, 2005). For this reason, winter returns tend to be higher, because market players are trading in a more aggressive manner. On the other hand, Jacobsen and Marquering (2008) presented evidence that the weather factor is hardly a Halloween effect's source on the stock market. On the other hand, even if this is true for the stock market, the weather definitely has an impact on the seasonality of trading on the markets of agricultural commodities (Arendas, 2017). E.g., Ott (2013) showed that the intra-year agricultural commodities price volatility is strongly affected by the stock-to-use ratio. Weather, therefore, significantly affects production cycles of different commodities and stock levels and need to be taken into account when dealing with price volatility on the markets for agricultural commodities

Conclusion

This study investigates the presence of the Halloween effect on the markets for agricultural commodities over the 36-year period. The sample of commodities consist of 27 major agricultural goods, including meats, cereals, oil, and soybean subgroups.

The results of testing the hypotheses, stated in this paper, show that the Halloween effect is present on the markets for agricultural commodities. 20 out of the 27 sampled commodities have higher average winter period returns that the average summer period returns and in half of the cases, the results are statistically significant. Also we've detected the statistically significant presence of the "reverse Halloween effect" on the markets for poultry and tea.

The results of the study show that seasonality on a number of the agricultural commodities markets may generate excessive returns due to differences between summer and winter periods average returns. Such anomaly may be used by professional traders, agribusiness subjects for their purposes.

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Endogenous and Exogenous Determinants of Agricultural Productivity: What Is the Most Relevant for the Competitiveness of the Italian Agricultural Systems?

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Abstract

Several factors are deemed to influence farms' economic performance and competitiveness: endogenous characteristics, such as farm structure and entrepreneur's features, as well exogenous factors related to the infrastructure endowment, networks and immaterial factors. A deeper knowledge of the role each factor plays in different geographical areas can help to better address the rural policies and to improve their efficacy. In this respect, the present study aims at analyzing how factors that potentially affect competitiveness differ within Italian agriculture and the way those factors act on the economic performance of agriculture at provincial level. The analysis was carried out in two steps. First, in order to define the main characteristics of the Italian agricultural systems a Principal Component Analysis (PCA) has been carried out using data collected by the last Italian Agricultural Census, carried out in 2010, at provincial level and component scores have been used to characterize provincial agricultural systems. In a second step, PCA results were used as explanatory variables in regression models to evaluate their relationship with agricultural productivity and performance indicators at provincial level. The work highlighted two main results. First, agricultural differentiation factors identified in the PCA discriminate two main territorial agricultural models linked to different agricultural systems organization and development strategies. Secondly, the determinants of agricultural productivity and performance are mainly endogenous to the sector and only few context indicators seem to act as explanatory variables.

Keywords

Italian agricultural systems; competitiveness, NUTS3; rural development policy.

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Introduction

Over last decade farm competitiveness has become a topic of increasing relevance in the EU agricultural and rural policies. During the past programming period, the actions aimed at improving the competitiveness of the agricultural and forestry sectors have been included in the first thematic axis of Rural Development Programs (RDP) and, although the logic of intervention in the new rural policy is quite different, fostering the competitiveness of the agricultural farms remains one of the long term strategic objectives for the EU rural development policy from 2014 to 2020. This goal should be pursued through priorities that reflect the thematic objectives of the Community Support Framework. In particular, agriculture competitiveness can require a focus on (Reg. EC 1305/2013):

- ”fostering knowledge transfer and innovation in agriculture, forestry, and rural areas (...);
- enhancing farm viability and competitiveness of all types of agriculture in all regions and promoting innovative farm technologies and the sustainable management of forests;
- promoting food chain organization, including processing and marketing of agricultural products, animal welfare and risk management in agriculture (…)”.

The measures through which priorities should be achieved act on one or more factors which are considered determinants of farm and sector competitiveness and RDPs should include the support to training and advisory services, investments on physical assets, aids to young farmers and to the setting-up of producer groups and organizations, interventions aimed at the development of horizontal and vertical co-operation among supply chain actors, and so on.

Indeed, several factors are deemed to influence farms' economic performance and competitiveness. Competitiveness has been analyzed by adopting different approaches and perspectives (micro/macro, theoretical/empirical, static/dynamic), which focused on determinants both internal and external to the farm/sector: the economies of scale and scope, firm's organization, human capital, social capital, networks and inter-firms' relationship, socio-economic context, governance models and policies.

A deeper knowledge of the role each factor plays in different geographical areas can help to better address the rural policies and to improve their efficacy (Bartolini and Viaggi, 2013; D'Amico et al., 2013). In this respect, the goals of the present study are twofold: (1) first, it aims at analyzing how factors that potentially affect competitiveness differ within Italian agriculture; (2) second, it wants to test the way those factors act on the economic performance of agriculture at NUTS3 level.

In particular, the paper intends to explore how much the agricultural economic performance depends on specific structural characteristics and farming typologies as well as on other variables such as human capital and farm strategies. Moreover, as the analysis was carried out at NUTS3 level (the Italian provinces), the work can provide useful insight to verify whether the economic performance fits a territorial systematic pattern or it is more linked to specific local factors.

The paper is organized as follows. It begins with a short review of the competitiveness factors that previous studies have highlighted as determinants in farms' economic performance. After the description of data and methods used in the analysis, the following section presents the main results of the research and last paragraph draws some conclusions and implications for future rural policy.

The determinants of the competitiveness

Studies that dealt with competitiveness took into account several dimensions of this complex concept - cost superiority, productivity, efficiency, profitability, market performance and used different approaches to measure it (Man et al., 2002; Latruffe, 2010; Di Vita et al., 2015). This depends on the disciplinary approach of the researcher and on the level (firm/industry/region/nation) at which competitiveness is analyzed, affecting both the definition of competitiveness used and the list of factors that are considered its determinants/drivers.

In the firm's level perspective, competitiveness is generally conceived of in terms of long-term performance of the firm with respect to its competitors. As a consequence, the competitiveness can be viewed as: i) long term-oriented; ii) a controllable characteristic, as it relates to the resources and capabilities of the firm; iii) a relative and iv) dynamic concept (Man et al., 2002). At the firm's level, competitiveness has been mainly analyzed in terms of productivity and efficiency and studies have been focused on the effect of the internal firm's factors (Amit and Schoemaker, 1993), the external environment (Nickell et al., 1997; Fried et al., 1999), or the entrepreneur's characteristics (Cooper and Gimeno Gascón, 1992; Man et al., 2002).

With reference to the size-efficiency relationship, larger firms are assumed to be more efficient because of specialization and scale's and scope's effects (Seth, 1990; Balk, 2001), but size can influence the firm's competitiveness also because it is an approximation of larger resources availability and thus implies the possibility to innovate and to reach a wider market (Schumpeter, 1934). However, the direct size-efficiency relationship has not always been proved and, on the contrary, some studies argued that efficiency is higher for smaller firms because of their flexibility and better adaptation ability (Scherer, 1991; Halkos and Tzeremes, 2007). Moreover, the size-efficiency link could hide the effect of other variables, such as the firm's organization and the management factor (Geroski, 1998), and the characteristics of the industry where the firm competes -concentration, entry and exit barriers- can influence the profit rate and growth (Schumpeter, 1934, Di Vita et al., 2014). As entrepreneur characteristics are concerned, human capital quality has been linked to firms' efficiency because of its influence on the propensity to risk and to innovate. The manifold studies on this issue have mainly focused on features such as age, experience and education, as well as on gender (Doss and Morris, 2000; Man et al., 2002; Latruffe, 2010).

Networks and immaterial factors, such as the institutional environment and the social capital, are deemed to be even more important when a territorial perspective of competitiveness is assumed (Capello et al., 2011; Esposti, 2011). In this approach, the relationship between territory and competitiveness has been investigated by two main points of view. On one side, the attention has been focused on the role the territory plays in firm and system competitiveness (Maskell and Malmberg, 1999; Budd and Hirmis, 2004). On the other side, the concept of competitiveness has been applied to a territorial dimension and the analysis has concerned the performance of regions and nations and the factors that potentially affect the competitive advantages. Concerning this last approach, the basic assumption is that countries compete with each other in the same way corporations do and the attention is mainly focused on the international trade (Porter, 1990; Fagerberg, 1996; Krugman, 1996; Budd and Hirmis, 2004). The territory matters for firm competitiveness not only because the infrastructural endowment affects average costs of production, but also because of collective learning processes. These can be considered as territorially specific and result in a “socialized growth of knowledge embedded in the internal culture of firms and in the local labour market” (Camagni, 2002).

With regard to the agricultural sector, several empirical studies have tested the effect of the one or the other factor.

Human capital has been related to farm performance mainly because it influences the decision-making with respect to adoption of new technologies (Mathijs and Vranken, 2001; Adrian et al., 2005), intensity of production and land use (Solano et al., 2006), diversification strategies (Ondersteijn et al., 2003), access to credit and to complementary inputs (Doss and Morris, 2000). In particular, farmers’ age is inversely linked to competitiveness and previous studies argued that young farmers: i) reach higher economic performance (Carillo et al., 2013); ii) have a higher propensity to invest, because of their longer term horizon (Corsi, 2009); iii) are more able to put innovations into practice. Age can act in the inverse direction and older farmers are more conservative in relation to the uptake of innovation and new management practices. Moreover, other farmers’ features can influence the propensity to introduce changes and then the reaching of competitiveness in a dynamic view. Farmer’s education level as well as entrepreneur’s motivations, which can push him to put innovations in practice, can positively affect farm management and productivity (Prokopy et al.; 2008, Phillips, 1994). Finally, previous research found that the involvement in farm advisory programmes is positively associated with farmers’ adoption of best management techniques (Millar, 2010) and recent studies on the propensity of farms to consume services (De Rosa et al., 2013) showed that the farm’s structure and the life cycle of family farms, as well as relational aspects, can considerably affect the use of services.

Focusing on territorial determinants of competitiveness, Gellynck et al. (2007) argued that firms participating in regional networks demonstrate stronger innovation competences and are more oriented towards international markets. In this respect, García Álvarez-Coque et al. (2013) found that education, physical access to knowledge centres and the localization in a food specialized industrial districts are the territorial factors mostly affecting innovation (and performance) of the agri-food firms.

Indeed, a complex concept such as competitiveness calls for manifold explanation factors and needs to take into account more than one point of view for its interpretation.

In order to better understand the role of different determinants on competitiveness in the agricultural sector, in this work the most relevant factors highlighted in the literature have been related to competitiveness with reference to the Italian case.

Materials and methods

To investigate the relationship between agricultural competitiveness and the farm’s internal and external determinant factors, a first relevant choice concerned the indicator to measure agricultural competitiveness. In the present work we chose productivity as proxy of competitiveness both because of the level of the product aggregation (sector) and the spatial extension of the analysis (NUTS3) and because of data availability constraints. There are several measures of productivity that can be used as well as different approaches to evaluate them (OECD, 2001): simple partial productivity indicator (ratio between output and one relevant factor) or the more comprehensive Total Factor Productivity (TFP) that takes into account the multifactor dimension of production; indicators evaluated in physical units or in value-added terms. In the present work, simple partial productivity indicators, referred to work and utilized area, were used. Moreover, the average farm productivity was analysed as indicator of the farm's ability to remunerate all employed resources and the sustainability of the local agricultural sector in a long-term perspective.

As far as determinants of competitiveness are concerned, the basis hypothesis of the present paper is that it depends on two types of factors. The first ones are endogenous to the farm. They relate to farm structure, quantity and quality of land, capital endowment, production systems, but also to socio-demographic characteristics of the owner, his/her goals and values that result in different management strategies (Hall and LeVeen, 1978; Ordersteijn et al., 2003; Ahearn et al., 2005). Of course, these factors are strongly related one to the other, as land characteristics, factor intensity, defined in terms of capital/land and labour/land ratios, as well as type of farming, both are influenced by and influence the holder' features and strategies.

The second group of factors that affect competitiveness is exogenous to the farm and deal with the context in which the farm operates. As a matter of fact, farm performance can depend on the economic infrastructures, the market development, the characteristics of social capital and network relationships (Ahearn et al., 2005). These can be territorially specific and can affect the ability to reach markets, the way farms interact within the food chain, the possibility of combining in-farm and off-farm work.

Taking that into account, in order to define the main characteristics of the Italian agricultural systems a Principal Component Analysis (PCA) has been carried out using data at NUTS3 level collected by the last Agricultural Census carried out in 2010. PCA is a multivariate analysis technique that allows synthesizing a large set of interrelated variables in a relatively small number of uncorrelated factors (the principal components). In general, the PCA aims at reducing the dimension of the variables space while maintaining most of the variance of the original variables and is useful to simplify the description of a dataset and to investigate data structures (Abdi and Williams, 2010).

The PCA model is expressed by the following formula:

$$Y_i = W_{i1} X_1 + W_{i2} X_2 + \ldots + W_{ip} X_p$$

where Y_i, the i component, is a linear combination of the p standardised original variables X_1, X_2, ... X_p and W_{i1}, W_{i2}, ... W_{ip} are the associated weights.

Two preliminary tests are relevant to assess the adequacy of the data to the assumptions of the model specified: Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) test.

The Bartlett's test allows testing the hypothesis that the correlation matrix coincides with the identity matrix. The test is based on a chi-square transformation of the determinant of the correlation matrix and low values of the test indicate that the hypothesis of identity matrix cannot be rejected and then the use of the factor model might not be appropriate.

The KMO test compares the magnitude of observed correlations with partial correlation coefficients:

$$KMO = \sum_{i}^{p}\sum_{j\neq i}^{p} r^2\ ij \Big/ \sum_{i}^{p}\sum_{j\neq i}^{p} r^2\ ij + \sum_{i}^{p}\sum_{j\neq i}^{p} c^2\ ij$$

The values of KMO range between 0 and 1: low values of the index suggest the potential inadequacy of the analysis since correlations between two variables cannot be explained by other variables. Kaiser and Rice (1974) suggest that values above 0.7 can be considered satisfactory, while values below 0.5 are substantially unacceptable.

Some issues are very relevant when carrying out a PCA. A critical phase is the choice of the variables to be considered. Original variables should cover all aspects deemed to represent the analyzed phenomenon and reflect the theoretical interrelation model of the researcher. Within groups of original variables the selection can be based on the value of communalities, that is the total variance an original variable shares with all other variables included in the analysis. In this study, taking into account the different endogenous factors that are considered determinants for competitiveness and performance in the agricultural sector, variables were selected to get information on the agricultural activity (crops, farm's size, labour use intensity, irrigated land, quality of land in terms of UAA located in plain), on farmers' characteristics (education, percentage of retired farmers), on market and management strategies (orientation to the market, organic production, processing and diversification of in-farm activities).

Table 1 shows the final set of 19 endogenous variables used in the PCA. The statistical package SPSS (version 20.0) was used to perform the analyses. The adequacy of sampling for PCA was tested by means of the KMO and the Bartlett's tests. Values of both tests (KMO = 0.716; Bartlett's test = 1,766.26 Sig. 0.000) indicate that data are suitable for factor analysis.

Farm structure	UAA per holding
	Number of livestock per holding
	Working days per holding
	Share of UAA with green house endowment
Quality of land	Share of irrigated land
	Share of plain land
Holder's characteristics	Share of holders with agricultural degree
	Share of retired or housekeeping holders
	Share of holders using ICT
Production system	Share of UAA with permanent crops
	Share of UAA under cereals production
	Share of UAA under labour intensive crops (vegetables, flowers, fruit)
	Share of UAA occupied by vineyard
Management strategies	Share of holdings with diversified activities
	Share of UAA under organic crops
	Share of holdings participating to associations and co-operatives
	Share of holdings market oriented
	Share of UAA with Protected Designation of Origin (PDO) and
	Protected Geographical Indication (PGI) products
	Share of holdings making products processing

Source: own processing

Table 1: Agricultural variables used in the PCA.

A second issue in PCA relates to the number of components to extract. Many criteria have been suggested in literature. In the present work, components have been selected on the basis of 1 eigenvalue criteria (Kaiser, 1960), that is only components that account for a variance greater than 1 have been considered[1].

Another important topic is the interpretation of the components. The components meaning can be deduced by the factor loadings matrix, that contains the correlation between the original variables and each component: the greater the absolute value of the coefficient, the greater the importance of that variable for the component. The interpretation of components can be increased by the rotation of the components' space. In the present study a Varimax rotation has been performed, an orthogonal rotation that minimizes the number of variables that have high loading in a component (Kaiser, 1958).

Once components have been extracted, the factor weights are used in conjunction with original variable values in order to calculate each observation's score. Therefore, the component scores represent the position of each observation in the new component space and are standardized to reflect a z-score: zero values of the components represent the average of the investigated sample, while values above/under zero identify observations above/under the average as component characteristics are concerned.

As previously underlined, only farms' endogenous variables have been included in the PCA. In a second step of the analysis, PCA results were used as explanatory variables in a regression model together with some indicators at NUTS3 level that can approximate farms' exogenous competitiveness and performance determinants. Data on territorial characteristics were extracted from the database made available by the Department for the Development of Territorial Economies of Italian Government[2] and refer to year 2011, therefore are compatible with the year of the agricultural census data.

The indicators to test were selected taking into account the main determinant factors underlined in the literature. Some of them can directly affect competitiveness of the agriculture in a territory, such as the infrastructures endowment or the ICT services diffusion that are deemed as critical factors for the efficient functioning of the economy, or human capital quality that is relevant to characterize the local labour market.

Other indicators give information on the viability of the socio-economic system. They can reflect the action of competitiveness factors but, at the same time, can be deemed to favour the development of the agricultural sector. In this group, the growth rate of firms can be considered an indicator of an institutional and economic environment that can be more or less favourable to entrepreneurial development. The rate of openness of the economic system, estimated by the trade value/GDP ratio, is the sign of a dynamic economic system that

[1] Working with standardized variables, components with a variance lower than 1 are not better than a single variable

[2] http://www.tagliacarne.it/banche_dati_e_informazione_statistica-14/banca_dati_statistica_diset_presidenza_del_consiglio_dei_ministri-6/

can be determined by the action of territorial competitiveness factors and reflect the existence of intense networks' system and market relationships. Similar meanings can be ascribed to indicators such as the innovation rate, social capital endowment, the rate of crimes and so on.

Three separate regression models have been tested where the dependent variable were labour and land productivity, and the value added per farm at provincial level, such that:

$y_i = X'_i b + e_i$,

$E[e_i|X_i] = 0$, $e_i \sim N[0,1]$ with $i = 1, \ldots, n$.

where X'_i is the vector of the factor scores and infrastructural and territorial socio-economic characteristics referred to the *i* NUTS3.

Results and discussion

1. The PC analysis

The PCA extracted five principal components, which explain 77.2% of the variance (Table 2). Factor loadings matrix can help to interpret the components' meaning. As previously underlined, the loadings represent the correlation between the original variables and each of the extracted components and the higher is the loading, the more the variable is related to the component and allow explaining its meaning. In the analysis of the loadings matrix only minimum values of 0.35 were considered (Overall and Klett, 1972, De Lillo et al., 2007).

The first component account for 22.1% of the variance of original data and synthesizes the "level of professionalism" of the agricultural activity. In fact, the positive correlation with the number of working days per farm and with the physical size of the holding, as well as with variables such as the owner's educational level and the share of ICT users, gives information on the employment role of the farm and on the holder's skills. Moreover, the negative correlation with the share of owners who are homemakers or retired increases the relevance of the farmer's characteristics in influencing the lower/higher commitment in the farm activity, while the positive correlation with the average number of livestock units indicates that a higher level of professionalism more likely occurs the more the farm is specialized in livestock farming.

The second component differentiates the "quality of resources and market orientation". In particular its positive values identify irrigated crop and/or livestock farming that are market oriented. It includes some variables that refer to natural resources endowment (percentage of land in plain area, percentage of irrigated land), others that identify land use (share of UAA occupied by cereals), some others relating to the market role (percentage of farms whose production is sold to the market, percentage of farms participating to associations and co-operatives). A positive, smaller, correlation also exists between this component and the farmer's educational level, on one side, and the livestock size, on the other side. Then, positive values of the second component are associated with situations with a good quality soil, larger size, livestock farming and characterized by more intense horizontal relationship. On the contrary, negative values of the component identify cases of marginal agricultures in terms either of structural endowment and soil quality, or of production systems.

"Management strategies" are synthesized by the third component that explains 13.6% of the variance. This component shows a negative correlation with the share of UAA occupied by organic crop, corresponding to a *deepening strategy*, and a positive correlation with the share of holdings that adopt a diversification strategy following a *broadening* pattern by expanding in-farm activities (van Der Ploeg and Roep, 2003). Then, from negative to positive values of the third component, the prevailing of deepening vs broadening strategies can be distinguished. The high positive correlation between the component and the weight of farmers using ICT, on one side, and the number of working days per farms, on the other side, highlight that broadening strategies are more likely to occur the higher is the innovation propensity and the more labour intensive is the farming type.

Last two components are directly linked to the farming typology. The fourth one (11.8% of the variance) is positively related to the share of UAA occupied by permanent crops, vineyard in particular, and by PDO and IGP production ("Permanent crops and quality products' agriculture").

The fifth factor explains 11.2% of the variance. It is positively related to the weight of horticulture, flowers and fruit crops, and negatively correlated to the average farm size. Therefore, from negative to positive values the components represents

	Factors				
	Level of professionalism of the agricultural activity	Quality of resources and market orientation	Management strategies	Permanent crops and quality products' agriculture	Level of intensive agriculture
Share of retired or housekeeping holders	**-0.798**	0.206	-0.121	0.179	-0.130
Working days per holding	**0.794**	0.105	**0.538**	0.007	0.021
Share of holders with agricultural degree	**0.780**	0.324	0.125	0.032	-0.130
Share of holders using ICT	**0.754**	0.273	**0.529**	-0.001	-0.073
Number of livestock units per holding	**0.752**	0.304	-0.022	-0.125	-0.081
UAA per holding	**0.679**	0.213	0.077	-0.274	-0.396
Share of holdings market oriented	0.035	**0.880**	0.124	0.169	0.072
Share of plain land	0.366	**0.776**	0.033	0.025	0.119
Share of UAA under cereals production	0.191	**0.755**	0.001	-0.167	-0.245
Share of irrigated land	**0.520**	**0.745**	-0.047	-0.032	0.179
Share of holdings participating to associations and co-operatives	-0.147	**0.700**	0.167	0.427	-0.111
Share of holdings with diversified activities	0.399	-0.167	**0.818**	-0.022	-0.107
Share of holdings product processing	0.050	0.012	**0.787**	0.003	0.272
Share of UAA under organic crops	-0.064	-0.213	**-0.663**	-0.020	0.129
Share of UAA occupied by vineyard	-0.130	0.141	-0.078	**0.890**	-0.034
Share of UAA with Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) products	-0.042	0.053	0.110	**0.888**	0.044
Share of UAA with permanent crops	-0.231	-0.199	-0.425	**0.544**	**0.498**
Share of UAA under labour intensive crops (vegetables, flowers, fruit)	-0.131	0.136	0.058	0.064	**0.868**
Share of UAA with green house endowment	0.038	-0.065	-0.005	-0.056	**0.831**
% of explained variance	**22.1**	**18.5**	**13.6**	**11.8**	**11.2**

Source: own processing

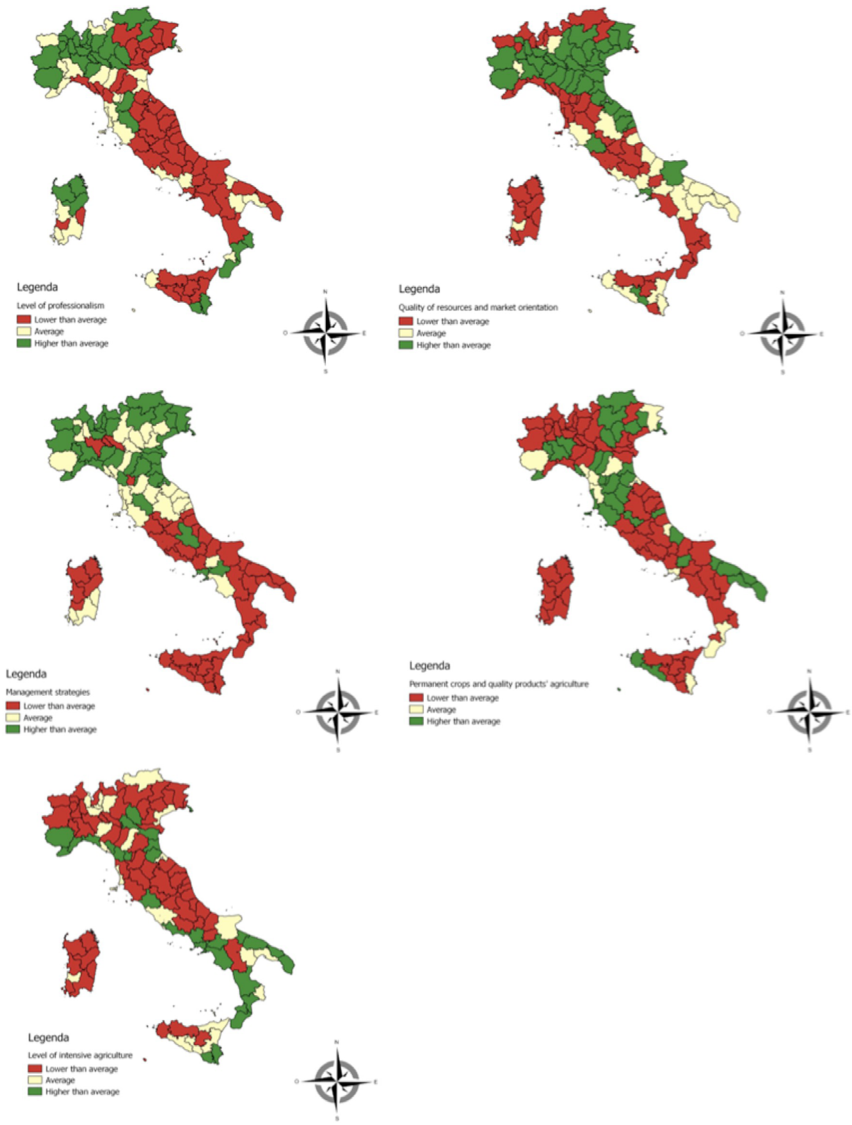
Table 2: Matrix of factor loadings.

the extensive vs intensive agriculture ("level of intensive agriculture").

To illustrate how the extracted components characterize Italian agriculture, in Figure 1 Italian provinces have been identified by level of component scores according to three classes of values (1 = average, when values fall in a range of ±20% around the average, 2 = higher and 3 = lower than average). Some main aspects can be underlined.

Generally speaking, components show a territorial pattern and geographical contiguity often reflects in closeness of component values. This is true when components synthesize features related to physical and environmental conditions, such as quality resources or farming typologies, but keeps to be true with respect to components dealing with management strategies. In particular, values of component 3 are territorially specific and, while farms localized in the North base their development patterns on diversification and processing strategies, in South Italy organic agriculture is a preferential way to increase farm profitability. Thus, agricultural development seems to follow a territorial pattern affected by the exogenous context (Niedertscheider and Erb, 2014).

More in detail, a high level of professionalism, mainly linked to livestock farming, and a well developed association's system are matched to a good resources quality and a strong market orientation in the agriculture of some Northern Italy provinces, localized in the so called Padana Plain. High values of the first component, with a high employment level, bigger size farms and livestock farming systems characterize the agriculture of some Southern provinces in Sardinia, too. Nevertheless, in these last cases quality of resources and market orientation are lower than the average, so that these production systems should be very different from the previous ones, either in terms of farm organization or in terms of economic performance. Low levels of professionalism and/or crop oriented farming



Source: own processing

Figure 1: Italian provinces by class of component values.

systems occur in a context of poorer land quality and natural disadvantages in the Apennine Mountains of Central and South Italy. As far as management strategies are concerned, Southern and Northern provinces are characterized by very different agricultural patterns. The first ones seem mainly oriented towards a deepening strategy based on the organic agriculture, while a broadening pattern better characterizes the Northern agriculture. The product specialization is less territorially defined, but intensive farming typologies (fruit, horticulture and flowers) are more widespread in the South. Anyway, it should be underlined that, even when the production system is similar and a quality pattern has been developed, a higher integration in the food chain and in-farm diversification strategies are more likely to occur in the Northern Italy provinces.

Thus, the differentiation factors identified in the PCA seem to discriminate two main territorial agricultural models and the historical “socio-economic divide” between Southern and Northern Italy also reflect in a different way the agricultural systems organize and choose their development strategies. Territorial differences have been tested by performing the Levene’s test to verify the hypothesis of homogeneity of variances followed by the Kruskal-Wallis test on components 1 to 3 and ANOVA for components

4 to 5 (Tables 3 and 4). Statistical differences were proved for components 1 to 3, thus confirming that agricultural development pattern can be territorially specific, even if farming typologies are not. Post hoc estimation tests underlined that North/South divide is always verified, while the agriculture of Central Italy is statistically different from North with respect to the first and third component, and from South as component 2 and 3 are concerned.

As competitiveness is concerned, Figure 2 gives a picture of Italy with respect to agricultural labour and land productivity and farm's value added at provincial level. Provinces have been distinguished by considering three classes of values: 1) average, when values fall in a range of ±20% around the average, 2) higher and 3) lower than average. Figure 2 highlights two main aspects. Firstly, while labour productivity value is quite similar all over, with only few areas characterized by extreme values, indicators of value added per hectare and per farm show a stronger polarisation. Secondly, the distribution of the value added per farm quite reflects the economic divide between Northern Italy and other areas. That partly might be the result of the contiguity of resources quality and context factors that are the base of the observed territorial economic gap.

Territorial differences of productivity and performance indicators were tested (Tables 5 and 6). Only mean values per farm and per unit of work are statistically different among areas. In particular, value added per farm is statistically lower in Southern provinces with respect to any other areas, while differences exist in value added per unit of work only between South and Centre Italy.

2. The regression analysis

The regression analysis was carried out to test the extent the differences previously underlined, both of structural and productive characteristics of Italian agriculture and of farms' management strategies, can affect the value of agricultural productivity at territorial level. Besides the PCA scores, the role of several indicators of the socio-economic context has been tested, such as infrastructural endowment indexes, indicators referred to innovations, to human and social capital and firms' dynamics. Only few of them have been found to be relevant with reference to one or the other dependent variable. The results of regression analyses are reported in tables 7 where only significant coefficients have been reported.

As far as agricultural characteristics are concerned, the first model shows the relationship between labour productivity, on one side, and professionalism level, market orientation of the farm and the level of intensive agriculture,

Component	Levene's statistics	df1	df2	Sig.
Level of Professionalism	6.695	2	107	.002
Quality of resources and market orientation	14.772	2	107	.000
Management strategies	5.296	2	107	.006
Permanent crops and quality products' agriculture	1.494	2	107	.229
Level of intensive agriculture	1.689	2	107	.190

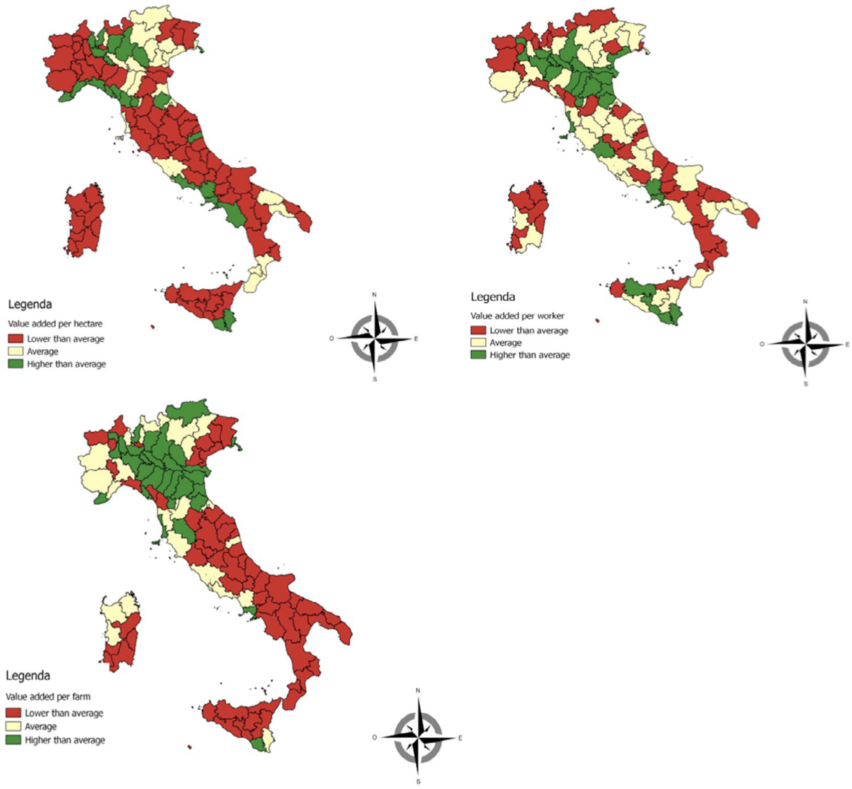
Source: own processing

Table 3: Statistical differences of component values by Northern, Central and Southern provinces – Levene's test.

Component	Statistic	Sig.
Kruskal-Wallis		
Level of Professionalism	10.536	.005
Quality of resources and market orientation	6.360	.042
Management strategies	55.876	.000
ANOVA		
Permanent crops and quality products' agriculture	0.738	.481
Level of intensive agriculture	1.229	.297

Source: own processing

Table 4: Statistical differences of component values by Northern, Central and Southern provinces – ANOVA and Kruskal-Wallis.



Source: own processing

Figure 2: Italian provinces by class of labour and land productivity and by class of value added per farm.

Component	Levene's statistics	df1	df2	Sig.
Value added per unit of work	1.017	2	107	.365
Value added per hectare	.763	2	107	.469
Value added per farm	6.363	2	107	.002
Level of intensive agriculture	1.689	2	107	.190

Source: own processing

Table 5: Statistical differences of productivity and performance indicators by Northern, Central and Southern provinces – Levene's test.

Indicators	Statistic	Sig.
Kruskal-Wallis		
Value added per farm	33.695	.000
ANOVA		
Value added per unit of work	4.874	.009
Value added per hectare	1.601	.206
Level of intensive agriculture	1.229	.297

Source: own processing

Table 6: Statistical differences of productivity and performance indicators by Northern, Central and Southern provinces – ANOVA and Kruskal-Wallis.

on the other side. With respect to the economic context indicators, the positive relationship with the rate of firms' growth and with the openness of the economy confirms the relevance of the networks and the density of economic relationship as factors of territorial competitiveness. As it was expected, agricultural characteristics play a main role in influencing labour productivity.

Component	Value added per full time worker	Value added per hectare	Value added per farm
Level of Professionalism	3.7490*** (3.87)		16.9070*** (10.29)
Quality of resources and market orientation	7.4796*** (6.24)	-0.4564** (2.16)	6.0744*** (6.3)
Management strategies		0.7645*** (4.54)	
Permanent crops and quality products' agriculture		0.4620** (2.52)	
Level of intensive agriculture	4.1569*** (3.18)	2.4085*** (6.26)	
Road infrastructure index		0.01701*** (3.29)	
ICT services index			0.1052*** (3.75)
Share of adult population with only lower secondary education level			-0.4886*** (-3.79)
Growth rate of firms	2.4151** (2.36)		
Rate of openness of the economic system	0.0540 * (1.81)		
Constant	33.4967*** (18.49)	1.3346*** (2.93)	37.3239*** (5.36)
R-squared	0.5122	0.6271	0.7742

Nore: ** p<0.05; *** p<0.01
Source: own processing

Table 7: Regression results.

In particular, the Value Added per hectare is highly affected by the intensive use of land, but also by management strategies directed to diversification, product processing and quality products. The negative sign of the second component (Quality of resources and market orientation) can be explained by the effect of some characteristics that enter in the second Principal Component, in particular the share of land covered by cereals. The only exogenous variable that enters in the model is the road infrastructure index with a positive sign.

More interesting is the Value Added per farm model. In this case the level of professionalism is a major factor affecting farm performance, along with the quality of resources and market orientation component. Moreover, the farm performance depends on the ICT services index at provincial level, with a positive sign, and on the share of population with only lower secondary education level, with negative sign.

Conclusion

The work was aimed at analysing farm characteristics and their relation with territorial features in determining the economic performance and competitiveness of the agricultural sector at NUTS3 level. Despite agricultural land use in Europe has deeply changed over last years, agricultural surfaces are still significant high. The question for the future is what will happen in agricultural land use, farming models and land abandonment processes. That will strongly depend on farms' competitiveness, on one side, and on how agriculture will be able to undertake a multifunctional pattern and to answer to changes in consumption models, on the other side. These factors are related to agricultural characteristics that vary at territorial level.

As Italian agriculture is concerned, the results of the present work allow drawing three main considerations.

Firstly, the picture of Italian agriculture is very diversified and great territorially differences exist both in terms of productivity and performance indicators and in terms of management strategies, farming typologies and level of professionalism. In particular, the strong dichotomy that characterizes the economic systems of Northern and Southern Italy can still be found with reference to farm performance. Therefore, even if it is not so easy to identify a real pattern of the agriculture development, a strong relationship between agricultural systems and economic indicators is feasible.

Secondly, the determinants of agricultural productivity and performance are mainly endogenous to the sector and only few context indicators are statistically significant as explanatory variables. As a matter of fact, the dynamicity of the economic context is related to the agricultural labour productivity and the endowment in ICT infrastructure and human level of education play a role when considering farm value added, but the relevance given by the theory to drivers of competitiveness such as human and social capital, economic infrastructures, innovation rate was not generally verified. This result could depend on the indicators selected as proxies of agricultural productivity but it can depend on the territorial level of the analysis, too. On one side, Italian provinces still include very diversified agricultures and socio-economic conditions and thus taking into account average data flattens the information and reduces the explanatory power of analysis. On the other side, the territorial level where the interactions of economic and social phenomena operate and their effects emerge is not really known and might be different according to the specific aspect under analysis. In our study the NUTS3 level might not be appropriate to catch the relationship between territory characteristics and agricultural performance.

A last consideration concerns implications of results on policy intervention. Results of the regression models confirm the role the new rural policy gives to factors such as food chain organisation and human capital quality (young farmers and high level of education). Agriculture structural characteristics and the level of commitment in the agricultural activity play a relevant role, too. At the same time, diversification strategies are relevant to land productivity, but do not affect labour productivity and the farm performance as a whole. That underlines the need for a deeper focus on structural factors by the policy intervention. A competitive and viable agriculture requires adequate farms' dimensions, professionalism, orientation to the market. Policies to support the farm's diversification can help its sustainability in the short term, but without a structural adjustment are not able to maintain a viable competitive activity in the long term.

Moreover, even if only few indicators of the socio-economic context were relevant in the regression analysis to explain territorial productivity differences, the dichotomy of Northern and Southern Italy of both the economic systems and the agricultural productivity values (in terms of value added per farm) underlines a link between these two aspects. That implies the need of an integrated policy approach. The integration in the programming as well in the implementation phase requires higher attention to endogenous and exogenous factors that can constrain the agricultural and rural development and the adoption of a holistic vision in the definition and carrying out of policy measures.

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Information Systems in Agricultural Enterprises: An Empirical Study in Slovak Republic

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Abstract

The development of information and communication technologies (ICT) is currently conditioned by the development of industry, society and many other factors. The ever increasing trend of ICT development is directly connected with the agricultural enterprises. ICT play important roles in the development of these enterprises and automation of their processes. Revitalisation of financing and budgets, dynamically evolving strong competitive environment and growing regulation lead to ever growing need for swift reactions and making precise decisions in all institutions and organisations, including manufacturing and agricultural organisations. Access to the right information in the right time is crucial for every subject. There are several fundamental areas for modern agricultural enterprises. All processes carried out in agricultural enterprises need to be planned and managed; automation of the processes via suitable information systems brings significant competitive advantages and strengthened market positions. Enterprise resource planning systems are convenient in this respect. The systems represent efficient instruments for planning and management of all crucial internal processes, particularly at the tactical and operational levels of management. The paper provides a picture of the current state of business information systems' application in agricultural enterprises in Slovak republic and analyses the influence of selected factors (benefits and functions of the information system) on the satisfaction of managers with the implemented information system.

Keywords

Information systems, information and communication technologies, management, benefits, agricultural enterprises.

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Introduction

The reproduction processes are characteristic with overlapping information systems and information technologies Implementation of information systems providing competitive advantages at domestic and foreign markets through efficient provision of information becomes a crucial factor of successful development and sustainable market position. Agricultural enterprises are also affected by the trend of computerisation. ICTs have a demonstrable positive effect on income growth in developing and developed countries (Röller and Waverman, 2001; Waverman et al., 2005). In rural areas, ICTs can raise incomes by increasing agricultural productivity (Lio and Liu, 2006) and introducing income channels other than traditional farm jobs. Current limited evidence from individual farmers and fishers in India supports the conclusion that ICTs improve incomes and the quality of life among the rural poor (Jensen, 2007; Goyal, 2010). The idea that wider access to and use of ICTs throughout a country will reduce inequalities in income and quality of life between rural and urban residents is compelling. Despite the scarcity of evidence to support this notion (Forestier et al., 2002), it underlies widespread policy initiatives to ensure equitable access to ICTs in all areas. Maumbe and Okello (2010) point to ICTs as a powerful tool in the area of agriculture and rural development also in developing countries.

After 1992, there was a boom of information systems in the sector of agriculture, when the unified business system and the medium management were gradually being supplemented by a large growth of new installations provided by various software companies, both domestic and foreign ones. During the transition period, the foreign software products (provided by e.g. KW or Siemens) did not position themselves between centrally planned economy and market economy in the specific conditions of agriculture. Software products of domestic companies such as Softteam, Kubiko Codex, Aurus or Intes have currently marked the trend of the qualitative improvement.

Globalisation processes significantly affect the ways of practical management. The needs for pertinent information and the detailed knowledge of internal and external environment of an enterprise come to the forefront. There have been opened new possibilities for positioning at foreign markets, after Slovakia entered to the European Union. This has conditioned the increased requirements for information security. The new conditions within the European Union must also be reflected by information systems of agricultural subjects. Information policy stipulates the activities which are about to be implemented in the sphere of information technologies in organizations and what the reasons behind the activities are.

In the short-term to the medium-term period, agriculture in the Slovak Republic must react to several challenges stemming from the finishing transformation of economy, changes in the world economy and access to the common market of the European Union in 2004. Agricultural sector (Kuncova et al., 2016) belongs to the primary sectors depending mainly on the natural resources. Although it is usually less important than the secondary and tertiary sectors (especially in the developed countries) it has an indispensable role in economy.

In the ever harsher competition, agricultural managers are aware of the value of information; however, corporate information systems are not at the sufficient level. In order to ensure permanent competitiveness, it is necessary to modify the existing information systems and link them with the external environments. The issue of computerisation is also tackled by the Ministry of Agriculture and Rural Development of the Slovak Republic. In order to provide systemic and complex approach to the duties connected with building efficient information systems, the ministry has elaborated a set of documents defining all necessary tasks which will have to be implemented in the sector of agriculture in accordance to the global development of information society. The implementation of the Conception of Agricultural Policy and Computerisation Programme is considered strategic from the viewpoint of the ministry management and its sections and also rom the perspective of creating the necessary information and communication links. Both documents represent conceptions of the sector focused on systemic enforcement of information and communication technologies in favour of building information systems and other necessary instruments. The structure and the content of the projects have been derived from the goals and priorities of the sector as well as the tasks related to the pre-accession strategy. The goal of the Computerisation Programme is to gradually complete the information system of the sector as a unified system of mutually connected and cooperating information systems, able to provide information and necessary services in favour of the sector management, other sectors and also public.

Management is a complex process and proper decisions need to be based on the available objective and trustworthy data. At the same time, it is necessary to differentiate operational, tactical and strategic management. The best solution is to possess data to address all needs of managers and to make them available on a real time basis. It is a complicated task at first sight. Moreover, when the ever growing volume of data is taken into consideration, the demand is quite problematic. However, implementation of suitable information system and technologies makes it feasible to store large volumes of data, process them in a short time and provide managers with outcomes in required formats (calculations, graphical depictions, multidimensional analyses).

A business information system providing relevant information has to take into consideration the character of business activities in an enterprise, information flows, implemented software and hardware, and it shall enable introduction of modern tools to support financial management.

Theoretical background

The current management and decision-making of top management are affected by turbulent and sometimes very unpredictable environment, which is linked to the large scale of globalisation and critical factors at financial and bank markets. Except of the previously mentioned impacts of globalisation on export economies (which is also the case of Slovakia), we also face other problems: swift changes, enormous increase in structured and particularly non-structured data, operationality etc. Top managers willing to maintain the competitiveness of their organisation need to cope with the reality in qualitatively new ways; i.e. to use the most recent managerial technologies in combination with the IT instruments. Primarily, they need to adopt the use of the Enterprise Resource Planning (ERP) and Business Intelligence (BI) systems as the inevitable instruments of management. This problems are closely related to the sector of agriculture, too.

The ERP systems automate and integrate crucial business processes such as receiving orders, planning processes, registering supplies and financial data. The ERP systems contribute to improved business efficiency. Among the most important advantages of such systems belong (Novotný et al., 2005, Williams and Williams, 2007, Basl and Blažíček, 2008; Gartner, 2016):

- assistance in defining business processes and assuring they are preserved in the whole supply chain,
- protection of important business data through appropriate role definition and access policy,
- work-time planning based on existing orders as well as predictions,
- providing customers with tools at high level of services,
- transformation of business data to a form convenient for flexible decision-making

The modern ERP solutions cover a decisive part of business processes; therefore, it can be stated that one of the most important tasks in defining the information strategy of a corporation is paying enough attention to defining the most suitable ERP system.

The most relevant reasons for introducing the ERP systems are as follows (Novotný, et al., 2005, Williams and Williams, 2007, Basl and Blažíček, 2008; Gartner, 2016):

1. providing a corporation with a wide scale of functions covering the wide scope of basic activities,
2. support of internal and external processes and the possibility to optimise the processes,
3. possibility to decrease the number of operational systems,
4. ERP is a corner stone of a corporate IT architecture,
5. globalisation requires introduction of the homogenous ERP system,
6. efficient corporate strategy is based on aggressive and effective use of information technologies,
7. competitive advantage or becoming equal to compete.

Requirements related to system functions, references or criteria related to solution suppliers are important and even unambiguous.

Business intelligence helps to clarify achieved results, optimise operational models and support flexible and swift decision-making process. The following definition of business intelligence is widely accepted: business intelligence (BI) is a set of procedures, processes and technologies aimed at efficient and purposeful support of decision-making processes in corporations. It represents a complex of applications supporting analytical and planning activities of enterprises and organisations based on specific, so-called OLAP technologies and their modifications. Recently, the term Business Intelligence has been used to replace the term MIS (Management Information System). The areas covered by BI are not strictly defined; e.g. it is used to support business strategy and marketing. Competitive Intelligence (analysis of competition and competitive environment), expert systems or DSS (Decision support system) are examples of areas often incorporated to BI; however, they can be also addressed as separate units (Basl and Blažíček, 2008).

There is still a low level of the Business intelligence introduction among businesses, which could be explained by low level of information about the software. According to the research by Hamranová (2013), there are only 22 % of enterprises in Slovak republic with the implemented Business intelligence applications. The Business intelligence applications are important in agricultural enterprises, too (Tyrychtr et al. 2015). The current Business intelligence applications are focused particularly on flexibility, interactivity and the ability to acquire the most exact information possible in the shortest possible time period and in the simplest possible way so that further new facts could be derived from the information and thus create an added value to decision-making. The most exact and complex data possible, able to reveal background effects leading to undesired deviations, are necessary for daily operative and tactical decision-making as well as singular crucial strategic resolutions. The Business intelligence applications help managers to find answers to many questions. The Business intelligence applications are useful for making activities in corporations more efficient while enhancing independent thinking.

The access to information is not available without the use of new ICT – all technological, programme-related and organisational means aimed at processing information. Each enterprise owns a set of information located in files, databases and documents. The information is vital for decision-making at all management levels. To make the decisions as flawless as possible, managers need the access to correct, precise and consolidated information in proper time.

Stuchly and Krutakova (2015) claim that currently, enterprises must fight with uncertainty if they want to survive in the strong competition and try to alleviate it. Each enterprise is doing it a little different way, and choosing a different strategy. It is important to constantly developing and adapting of management system to external conditions and strategies which the enterprise decided to apply.

The managers, who want to maintain the competitiveness of their organisation, need to cope with the reality in qualitatively new ways; i.e. using the most recent managerial technologies in combination with the IT instruments (Scheps, 2008).

An important factor for a successful development and maintenance of competitiveness of business subjects is implementation of economic information systems, providing competitive advantages at domestic and foreign markets through effective use of information. An economic information system (Kokles and Romanová, 2007) represents an essential part of a corporate information system. It is primarily focused on gathering, processing and providing information, expressing the economic reality of a corporation.

It is necessary that a software application addressing accounting provides databases meeting operational, tactical and also strategic needs – this is the fundament of a properly designed business information system.

According to Tóth (2012), an accounting system has to be understood as an integral part of a business information system. Automated processing of accounting information could be considered to be a routine. A software solution is important in this respect. Enterprises could choose from desktop versions, but the trend of evolution in this area leads to cloud versions of software. Cloud computing is considered to be a concept of providing information technologies through the Internet via rental. Electronic information is stored and saved on external servers in large data centres (Armbrust et al., 2010). The current trend of ICT development, the demand on early and relevant information makes the enterprises use cloud solutions and to integrate the module accounting to the existing IS, or to implement complex ERP systems. In our opinion, it is proper to choose the variant, as it makes the processes more efficient, leading to increased competitiveness of enterprises, though cloud computing brings also certain risks. The most important risk is related to the information security – safety and access to sensitive data and trustworthiness of a provider. The service availability is not that risky nowadays since technologies work on the principle of offline/online Internet connection to the service.

It could be stated that information and communication technologies are essential for increasing competitiveness of agricultural enterprises and business dealing with agritourism (Havlíček et al., 2009). They pose a competitive advantage and offer possibility to make a difference on the market, to strengthen a market position and attract new clients. Maumbe and Okello (2010) also claim that information and communication technologies are powerful instruments for strengthening competitiveness in agriculture and rural development even in the Third World.

Materials and methods

The main research objective is to identify benefits and functions of business information systems representing a crucial support for management and decision-making in agricultural enterprises, assisted by accounting data.

Business information systems in the selected agricultural enterprises are the objects of interest. With respect to the objectives, we put emphasis on business information systems and economic software.

When processing background materials, we analysed internal guidelines, external and internal documents of the enterprises, project and programme documentation, software applications, accounts, questionnaires, available domestic and foreign publications and legislative acts related to the issues in question.

When conducting analyses, we focused predominantly on information background of management processes, business information system concepts, integrity and functionalities of business information systems, accounting methods and systems, reliability of the accounting systems, stability of the systems in relation to management and demands of managers related to quality and accessibility of information. Business information systems of the selected enterprises were analysed from the perspective of providing data for managers, demands related to management and decision-making, functional and legislative reliability and possibilities for supporting the competitiveness achievement.

When collecting data, the following data collection methods were used: direct and indirect observation, structured interview, questionnaire, business documents analysis.

As for the methodology, the following basic research methods are applied: analysis, synthesis, comparison, graphical depiction and horizontal as well as vertical data analysis. Processing and evaluation of the research conducted among the selected agricultural enterprises was supported by large volume of statistical data. The selected agricultural enterprises comprised of limited liability companies, cooperatives, joint stock companies and also natural persons. The enterprises use both single entry and double entry accounting. Then, we focused on examination of the available economic software solutions by Slovak and Czech companies, with functionality applicable in all spheres of agricultural enterprises' activities. As many as 65 agricultural enterprises took part in the research. Size of enterprises by number of employees: <10 – 15.91 %; 11-50 – 68.18 % and 51-250 – 15.91 %. The enterprises are located in 6 counties. The most frequent group is represented by enterprises with 11 – 50 employees – medium-sized companies 68.18 %.

The questionnaire consisted of 27 questions, with both open-ended and closed-ended questions. The Likert scale was also applied. The questionnaire was conceptualised on the basis of literature and some previous research. Some enterprises took direct part in the questionnaire design and cooperated in conducting the semi-structured interviews during querying.

The following indicators were devised for the questions focusing on the benefits and functions of information systems (Table 1).

	Information system benefits
B1	Significant reduction of time necessary to achieve required data.
B2	Information from various sources is available in one spot.
B3	Information from various sources is available in a unified format.
B4	System enables to monitor the elementary indicators.
B5	System enables to analyse and examine the reasons behind emerging situations.
	Information system functions
F1	Conducting financial analyses.
F2	Configuration of plans, budgets, calculations.
F3	Support for decision-making.
F4	Manufacturing management.
F5	Real-time stock management.
F6	Control of plans execution.
F7	Transportation management.
F8	Data of business partners.
F9	Remote access to data.

Source: own processing

Table 1: Research model indicators.

The data analysis was carried out with a help of a large statistical apparatus. Besides the basic descriptive statistics, correlations and extrapolation, we also used systemic methodology, aimed at searching connections among the individual issues in question. When designing models of satisfaction with information systems, we used multiple linear regressions and analysis of variance Anova. We examined the dependence of interval variable Y on several nominal variables (factors). The equation was devised on the basis of the general equation $Y = b_o + b_1 x$ and the acquired results.

Results and discussion

Information systems in enterprises are important from the perspective of strategic management and decision-making of top managers. They form a data base necessary for both internal and external users. A high-quality information system could provide real and updated information, thus becoming a useful instrument for managers, increasing efficiency of employees, ensuring and enhancing flexibility of an enterprise, fostering improved relations with customers and creating a strong tool for management of activities in an enterprise.

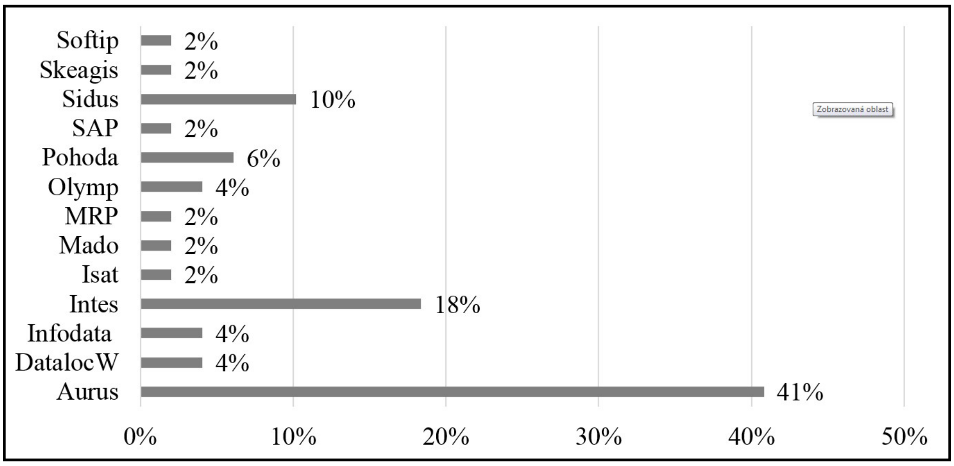
The decisions on business information systems are strategic and their consequences will become visible in a longer time horizon (Sirota et al., 2013).

The addressed agricultural enterprises use automated information systems. All of the respondents claimed to have implemented a business information system. The most frequently implemented information systems are listed below (Graph 1).

The Aurus information system belongs to the most frequently used ones among agricultural enterprises (40.82 %). The most often implemented version is Ekopacket, providing complex services for its users. Aurus Ekopacket is the second generation of a complex, multi-user package of economic programmes designed for large, medium and small enterprises focused on trade, manufacturing or services, and also for budgetary and contributory organisations. The second most frequently used information system is Intes (18.37 % share). The information system is aimed at recording the use of fertilizers, seeds, chemical preparations and other components of the Good Farming Practice, and it is based on the use of traditional documents adjusted for use in electronic forms for control bodies. The third most frequently used information system in agricultural enterprises is SIDUS (10.20 % share). The SIDUS system is a product of a group of designers, analysts and programmers, contributing to the development and maintenance of the ASR ZpoK system (predecessor of SIDUS). Besides experience and traditions, the SIDUS system brings new approaches to information systems, it uses graphical environment to the maximal possible extent and efficient hardware with no limits and offers new options for users. Other software solutions are implemented by less than 10 % of enterprises. Some 6.12 % of them use the more universal and typical Pohoda software. The Pohoda software is often called economic software. The Skeagis (2.04 % share), geographical information system, providing information of the operational management of agriculture, enabling to process and use data of subjects located on the ground Skeagis offers three basic modules: Land register, Tenancy and Plot together with a GPS module. The system links written and graphical parts with the exact localisation of production spots in the field based on orthophotography.

It is very important for agricultural enterprises that their systems are connected with a land register, maps and agrarian portals, while being efficient in processing the agricultural agenda.

In the current rapidly changing society based on knowledge, information and ICT, it is not enough to implement an information system – users must be information-literate and information security must be ensured. Based on the research conducted in the selected agricultural enterprises, it could be stated that the number of employees has decreased recently and managerial functions are cumulated in enterprises. There was no independent department focused on administration and management of ICT established, in most of the examined enterprises. Absence of such a department significantly affects the emergence of a security incident. Although employees do have ICT at their disposal, they often have to make do with basic knowledge only; i.e. at lower levels of management, there is only a low level of knowledge of the given issue. This also affects behaviour of employees, which is often careless, regarding the information security (not enough attention is paid to basic data security, e.g. access passwords are either not defined or used by several employees). Currently, the quality of trainings and courses focused on increasing the information literacy of managers



Source: own processing

Graph 1: Information systems in the selected enterprises.

is at a very low level. Agricultural managers often underestimate the risks related to the information security and rely on basic protection provided by antivirus software. Simultaneously, the enterprises lack proper technological equipment (outdated technology), though at the same time it must be noted that software applications are being regularly updated. However, it is clear that small and medium-size agricultural enterprises lack internal directives focused on administration and management of information and communication technologies. The research results claim that the financial resources are the main reason behind the detected imperfections.

The most important benefit (scale: 0 for unsatisfied to 5 for the most satisfied) of business information systems according to the enterprises is B1 – significant reduction of time necessary to acquire the demanded data, M = 4.30 pts, STDEV = 1.05 pts; followed by B2 – data from various sources available in one place, M = 4.25 pts, STDEV = 0.97 pts; B4 – a system enables users to monitor basic indicators, M = 4.23 pts, STDEV = 1.09 pts; B3 – information from various sources is available in a single format, M = 3.93 pts, STDEV = 1.02 pts; the least important benefit according to the enterprises is B5 – a system enables analysis and determining causes of the emerging situations, M = 3.45 pts, STDEV = 1.32 pts.

Then, the significance of business information systems' functions was examined. The enterprises implied the following ranking of the significance: F1 – preparation of financial analyses, M = 4.16 pts, STDEV = 1,10 pts; F2 – preparation of plans, budgets and calculations, M = 4.11 pts, STDEV = 1.13 pts; F5 – real-time stockholding, M = 3.80 pts, STDEV = 1.17 pts; F8 – data of business partners, M = 3.61 pts, STDEV = 1.38 pts; F3 – support for decision-making, M = 3.52 pts, STDEV = 1.21 pts; F9 – remote access to data, M = 3.48 pts, STDEV = 1.69 pts; F4 – Production management, M = 3.39 pts, STDEV = 1.56 pts; F6 – control of the plan implementation, M = 3.09 pts, STDEV = 1.60 pts; the least important function of a business information system according to the respondents is F7 – Transportation management, M = 1.93 pts, STDEV = 1.63 pts.

The overall satisfaction with meeting the requirements on the current business information systems related to decision-making and management is at the level of M = 3.91 pts, STDEV = 0.94 pts. The level of satisfaction is considered adequate.

The levels of satisfaction with the implemented business information systems directly affect the need to change systems or to purchase further modules. Purchase of the further modules is affected by increasing computerisation, limitations of the current systems and also external factors. The total of 14 % of enterprises plan replacing the current information systems with the complex ones; 5 % of enterprises plan purchasing further modules to the implemented business information systems.

After the analysis of satisfaction with the implemented information systems, the benefits affecting the rate of satisfaction were examined.

Satisfaction with business information systems is predetermined by all benefits of information systems at the significance level of $p = 0.05$. The model is statistically significant, as the value $p < 0.000$. However, not all benefits in the model are significant at the significance level of $p = 0.05$. Hence, it is necessary to eliminate and reduce several benefits and create the following model

	Model 1A			*Modify Model 1A*		
Explanatory variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*
B1	0.013	0.213	0.014			
B2	0.392	0.244	0.405	0.456	0.125	0.472**
B3	0.212	0.145	0.231			
B4	- 0.068	0.210	- 0.074			
B5	0.173	0.106	0.244	0.211	0.092	0.027*
Adjusted R^2		0.384			0.395	
F (5,38)		6.352**		F(2,41)		15.050**
N			65			

Note: *p < .05, **p < .01
Source: own processing

Table 2: Model of the rate of satisfaction with the implemented business information systems in relation to the proclaimed benefits.

(Modify 1A).

The model determining the satisfaction of the enterprises with their business information systems is statistically significant $p < 0.000$ at the significance level of $p = 0.05$. Up to 39.50 % of points for satisfaction is attributed to the B2 and B5 benefits - data from various sources available in one place and a system enables analysis and determining causes of the emerging situations, respectively. Based on the above, the following formula could be drawn up:

$$S = 1.242 + 0.456*B2 + 0.211*B5 \quad (1)$$

If the benefit B2 rate increases by 1 point, the satisfaction with a business information system increases by 0.46 pts. If the benefit B5 rate increases by 1 point, the satisfaction with a business information system increases by 0.21 pts. If B2 and B5 are equal to zero, the satisfaction with a business information system is 1.242 pts.

The satisfaction with the implemented business information systems are affected both by benefits and their functions.

Satisfaction with business information systems is predetermined by all functions of business information systems at the significance level of $p = 0.05$. The model is statistically significant as the value $p = 0.019$. However, not all benefits in the model are significant at the significance level of $p = 0.05$. Hence, it is necessary to eliminate and reduce individual benefits and create the following model (Modify 1B).

The model predetermining the satisfaction of the enterprises with the implemented business information systems is statistically significant $p < 0.000$ at the significance level of $p = 0.05$. Up to 28.90 % of points related to the satisfaction are explained by the information system functions F2 and F8, preparation of plans, budgets and calculations and data of business partners, respectively. Based on the above, the following formula could be drawn up:

$$S = 1.542 + 0.372*F2 + 0.232*F8 \quad (2)$$

If the function F2 rate increases by 1 point, the satisfaction with a business information system increases by 0.37 pts on the average. If the function F8 rate increases by 1 point, the satisfaction with a business information system increases by 0.23 pts. If F2 and F8 are equal to zero, the satisfaction with a business information system is 1.542 pts.

Agricultural managers evaluate the implemented information systems according to their functions. There are several reasons leading to implementation of information systems and automation of processes. They could be derived from benefits of the implemented information systems. Significant reduction of time necessary to reach the required data, available in one place is the most important benefit of information systems. Systems enable monitoring the basic indicators and information from various resources is at disposal in one place and in a single format. Satisfaction with the implemented systems is determined by their functions. According

	Model 1A			*Modify Model 1A*		
Explanatory variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*
F1	-0.070	0.177	-0.083			
F2	0.260	0.170	0.313	0.372	0.107	0.447**
F3	0.109	0.174	0.141			
F4	0.080	0.143	0.133			
F5	0.157	0.140	0.197			
F6	-0.004	0.100	-0.007			
F7	-0.075	0.100	-0.130			
F8	0.152	0.123	0.225	0.232	0.087	0.343*
F9	0.052	0.103	0.094			
Adjusted R^2		0.258			0.289	
F (5,38)		2.660*		F(2,41)		9.731**
N			65			

Note: *p < .05, **p < .01
Source: own processing

Table 3: Model of the rate of satisfaction with the implemented business information systems predetermined by their functions.

to the agricultural managers, ability to prepare financial analyses, plans, budgets and calculations, stock management in a real time basis, data on business partners, support for decision-making, remote access to data, manufacturing management and plan implementation control are the most important functions of business information systems. The overall satisfaction of managers with the business information systems reached M = 3.91 pts, STDEV = 0.94 pts (scale: 0 for unsatisfied to 5 for the most satisfied). This level of satisfaction with the implemented business information systems is considered satisfactory. It could be summarised that it is very important for an implemented business information system to meet all needs of managers. The rate of satisfaction with the implemented business information systems directly affects the need to change information systems or to purchase modules. The purchase of new modules is limited by computerisation, limits of the currently implemented systems and also by external factors. However, 14 % of the enterprises plan to replace their systems with the complex ones and 5 % of enterprises plan to purchase further modules to their already implemented business information systems.

Complex business information systems used by agricultural enterprises cover several areas: accounting 97.73 %, stock management 86.36 %, human resources and payrolls 86.36 %, non-current assets 90.91 %. The modules are integrated into a single business information system providing complex processing, analyses and output reports. The selected enterprises use business information system predominantly to carry out accounting, address non-current assets, stock management and finally also human resources and payrolls. Accounting data represent essential background source facilitating decision-making. It is important that they are complete, trustworthy, early and complex. Within the research, managers of the agricultural enterprises claimed that they identified mistaken decisions due to incomplete, untrue or belated information up to 5 times in 65.91 % of cases, often in 11.36 % of cases and 22.73 % of managers had not experienced such a mistake throughout their practice.

High-quality planning is more than important for successful management, as it helps in estimating opportunities and risks and also enables the permanent control of reaching the set goals. Information systems are able to contribute to improved management functions and they are also suitable instruments for automation of processes.

An enterprise could devise its own manufacturing, financial and time plan of plant production. Each farmer must record his/her activities regarding the agricultural land and document adhering to relevant legislation.

Based on the above information, it is necessary that the managers reconsider their information systems and modify them according to the needs of enterprises and conditions of markets. However, it is necessary to realise that modifications shall not remove imperfections only but after modifications, systems shall enable enterprises to achieve long-term prosperity and competitiveness at domestic and also foreign markets.

In the proposed paper, we have presented the results that we have gained in examining agricultural enterprises' information systems in the Slovak Republic. Agricultural enterprises in the Slovak Republic prefer information systems that allow recording, processing and evaluation of data from in-house accounting with a focus on plant and animal production. Based on the survey and the analysis, which is part of the research project named Modeling of Harmonization Solutions for Financial and Tax Accounting at Agricultural Business Organisations (coordinated by Aleksandras Stulginskis University, Lithuania), we have identified a requirement to improve and streamline monitoring of accounting information in the agricultural information systems. The most common problems include: the linking of economic modules to the plant and animal production monitoring systems, the incompatibility of individual software that makes it difficult to provide data for business management and data collection for government institutions.

Based on the processing of the data obtained from the survey, we have identified certain deficiencies in the area of data processing and provision. We propose to innovate these agricultural enterprise information systems, namely:

- Improve the module for the plant and animal production recording by supplementing the system of creation and monitoring of calculations,
- Automate the data provision for the external environment, such as data on agricultural production for the purpose of institution monitoring at the national level as well as at the level of European Union institutions,
- expand enterprise information systems to track and manage customer relationships (CRM),

- add a module for monitoring the quality of plant and animal production,
- provide information support for ecological management,
- improve communication with external business partners and the availability of information from foreign markets,
- respond more quickly to the development of information technologies and their implementation in the agricultural environment. Currently, the availability of data is addressed via cloud computing.

At present, besides the above mentioned issues, we are also involved in integrating the functionality of data recording and evaluating from the enterprise information systems in agricultural enterprises within the in-house environment, which will be the underlying asset for decision-making. Our findings of the current state and suggestions can be beneficial to countries that have not implemented similar information systems in their enterprises (see our paper), respectively their level of informatisation is lower.

Conclusion

Agricultural enterprises come across the growing trend of computerisation in all spheres of plant production, animal production and management. ICTs digitalise the following processes: seed selection, soil preparation, sowing, harvesting, processing, storage and distribution. They are incorporated into management and are inevitable for acquiring, processing and storing data. Modern technological tools, machines, devices and mechanisms are directly operated by software applications and systems. Virtualisation of the processes through cloud computing establishes a single modern and complex system of agricultural smart enterprises supported by ICTs.

Efficient business software becomes inevitable for agricultural enterprises. Such software must possess high-quality intranet and Internet structures. Implementation of such a model requires suitable technological background as well as methodological and organisational conditions within an enterprise.

Currently, enterprises react to the need to modify their business information systems in three ways: purchase of new software, development of new software, or improvement of the existing software (already implemented in an enterprise). It is crucial that implementation of an information system leaves a satisfied user and fulfilled (more or less) strategic goals of an organisation, or goals related to all levels of management and all areas using IS/IT.

The demands of managers on information systems were also identified. Flexibility and integration are the basic factors of well-functioning economic systems. It is necessary that systems react swiftly on changes not only in ordinary situations, but also in the strategic activities related to products and markets. Systems shall lead to optimisation of operational and economic processes and be able to warn users in cases of undesired developments.

The level of computerisation in the examined enterprises is given by their location, access to the Internet, digital literacy of their employees and used technologies. However, it is clear that the use of new information and communication technologies and information systems could make agricultural enterprises more efficient, strengthen their competitive positions and equip them with strategic competitive advantages.

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Estimating Spatial Effects of Transport Infrastructure on Agricultural Output of Iran

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Abstract

This paper examines the possibility of spatial spillover effects of transport infrastructure in Iran provinces. We estimate the regional spillovers of the transport infrastructure stock by applying a spatial Durbin model from 1980-2015. The results indicate that positive spillover effect exist due to the connectivity characteristic of transport infrastructure at the national level. A spatial Durbin model that obtains spatial dependence in a given province has a positive direct effects on agricultural output. Also, at the national level, the spillover effect of road infrastructure on elasticity of output in neighboring provinces varies with respect to the spatial weight matrix used in the spatial Durbin model. Moreover, our analysis shows that enhancement in road infrastructure in the provinces, south region shows a larger positive spillover effect on agricultural output when compared to central or west provinces. At the regional level, transport infrastructure spillover effects change significantly all the time among Iran's five macro-regions.

Keywords

Spatial Durbin model, agricultural production, spillover effect, transport infrastructure.

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Introduction

Investment in roads and improved road connectivity positively affect agricultural productivity and output. Such evidence includes econometric analysis of subnational data on the positive effects of public investments on agricultural output in the China and India (Fan and Hazell, 2001). The discussion of the economic impact of public infrastructure expanded significantly following a series of papers by Aschauer (1989), who argued that enhancing infrastructure investment will improve regions in achieving their economic potentials. Munnell and cook (1990) considered the relationship between pubic capital and economic performance at the national and state level. The output elasticity of public capital stock was found to be 0.15 and with highway alone contributing 0.06. Transportation infrastructure may have a positive effect on regional economic growth because the benefits generated from the infrastructure might not be limited to that specific region (Moreno and López-Bazo, 2007). To test the hypothesis empirically, different types of spatial models have been adopted (Cohen and Morrison Paul, 2004). However, because of the different focuses of each study, there is no consistent conclusion on whether spillover effects of transportation infrastructure are positive or even exist at a significant level. Boarnet (2002) constructed a spatial lag model in a Cobb-Douglas production function form to investigate the spatial effects of public infrastructure (roads and highways) in California counties. His study found a negative spatial lag effect for California road systems, which he believed was caused by migration. By relying on panel data for the 48 contiguous states over the years from 1969 to 1986, Holtz-Eakin and Schwartz (1995) found that highway stocks do not have important spillover effects on private productivity. They found the estimation results are sensitive to model specification. A negative effect of highway stock is also found when introducing a variable representing the investments made in counties located further away from the investment location (Ozbay et al., 2007). The theoretical motivation of this study is to follow the path of the new economic geography theory in testing for spillover effects of public transportation infrastructure under a systematic spatial econometric approach. As Fingleton and López-Bazo (2006) pointed out, many regional studies externalities in a somewhat often fails to consider the causes of externalities. The diversity of empirical results of the literature on the regional effects of public capital on private sector performance could, at least partially, be explained by the fact that they ignore spillover effects of public capital across regions. In fact, spillover effects should not be ignored when investigating the effects of public capital on private sector performance at the regional level, since public capital installed in one region might well have positive impact on the production of other regions. In other words, public capital in other regions could induce better accessibility of a region to the rest of country (Pereira and Andraz, 2006). Pereira and Roca-Sagalés (2003) and Pereira and Andraz (2006) found positive spillover effects of public capital for almost all regions for Spain and Portugal, respectively. The positive spillover effects arise from network effects from transport infrastructure. Since economic activities in different regions are spatially connecting, economic effects can diffuse through the transport network. Providing a new link or upgrading an existing link not only improve accessibility of the investment region, but also improve accessibility of other regions involved in the transport network. In a spatial econometric framework, positive spillover effects were confirmed by Cantos et al. (2007). Using US state-level data on highways, Jiwattanakalpaisarn et al. (2010) provide evidence of positive output spillovers from highway infrastructure in immediately adjacent more distant states. However, some studies found no clear evidence of positive linkage between public capital formation and private sector output at the regional level for some countries (Pereira and Roca-Sagalés, 2001). Our study aims to evaluate for the presence of regional spillovers of transport investment and to measure their magnitude both in the country as a whole and in specific parts of Iran. However, most of these studies do not estimate spillover effects subnational level, which would be more useful for the public decision making on the planning for large transport projects. Particular emphasis in this paper is the regional difference in the spatial effects of transport infrastructure on agricultural output. This paper attempts to contribute to the literature by examining the existence links between transport infrastructure investment and agricultural production in the state-level agricultural output of Iran. The structure of the paper is as follows. At the first section introduces the methodology and database to quantify spatial spillovers of transport investment in the Iran provinces, and it also presents the results. To improve our understanding of the regional differences in spillover, a deeper analysis of the changes in spillover effects of transport infrastructure among Iran five macro regions will be presented in the next section.

Materials and methods

In order to assess the role of different forms of infrastructures in regional economic performance, the empirical strategy pursued in this paper starts with a base line model, where the relationship between infrastructure and economic performance is modeled with a Cobb-Douglas production function. Our empirical strategy was to consider the production function as benchmark and then proceed with a specific approach by extending the empirical model with spatial interaction effect (Elhorst, 2013; Lesage and Pace, 2009). Therefore, the baseline empirical model is defined by the following equation:

$$Y_{it}=emp_{it}^{\beta Em}K_{it}^{\beta k}e_{it}^{\beta e}La_{it}^{\beta l}R_{it}^{\beta r}Ex_{it}^{\beta ex}GDP_{it}^{\beta g} \quad (1)$$

The SDM, which is the basis for the empirical analysis of equation 1, is of the form:

$$Y=\alpha\kappa+\rho Wy+X\beta+\theta WX+\varepsilon \quad (2)$$

Where Y is agricultural output; i and t are the indices of province and year respectively, where W is a contiguity matrix based on the inverse of geographical distance, ρ is the spatial lag (SAR) coefficient, X is the matrix of control variables, which include, θ is the vector of coefficient estimates associated with the spatially lagged independent variables and κ is a vector of ones. The SDM includes a spatial lag of the dependent variable as well as spatial lagged explanatory variables. Our empirical mode is thus:

$$\begin{aligned}\ln y_{it} = \rho \sum_{j=1}^{N} W_{ij} \ln y_{jt} + \alpha_0 + \alpha_1 \ln \text{employment}_{it} \\ + \alpha_2 \ln \text{Capital}_{it} + \alpha_3 \ln \text{energy}_{it} + \alpha_4 \ln \text{Land}_{it} \\ + \alpha_5 \ln \text{Road Stock} + \alpha_6 \ln \text{Export} + \alpha_7 \ln \text{GDP} \\ + \gamma_1 \sum_{j=1}^{N} W_{ij} \ln \text{employment} + \gamma_2 \sum_{j=1}^{N} W_{ij} \text{Capital}_{it} \\ + \gamma_3 \sum_{j=1}^{N} W_{ij} \text{energy}_{it} + \gamma_4 \sum_{j=1}^{N} W_{ij} \text{Land}_{it}\end{aligned}$$

$$+\gamma_5 \sum_{j=1}^{N} W_{ij} \text{Road Stock}_{it} + \gamma_6 \sum_{j=1}^{N} W_{ij} \text{Export}_{it}$$

$$+\gamma_7 \sum_{j=1}^{N} W_{ij} \text{GDP}_{it} + e_{it} \quad (3)$$

The SDM specification allows for spatial effects arising from the SAR of the dependent variable, the explanatory variables and a contagion effect:

$$y=(1-\rho W)^{-1}(\alpha\kappa+X\beta+\theta WX+\varepsilon) \quad (4)$$

The SDM is a general spatial model, which, in a restricted form, can be interpreted as a SAR model or SEM. The choice of this unconstrained specification was driven by LM tests and LR tests. The LR tests are each based on a restriction: in the quation 2, the first restriction, "$\theta = 0$" , which corresponds to the case of the SAR model; then, we tested a second restriction, the so-called common factor restriction ("$\rho\beta + \theta = 0$"), which implies the SEM. In particular, the SEM specification arises when the common factor restriction holds and spatial interaction among units of observation is spatial dependence in the disturbance process (Lesage and Pace, 2009). According to Lesage and pace (2009), the SDM specification contains spatially lagged values of both the dependent and the explanatory variables. They provided the theoretical framework to interpret these direct and indirect effects, by transforming the spatial weight matrix and considering the role of off and on diagonal elements. Inference of these measures was calculated, we apply Maximum likelihood (ML) in estimating spatial panel data models. The spatial panel model can be computed by the spatial econometrics library for MATLAB provided by Lesage. In this the study, we follow the Elhorst (2012) spatial model testing procedure to test which spatial model is preferred technically. Although Lagrange multiplier (LM) test shows a spatial lag model is preferred, the general test (LR test) recommends that a spatial Durbin model is more efficient. To provide a comprehensive view to robustness, estimations of both a spatial lag model and a spatial error model are summarized in the final results. The LR test results, as displayed in the Table 2, exhibit that both spatial fixed effect and time fixed effect are jointly significant. The spatial order rook contiguity weight matrix was constructed in a similar way (Haandrikman et al., 2010) but it also takes the neighbors of neighbors into account.

Data collection

The data used in this research are collected from a number of different from Iran sources, including the period from (1980-2015) the statistical Yearbook of Iran provinces. Data on transportation infrastructure include road investment. Transport investment (Road) data were generated from the Highway Statistics series published by the Management and Planning Government of Iran (MPO), and includes the investment outlay on interstate highway systems, other road and streets, and maintenance services. The index of agricultural output data (*Y*) is generated by physical quantities and market prices of crops that these data have been taken from Agricultural Statistical Yearbook. The index of capital input is determined from the provincial capital stock, while the index of employment input includes working hours of labor. The index of energy input consists of fuel consumption for agriculture sector. The index of land input measures the intertemporal price index of the land. The capital, energy and land data have been provided from Iran Statistical Yearbook. The data of Karaj is combined with those of Tehran province until 2006. We use data from a panel of 30 Iran provinces for the period 1980-2015 on agricultural output, capital, employs labor, energy, land, transport infrastructure investment and public investment, export, and gross domestic production (GDP). The descriptive each statistics of each variable are summarized in the Table 1.

Variables	Mean	Std.dev.	Min	Max
Capital	37.26	0.54	12	63.6
empolyment	7.73	0.32	1.9	14.2
energy	45.87	0.78	16.5	76.8
Land	31.15	1.05	11.8	40.8
Road Stock	44.97	1.63	28	65.2
Export	30.96	0.84	18	45.6
GDP	10.91	0.62	9.6	14.7

Source: own processing

Table 1: Summary statistics of variables in logs.

Results and discussion

In order to compare the changes of the spillover effects over time, we also ran the spillover effects over time, and the next section we also ran the spillover effects model for three sub-times, 1980-1991, 1992-2003, and 2004-20015, respectively. The key results at the national and regional levels are presented in the Table 2, 3, 4. In this study, statistical significance at the 5% level; those variables and test statistics are henceforth referred to as significant in the discussion below.

Spillover effects at the national level

The results for the model 1 in the Table 2 show that labor, land, and energy affect a state's agricultural output. An increase in road disbursement has significant effect on agricultural output. However, the model 4 does not capture the spatial interaction effects among variables, which may produce biased estimations. This study adopted the bias-correction method proposed by Lee and Yu (2010) to capture unbiased estimator in the presence of spatial and time period fixed effects. The Table 2 displays estimation results of the regional impacts of total public transportation infrastructure from OLS with fixed effect, SEM, SAR, and SDM with spatial fixed effect. The null hypothesis of the LR test for joint significance of spatial fixed effects is rejected, as a result the model should include spatial fixed effects (SDM). In the non-spatial model, the general impact of transportation infrastructure is 0.051, which is lower than the result in SDM, SEM and SAR. The spatial lags of independent variables are highly statistically significant in the SDM model the Table 2 except spatial lag of GDP. Spatial lag of employment and energy is found to be the most important factor for agricultural output. The result of the SDM model show that capital, energy, road stock affect a province's agricultural output. The direct and spillover effects of the parameters using the decomposition approach discussed in the methodology section were estimated with four different neighbor contiguity in the Table 3. The results show that spillover effect of private capital has positive and significant effect at the 5% level for the second nearest neighbor. The total effect of employment is 0.37 indicates that employment play a key role in agricultural output under second nearest neighbor. Land was observed to have a negative and significant total effect on agricultural output. The direct and spillover effects of land on agricultural production is negative under all weight matrices. This negative impact may result from productivity growth indicating that less land are required to increase agricultural production (Ball et al., 1997). In terms of spillover effect comparison, the road stock variable has both significant and positive direct and indirect effects. The spillover effect of road output elasticity is 0.16, which exhibits that an one percent increase in highway infrastructure is associated with a 0.16 percent increase in agricultural output at the second order of contiguity neighbor. This finding implies that instead of a negative spillover effects (Boarnet, 2002), public highway infrastructure has a positive spillover effects on output elasticity. The Table 3 also indicates that a 1% increase in energy input in a province increases agricultural output by 0.20-0.38% using second nearest neighbor. As hypothesized, a statistically significant spillover effect of road infrastructure is found. However,

	SDM	SEM	SAR	Pooled OLS
	Spatial Fixed	Spatial Fixed	Spatial Fixed	Fixed effects
Capital	0.195(0.01)*	0.174(0.00)*	0.166(0.00)*	0.188(0.00)*
employment	0.343(0.01)*	0.284(0.00)*	0.292(0.05)*	0.303(0.01)*
energy	0.315(0.00)*	0.317(0.00)*	0.332(0.00)*	0.326(0.00)*
Land	-0.126(0.00)*	-0.104(0.01)*	-0.112(0.00)*	-0.108(0.00)*
Road Stock	0.071(0.01)*	0.063(0.00)*	0.058(0.00)*	0.051(0.04)*
Export	0.095(0.21)	0.091(0.00)*	0.098(0.31)	0.096(0.06)
GDP	0.086(0.04)*	0.081(0.08)	0.078(0.01)*	0.076(0.05)*
Capital.splag	0.126(0.05)*	0.119(0.04)*	0.125(0.01)*	0.128(0.00)*
employment.splag	0.351(0.01)*	0.286(0.00)*	0.348(0.12)	0.361(0.03)*
Energy.splag	0.327(0.00)*	0.291(0.04)*	0.327(0.07)	0.376(0.01)*
Land.splag	-0.083(0.01)*	0.079(0.12)	-0.081(0.00)*	0.086(0.10)
Road Stock.splag	0.119(0.03)*	0.126(0.00)*	0.124(0.02)*	0.117(0.00)*
Export.splag	0.065(0.05)*	0.071(0.16)	0.068(0.09)	0.074(0.04)*
GDP.splag	0.074(0.12)	0.079(0.04)*	0.081(0.01)*	0.083(0.26)
LR Spatial fixed effects test	1750(0.00)*			
LR Time period fixed effects test	312.06(0.00)*			

Note: P-value is in parenthesis.*Statistical significance at the 5% level.

Source: own processing

Table 2: Estimation results of panel data with spatial interaction effects.

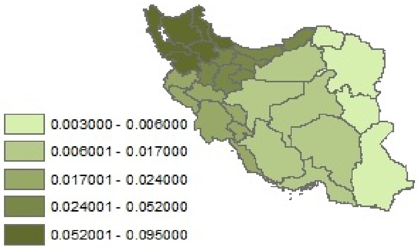
	Direct effect		Indirect effect		Total effect	
Spatial weight matrix	Coef	P-Value	Coef	P-Value	Coef	P-Value
Nearest neighbor 1						
Capital x W_1	0.141	(0.00)*	0.125	(0.05)*	0.196	(0.00)*
employment x W_1	0.227	(0.04)*	0.329	(0.00)*	0.389	(0.01)*
energy x W_1	0.246	(0.05)*	0.316	(0.03)*	0.393	(0.01)*
Land x W_1	-0.105	(0.00)*	-0.098	(0.00)*	-0.146	(0.05)*
Road Stock x W_1	0.114	(0.15)	0.104	(0.24)	0.179	(0.06)
Export x W_1	0.086	(0.00)*	0.094	(0.02)*	0.125	(0.14)
GDP x W_1	0.075	(0.04)*	0.106	(0.26)	0.125	(0.05)*
Nearest neighbor 2						
Capital x W_2	0.069	(0.03)*	0.086	(0.00)*	0.115	(0.05)*
employment x W_2	0.217	(0.03)*	0.278	(0.21)	0.386	(0.24)
energy x W_2	0.209	(0.19)	0.337	(0.01)*	0.385	(0.01)*
Land x W_2	-0.075	(0.01)*	-0.125	(0.04)*	-0.106	(0.17)
Road Stock x W_2	0.056	(0.00)*	0.166	(0.00)*	0.174	(0.05)*
Export x W_2	0.046	(0.12)	0.091	(0.05)*	0.138	(0.00)*
GDP x W_2	0.096	(0.00)*	0.084	(0.09)	0.192	(0.00)*
Nearest neighbor 3						
Capital x W_3	0.109	(0.00)*	0.145	(0.19)	0.214	(0.01)*
employment x W_3	0.238	(0.25)	0.232	(0.01)*	0.397	(0.04)*
energy x W_3	0.262	(0.01)*	0.256	(0.08)	0.465	(0.17)
Land x W_3	-0.106	(0.04)*	-0.098	(0.00)*	-0.127	(0.00)*
Road Stock x W_3	0.102	(0.00)*	0.154	(0.03)*	0.277	(0.00)*
Export x W_3	0.093	(0.24)	0.126	(0.00)*	0.168	(0.09)
GDP x W_3	0.104	(0.01)*	0.082	(0.08)	0.143	(0.00)*
Nearest neighbor 4						
Capital x W_4	0.148	(0.02)*	0.108	(0.00)*	0.203	(0.35)
employment x W_4	0.208	(0.08)	0.313	(0.03)*	0.401	(0.00)*
energy x W_4	0.256	(0.05)*	0.222	(0.15)	0.468	(0.08)
Land x W_4	-0.043	(0.00)*	-0.064	(0.04)*	-0.096	(0.14)
Road Stock x W_4	0.104	(0.01)*	0.115	(0.05)*	0.148	(0.04)*
Export x W_4	0.054	(0.07)	0.087	(0.03)*	0.135	(0.00)*
GDP x W_4	0.076	(0.14)	0.107	(0.25)	0.116	(0.00)*

Note: P-value is in parenthesis.*Statistical significance at the 5% level.

Source: own processing

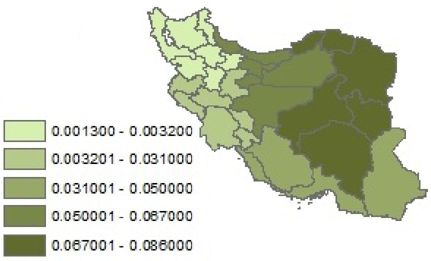
Table 3: Direct and indirect effects of SDM results with different weight matrices.

the significance of spillover effects of road infrastructure on a state's agricultural output is not consisting over the four spatial weight models. When using a spatial weight matrix considering for the all neighbor states, the spillover effect of road stock is not significant effect for order one. However, when the neighboring provinces are extended by including one more layer of adjacent states in the second, and third order, the spillover effect of road disbursement becomes significant. Combining the positive and significant direct and spillover effects of road disbursement under second order, a 1% increase in road investment in a particular province increases the agricultural output across all provinces by 17%. The significant spillover or total effect of transportation infrastructure on a state's agricultural output are found when further adjacent layer were considered as the forth neighbor states. The spillover effects of Fars and Mazandaran are the largest (0.18%), suggesting an improvement in the road investment in these two states respectively would have higher spillover effects on the agricultural output of other provinces based on the estimated parameters using the second nearest neighbor (see Figures 2 a, b).



Source: own processing

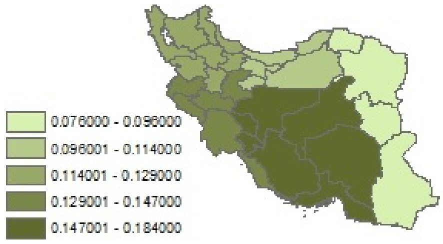
Figure 1a: The spillover effect from %1 percent change in road stock in East Azarbaijan province.



Source: own processing

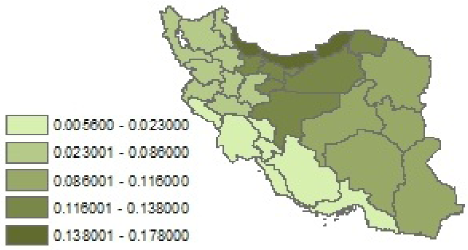
Figure 1b: The spillover effect from a %1 change in road stock in Razavi Khorasan province.

The spillover effects of road stocks in Esat Azarbaijan province have relatively low spillover effects on the agricultural output of other provinces because of the geographic location of those provinces. Figure (1a, b) show the spillover effects pattern associated with a 1% increase in road investment in East Azarbaijan and Razavi Khorasan provinces, respectively. Both figures show that the spillover effects extend across through the whole nation but diminish as the order of neighbor increases. The spillover effects of the investment in East Azarbaijan as the order of neighbor increases. The spillover effects of the investment in East Azarbaijan expand to center but decline after the first order neighboring provinces while the spillover effects of the investment in Mazandaran spread out in all directions and stay sustainable until reaching those boundary. The spatial spillover effects of improvements or investment in transportation infrastructure in a given state on the output of other states can be explained as the improvement of efficiency of the inputs (Cohen, 2010) or in the geographical distribution of economic activities (Kemmerling and Stephan, 2008; Duranton and Tunet, 2012). For instance, improved road infrastructure in Mazandaran province can increase the availability of input factors for other agricultural states, Gilan province (nearest province to Mazandaran province) therefore improving production in those provinces. The results in Figures 1a, 1b and 2a, b indicate that the amount and structure of spatial spillover effects. The positive and significant impacts of the spillover effect of road investment found under second nearest neighbor, but not observed under first nearest neighbor" " can be connected to the feature of Iran agriculture. Macro-regions in Iran are shown in the Figure 3.



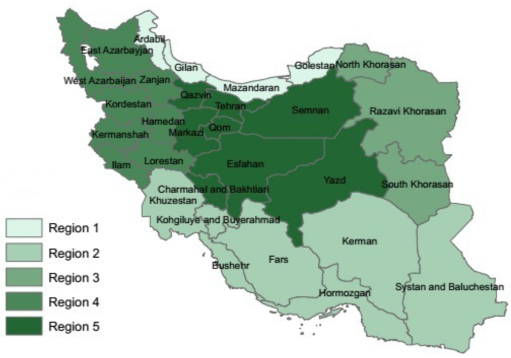
Source: own processing

Figure 2a: The spillover effect with a %1 change in road stock in Fars province.



Source: own processing

Figure 2b: The spillover effect with a %1 change in road stock in Mazandaran province.



Source: own processing

Figure 3: Macro regions in Iran.

The Table 3 reports the results of the estimation of the spatial Durbin model, and we can find that the coefficients of the labor employment, energy, capital stock are positive and significant. In the terms of the spatial lagged independent variables, the agricultural output is a positive function of public capital, and transport infrastructure endowment in the neighboring provinces, also the spillover effects of labor is positive and significant. However, these estimators just provide an idea of interactions among provinces, thus we provide the sign and amount of the direct and indirect impacts in order to provide the accurate spillover effects, particularly associated with transport infrastructure in the Table 3. Using these alternative weight matrices to determine capital stock, energy spillover effect, we find that different spatial weight schemes have positive effect on agricultural output. The results also provide a reasonable estimate for the employment and energy factor, which indicates that labor and energy input growth has the largest impact on Iran real agriculture growth. This finding implies that the spillover effects played an important role in raising agricultural production because of transport network expansion. This expansion helps brings indirect externalities due to the development of transport network accessibility.

Spillover effects at the regional level

Considering mostly on the spillover effect of transport infrastructure (represented by φ), as can be determined distinctly in the Table 4, the elasticities of the spillovers differ considerably across regions in the entire time under study (the coefficients are, 0.15 and 0.09 for the region 1 and 5, respectively). When we compare our results for the three sub-term, we can observe that the changes in spillovers differ considerably among these regions. The neighboring transport investment will lead to positive effects in the region 4 (western region), and the output elasticity is, 0.06 (coefficient is statistically significant), which means the agricultural output will increase by 0.06% if the transport stock in the neighboring region increases by one percent at the second time while the road disbursement have no significant effect for the first time. For the region 2 (south region), the transport stock in the neighboring region has a positive external impact during the considering time. The regression results illustrate that the agricultural production elasticities of neighboring transport infrastructures for the three times are significant and positive (the coefficients are 0.16, 0.16, 0.18). For the region 5 (central region), no significant spillovers can be found in time 2, but positive spillovers can be observed in the first time (the coefficient is 0.09). In the last time, positive externalities can be found (the coefficient is 0.10). In the region 1 (north region), the estimated coefficients of spillovers are 0.13 during 1980-1991, 0.17 during 1992-2003, 0.16 during 2004-2015, which means that the growth of the transport stock in neighboring regions actually had a positive impact on agricultural output in the north region all the time. For the region 3 (eastern region), the results show that agricultural output elasticities of neighboring transport investments are significant (0.04, 0.08, 0.06), which indicates transport investment of neighboring regions had a positive impact on agricultural output in the eastern region all the time. Our paper adopted an advanced spatial Durbin model, considering both the spatial lagged dependent and independent variables: meanwhile the spatial spillovers from all the regions were measured in our study, which could make our estimators are more precise and persuasive. The different definitions of regions may also cause the incompatible results. In order to underline the spatial factors, five macro regions are classified considering the geographic position according to agricultural output level, which would make our estimate results of the spatial spillovers more realistic. The results from this study confirm the existence of spillover effects of transport infrastructure for the case of Iran. More specifically, changes in the spillovers between Iran's regions over time can be observed. For the aim of an in depth analysis in the regional difference in spatial spillovers, we will next investigate how the spillovers of transport infrastructure influence on agriculture output in Iran at the regional level. This study confirms the existence of spillover effects of transport infrastructure for the case of Iran. More specifically, changes in the spillovers between Iran's regions over time can be seen. For the aim of an in accurate analysis in the regional difference in spatial spillovers, we will next consider how the spillovers of transport infrastructure influence on agriculture output in Iran at the regional level.

Regions	Variables	1980-2015	Time 1	Time 2	Time 3
Region1	Capital	0.164(14.56)***	0.055(16.62)***	0.176(10.82)***	0.148(11.37)***
(North Region)	employment	0.233(15.46)***	0.291(12.31)***	0.241(14.96)*	0.312(12.30)**
	energy	0.362(25.16)***	0.32(21.17)***	0.373(17.58)***	0.256(16.44)***
	Land	-0.075(3.45)**	-0.126(4.86)***	-0.043(3.32)**	-0.126(4.65)*
	Road Stock	0.049(12.78)***	0.068(10.61)***	0.045(4.76)**	0.076(14.75)***
	Export	0.115(2.24)**	0.087(1.45)	0.064(2.87)**	0.142(3.54)***
	GDP	0.096(1.86)	0.108(3.67)***	0.087(4.54)***	0.128(6.87)***
	ρ	0.263(10.42)**	0.283(8.74)***	0.247(20.53)***	0.217(4.75)**
	Capital.Splag	0.187(5.27)***	0.012(2.98)**	0.143(2.64)**	0.045(2.26)*
	employment. Splag	0.318(1.94)*	0.283(4.28)***	0.361(2.63)**	0.293(6.54)***
	Energy.Splag	0.284(4.32)***	0.365(5.97)***	0.345(2.64)**	0.384(2.37)**
	Land.Splag	-0.016(4.46)***	-0.023(6.74)***	-0.028(2.44)***	-0.014(8.35)***
	Road Stock. Splag	0.085(3.25)***	0.068(8.36)***	0.042(2.58)**	0.092(6.48)***
	Export.Splag	0.178(4.48)***	0.096(2.68)**	0.164(1.75)	0.215(9.47)***
	GDP.Splag	0.084(9.70)***	0.057(1.53)	0.093(4.63)***	0.126(4.52)***
	φ	0.156(10.28)***	0.136(2.46)**	0.176(8.34)***	0.161(8.69)***
	Adj.R^2; Log Likelihood	0.546; 145.45	0.745; 128.64	0.456; 110.54	0.610; 132.43
Region2	Capital	0.212(8.34)***	0.155(7.15)***	0.078(3.84)**	0.146(10.93)***
(South Region)	employment	0.356(7.24)***	0.242(9.45)***	0.236(14.36)***	0.311(5.42)***
	energy	0.361(12.54)***	0.424(15.63)***	0.413(2.36)**	0.253(2.67)**
	Land	-0.087(14.46)***	-0.145(10.89)***	-0.091(16.75)***	-0.126(9.65)***
	Road Stock	0.098(15.71)***	0.096(4.56)***	0.043(8.32)***	0.067(6.41)***
	Export	0.175(8.54)***	0.096(12.85)***	0.164(2.64)**	0.156(1.86)
	GDP	0.078(2.46)**	0.054(1.63)	0.108(4.56)***	0.114(2.23)**
	ρ	0.185(8.54)***	0.196(2.34)**	0.127(6.95)***	0.148(8.75)***
	Capital.Splag	0.065(13.08)***	0.085(8.76)***	0.105(14.53)***	0.0951(5.43)***
	employment. Splag	0.303(14.67)***	0.316(12.43)***	0.356(9.45)***	0.287(2.34)**
	Energy.Splag	0.345(2.62)**	0.365(5.36)***	0.278(7.15)***	0.343(2.03)*
	Land.Splag	-0.020(13.76)***	-0.145(21.64)***	-0.167(10.76)**	-0.135(9.45)***
	Road Stock.Splag	0.175(6.53)***	0.174(16.43)***	0.145(12.45)***	0.179(2.74)**
	Export.Splag	0.156(6.14)***	0.114(2.48)**	0.063(13.93)***	0.084(3.79)***
	GDP.Splag	0.086(2.18)**	0.105(1.34)	0.065(2.54)**	0.147(6.85)***
	φ	0.168(7.34)**	0.162(9.56)**	0.164(2.46)**	0.184(4.76)***
	Adj.R^2 , Log Likelihood	0.845; 164.35	0.657; 184.85	0.762; 143.76	0.754; 156.74
Region3	Capital	0.176(12.43)**	0.225(8.45)***	0.174(10.53)***	0.193(8.65)***
(Eastern Region)	employment	0.315(13.87)***	0.269(3.67)**	0.324(1.84)	0.305(2.03)*
	enrgy	0.346(9.32)***	0.302(10.76)***	0.357(9.53)***	0.317(12.35)***
	Land	-0.08(10.49)***	-0.12(2.04)*	-0.04(4.56)***	-0.12(3.74)**
	Road Stock	0.046(16.86)***	0.065(10.75)***	0.046(2.67)**	0.052(2.16)*
	Export	0.071(2.68)**	0.098(8.53)***	0.146(1.68)	0.125(9.52)***
	GDP	0.076(10.42)***	0.044(1.57)	0.095(2.34)**	0.085(1.48)
	ρ	0.167(9.34)***	0.213(10.48)***	0.185(8.74)**	0.246(8.33)***
	Capital.Splag	0.115(2.56)**	0.068(3.44)**	0.092(1.80)	0.108(3.78)**
	employment. Splag	0.385(7.35)***	0.316(14.52)***	0.306(20.45)***	0.308(14.36)***
	Energy.Splag	0.357(12.56)***	0.348(10.84)***	0.329(6.52)***	0.311(9.83)***

Note: t-statistics are given in parenthesis. Time1, Time2, Time3 represent respectively. Numbers of observations equals to numbers of provinces in each region multiplied by analysis period. Here, we calculated and reported the indirect effect (spillover effects) of transport infrastructure for each region in different times, represented by φ. *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.
Source:

Table 4: Estimation of the Spatial Durbin model at the five selected region (to be continued).

Regions	Variables	1980-2015	Time 1	Time 2	Time 3
	Land.Splag	-0.128(2.34)**	-0.236(3.56)***	-0.104(6.78)***	-0.805(8.56)***
	Road Stock.Splag	0.055(8.67)***	0.076(9.63)***	0.042(6.52)***	0.067(2.03)*
	Export.Splag	-0.045(8.54)***	0.067(2.65)**	-0.086(10.32)***	-0.063(2.75)**
	GDP.Splag	0.037(4.76)***	0.042(2.64)**	0.125(6.98)***	0.104(2.35)*
	φ	0.065(13.41) ***	0.044(1.58)	0.078(2.11)**	0.062(8.64)***
	Adj.R^2, Log Likelihood	0.647; 143.65	0.538; 137.87	0.692; 165.79	0.718; 125.97
Region4	Capital	0.232(10.30)***	0.155(9.71)***	0.178(4.33)***	0.214(7.81)***
(Western Region)	employment	0.255(7.65)***	0.198(8.54)**	0.214(2.24)*	0.289(7.32)***
	energy	0.535(14.34)***	0.427(15.68)***	0.372(6.78)***	0.345(2.56)**
	Land	-0.082(12.56)***	-0.125(14.53)**	-0.149(8.69)**	-0110(2.93)**
	Road.Stock	0.048(9.56)***	0.075(6.84)***	0.063(11.57)**	0.053(2.32)**
	Export	0.064(2.05)*	-0.045(5.84)***	0.051(8.65)***	0.014(4.96)***
	GDP	0.106(4.76)***	0.145(1.95)	0.116(7.65)***	0.167(1.06)
	ρ	0.154(6.84)***	0.116(4.89)***	0.162(8.65)***	0.247(2.25)**
	Capital.Splag	0.168(2.34)**	0.147(3.76)**	0.239(7.68)***	0.204(4.31)**
	employment. Splag	0.345(15.46)***	0.312(1.98)	0.245(2.74)**	0.275(1.73)
	Energy.Splag	0.376(7.55)***	0.312(10.93)**	0.289(11.46)**	0.323(4.58)**
	Land.Splag	-0.097(2.58)**	-0.116(6.87)**	-0.156(8.51)**	-0.198(2.31)**
	Road Stock.Splag	0.043(13.64)***	0.074(4.56)***	0.076(6.85)***	0.088(10.62)***
	Export.Splag	-0.068(4.27)***	0.054(2.05)**	0.084(6.87)***	0.094(1.96)
	GDP.Splag	0.157(2.85)**	0.086(6.94)***	0.063(1.63)	0.154(4.52)***
	φ	0.075(2.06)**	0.048(1.65)	0.063(2.91)**	0.046(8.54)***
	Adj.R^2, Log Likelihood	0.578; 154.67	0.703; 175.64	0.682; 183.76	0.533; 164.43
Region5	Capital	0.265(12.54)***	0.146(10.32)***	0.178(9.81)***	0.207(14.26)***
(Central Region)	employment. Splag	0.352(8.13)***	0.245(12.45)***	0.226(10.67)***	0.316(8.43)***
	energy	0.317(15.43)***	0.295(4.84)***	0.334(14.52)***	0.268(12.31)***
	Land	-0.185(6.84)**	0.094(2.78)**	-0.126(9.68)***	-0.195(4.67)***
	Road Stock	0.074(8.72)***	0.054(10.43)***	0.056(2.96)**	0.066(4.54)***
	Export	0.134(2.89)**	0.086(5.96)***	0.157(2.06)*	0.124(9.85)***
	GDP	0.178(6.72)***	0.126(1.04)	0.087(1.98)	0.143(4.54)***
	ρ	0.183(2.45)**	0.156(5.89)***	0.129(9.46)***	0.174(2.36)**
	Capital.Splag	0.213(2.75)***	0.106(2.26)***	0.094(6.45)***	0.105(10.48)***
	employment. Splag	0.246(10.82)**	0.187(12.65)**	0.168(2.14)**	0.134(1.89)*
	Energy.Splag	0.258(9.86)**	0.179(2.57)**	0.217(6.38)***	0.196(2.86)**
	Land.Splag	-0.153(16.45)**	-0.091(12.87)***	-0.105(3.79)**	0.184(2.15)*
	Road Stock.Splag	0.114(7.14)**	0.128(2.74)**	0.148(9.43)***	0.106(10.58)***
	Export.Splag	-0.065(2.65)**	0.053(9.76)***	0.086(4.86)***	0.094(1.64)
	GDP.Splag	0.102(1.08)	0.145(2.86)**	0.096(2.64)**	0.118(5.86)***
	φ	0.094(8.63)***	0.098(5.87)***	0.041(1.35)	0.106(2.46)**
	Adj.R^2, Log Likelihood	0.604; 173.6	0.534; 184.5	0.627; 164.3	0.598; 174.56

Note: t-statistics are given in parenthesis. Time1, Time2, Time3 represent respectively. Numbers of observations equals to numbers of provinces in each region multiplied by analysis period. Here, we calculated and reported the indirect effect (spillover effects) of transport infrastructure for each region in different times, represented by φ. *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.
Source:

Table 4: Estimation of the Spatial Durbin model at the five selected region (continuation).

Conclusion

The effects of transportation infrastructure on agricultural output for 30 Iran provinces from 1990-2015 are estimated in this study. The SDM based on four different weight matrices is employed to evaluate spatial dependence in both dependent and independent variables. The positive spillovers exist at regional level, but the Iran's regions have considerable difference in their spatial spillovers across the different times under analysis. The existence of spatial externalities emerging from the contribution of transport infrastructure to agricultural output implies that the decision by altering investment patterns in the transport infrastructure relative.

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Geoinformatics and Crowdsourcing in Cultural Heritage: A Tool for Managing Historical Archives

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Abstract

Archives of historical photographs have a great potential for "geo- or spatial sciences", for they can provide highly relevant visual data on historical landscapes, populated places and settlement structures, including those now destroyed. Processing of these archives represents many challenges, among them the application of geoinformatic concepts and information technologies. The article presents the example of geo-referencing, crowdsourcing, and other computer-based technologies applied to the archival photographs of today-destroyed sites on the Czech – Bavarian border, where many villages, farm sites and monuments were destroyed in the 1950s or abandoned as a consequence of post-WWII development. In the situation of dramatically changing landscape and land use, historical photographs are an important source of documentation for both research and virtual reconstruction of disappeared places, landscape, and society.

Keywords

Geo-referencing, historical photographs, crowdsourcing, landscape reconstruction, cultural heritage, image analysis, digital humanities, digital archive, IT methods in cultural heritage, 3D reconstruction, destroyed cultural heritage.

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Introduction

Landscape and land use in the Czech Republic have changed significantly during the past hundred years, i.e. in the "contemporary" or "recent past" (Harrison and Schofield, 2010; Holtorf and Piccini eds., 2011; Krajíc et al., 2017; Vařeka, 2013). Turbulent social and historical development associated with the outcomes of World War I and II, such as the expulsion of the German population (Ahonen, 2010; Arburg, 2005; Glassheim, 2016; Staněk, 1991; Vařeka et al., 2008), settlement of newcomers (Pešek, 1986a; Pešek, 1986b; Pešek, 1986c; Pešek, 1986d), Socialist regime's collectivization (Blažek and Kubálek, 2008) and closing of the border and the construction of the Iron Curtain (Jílek and Jílková, 2006; McWilliams, 2013), transformed human lives, local social structure, and, especially in the border regions, the rural landscape defined by economic and agricultural production.

Important witnesses of these dynamic processes are historical photographs in the archival collections that reflect cultural, social and economic developments, nature, and climate changes, and provide visual sources for the interpretation of past events, activities and situations. Moreover, historical photographs are emotional documents and media of memory of the past that re-enact historical situations in the photographic medium. Besides the existence of specialized photographic archives, regional archives and museums hold an increasing number of photographs, images and digitized visual material documenting past situations. Preserving and presenting this rich material is one of the most important contemporary challenges in archival science. Interpreting historical photographs needs research environment, in which they are embedded, consisting of technical and content information (meta-data) as well as references to spatial and temporal contexts in which they were taken, and other relevant textual data, documentation and retrieval functionalities.

This means that the digitisation of archives is not the only task today, but also the improvement of documentation is needed to make archival material accessible and usable for research.

The aim of the article it to present the interdisciplinary approach and the first results of the Czech-Bavarian project PhotoStruk, focusing on geo-informatics and crowdsourcing as computer-based methods to speed up the process of classification and meta-data documentation of archives of historical photographs. Together with methods of non-destructive archaeology and history, they support research into the reconstruction of abandoned settlements, and lost historical landscape, and cultural monuments of the Šumava (Böhmerwald) border region. The region on the south-eastern border of the Czech Republic suffered from the abrupt social and economic changes as a consequence of the post-WWII development: expulsion of Germans and only partial re-settlement by Czechs, fundamental change in land use due to the reforestation, creation of military zone and destruction of numerous villages, farms, and sites. The IT method and tools are tested on a collection of photographs from the archive of the Museum Fotoateliér Seidel in Český Krumlov, Czech Republic. A family-held photographic atelier archive, it contains 140 000 photographs taken from the late 19th century until the 1950s. Historical photographs of Fotoateliér Seidel have not yet been systematically investigated in the research of extinct villages in the mountainous region of Šumava. Its digitized collection contains images of today-destroyed or abandoned villages in the region that provide valuable information for the virtual reconstruction of the sites, but also a number of undocumented and wrongly-tagged images that will be newly reassessed in the framework of the project, and valorized for their information value.

The article presents the first results of the Czech-Bavarian project PhotoStruk, focusing on geo-informatics and crowdsourcing as computer-based methods to speed up the process of classification and meta-data documentation of archives of historical photographs. Together with methods of non-destructive archaeology and history, they support research into the reconstruction of abandoned settlements, and lost historical landscape, and cultural monuments of the Šumava (Böhmerwald) border region. The region on the south-eastern border of the Czech Republic suffered from the abrupt social and economic changes as a consequence of the post-WWII development: expulsion of Germans and only partial re-settlement by Czechs, fundamental change in land use due to the reforestation, creation of military zone and destruction of numerous villages, farms, and sites. The IT method and tools are tested on a collection of photographs from the archive of the Museum Fotoateliér Seidel in Český Krumlov, Czech Republic. A family-held photographic atelier archive, it contains 140 000 photographs taken from the late 19th century until the 1950s. Historical photographs of Fotoateliér Seidel have not yet been systematically investigated in the research of extinct villages in the mountainous region of Šumava. Its digitized collection contains images of today-destroyed or abandoned villages in the region that provide valuable information for the virtual reconstruction of the sites, but also a number of undocumented and wrongly-tagged images that will be newly reassessed in the framework of the project, and valorized for their information value.

Material and methods

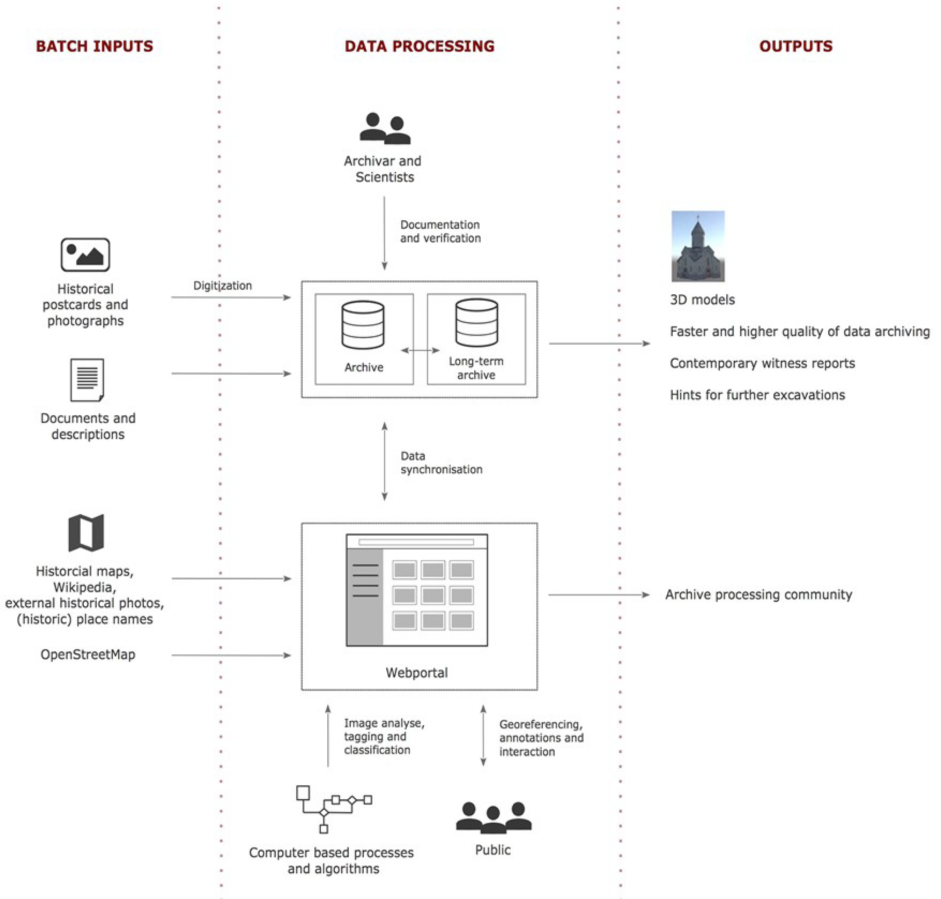
Photographs provide a rich source for identification of spatial changes over a period of time, such as development of historical landscape situations, settlements and buildings. Disciplines such monuments protection, landscape planning, as well as geomorphology, history and archaeology widely use them (Turner, 1990, Kadmon and Harari-Kremer, 1999, Chandler and Brundsten, 1995, Yilmaz et al., 2007, Arias et al., 2006, Estes et al., 1977). Tagging of books with a geo-reference to provide spatial metadata is an established approach in archival sciences (e.g. Lu et al., 2010). In terms of computer-based crowdsourcing, first attempts using it to interpret historical photographs have already been made. Kalfatovic et al. (2009) published images from the archive collection on the photographic platform Flickr to study public interaction with historical images, and to explore how this can help improving meta documentation. The project generated a huge public interest and a large number of data were provided by the public. Due to the technical limitation of the Flickr platform, user interaction was restricted to writing comments on the photographs, which had to be analysed manually for the extraction of semantic and spatial information. Crowdsourcing and geo-referencing was also applied to historical maps (Bill et al., 2015), indicating that the public can contribute to handle large amounts of archival data.

From the perspective of geomatics, the main difference between geo-referencing of maps by Bill et al. (2015) and Kalfatovic et al. (2009) is the level of accuracy, and the concept of sourcing geospatial information. Collecting geonames from comments, as applied by Kalfatovic et al. (2009), can provide spatially vague results, because geonames refer to either smaller or larger areas (theoretically ranging from field names to the names of districts or states). Working with coordinates for geo-referencing of maps, as used by Bill et al. (2015), requires skills in the interpretation of maps and forces the user to decide on a particular location (identified by the coordinates), where the user may possess only a vague or imprecise geospatial knowledge. His or her contribution can still be helpful, if he or she can provide at least some limited information, e.g. geonames in a comment[1]. The combination of both concepts may (1) be used to make crowdsourcing system accessible for a broader audience without map-reading skills, and can (2) be used to improve step by step the quality of geospatial information by narrowing down geonames to geo-coordinates involving information by several different users. To overcome technical and legal problems in using established platforms such as Flickr, the PhotoStruk team has developed own web application that integrates comments and geonames as well as geo-referencing based on maps and coordinates to provide a suitable data for 3D reconstructions of lost buildings and villages (Remondino and Campana, 2014).

Project rationale

Our project develops tools, which combine computer-based technologies to better extraction of valuable spatial and content metadata from the archive stocks (Figure 1). The project is based on the assumption that by means of automated image analysis, geo-referencing and crowdsourcing, a faster and more targeted access to the photographic archive material can be provided for the public, and a number of new metadata acquired, or improved in return. The project regards crowdsourcing as the computing method capable of mediating the knowledge

[1] Applications such as photogrammetry (Arias et. al., 2006, Yilmaz et. al., 2007) or monoplotting (Bozzini et al., 2011) to the images require a higher quality of geo-referencing too.



Source: own composition

Figure 1: Project concept.

of regional experts, local, and informed people (Košátková, 2011).

The project combines algorithmic approaches with controlled user interaction to generate documentation to historical photographs, and open up archives to the public interest. To achieve its goal, digitized photographs from an archive are made accessible through a specially designed web platform. This allows the interested public to access to the archived images and data, and invite the interaction in the form of comments and annotations, locating and geo-referencing on the map or providing other types of data, e.g. (historical) place names, identifications or texts. The crowdsourcing tool thus gives the broad public the opportunity to participate in research and identify displayed objects, locate them on a map and set up the photographer`s point of view (Figure 2).

- Batch inputs

  Partners of the PhotoStruk project (e.g. Museum Fotoatelier Seidel) are the main sources of data, which can be sent in batches. Data can also be digitized from non-digital sources.

- Archive

  The core of PhotoStruk is a long-term archive, which contains all the data, and its descriptions. Only authorized archivists and specialists can access this archive. They verify and complete the data and decide, which data can be made accessible to the public via the web portal.

- 3D modelling

  The projects also aims to analyse existing and newly-generated metadata, and use them for 3D modelling of lost monuments and building structures. 3D models of historical objects will be made accessible to the public via the web portal.

- Webportal

  The web portal is the central platform accessible to the public. Everyone can not only view the historical data, 3D models, images, and maps, but also add other data or images, and complete or correct the existing ones. This facility is based on the assumption that this contribution by public (known as citizen science) will be a valuable asset to the meta data documentation. Except the public, other external resources, e.g. Wikipedia and Geonames (geographical database), can be used to draw information from.

- Map

  The interactive map, and the facility to locate data and images on the map is the most essential part of PhotoStruk. The map has an additional dimension - time. Users can travel in time back and forth, and see the countryside of the specific periods, data related to the period, and photographs of that time.

- Data exchange

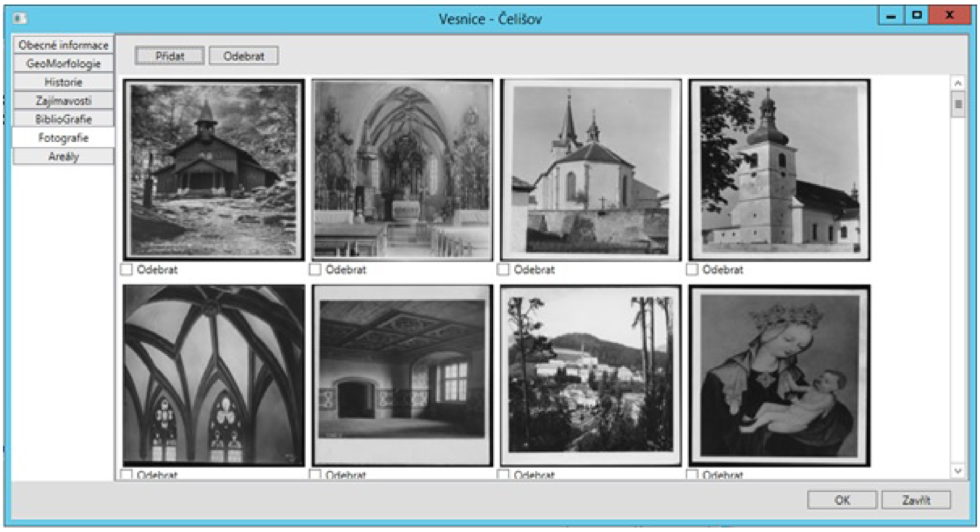
  The data sets of the archive and web portal are managed in two standalone databases, which have no direct access to each other. A controlled data exchange process allows data transfer without overriding any data sets. The database of the web portal is designed for geoinformation system operations. After verification of spatial and semantic metadata, the information is stored in the archive.

- Application for archivists and specialists

  The only people who have access to the archive are archivists and authorised specialists, who have to get authorization before accessing the archive. They work with the archive data with the help of the application created directly for them (Figure 3).

Source: Museum Fotoatelier Seidel, OpenStreetMap

Figure 2: Approach of image orientation and georeferenzing of depicted objects.



Source: J. Fesl

Figure 3: Image assignment to a specific village.

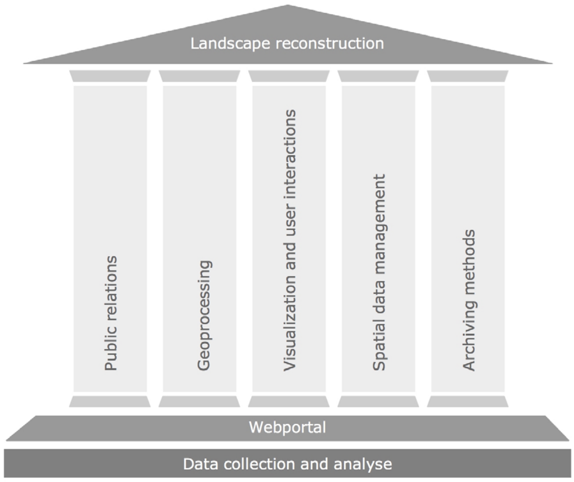
The web portal interface consists of the following main screens:

- Main webpage provides the access to system functionalities
- Fast villages overview - shows the basic information about all villages (i.e. sites) in the database
- GPS coordinates selection dialogue window allows to outline (by drawing contours) the specific geographic area of interest
- A photograph is assigned to a specific location (village) on the map, which defines a relation between a specific place and image (see the Figure 2)
- Interactive image searching tool is able to find the most relevant images according to the given keywords and sorts the results by the proximity value.

In the process, different ways of adding data to an image or its location on the map are offered to the users. Users can locate photographer`s position in the map directly by marking a point on a map; mark a known object in the photograph, whose location can be drawn from external data sources; give a geoname from the keywords or identify it in the published comments. Objects or landscape features on unknown photograph could also be compared to other images with similar features that have already been located, and this way an unknown photograph could be identified. This process can be repeated infinitely, which allows for multiple cross-checking between geo-referencing – this way crowdsourcing can contribute new data to a given image or data set. Upgrading of the data sets will be achieved by continuing process of multiple suggestions by different users, which improves the accuracy in successive steps.

The project develops in eight work phases (Figure 4), with the first step being the data collection and analysis. The data contains photographs, postcards and other digitized documents, which provide visual or textual information about the site. The processed data collection is published through a web portal for the interested public, e.g. local citizens, family members and descendants, who remember pre-war situation and the destroyed settlements, amateur historians, researchers, and students. The web portal is the central platform for interactive testing of of geo-referencing tools, web presentation, and direct users' interaction with digitized historical photographs. We are interested in the ways how public interacts with the images, and how substantial interest can be generated and used in the processing of the photographic archives in a targeted manner.

The rationale behind using crowdsourcing method is the assumption that one or a few persons would not be able to manage such a large data volume as a whole archive, and may be lacking local knowledge or expertise on a required geographical scale. Thus the images will be first analysed by automated image analysis technology, and then tested in crowdsourcing. The project also tests how to verify the crowdsourced data based on interactive user questioning. Thus it will be able to provide first Central European data on the usability of crowdsourcing for research in the humanities, and meeting the standards of scientific work with the aim to eventually be integrated into the classical methods of archival work.



Source: A. Weinfurtner

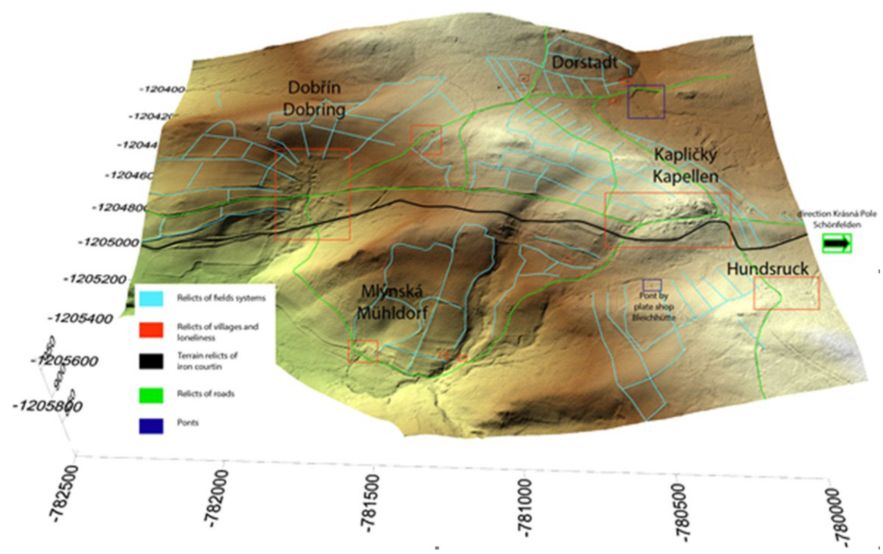
Figure 4: Project pillars.

Identification, documentation and interpretation of landscape changes

Once historical photos are digitized, registered in database and georeferenced, it is possible to supplement them with other information, drawn from non-destructive archaeology and history research, as shown on the example of Kapličky (Kapelln) village.

One of most important sources of added (mainly topographic and landscape) data is remote sensing, i.e. Light Detection and Ranging (LiDAR) and Airborn Laser Scanning (ALS) methods, which create the Digital Terrain Model (DTM). Relief map image DTM obtained from the Czech Office of Surveying and Cadastre (ČÚZK)©, which was processed in the Geographical Information Systems (Figure 1), was used to identify anthropogenic relics preserved under the vegetation (Gojda et al., 2013). The Lidar data were correlated with the images from the historical military aerial photographing taken in 1952, which depicts the form of the village Kapličky before its complete destruction (Figure 5). The macroscopic view of the landscape around Kapličky (Kramer, 1980) allowed to identify the relics of the village, isolated farmsteads, roads, ponds and field systems. It is interesting that the aerial photographs show a linear course of the sand zone, which was part of the first construction phase of the Iron Curtain. The DTM does not show the sand stripe, but clearly draws the course of the terrain edge, which is the relict of the wire signal wall barrier from the 1980s once equipped with the electric-wire fence.

Further concretization of village remains, such as individual buildings, followed. Correlation of the Digital Terrain Model and the aerial image with the detailed analysis of cartographic sources (military mapping (Figure 6), cadastral maps (Figure 7) and plans) and field survey of the site. As a result, we could identify individual remains, and link structures and sites with their names, the names of the original owners, crafts they were working in (shoemaker, carpenter, grave-digger, etc.), and communal institutions (school, etc.) (Figure 8).



Source: M. Preusz (author)

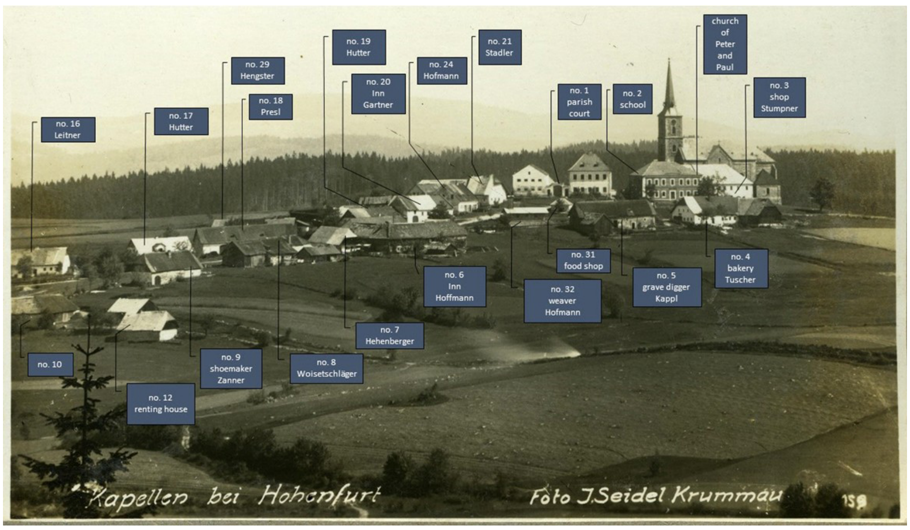
Figure 5: 3D visualization of the terrain in the immediate vicinity of the defunct Dobřín and Kapličky.

Source: Historical orthophoto. © CENIA 2010 and GEODIS BRNO, spol. s r.o. 2010, Underlying aerial photographs were provided by VGHMÚř Dobruška, © MO ČR 2009

Figure 6: Aerial photography of Dobřín and Kapličky from 1952.

Source: Český úřad zeměměřický a katastrální (2010) CZ-00025712-CUZK_COC. Císařské povinné otisky stabilního katastru 1:2 880 – Čechy. 2010-12-01, Prgue. [Online]. Aviable: ww.archivnimapy.cuzk.cz. [Accessed: 20 Jan. 2017].

Figure 7: Scheme of Kapličky village (Kappeln) on a stable cadastre from the 1830s.



Source: visualization by M. Preusz, data collection J. Doktorová, M. Zvánovec

Figure 8: Identification of individual buildings from Kapličky on photograph of 1930.

Source: K. Paclíková

Figure 9: Georeferenced historical photograph of Kapličky posted onto the present forested landscape.

Source: Závitkovská (2017)

Figure 10: The 3D model of the church in Kapličky.

The view of Kapličky from the bird's-eye perspective can be supplemented by the information drawn from historical photographs. Geo-referencing of historical photos allows us not only to establish the point, where the photographer stood, but also to compare the past and present of human activities in the landscape by juxtaposing the historical image with contemporary photograph (Figure 9).

In the following step, 3D model reconstruction of the destroyed village buildings or isolated farms and structures was created with the help of ground plans obtained from the archaeological prospection, the historical plans, aerial and LiDAR photographs and historical photographs. Among the buildings, St. Peter and Paul church in Kapličky, which was the dominant of the village and surrounding countryside, has been virtually reconstructed (Figure 10). The Czechoslovak army blew up the building in 1959, but thanks to the witness reports, historical photos and descriptions, we possess valuable information about its exterior and inner equipment.

Results and discussion

As shown in the case study, the main aim of the project is the long-term archiving and public accessibility of historical photographs that can be used in the research and reconstruction of destroyed historical and archaeological sites, extinct settlements and landscape transformation. Reconstruction of Kapličky village and its surroundings not only proves the benefits of using historical photographs in research and reconstruction of lost sites, but also the advantages of joining computer-based technologies when applied to photo processing. The result is a multi-step process of automatized image recognition, research data processing and public response.

On the organisation level, the project is based on interdisciplinary collaboration of IT experts with historians, archaeologists, and natural scientists, while a broad public can cooperate in the process of analysis and location of historical photographs on the map through tagging and crowdsourcing. The project is now running in its second year, but it has already contributed to a better understanding of the transformation of cultural and natural landscape elements in the Šumava landscape. As an obvious asset, the results of the work are directly accessible to the broad public via web portal (users can immediately browse both the research and crowdsourced data, distinguished from each other by specific marking) and will be better understood by it, as it directly participates in their collection.

On the research outcomes level, long-term archived and geo-referenced photographs have undeniable importance for in preserving local memory and cultural or natural heritage, especially in the former conflict zones. In the Czech border region this interest in lost sites and settlements started to evolve, after 1989 (Bureš, 2015) due to political changes after the fall of Iron Curtain. Using historical photographs as source of information with the help of automatized and IT tools enables to handle and mine large pool of data and diverse material (both textual and visual) to understand and reconstruct landscapes, which have undergone turbulent changes, sometimes due to tragic historical events, during the past one and half century. The suggested IT-based methods help to re-install historical photographs to their role as valuable witnesses of human past.

Conclusion

Alone standing historical photographs are valuable witnesses of human past. But enriched by detailed information about their content and even about the circumstances of the acquisition can tell us important stories. This article aimed to present current state of art of ongoing project PhotoStruk. The scope of this project is to develop tools and methodology for work with historical photographs hidden in archives. But also to indicate possibilities of their use for different science.

Acknowledgments

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Enriched Data Sharing Methodology

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Abstract

The aim of this article is to propose a methodology for improving the sharing of data between applications that support scientific activity, which are focused on agriculture, aquaculture, rural development, etc. The presented methodological approach is referred to as Enriched Data Sharing Methodology (EDSM). The presented methodology is based on two analyzes. The analysis of the data formats used for the metadata description of digital objects and the description of their mutual relations. And analysis of dictionaries of controlled descriptors.

The article presents part of the results of author's dissertation thesis.

Keywords

Metadata, application profile, social network service for scientists, data sharing, enriched data.

Stočes, M., Kánská, E., Šimek, P. and Vaněk, J. (2018) "Enriched Data Sharing Methodology", *AGRIS on-line Papers in Economics and Informatics*, Vol. 10, No. 2, pp. 85-92. ISSN 1804-1930. DOI 10.7160/aol.2018.100208.

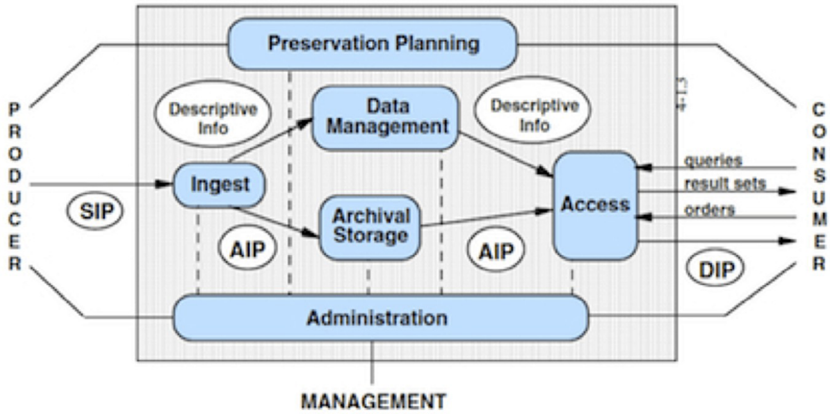
Introduction

Social networks have been the phenomenon of recent times in the scientific community. These sector-specific social networks have significantly changed the form of communication and knowledge exchange. Social networking applications such as Social network service for scientists ResearchGate have been established to support research activities. This new communication platform also affected science and research. Most scientists are forced to work with multiple applications. In each application, the user is prompted to create a profile and upload metadata of scientific publications. Each application creates a specific identifier for the user and his publications. It is difficult for the enriched data created in the system to be exported or transferred from one application to another. (Al-Aufi and Fulton, 2013) (Asmi and Margam, 2018)

The term digital library is very broad, and its definition is inconsistent. In the literature, the following definitions exist: "A managed collection of information along with corresponding services, the information being stored in digital form and accessible through the network. (Arms, 2000) An integrated system, including a set of electronic information resources and services to retrieve, process, search, and use information stored on that system. Digital libraries are accessed through computer networks. The purpose of building a digital library is to give users the opportunity to have unified access to digital or digitized documents, or secondary information about printed primary resources stored in the library. "Organizations providing resources (including dedicated staff), allowing for selection, structuring and accessing digital works collections, further distribute these works, maintain their integrity, and preserve them for the long term - all with regards to the easy and economical use by a particular community or set of user communities" (Van de Sompel and Hochstenbach, 1999).

The most elaborate general architecture of digital libraries is Kahn and Wilenski's architecture (Kahn and Wilensky, 2006). The term digital library is closely related to the term digital repository. According to some authors, there is no difference between these terms, some authors associate the concept of digital repository with specific institutions and the principle of open sharing of these data. The digital repository is addressed by the Open Archival Information System (OAIS), which has been accepted as a standard ISO 14721: 2003. The principle of the OAIP model is illustrated in Figure 1 (Epple et al., 2017).

The aim of this article is to propose a methodology for improving the sharing of data between



Note: Submission Information Package (SIP), the Archival Information Package (AIP), and the Dissemination Information Package (DIP)
Source: Epple et al. (2017)

Figure 1: OAIS reference model.

applications that support scientific activity. The presented methodological approach is referred to as Enriched Data Sharing Methodology (EDSM). The article presents part of the results of author's dissertation thesis. It follows the findings of Stočes et al. (2017).

Materials and methods

Two improvement methods were used in the Enrichment Data Sharing Methodology (EDSM). The first method is described by the PDSA cycle, also known as Deming Wheel. It is based on the English model "plan-do-study-act". It is a method of gradual improvement of many fields, including information technology. It consists of the following phases: (Rao et al., 1996; Deming, 2016):

- Phase 1 - P (plan) - problem identification (intent),
- Phase 2 - D (do) - implementing the plan,
- Phase 3 - S (study) - verification of the result of the implementation compared to the original plan,
- Phase 4 - A (act) - modification of intent and own implementation based on verification and implementation of improvements to practice, implementation of the best solution.

In the context of the PDSA cycle, the second method - the seven-step method - is also often mentioned (Rao, et al., 1996) (Table 1).

PDSA phases	Seven-step method
PLAN	Identification of the problem and its clear definition
	Analysis of current state
	Identification of possible causes of the problem
DO	Planning and implementation of the solution
STUDY	Evaluating results
ACT	Standardizing the solution
	Evaluating the solution and proposing plans and provisions for the future

Source: Rao et al. (1996)

Table 1: Relation between PDSA and seven-step method.

Repositories that focus on long-term storage and access to digital information seeks the status of a trusted long-term repository. ISO 114721:2003, resp. 2012 is the reference model of OAIS, a standard that defines the activities of the long-term repository, its objectives, and introduces the basic terminology and information model. ISO 14721:2003 defines what metadata should be stored by a long-term repository. ISO standard 16363:2012 (follow-up to the Trusted repository audit checklist) is a means of certifying a trusted long-term repository. The repositories that do not store OAIS metadata and do not publish the documentation required by ISO 16363 cannot be considered as trusted repositories in the long-term. (Šimek et al., 2013; Stočes et al., 2018; Planková, 2008; Hodge et al., 2008).

Institutional repositories, including local repositories, collect digital objects that have been created within the institution that established the repository. They are used mainly at universities and research institutions. The content type is limited only by the focus of the founding institution.

Central repositories or subject repositories are focused on a particular science field. They focus on collecting (aggregating) the documents from the institution or even written by independent scientists within the subject frame. Central repositories provide search services over metadata acquired by various local repositories. (Müller and Adelhard, 2002).

Central repositories include repositories that aggregate data according to a particular data type. These repositories include, for example:

- Repository of "Gray Literature" of the National Repository of Gray Literature (NUŠL).
- COnnecting Repositories (CORE) that aggregate hundreds of open-access repositories from different countries.
- Europeana Archive containing scanned artwork, films and books.
- Repository dblp aggregating the metadata of articles and contributions from the field of computer science - http://dblp.uni-trier.de/

Applications using metadata

Metadata of digital artefacts (objects) from digital libraries are used by science support applications. These are primarily web applications that are divided into the following groups:

- Social network services for scientists,
- Reference management software,
- Web search engines of scientific work.

(Thanos et al., 2017).

Social network services for scientists are social networks developed for scientists and serves to support their activities - primarily to promote mutual communication and knowledge sharing. Particularly younger users use social media to communicate and share their knowledge. According to Stočes (2015), it is recommended to integrate some social networking features directly into learning management systems (LMS), which then serve as a communication tool between lecturers and students or even students among themselves. And it will enable students to get the latest knowledge in the area. These networks include, for example, *ResearchGate*, *academia.edu* or *VOA3R (Virtual Open Access Agriculture & Aquaculture Repository) portal* (Gemma and Ángel, 2013).

Reference management software are applications used to manage references or for personal bibliographic management. These software packages usually consist of a database that can provide full bibliographic links and a system for generating selective lists of articles in various formats that are required by publishers and scientific journals. Modern link management packages can usually be integrated with word processors, so a list of references in the appropriate format will automatically be generated when writing an article, thereby reducing the risk that the quoted source will not be included in the list of links. These systems can also link metadata to specific profiles of authors. These are primarily commercial applications. The most important applications of this type include: *Mendeley, EndNote* or *REFWORKS* (Ortega, 2015).

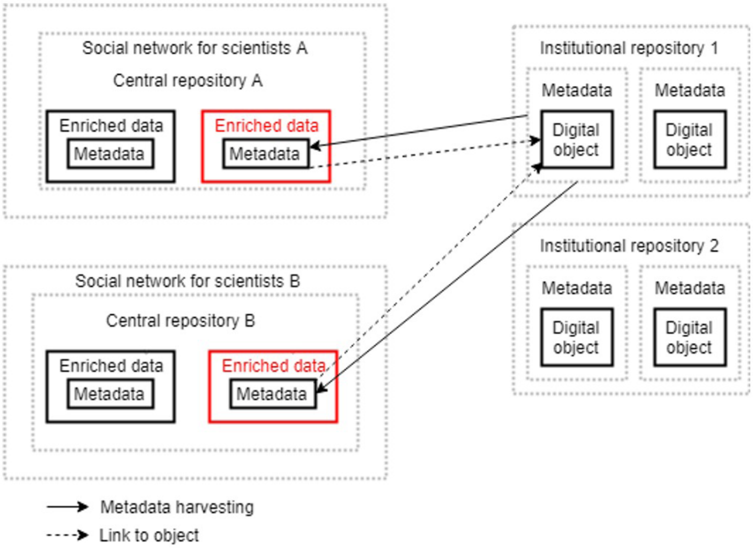
There is a whole range of *Web search engines of scientific work*, most of which are focused on a specific scientific field.

Google Scholar is a freely-accessible web multidisciplinary search engine that indexes full text or metadata of professional literature in a variety of publishing formats. The Google Scholar Index, released in the beta version in November 2004, contains the most reviewed online academic journals and books, conference articles, theses and dissertations, prepress, abstracts, technical reports, and other professional literature, including court testimonials and patents. Google Scholar is the most popular and most comprehensive application in this category. Google Scholar allows you to link your own google profile with indexed articles (Masner et al., 2016).

Results and discussion

Social networking applications for scientists allow users to search for repository objects and add additional data. These data can be called "enriched" data. Enriched data is stored within the social network and can only be accessed through that specific network. The principle is illustrated in Figure 2. Enriched data can be classified into two groups, namely linking and other metadata. The structure and function of other metadata is created by each social network separately. Examples of such data may be comments, ratings, etc. Linking metadata includes the following links:

- Digital artefact - Person (author, co-authors)
- Digital artefact - Digital artefact (citation, reference)



Source: Author

Figure 2: Relation between Institutional repositories and Social networks for scientists.

The new proposed methodological approach is based on the analytical findings. It aims to improve the metadata transfer, which is enriched by the social network services for scientists. The new methodology is referred to as Enriched Data Sharing Methodology (EDSM). The presentation of the design uses the UML (Unified Modeling Language) specification diagram. The issue of metadata descriptions that are used in the methodology is dealt with by Stočes (2017).

EDSM methodology formulation

The presented Enriched Data Sharing Methodology consists from two stages:

1. Identifying metadata describing digital artefacts (objects).
2. Creating an application profile.

Stage 1 - Identifying metadata

This preparatory stage is focused on identifying and categorizing the structure of the data model (metadata structure) of the application, to which elements will be assigned to the next stage. Stage 1 consists of two phases. Identification of the data model (metadata structure) is based on the knowledge gained from the metadata format analysis.

Phase 1 - Identifying primary metadata

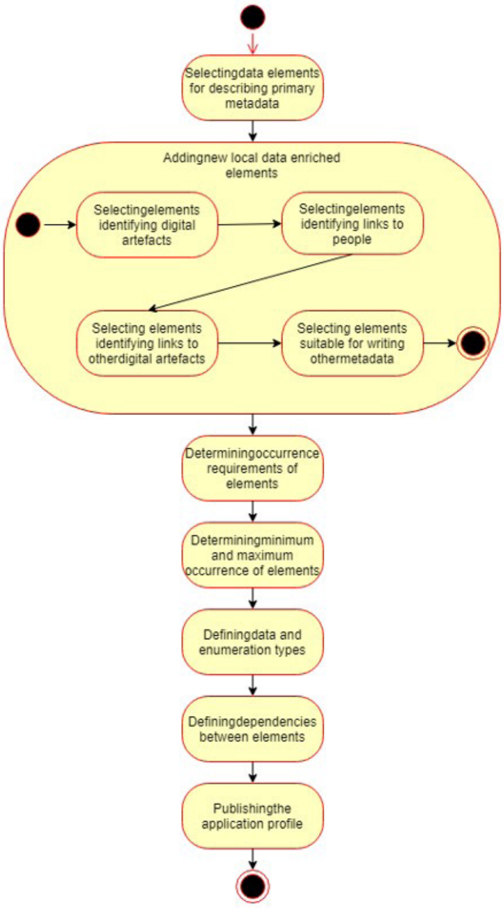
The initial phase identifies metadata that did not result from social networking applications for scientists. These are metadata descriptions made when publishing digital artefacts, e.g.: name, authors, licenses, etc. These elements are also referred to as primary elements. Each local repository (publisher) has a different metadata model, so it is necessary to identify primary elements as an intersection of all metadata models whose digital artefacts are in the application.

Phase 2 - Identifying enriched data

In the second phase, the metadata created by social networking applications for scientists is identified. Firstly, metadata specifying links to author profiles or other digital artefacts (quotes, references, projects) is identified. Next is the identification of other enriched data specific to given application, examples of which may be various comments, ratings, terms from specific thesaurus (e.g. agriculture thesaurus AGROVOC) etc.

Stage 2 – Creating an application profile

Stage 2 consists of seven phases, based on CEN/ISSS and the Singaporean application profile creation framework. Is uses the DC, MODS, and LOM metadata element names for description (Stočes et al., 2017). The dependency of the individual phases is shown in the UML task diagram (see Figure 3), the term "phase" is used for different activities within the diagram. The resulting application profile can be presented in a table format describing the individual elements and their properties or as XML template written in XSD or RDF format. (Carey et al., 2012; Taheri and Hariri, 2012).



Source: Author

Figure 3: EDSM – Activity diagram of creating application profile.

Phase 1 - Selecting data elements for describing primary metadata

First, elements will be selected to describe primary (original) metadata from which a new application profile will be created. This phase will use elements from the Dublin Core namespace.

Phase 2 - Adding new local data enriched elements

New local elements (elements created by social networking activities) of enriched data will be added. This phase can be divided into four steps:

Phase 2a - Selecting elements identifying digital artefacts

The data part identifying the digital artefact itself is created using the MODS standard by using the identifier element.

Phase 2b - Selecting elements identifying links to people

The data part identifying the link to a person (link: digital artefact - person) is created by combining elements of the namespaces of LOM and MODS. These are the elements: lom:lifeCycle, lom:contribute, lom:role, lom:source, lom:value, and mods:identifier. The most important of these links is the identification of the author of the digital artefact.

Phase 2c - Selecting elements identifying links to other digital artefacts

The data part identifying the links to other digital artefacts (link: digital artefact - other digital artefacts) is created using the MODS schema. The following elements are used: relatedItem and identifier. Links to other digital artefacts include, above all, the identification of citations and references.

Phase 2d - Selecting elements suitable for writing other metadata

The structure of the description of other metadata is designed based on their nature, depending on given social network, by using selected elements from LOM, DC, MODS or their combinations, or by defining new elements. An example might be an extension of the keywords for a dictionary item. Or, if the social network enriches some elements of education, the relevant specific elements of the LOM standard can be used.

Phase 3 - Determining occurrence requirements of elements

This step determines the requirements for occurrence of individual elements:

- mandatory
- recommended
- conditional
- optional

Mandatory elements must include at least the name of the digital artefact (<dc: title>) and the type (<dc: type>) whenever describing text, visualization, sound, etc.

Phase 4 - Determining minimum and maximum occurrence of elements

In addition, it is necessary to determine the minimum and maximum number of occurrences of individual elements. For elements identifying links to other artefacts or individuals, it is recommended not to restrict the upper limit of occurrence.

Phase 5 - Defining data and enumeration types

The definition of data types and enumerations of values is based on chosen metadata standard, or a new data enumeration type can be created.

Phase 6 - Defining dependencies between elements

The final stage before publishing the application profile is to define the dependencies between the individual elements. Defining dependencies serves primarily to explain the logic dependence of some elements and to reduce duplicate entries.

Phase 7 - Publishing the application profile

The final stage is to create an application profile, represented as an XML schema, an RDF format, or a text list containing the element names, their properties and constraints.

The methodology was verified by compiling the application profile and transforming dozens of scientific records into the desired format. Figure 4 shows a part of the XML schema created by EDSM and demonstrates a description of a digital object (references, citation).

```
<xs:element name="relatedItem" type="relatedItemDefinition"/>

<xs:complexType name="relatedItemDefinition">
  <xs:group ref="modsGroup" minOccurs="0" maxOccurs="unbounded"/>
  <xs:attribute name="type">
    <xs:simpleType>
      <xs:restriction base="xs:string">
        <xs:enumeration value="preceding"/>
        <xs:enumeration value="succeeding"/>
        <xs:enumeration value="original"/>
        <xs:enumeration value="host"/>
        <xs:enumeration value="constituent"/>
        <xs:enumeration value="series"/>
        <xs:enumeration value="otherVersion"/>
        <xs:enumeration value="otherFormat"/>
        <xs:enumeration value="isReferencedBy"/>
        <xs:enumeration value="references"/>
        <xs:enumeration value="reviewOf"/>
      </xs:restriction>
    </xs:simpleType>
  </xs:attribute>
  <xs:attribute name="otherType" type="xs:string"/>
  <xs:attribute name="otherTypeAuth" type="xs:string"/>
  <xs:attribute name="otherTypeAuthURI" type="xs:string"/>
  <xs:attribute name="otherTypeURI" type="xs:string"/>
  <xs:attribute name="displayLabel" type="xs:string"/>
  <xs:attribute name="ID" type="xs:ID"/>
</xs:complexType>

<xs:element name="identifier" type="identifierDefinition"/>
<!-- -->
<xs:complexType name="identifierDefinition">
  <xs:simpleContent>
    <xs:extension base="stringPlusLanguage">
      <xs:attribute name="displayLabel" type="xs:string"/>
      <xs:attribute name="type">
        <xs:simpleType>
          <xs:restriction base="xs:string">
            <xs:enumeration value="ISBN"/>
            <xs:enumeration value="ISSN"/>
            <xs:enumeration value="DOI"/>
          </xs:restriction>
        </xs:simpleType>
      </xs:attribute>
      <xs:attribute name="typeURI" type="xs:anyURI"/>
      <xs:attribute name="invalid" fixed="yes"/>
      <xs:attribute name="altRepGroup" type="xs:string"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
```

Source: Author

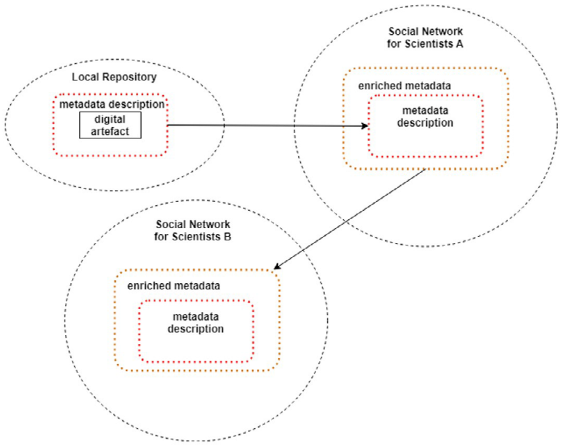
Figure 4: XML schema description of a digital object (references, citation).

Conclusion

The proposed method is designed for social network services for scientists who also publish their results from an agriculture area, forestry, aquaculture or rural development. It is used to create the application profile for the metadata of the digital artefact (object) that occurs in the given application. The application profile will allow social networking application users to import or export the metadata describing a digital artefact (object) from/to the application.

The main benefit of the EDSM methodology is to simplify the transfer of metadata descriptions between social networking applications for scientists. Figure 5 describes the principle of transferring metadata from a local repository to a social networking application for scientists and the subsequent transfer of enriched metadata to another application. Transferring between a local repository and an application may occur by automatic retrieval (e.g., OAI-PMH) or by writing the data by users. Metadata from application A is exported in XML format and then transferred to application B. Transmission can be done manually by the user or using the OAI-PMH protocol.

Using this methodology, an application profile is created to create specific metadata records of specific digital artefacts. These artefacts can be easily transformed and used to transfer data among other applications to support scientific work. The resulting record is expected to be both human-readable and machine-readable.



Source: Author

Figure 5: Transfer of metadata between applications.

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Rural Households Livelihood Strategies and its Impact on Livelihood Outcomes: The Case of Eastern Oromia, Ethiopia

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Abstract

This study analyzed the factors affecting smallholder farmers decisions to adopt livelihood strategy choices and its impact on rural households' livelihood outcomes in the Meta district, Eastern Ethiopia during the 2016/17 production year. The data used for the study were obtained from 180 randomly selected sample households. Multinomial logit model was employed to analyze the determinants of farmers' decisions to adopt livelihood strategies. The average effect of adoption on households' farm incomes was estimated by using propensity score matching method. The result of the multinomial logistic regression showed that age of the household head, distance from irrigation sources, social status, soil fertility status, education level, distance from Developmental Agents (DAs) office, economical active members, soil fertility status, soil conservation and transportation services were significantly affects households' adoption decision. Impact evaluation results showed that about 12.9, 45.2 and 41.9 percents of the sample households who using crop farming only, crop + livestock farming, and crop + livestock + off/non-farming strategies were non poor, respectively. Similarly, about 9.4, 30 and 19.4 percents of the sample households who using crop farming only, crop + livestock farming and crop + livestock + off/non-farming strategies were food secured, in that order. The estimation results provides a supportive evidence of statistically significant effect of livelihood strategies on rural households livelihood outcomes measured by food security status and poverty status. Therefore, policy makers should give due emphasis to the aforementioned variables to reduce households level food insecurity status and improve the livelihood of rural households.

Keywords

Households, livelihood strategies, outcomes and multinomial logit model.

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Introduction

Ethiopia is one of the Sub-Saharan African countries which liberalize its economy to maintain in all sectors to sustained economic growth and reduce poverty. However, five years later this was declining to 29.6%. Moreover, poverty head count is still more prevalent in rural (30.4 percent) than urban areas (25.7 percent) in Ethiopia (CSA, 2015). In Ethiopia, about 83.9 % of total population are live in rural area and agriculture is main source of their livelihood. Since 2010, agriculture becomes the second most dominant next to service sector of the country's economy by providing employment for 80 % of the total labors force and contributes 42.7 % to Gross Domestic Product and 70 percent of foreign exchange earnings (NBE, 2013; CSA, 2013).

Rising the agricultural production at the national level leads to improve overall economic growth and development. However, currently climate change has become a serious threat to sustainable economic growth (Gebreegziabher et al., 2012). Disturbance like drought, eviction, climate change will affect livelihoods and will push households to both farm and nonfarm activities (Baird et al., 2009; Chilongo, 2014). Baird et al. (2013) study revealed that eviction plays a role in shaping diversification strategies in the developing world.

As depicted by FAO (2012), despite agricultural contribution to the livelihood of the society, the increasing population growth in developing countries, including Ethiopia forced households to cultivate and make their living on the small size of land. Due to the decline in land holding per individuals as well as fragmentation of their holding and low income obtained from farming activity, the majority of rural households are exposed to food insecurity and chronic poverty. In addition, due to periodic drought and extremely variable environment, making farming risky economic activity farmers face fluctuation in their income. As for Amsalu et al. (2014) finding, rural households diversify their activities into off-farm and nonfarm activities to off-set the diverse forms of risks and uncertainties associated with agriculture; create a way of smoothing their income over the years and seasons; and reduce their vulnerability to different kinds of shocks, seasonality and trends.

The severity of rural livelihood and poverty in developing countries like Ethiopia has necessarily informed a drift in her agricultural systems from the strengthening of national research systems towards systems that enable innovations from individuals and communities, proper transfer and utilization of knowledge and overall transformation. Agricultural productivity remained low as a result not only lack of appropriate technologies and lack of access to those technologies, inputs, credit and access to markets and rural infrastructure, but also because of gaps in information and skills that prevented rural producers from effectively utilizing and adopting technologies (Sanginga et al., 2009). Therefore, the role of agricultural productivity in poverty reduction, improving livelihood and enhancing productivity outcomes cannot be over emphasized. Agricultural productivity and improved livelihood remained low as a result not only of the lack of appropriate technologies and the lack of access to those technologies, inputs, credit and access to markets and rural infrastructure, but also because of gaps in information and skills that prevented rural producers from effectively utilizing and adopting technologies (Miriam et al., 2011).

Livelihoods strategies cannot be identified by a single activity variable only, as the diverse mix of assets available to individual households typically produce a wide range of different asset allocation choices (Barrett et al., 2001). For example, two households endowed with equal areas of land might choose to use that land differently depending on other factors such as human and financial capital at their disposition. Hence, livelihood strategy identification requires clustering a vector of activity variables (e.g., Brown et al., 2006; vanden Berg, 2009), which requires starting with pre-determining a more-or-less arbitrary number of cluster centers. Therefore, this study uses the latent class clustering technique in livelihood strategy identification, which involves a less arbitrary cluster selection technique based on parameter estimation and model testing. The overall objective of this article is to contribute to the understanding of empirical regularities of important sources of income among rural livelihood strategies in developing countries and the factors associated with choice of strategies.

Therefore, enhancement of agricultural productivity is thus an important condition for alleviating rural poverty, and due to it increases household income and stimulating the growth of non-farm activities among rural households. It is widely argued that, achieving agricultural productivity growth will not be possible without developing and disseminating improved agricultural technologies that can increase productivity to smallholder agriculture farm (Asfaw et al., 2012). Like in many other Sub-Saharan African countries, agriculture is the most important sector for economic growth and for the enhancement of household income in Ethiopia. However, lack of adequate farm management practices and low level of inputs applied, the highly rain fed dependent agriculture system are major challenges to sustain the agricultural production in Ethiopia (Pender and Gebremedhin, 2007; Kassie et al., 2009). Despite the fact that, the agriculture sector is mostly susceptible in seasonal rain fall, the rural households are generating their family income from difference sources to averse the risk associated in agricultural farm sector. As a result the main source of income in most rural household of Ethiopia is derived from farm and non-farm activities.

Agriculture is the primary source of rural income as 80% percent of the rural labor force is engaged in this sector (CSA, 2013). Non-farm income of the rural household referred to an income that the rural households generate from none of crop or livestock production during a one year of agriculture production period. Non-agricultural activities are not getting prevalence in rural Ethiopia because households are rarely practicing dominated by a subsistence agriculture sector. As a result of this, the income from nonfarm activity is also very low. This subsistence agriculture and low level of rural household income is socially and economically could make unstable the rural society. Therefore, it is significantly important to identify the factors that affect agricultural productivity and find the methods of the rural household income improvements.

Rural households in the study area engage in diverse livelihood strategies away from purely crop and livestock production towards nonfarm and off-farm activities which are undertaken to generate additional income for survival and cope with harsh conditions. But, there was no empirical data that substantiate or supports the existing livelihood strategies practiced by the farmers in the study area. To intervene the problem, there needs to untie the interwoven factors which can motivate rural households to diversify their livelihood strategies and improve their participation in different off -farm and /or non-farm activities have got paramount importance to development practitioners and policy makers to find the way out (Gebrehiwot and Fekadu, 2012). Therefore, a thorough understanding of factors determining choice of livelihood strategies is important to improve the response mechanisms related to poverty, food security and livelihood improvement. Hence, this study aimed at investigating the livelihood strategies practiced by rural households and its impact on livelihood outcomes. This study was focused on rural households' livelihood strategies and its impact on households' livelihood outcomes at the farm household level in eastern Ethiopia at large and in Meta district of eastern Hararghe zone in particular. The objective of the study was, therefore, to identify the determinants of rural households' choice of livelihood strategies and its contribution in improving rural livelihood outcomes in Meta of Oromia, eastern Ethiopia.

Materials and methods

1. Description of the study area

The study was conducted in Meta district among 19 districts of eastern Hararghe zone of Oromia regional state. Based on statistical figures published by the Central Statistical Agency (CSA) in 2015, this district has an estimated total population of 240,285 of whom 117,864 are men and 122,421are women; 12,459 or 5.19% of its population are urban dwellers, which is less than the Zonal average of 6.9%. Meta has an estimated population density of 365.7 people per square kilometer, which is greater than the Zone average of 102.6. In general, the district is designated as famine prone and frequent crop failure is a common problem usually leading to food shortage. Drought induced food insecurity has been a common recurrent phenomena exacerbating the vulnerability of resource poor farm households in the area to be food insecure (MARDO, 2013). The land use pattern of Meta district consists 48% arable and 13% pasture and forest, and the rest 39% regarded as degraded (CSA, 2013). Sorghum, maize, barley and wheat are the major food crops in the district, whereas khat and coffee are the major cash crops. The farming system of the administration consists of crop production (4.1%), livestock production (7.9%) and householders that are engaged in mixed crop and livestock production (88.0%).

2. Sources of data and methods of data collection

As sources of information both primary and secondary data sources were used. The primary data were collected by the trained enumerators. In addition to primary data, secondary data were also collected from relevant sources such as published and unpublished documents from the relevant institutions for general description and to augment primary data.

3. Sample size and sampling technique

Meta district was selected purposively due its potential area for cereal crops and problems of rural households livelihoods. From this district two peasant associations were selected purposively because of their accessibility. Then the sample from each peasant association selected randomly based on probability proportion to size. Finally, a total of 180 sample respondents were interviewed.

4. Methods of data analysis

To address the objective of the study, both preliminary statistics and econometric methods were employed. Mean comparison was employed for impact evaluation and Multinomial logit was used to identify determinants of smallholder farmers decision to choice livelihood strategies

5. Food security measure

Food security pillars: Access, availability, utilization and stability are frequently cited in the literatures as organizing principles for food security measurement (Jones et al., 2013; Carletto et al., 2013; Coates, 2013). However, many authors note that the "pillars" analogy can hamstring improved food security measurement efforts because each one has not been well-defined (Berry, 2015; Coates, 2013; Moltedo et al., 2014). Household surveys yield information about household expenditure decisions and take the actual demographic structure of the household into account (de Haen, 2011). They are also costly to implement and tend to be infrequently administered (Jones et al., 2013; de Haen, 2011).

Perhaps recent research suggests household food consumption expenditure results can vary significantly based on survey design, with some authors arguing this should be only be used with great caution until more consistent and comparable survey data collection can be completed (de Weerdt et al., 2015; Carletto et al., 2013). Therefore, in this study household food expenditure was used. In this measure the frequency of dietary food consumption of different food groups consumed by a household during the last 7 days before the survey was calculated and consumption score is then calculated using weights assigned to each food group using the cut-off point of 2200 kilocalories as the minimum caloric requirement, used by official reports in Ethiopia (MOFED, 2010).

6. Construction of poverty indexes

Based on poverty line, three poverty measures that were identified by Foster et al. (1984) were employed. The headcount index indicates the proportion of population regarded as poor. The headcount index was estimated as:

$$Headcount\ Index\,(HC) = \frac{P}{n} \qquad (1)$$

Where, P = the number of poor people; n = population size.

On the other hand, poverty gap index was calculated as following. to determine the poor below the poverty line on average. If Z is a poverty line, Y_i is the per capita income of i, then the poverty gap is

$$Poverty\ \ Gap\ \ (PG) = 1/n \sum_{1-i}^{n} \left[\frac{Z - y_i}{z} \right] \qquad (2)$$

Where, Z = poverty line; Y_i = the per capita of i. In the equation, $z - y_i = 0$ if $y_i > z$.

Squared poverty gap measures the severity of poverty giving more weight to the poor and was depicted as follows.

$$Squared\ \ poverty\ \ gap\ \ (GP)^2 = 1/n \sum_{1=i}^{n} \left(\frac{z - y_i}{z} \right)^2 \qquad (3)$$

All the above three measures, which depend on parameter, is given below.

$$p_{(\alpha)} = 1/n \sum_{1-i}^{q} \left(\frac{- y_i}{z} \right)^{\alpha} \qquad (4)$$

Where α takes a value of zero for the headcount index, one for the poverty gap index and two for the squared poverty gap index

7. Determinants of the choice of livelihood strategies

Multinomial Logit (MNL)

The MNL model was used by many researchers to the model determinants of households' choices of livelihood strategies in the context of multiple choices (Deressa et al., 2019, Nhemachena and Hassan, 2008). To describe the multinomial logit model, let Yi denoted vector of options for strategies to chosen by farmer household. This model for a livelihood choice specifies the following relationship between the probability of choosing option and the set of explanatory variables Xi as (Greene, 2003)

$$\Pr ob(yi = j) = \frac{e^{\beta jxi}}{\sum_{k=0}^{j} e^{\beta kxi}} \qquad (5)$$

Equation (6) was normalized to remove indeterminacy in the model by assuming $\beta_0 = 0$ and the probabilities were estimated as:

$$\Pr ob(yi = j / xi) = \frac{e^{\beta jxi}}{1 + \sum_{k=0}^{j} e^{\beta kxi}}$$

$$j = 0,1,2....j,\ \beta_0 = 0 \qquad (6)$$

Where, j stands for livelihood strategies, x stands for explanatory variables and β'' stands for parameters to be estimated. The estimated parameter of the MNL model provide only the direction of the effect of the explanatory variables on the dependent variable (livelihood strategies), but do not represent either the actual magnitude of change or probabilities. To interpret the effects of explanatory variables on the probabilities, marginal effects are usually derived as indicated by Greene (2003). Maximum likelihood estimation of equation (8) yielded the log-odds ratio. The dependent variables of any adaptation option is therefore the log of odd in relation to the base alternative.

$$\ln\left(\frac{pij}{pik}\right) = xi(\beta j - \beta k) = xi\beta j, \quad \text{if } k = 0 \qquad (7)$$

According to Greene (2003), the MNL coefficients are difficult to interpret and associating with the j^{th} outcome is tempting and misleading. Marginal effect is useful to interpret the effect of independent variable on the dependent variable in terms of probabilities.

$$\frac{\partial pj}{\partial xi} = pj(\beta j - \sum_{k=0}^{j} pk\beta j) = pj(\beta i - \beta) \qquad (8)$$

Results and discussion

1. Descriptive statistical results for continuous variables

The results of the study showed that, the mean age of household age was 36 years and the mean household size and economical active members were 5 and 2.98 in person and men equivalent, respectively (Table 1). Similarly, the mean cultivated land and livestock holding were 0.397 and 3.55 in hectare and tropical livestock unit, in that order. Likewise, the descriptive result indicated that the total crop output and livestock income were 1474.23 and 4399.27 in quintals and birr, respectively. The results of infrastructural distances from the residence indicated that, on average there were about 10.5, 24.3, 26.7 and 88 meter distances in terms of irrigation sources, DA office and weather road in munities, respectively.

2. Descriptive statistical results for dummy variables

The results of the study revealed that, on average about 90, 68.89, 65 percents of the sample households were male, participated in soil conservation and farmers training, respectively. Similarly, about 36.11 and 66.11 percents of the sample farmers were participated in social status and had fertile cultivated land, respectively. Whereas, about 22, 64 and 13 percents of the sample farmers used human force, pack animals and vehicles for transportation of their farm inputs and out puts, respectively (Table 2).

Sex	Freq.	Percent
Female	18	10.00
Male	162	90.00
Total	180	100.00
Soil conservation	Freq.	Percent
not	56	31.11
conserved	124	68.89
Total	180	100
Farmer training	Freq.	Percent
Otherwise	63	35.00
Participated	117	65.00
Total	180	100
Transportation	Freq.	Percent
human labor	40	22.22
pack animals	116	64.44
Vehicles	24	13.33
Total	180	100.00
Social status	Freq.	Percent
Not	115	63.89
Participated	65	36.11
Total	180	100.00
Soil fertility status	Freq.	Percent
otherwise	61	33.89
fertile	119	66.11
Total	180	100.00

Source: own survey, 2017

Table 2: Descriptive results for dummy variables.

3. Determinants of farmers' choice of livelihood strategies

Multinomial logit model was used to identify the determinants of rural households' choice of livelihood strategies (Table 3). The model analysis used relying on farm alone as the base

Variable	Mean	Std. Dev.	Min	Max
Age in years	35.72778	7.439762	19	71
Education in grade	2.583333	3.659952	0	12
Family size in number	5.827778	1.703859	1	9
Economic active	2.985	1.018761	.8	6.15
Cultivated area in hector	.3975694	.5414781	.0625	5
Crops output in quintal	1474.239	2511.319	240	25540
Livestock income in birr	4399.272	3873.179	0	30000
Livestock holding in TLU	3.546433	2.325793	0	8.949
Irrigation distance in minute	24.33333	11.54684	2	50
DA office distance in minute	26.71667	13.33424	2	60
W/road distance in minute	88.25	30.96888	30	180

Source: own survey, 2017

Table 1: Descriptive results for continuous variables.

category for no diversification and evaluates the other choices as alternatives to this option. The overall model is significant at 1%. Therefore, in this study, only those variables, whose coefficients were statistically significant at less than or equal to 10% level of significance were discussed. Age of the household head, distance from irrigation sources, social status, soil fertility status, education level, distance from DA office, Economical Active members, soil fertility status, soil conservation and transportation services used were statistically significant variables that determining rural household's choice of livelihood strategies in the study area.

- **Age of household head:** It affected farmers' decision to diversify livelihood strategy positively and significantly at 5% (Table 3). Holding other variables constant, the likelihood of household head to choice crop farming strategy increases by 0.05 units, when age increase by one year relative to the base category is relying on farm and livestock farming. The possible reason is that elder farmers are well established and more experienced in agricultural production, more resistant to new ideas and information and they are more likely to be set in their ways and may not venture into new diversification activities, as also revealed by other study (Fikru, 2008).
- **Education level:** It was found to have a positive and significant effect on the use of farm plus off-farm strategies at 5% significance level (Table 3). Ceteris paribus, one extra grade in the household education increases the likelihood of using farm plus off/non-farm strategies by 0.248 units. This could be due to the relation between farmers education in order to meet basic needs of the family relative to the benchmark alternative farm alone. Furthermore, educated families are able to practice multiple activities, whereas uneducated ones tend to practice only crop production activity. This current finding is in agreement with previous observation (Bezemer and Lerman, 2002).
- Total agricultural outputs: As expected, this variable found to have a positive and significant influence on household's choice of on-farm plus non-farm, and a combination of on-farm and off/non-farm livelihood diversification strategies at less than 10 % level of significance (Table 3). From the model result, other things being constant, the marginal effect reveals that the probability of a household using on-farm plus non-farm and combination of on farm and off/non-farm activities increased by 0.00043 unit. For those farm households output increased by one quintal. This is because households with large total output can easily meet their consumption as well as other family requirements and beyond that they go for demand pull livelihood outcomes (such as accumulation of assets, more income, etc.). Thus, they can easily overcome financial constraints to engage in alternative non/off-farm activities. Also, Yizengaw et al. (2015) found a positive and significant on this variable .
- **Soil fertility status:** It positively and significantly influenced the use of crop farm and on farm plus non/off-farm livelihood strategies at 5% significance level (Table 3). That means, Ceteris paribus, being the farm households soil fertility status fertile, the probability of the households using crop farming and on farm plus off/non farming strategies increases by 1.08 and 2.19 units, respectively. This is explained by the fact that fertile land is a proxy for wealth status of farmers. Those farmers with fertile land can easily meet their family food and other requirements and have a better chance to earn more money to invest in non-farm income generating activities with an intention of accumulating assets for the future. This result is inconsistent with the findings of Amare and Belaineh (2012).
- **Developmental Agent (DA) office distance:** It has a negative and significant impact on diversification of livelihood strategies at 5% significance level (Table 3). From the model result, other things being constant, the probability of a household using on-farm plus off/non-farm activities decreased by 0.06 units as DA office distance increases by one minutes. The possible justification is that extension services are an important source of information on agronomic practices. The availability of better agricultural information and technical assistance on agricultural activities helps farmers to produce alternative crops; and to obtain higher production and income. Similar observations were also reported by other researchers (Seid et al., 2016).

- **Soil conservation:** It has a negative and significant impact on livelihood of using the crop farming activities only at 5% significance level (Table 3). From model result, other things being constant, the use of soil conservation decreases the probability of a household using on farm activities by 1.048 units. This is because farmers use conservation technologies to improve their agricultural production and productivity. These in turn help them to satisfy family consumption requirements and improve their income rather than using a combination of on-farm and non-farm activities.

- **Membership to social status:** As expected, this variable found to have a negative and significant influence on household's choice of only crop farming strategy at less than 5% level of significance (Table 3). The coefficient reveals that, holding other things constant, being a member of social status decreases the probability of a household using only crop farming strategy by 1.42 units. This is because a social capital that promotes sharing of knowledge, information, experience, etc., regarding the value of off and non- farm activities that helps them to improve their livelihood. In addition, cooperatives serve as a means of gaining off-farm and non- farm employment opportunities. This finding is inconsistent with the findings of Adugna and Wagayehu (2012).

- **Economical active members:** It is found to have a positive and significant effect on the combined use of on-farm and non/off farm as a livelihood strategy at 5% significance level as compared with relying only on-farm activities to drive their livelihood. The marginal effect reveals that, holding other things constant, having one more active member increases the livelihood of a household using combination of on-farm and non/off-farm activities by 0.164 units. This is because most of the economical active farmers were on ways of improving agricultural production and productivity. This in turn helps them to get better production, and then this most likely leads to obtain more income to fulfill their family requirements by enhancing their agricultural production skills, knowledge and experiences. The result of the study is inconsistent with the findings of Yishak et al. (2014).

	Crop framing only			Crops, livestock and off/non farming users		
Variables	Coefficients	Std.error	p>z	Coefficients	Std.error	p>z
Age	.0532166*	.0284842	0.062	.0294265	.044793	0.511
Education	.0516751	.0676691	0.445	.2483477**	.0971032	0.011
DA distance	.0138037	.0165707	0.405	-.0603002**	.023963	0.012
Eco Active	-.1113461	.2619369	0.671	.614172**	.3124958	0.049
Cultivated	.0839905	.3433125	0.807	.0676469	.4345916	0.876
Soil conservation	-1.048595**	.4737368	0.027	-.5460457	.6281843	0.385
Livestock	-.0000624	.0000738	0.398	.000054	.0000719	0.453
Crop output	-.0001857	.0002977	0.533	.0001437*	.0000774	0.064
Irrigation distanc	.0743335***	.0234058	0.001	-.0130695	.0381273	0.732
Farmer training	-.4355286	.4814686	0.366	1.728082	1.107863	0.119
Transportation	.1484154	.2707957	0.584	.610888**	.2994302	0.041
Social status	-1.420355**	.5093427	0.005	.0863504	.5732678	0.880
Soil fertility	1.082839**	.5397402	0.045	2.193368**	1.110765	0.048
Weather R dista	-.0122553	.0085411	0.151	-.0180528	.0141641	0.202
constant	-2.909335	1.853647	0.117	-4.390809*	2.635288	0.096
Number of obs = 180		LR $chi^2(28)$ = 129.13				
	Prob > chi^2 = 0.0000					
Log likelihood = -124.29825	Pseudo R^2 = 0.3419					

Note: ***, **,* means significant at 1%, 5% and10% percent level of significance
Sources: own survey result, 2017

Table 3. Multinomial logit result for determinants of livelihood strategy choices.

- **Means of transportation:** the model result showed that transportation positively and significantly affected using a combination of on-farm and non/off-farm activities as a livelihood strategy at 5% significance level as compared with the base category (Table 3). The marginal effect of the model reveals that, holding other things constant, using pack animals transportation in agricultural production increases the livelihood of a household using a combination of on-farm and non-farm activities by 0.611 units. The possible reason could be better transportation most likely increase the production and productivity of crops produced by the farmer, and this can help a farmer to get access to more food and generate more income so that they satisfy their family requirements. In conformity with the current result, Woinishet (2010) reported that transportation positively and significantly affected using the combination of on-farm and non/off-farm activities as a livelihood strategy.

4. Impacts of livelihood strategies on rural livelihood outcomes

This section provides evidence as to whether or not the choices of livelihood strategies have brought significant changes on rural livelihood outcomes. Accordingly, the estimation result provides a supportive evidence of statistically significant effect of livelihood choice on rural households livelihood outcomes measured by food security and poverty status (Tables 4 and 5). After controlling for pre-participation differences in demographic, location and asset endowment characteristics of the user and non- user households, it has been found that, on average, about 12.9, 45.2 and 41.9 percents of the sample households who using crop farming only, crop and livestock farming and crop + livestock and off/non farming strategies were non poor respectively. The chi square test results showed there were statistically significant mean differences among these groups at 1 percent significant level (Table 4).

The survey result also indicated that, on average; about 9.4, 30 and 19.4 percents of the sample households who using crop farming only, crop + livestock farming and crop + livestock + off/non farming strategies were food secured, respectively (Table 5).

The chi square test results showed were statistically significant mean differences among these groups at 1 percent significant level (Table 5).

Variable		Livelihood strategies								
		Crop farming only		Crop + Livestock		Crop + Livestock + off/non-farm		Total		Chi^2
		Numb	%	Numb	%	Numb	%	Numb	%	
Poverty Status	Non-poor	12	6.7	42	23.3	39	21.7	93	51.7	
	Poor	38	21.1	45	25	4	2.2	87	48.3	41.958***
	Total	50	27.8	87	48.3	43	23.9	180	100	

Note: *** means significant at 1 percent level of significance
Sources: own survey result, 2017

Table 4: Impacts of livelihood strategies on household level poverty status.

Variable		Livelihood strategies								
		Crop farming only		Crop + Livestock		Crop + Livestock + off/non-farm		Total		Chi^2
		Numb	%	Numb	%	Numb	%	Numb	%	
Food Security Status	Not sec	33	18.3	33	18.3	8	4.4	74	41.1	
	Secured	17	9.4	54	30	35	19.4	106	58.9	22.15***
	Total	50	27.8	87	48.3	43	23.9	180	100	

Note: *** means significant at 1 percent level of significance
Sources: own survey result, 2017

Table 5: Impacts of livelihood strategies on household level food security status.

Conclusion

Increasing rural livelihoods through investment in sustainable agricultural practices and off/non farming activities are important for the reduction of hunger and poverty in Ethiopia. In this study, we analyzed the factors determine probability of livelihood choices and its contributions to rural households livelihood outcomes by smallholder farmers in east Oromia, Ethiopia using farm household level observations. The data were collected from 180 sample household in 2016/17 cropping year. Multinomial logit model is used to identify the factors that determine the probability of the choices of livelihood strategies and mean comparison was used for impact evaluations.

The Multinomial result indicated that; age of HH head, distance from irrigation sources, social status, soil fertility status, education level, distance from DA office, Economical Active members and soil fertility status, transportation and annual agricultural output were significant variables determining household's choice of livelihood strategies.

The estimation result provides a supportive evidence of statistically significant effect of livelihood strategies on rural household livelihood outcomes measured by food security status and poverty status. The result indicated that on average, about 12.9, 45.2 and 41.9 percents of the sample households who using crop farming only, crop and livestock farming and crop, livestock and off/non farming strategies were non poor respectively. Similarly, about 9.4, 30 and 19.4 percents of the sample households who using crop farming only, crop and livestock farming and crop, livestock and off/non farming strategies were food secured respectively. Both results were statistically significant at 1 percent significant level.

Therefore, it can be concluded that household level choice of livelihood strategies are crucial in increasing the households' food security status and reducing poverty levels of farmers which in turn could affect the welfare of the rural farm households. Therefore, government and non government and other stakeholders should encourage the current effort of encouraging rural livelihood diversifications which assists to improve their farm households' welfare by increasing their sources of income.

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