International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 7, Issue 2, 2019

Enhancing Agricultural Labour Productivity through Agricultural Research and Development and Extension Services: Evidence from ASEAN Countries

Sakapas Saengchai[a], Chayongkan Pamornmast[b], Kittisak Jermsittiparsert[c,d*], [a]Faculty of Humanities and Social Science, Suan Sunandha Rajabhat University, Bangkok, Thailand, [b]Faculty of Business Administration, Mahanakorn University of Technology, Bangkok, Thailand, [c]Department for Management of Science and Technology Development, Ton Duc Thang University, Ho Chi Minh City, Vietnam, [d]Faculty of Social Sciences and Humanities, Ton Duc Thang University, Ho Chi Minh City, Vietnam,
***Corresponding Author Email:** [c,d*]kittisak.jermsittiparsert@tdtu.edu.vn, [a]sakapas.sa@ssru.ac.th, [b]chayongkanp@hotmail.com

The purpose of the current study was to assess the role of agricultural RandD and agricultural extension services (AES) in enhancing agricultural labour productivity (ALP). To achieve the purpose, the current study examined the impact of agricultural RandD and AES on ALP by considering evidence from ASEAN countries. Thirty years' worth of data was collected from ASEAN countries about their AES, ALP, and agricultural RandD through official databases and archives. The data was subjected to analysis using the ARDL approach and then analysed to determine the short-term and long-term impact of AES and agricultural RandD on ALP of ASEAN countries. Descriptive, co-integration, panel unit root and heteroscedasticity tests were applied prior to ARDL modelling. The results of this modelling revealed that Agricultural RandD and AES significantly influences the ALP in the long term. However, there is no significant impact of agricultural RandD and AES on ALP in the short term. The current findings will be of great importance to ASEAN countries because they will set guidelines to enhance their ALP. Findings will also contribute to the literature on the subject through the empirical findings of the current study.

Key words: *Agricultural Labour Productivity, Agricultural RandD, Agricultural Extension Services, ASEAN Countries.*

Introduction

Since 2000, ASEAN agricultural sectors have donated approximately 1.5% for new occupation development. Agriculture currently accounts for around 44.4% of total ASEAN employment, although with substantial differences across countries (Heisey and Fuglie, 2018). Significant disproportions between members ASEAN nations are apparent with regard to labour productivity. The labour productivity of Singapore before 2000 was approximately twelve times more than Cambodia, nine times more than Myanmar and eight times more than Vietnam (Takeshima and Joshi, 2019). However, statistics vary across the years with, for example, Myanmar now excelling (Heisey and Fuglie, 2018). The discrepancy of labour productivity, comparable to $27,581.59 for ASEAN republics, suggests inconsistent labour productivity levels in regions such as Laos, Indonesia, Vietnam, and Cambodia (Tsuji, Ueki, Shigeno, Idota, and Bunno, 2018).

Figure 1. Last 10 years RandD for agriculture of ASEAN Countries

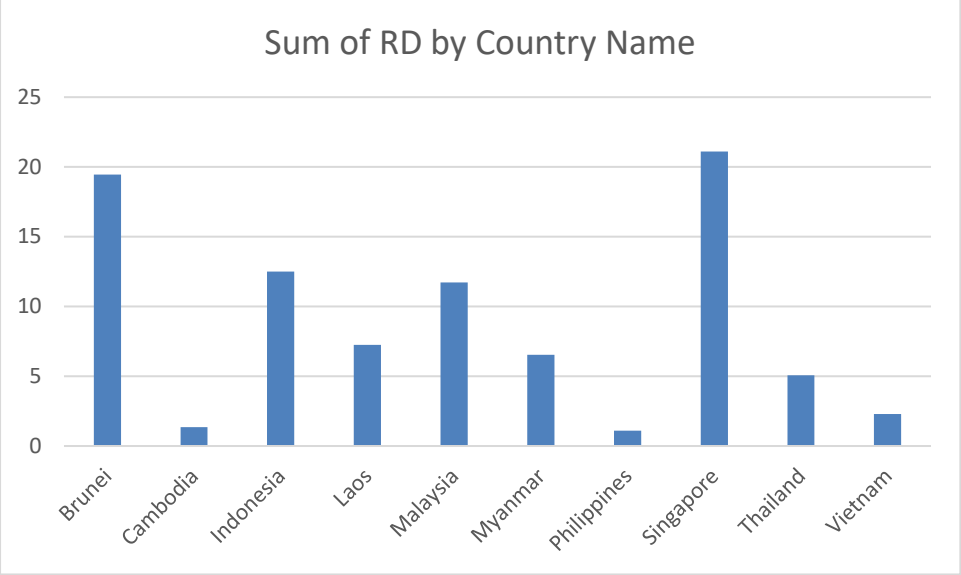

Figure 1 presents countries' ten-year investments of research and development in the agricultural sector, where, clearly, Singapore consistently invests the highest amount for RandD over this time. Labour productivity can be attributed to agricultural RandD and extension services in most ASEAN countries. Much of the development in herbal supplies is credited to the efforts of the public sector. However, 'mechanical revolutions' greatly attribute to RandD services (Charlton, Taylor, Vougioukas, and Rutledge, 2019). The use and dispersal of both mechanical and biological advances takes several years. This time delay

impacts RandD costs causing an approximate thirty to forty-year implementation delay. (Suphannachart, 2017). Knowledgeable agriculturalists are usually better at observing and familiarising with novel expertise, farmer's schooling is a significant influential factor, which is provide by extension services. Productivity-enhancing knowledge is contingent on the level and availability of emerging and current technology available to farmers. It is also contingent on the rate at which it is accepted and spread into further areas and the volume of the receiver republics to recognize, modify and absorb it (Noi, 2018).

In most ASEAN countries, the imbalance between extension services and RandD has been a concern for many years, especially since critics commented that most farmers had little to no provision due to scant RandD. Extension services have declined because of poor and inadequate funding. Nevertheless, they are both highly significant for labour productivity in agricultural (Takeshima and Joshi, 2019). For the labour population of ASEAN countries, and despite a constructive mean rise in labour productivity, the provision of labour and subsequent productivity failed to greatly increase (Paudel, 2016). The same challenge confronts most ASEAN countries as well as other countries such as the United Kingdom, Brazil, Pakistan, India and Africa. These countries constantly aim for increased labour productivity due to their dependence on agriculture for national revenue (Heisey and Fuglie, 2018). Therefore, their strategies, innovations and subsequent affects are necessary to research.

A literature review identified gaps in the field since research data had not been obtained for ASEAN countries (Noi, 2018). Agricultural RandD was assessed in most studies for its impact on labour productivity and extensions services were similarly assessed for their impact on labour productivity in select ASEAN countries (Paudel, 2016). However, their combined productivity was not examined in a single study (Suphannachart, 2017). Therefore, thorough exploration of the literature is a prerequisite for such a study.

The present study will emphasise assessing the influence of extension services and agricultural RandD on labour productivity of ASEAN countries.

The research questions formulated for the current study are given below:

1. To investigate the effect of agricultural RandD in enhancing labour productivity in ASEAN countries
2. To determine the effect of agricultural extension services in enhancing Labour productivity in ASEAN countries.

Investment in agricultural RandD demonstrates an essential part in empowering labour forces in ASEAN republics. This is done to maintain a profitable business through maximum

output, which is imperative in labour productivity of agricultural sector. Growing research investment assists ASEAN countries to attain financial growth in agriculture, a rise in the domestic budget, as investment is valuable for local farmers (Greenville and Kawasaki, 2018). Recently, the role of extension services has gained importance and demonstrates positive impact on the labour productivity of peasants and farmers. In this instance, it is the knowledge and expertise required for their everyday chores (Fukugawa, 2019). The instilled knowledge reinforces production and motivates them to maximise their yield, with the help of subsequent research and development in the sector. It contributes to and delivers knowledge through the use of modern techniques in most ASEAN countries (Anderson, 2016). Increasing labour productivity puts downward weight on food costs and, at the same time, refines rural revenue streams, thereby rising living standards as decreasing poverty in most ASEAN regions (Birthal, Joshi, Roy, and Pandey, 2019).

Literature Review

Economic Theory of Agriculture

Wharton (2017) presents different theories related to various domains, fields and concepts. They define the economic theory of agriculture to be the applications of labour, investment, human resources and other economic factors to increase agriculture growth and productivity with the help of these factors. Barlett (2016) economic theory elaborates the study via specific hypotheses that create models for agriculture development. Analysts such as Cannan (2016) express opposing theoretical points of view and believe that agricultural development is a sub-set of rural development. However, it is a fact that many rural areas cannot be developed without its agriculture being developed.

Agriculture development is considered as the empowering and welfare determinant for people living in rural or urban areas. It contributes to maintaining the social and economic welfare of farmers and other labours. Zhang's (2018) economic theory ensures and maintains productivity capacity for the future and increases productivity without damaging the environment, exploiting natural resources and destroying the natural landscape. Theories (Capalbo and Antle, 2015) relating to the agricultural sector are presented in the urban-industrial impact model. This model is an economic theory about the development of agriculture (Dong et al., 2017) where an increase in the growth rate of crops simultaneously results in an increase in GDP.

Agricultural RandD and its impact on Agricultural Labour Productivity

Former studies (Paini et al., 2016) examine the effects of agricultural R and D and the economic impact on the agricultural sector. Implications of economic theory on agricultural study causes increase in the agricultural Labour productivity (King et al., 2015) to enhance

the process of agricultural R and D. Agricultural productivity may include food, shelter for farmers, cattle and other livestock. However, other studies (Rusch et al., 2016) further explain that agriculture plays a key role in providing food security and which further develops economic impact on agricultural labour productivity. Labour plays an important role in the maintenance of crops, the increase in crop yield and farming sustainability so that farming yields increase Labour also plays an important role in pasteurisation in order to achieve economic and environmental sustainability.

Labour productivity highly depends upon R and D productivity (Clark and Tilman, 2017) while 90% of rural labourers are engaged in agricultural practices. International journals (Tsiafouli et al., 2015), believe that Nigeria seeks to become a leading country with a highly developed economy because of their complete reliance on agriculture farming. The country is a major player in global economic and political agricultural affairs. Nigeria receives much foreign aid in order to increase its economic growth, and not just its agricultural and farming growth. Studies by Powlson, Stirling, Thierfelder, White, and Jat (2016), also explain that many agriculturally dependent countries increase their economic growth by focusing on vital sectors such as education, health, energy, agriculture and manufacturing. R and D improvement in the agricultural sector leads to an increase in the production of export crops and an improvement in the quality, quantity and grades of such export crops.

Lawrence and Vandecar (2015) explains agricultural R and D depends on four main factors through which agricultural labour productivity can increase:

(i) the availability and supply of food for domestic consumption and for export purposes that further releases labour for industrial employment;
(ii) the size of the domestic market for the manufacturing sector,
(iii) the increased supply of domestic savings with the help of increased labour costs to benefit the farmers and labours at the same time,
(iv) the availability of foreign exchange earned (Gago et al., 2015) especially by the agricultural exports.

These factors contribute equally in the development of R and D which further develops the value of agricultural Labour productivity. R and D values the use of current and emerging technology, on which mainly the green revolution depends. Agriculture based R and D creates a platform for sustainable agricultural development paths which, in turn, improves the quality of life for farmers and labours (Gurr et al. 2016) Labours can increase productivity through ensuring enough food for present and future generations and which then generates sufficient income for farmers.

Thus, the following hypothesis is proposed:

H1: That agricultural R and D has a significant impact on agricultural labour productivity.

Agricultural Extension Services and its impact on Agricultural Labour productivity

Theoretical studies (Bustos, Caprettini, and Ponticelli, 2016) regarding the sustainability of economic theory correspond to the development of extension services within the agricultural sector which develops a positive impact on the agricultural Labour productivity through the performance of agricultural based extension services that includes the involvement of agricultural authorities and other extension offices that provides assistance to many Labours and farmers, which further increases the agricultural Labour productivity.

Snapp and Pound (2017) explore extension services and their economic and environmental sustainability, including adequate farmers' incomes, productivity for the future, improved food security and the availability of social sustainability. These extension services are the most important elements in agriculture development. Extension service personnel provide farmers and labours with beneficial outcomes as a result of their abilities, skills and input.

Studies by Ragasa and Mazunda (2018) highlight the role of extension services in the development of agricultural labour productivity.

Authors like FitzSimmons (2017) see extension services bridging the gender divide between male and female workers. Studies by S. L. Wang, Heisey, Schimmelpfennig, and Ball (2015) explore the involvement of male farmers in the agricultural sector because of their efficiency, effect, familiarity with the latest farming methods and technology. On the other hand, female labours are not able to compete with male farmers to increase the productivity and growth of the agriculture sector. Researchers (Rada and Fuglie, 2019) explain the phenomenon of structural transformation that is associated with the practices of extension services and include technical changes in the agricultural sector that further promote agricultural productivity at a global level.

Economists establish a relationship between economic and environmental extension services in order to demonstrate labour productivity and how this contributes to improvements in basic needs and lifestyle. Studies also elaborate (J. Wang, Chen, Das Gupta, and Huang, 2015) on findings of national and international integration of the agricultural sector. From this elaboration two paths are clearly evident: one structural and other geographic.

The farming sector requires deep and insightful analysis to explain how agricultural and farming expertise operates. A similar analysis is required to understand how labour in the agricultural sector through targeted investments.

Agricultural development and economic theory provides an insight into the dynamics of agricultural growth via the development of extension services (Birkhaeuser, Evenson, and Feder, 1991). Here, consideration needs to be given to output growth at a rate of 1.0% or less compared to an annual output growth of 4.0% or more. This statistic involves the use of extension services to enhance labour productivity and growth of in terms of cost and agricultural growth production. Studies by Evenson (2001) highlight the effect of the urban-industrial model which consists of location variations in agricultural development. The model pinpoints the differences in environmental factors that increase the level of economic development. A comprehensive study by Wossen et al. (2017) regarding the influence of extension services briefly explains the geographic variations in the intensity farming systems and which impacts labour productivity in an industrialized society involving agricultural farming and crop yields.

Research by Elias, Nohmi, and Yasunobu (2016) investigates the most effective performance indicators of extension services. Consideration is given to product marketing services in agricultural and non-agricultural sectors characterised by rapid urban-industrial development. Limited agricultural states require high levels of extension services because they are required to operate at full potential in order to facilitate farmers and the labourers' growth. Growth takes places with the help of technical knowledge and lessening productivity differences among farmers and regions.

Thus, the following hypothesis is proposed:

H2: That agricultural extension services have a significant impact on agricultural labour productivity.

Methodology

Sample and Data

The current study is based on panel data from ASEAN countries over the previous 30 years. The current study examines the influence on "agricultural labour productivity" (ALP) triggered by "Agricultural extension services" (AES) and Agricultural R and D. Since the study needed to examine this impact in the short and long term, the ARDL Panel approach was used for data analysis. The population of the current study consisted of archival data of AES, ALP and agricultural R and D of ASEAN countries over a 30 year period (1988-2017).

The researcher used data from The World Bank website to collect macroeconomic indicators included in the current paper.

Definition and Measurement of Variables

The current study and model allowed for the following key variables:

Dependent variables

The current study has one dependent variable i.e. "agricultural labour productivity" (ALP). This variable has been measured by taking the percentage of GDP which was accounted for by agricultural labour.

Independent variables

The present study has two independent variables that have been investigated as determinants of ALP in an ASEAN context: "Agricultural extension services" (AES) and "Agricultural R and D" (ARD). AES has been measured as a dummy variable which has a regarded value of 1 or 0 for each country. ARD was measured by taking the percentage of R and D for each country made in the agricultural field for a given year.

Control Variables

The current model involves two control variables that were added to achieve the desired results: "economic growth" and "carrier yields" (CY). Economic growth was measured through GDP of each country for the selected time period and CY was measured through the proxy carrier yield of each country for a given year.

Modelling and Methodological Framework

In the current study, the short term and the long terms effects of AES and Agricultural R and D on ALP have been checked and it was determined that the ARDL approach was best appropriate for this study. Since the ARDL approach enables the researcher to analyse relationships in terms of short-run and long-run impacts, the ARDL panel approach was applied in the current study. Zaidi and Saidi (2018) used a similar approach to examine the short and long-term association of 'CO2 emissions, GDP, and health expenditure'.

ARDL Approach

'Autoregressive Distributed Lag' is an approach to check the 'short-term and long-term relationships between variables' in a single model. 'Autoregressive Distributed Lag' modelling is an important approach which allows the researcher to assess the relationship of variables in the short and long-term.

The ARDL model for the long-run effects in the current study is as follow:

$$\Delta ALP_{it} = \alpha_i + \sum_{j=1}^{m-1}\beta_{ij}\,\Delta ALP_{i,t-j} + \sum_{l=0}^{n-1}\varphi_{il}\,\Delta AES_{i,t-l} + \sum_{r=0}^{p-1}\Upsilon_{ir}\,\Delta ARD_{i,t-r} + \sum_{u=0}^{s-1}\theta_{iu}\,\Delta DP_{i,t-u} + \sum_{v=0}^{q-1}\rho_{iv}\,\Delta CY_{i,t-v} + \delta_1 ALP_{i.t-1} + \delta_2 AES_{i.t-1} + \delta_3 ARD_{i.t-1} + \delta_4 DP_{i.t-1} + \delta_5 CY_{i.t-1} + \varepsilon_{1i,t}, \quad (1)$$

ALP is the "agricultural land productivity" and is the dependent variable for the current model. AES denotes the "agricultural extension services" where ARD denotes the "agricultural R and D". $\boldsymbol{\alpha}_i$ indicates the constant (intercept) which is country-specific and $\varepsilon_{ki,t}$ is an error term.

To complete the ARDL modelling, there is need to determine the lag length for each current variable. The minimisation of "Schwarz information criterion" (SBIC) was used for grid searches through which co-integration is checked among variables. The null hypothesis states no co-integration in the data while alternative hypotheses state presence of co-integration in data. Following is the null hypothesis for the current ARDL model:

$$H_0: \delta_1 + \delta_2 + \delta_3 + \delta_4 + \delta_5 = 0$$
$$H_1: \delta_1 + \delta_2 + \delta_3 + \delta_4 + \delta_5 \neq 0$$

An analysis of integration among variables shows that a the long-term association between them was proven. The equation for the long term association for the ARDL model of this study (1) is given below:

$$ALP_{it} = \mu_i + \sum_{j=1}^{m-1}\lambda_{1j}\,ALP_{i,t-j} + \sum_{l=0}^{n-1}\lambda_{2j}\,AES_{i,t-l} + \sum_{r=0}^{p-1}\lambda_{3j}\,ARD_{i,t-r} + \sum_{u=0}^{s-1}\lambda_{4j}\,GDP_{i,t-u} + \sum_{v=0}^{q-1}\lambda_{5j}\,CY_{i,t-v} + \nu_{1i,t}, \quad (2)$$

It has been assumed in the development of this model that the "coefficients of long-term relationships" stays the same for each country. The "error correction terms" for the current model are as follow and were used to estimate short-term relationships between variables:

$$\Delta ALP_{it} = \alpha_i + \sum_{j=1}^{m-1} \beta_{ij} \Delta ALP_{i,t-j} + \sum_{l=0}^{n-1} \varphi_{il} \Delta AES_{i,t-l} + \sum_{r=0}^{p-1} \Upsilon_{ir} \Delta ARD_{i,t-r} + \sum_{u=0}^{s-1} \theta_{iu} \Delta GDP_{i,t-u} + \sum_{v=0}^{q-1} \rho_{iv} \Delta CY_{i,t-v} + aECT_{t-1} + e_{1i,t}, \quad (3)$$

$e_{ki,t}$ is the "residual" i.e. (k=1,2) while ECT_{t-1} is the "error correction term" which can be defined as the "long-run equilibrium relationship" between variables.

Panel Unit Root Test

The Panel Unit Root Test was adopted to assess the fixed macroeconomic and financial data. It also assumes the null hypothesis with no stationary data and an alternative hypothesis with stationary data. 'ADF Fisher Chi-square (ADF Fisher) and Levin, Lin and Chi (LLC) unit root tests' are key tests that were applied in the current analysis for macroeconomic data.

Findings

The current study investigates and analyses data collected from ASEAN countries through "descriptive statistics, panel unit root test, co-integration test, heteroscedasticity test, and Panel ARDL approach." It does this through analysing AES, APL, ARD, GDP and CY.

Descriptive statistics

The normality and adequacy of current data was assessed through descriptive statistics. In doing this, the skewness, kurtosis, mean values and standard deviation were considered to check the normality and adequacy of the data.

Table 1 presents the results of descriptive statistics.

Table 1: Descriptive statistics

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
AES	1.420000	1.000000	2.000000	1.000000	0.496045	0.324176	1.105090
ALP	94.19240	83.73000	205.8800	52.98000	34.64955	1.703039	2.269991
CY	3482.100	3592.850	5601.200	514.7000	1332.102	-0.5047	2.587264
GDP	1.557665	1.787309	2.723948	-2.44534	0.681346	-1.63573	3.06258
ARD	0.883800	0.740587	2.159960	0.055300	0.693801	0.587140	2.075627

The results presented in Table 1 depict the mean value of all variables falling between the minimum and maximum value of that variable. The Std. Deviation also falls within an acceptable range for each variable. This means that there is no outlier in the current data

because no extreme value in the data and minimal variation in the data exists. The values of skewness for ALP, AES, ARD, GDP and CY fall within an acceptable range (i.e. -1 to +1). Similarly, the values of kurtosis fall within an acceptable range (i.e. -3 to +3). Given this, the descriptive statistics confirm the normality and adequacy for the data for further analysis.

Panel Unit Root Test

The Panel Unit Root Test is applied to check stationary of data. This test becomes more necessary where there are financial and macroeconomic variables in a model. Since the current study involves the data about macroeconomic indicators, the chosen test is necessary for the current data.

Table 2 presents the results of "Panel Unit Root Test" for each variable:

Table 2: Panel Unit Root Test

Variables	**ADF Test**		**LLC Test**	
	At level	**1st difference**	**At level**	**1st difference**
AES	32.0343***	45.5022***	-3.09829***	-7.40760***
ALP	57.9914***	38.8859***	-8.10598***	-8.28055***
CY	41.9447**	47.3190***	-6.56632**	-7.70370***
GDP	40.9363**	49.3626**	5.60979	10.4075
ARD	28.5654	25.8970*	-4.30799***	-3.98399***

From Table 2 above, most of the current variables are stationery at the first level. Therefore, the condition for ARDL modelling is fulfilled and further analysis can proceed based on the results of the "ADF test LLC test".

Co-integration Analysis

If the residuals of a variable are proven to be stationary, then variables should be co-integrated. The co-integration of current variables was analysed through Eviews and demonstrated a null hypothesis: that there is co-integration between variables.

Table 3 presents the results found through co-integration test.

Table 3: Co-integration Test

Alternative hypothesis: common AR coefs. (within-dimension)					
				Weighted	
		Statistic	Prob.	Statistic	Prob.
Panel v-Statistic		0.445007	0.3282	-0.989698	0.8388
Panel rho-Statistic		1.646017	0.9501	1.661721	0.9517
Panel PP-Statistic		-13.07293	0.0000	-9.235409	0.0000
Panel ADF-Statistic		-4.902200	0.0000	-2.545761	0.0055
Alternative hypothesis: individual AR coefs. (between-dimension)					
		Statistic	Prob.		
Group rho-Statistic		3.316693	0.9995		
Group PP-Statistic		-15.45936	0.0000		
Group ADF-Statistic		-4.177039	0.0000		

Table 3 indicates that there is significant co-integration between variables in the current data because the p-value for most of statistics shows significant co-integration. However, the Panel v-Statistic, Panel rho-Statistic, and Group rho-Statistic show the insignificant co-integration because the p-value is more than 0.01, 0.05 and 0.1. The overall statistics of co-integration prove the presence of co-integration so a null hypothesis is rejected.

Heteroscedasticity Test

This test was applied to the data to ensure the homoscedasticity of errors. The null hypothesis assumed that there is no heteroscedasticity present, while the alternative hypothesis assumed the presence of heteroscedasticity in the data.

A summary of heteroscedasticity test results is presented in Table 4 below:

Table 4: Heteroscedasticity test

	Value	**Df**	**Probability**	
Likelihood ratio	189.7282	10	0.6483	

The results of Table 4 prove that a null hypothesis of heteroscedasticity is accepted because p-value is more than 0.5. It means that errors are homoscedastic throughout the data.

ARDL Model

The PMG method was used in ARDL modelling because this method assumes the presence of co-integration proven earlier. This approach was used to assess the long and short-term impact of AES and ARD on APL.

The results of ARDL modelling have been provided in Table 5.

Table 5: ARDL Results (dependent Variable: ALP)

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
	Long Run Equation			
AES	-4.971471	0.331590	-14.99282	0.0000
ARD	-44.84525	5.783076	-7.754567	0.0000
CY	0.062398	0.001714	36.41076	0.0000
GDP	6.108615	3.436803	1.777412	0.0840
	Short Run Equation			
COINTEQ01	-0.649897	0.415174	-1.565360	0.1262
D(AES)	2.147776	2.116042	1.014997	0.3169
D(RD)	51.74753	49.19678	1.051848	0.2999
D(CEY)	0.018420	0.011775	1.564343	0.1265
D(GDP)	23.58894	22.28217	1.058647	0.2968
C	20.46536	48.34220	0.423344	0.6746
Mean dependent var	2.950222	S.D. dependent var		6.393405
S.E. of regression	3.501358	Akaike info criterion		4.182161
Sum squared resid	441.3424	Schwarz criterion		5.849470
Log likelihood	-145.1081	Hannan-Quinn criter.		4.856951

It is clear from the findings of ARDL modelling that AES and ARD have a significant but negative impact on ALP in the long-term because the p-values against their long-term effects on ALP are <0.05. The control variable CY also has significant long-term effects on the ALP; however, there is no significant impact of GDP on ALP in the near future. The results of the short-run equation depict no significant impact on any independent or control variables because the corresponding p-values were more than 0.05. This means that AES, ARD, GDP and CY do not have any significant impact on ALP in short term.

Discussion

The aim of this study was to examine the impact of agricultural research and development (ARD) on agricultural labour productivity (ALP), and, in turn, the impact of agricultural extension services (AES) on ALP.

This study considered cereal yield (CY) as a control variable to understand its impact on ALP. This study provided a detailed literature review of all variables and subsequently proposed specific hypotheses. These hypotheses were tested using data analysis techniques and results subsequently presented and discussed. The first hypothesis proposed that "ARD casts a significant impact on ALP." This hypothesis was accepted for the present time and in light of similar tests and research of Y. Hayami, ARD has insignificant impact on ALP in the long-term, while in the present time a significant impact exists (De Santis and Jona Lasinio, 2016).

The second hypothesis proposed in the study was that, "AES has a significant impact on ALP." Similarly to the first hypothesis, Hypothesis 2 is accepted for the time being as the tests and analysis demonstrated that AES has an insignificant impact on ALP in the long run; yet significant impact in the short-term (Hoang and Bui, 2015). This is also verified by studies conducted by JM. Alston, JM. Beddow and PG. Pardey. Lastly, the study examined the impact of the Cereal Yield control variable and was verified. Similar tests and studies of J. McMillan, J. Whalley and L. Zhu's *Journal of Political Economy* show that CY has an insignificant impact on ALP in the near future; yet significant impact in the short-term (Lee and Narjoko, 2015).

Conclusion

The aim of this study was to assess the impact of ARD on ALP and the impact of AES on ALP. This study also took CY as a control variable in order to assess its impact on ALP. This study was carried out in ASEAN countries with the help of panel data analysis techniques. The countries included, Indonesia, Thailand, Malaysia, Singapore, Philippines, Vietnam, Brunei, Cambodia, Myanmar and Laos, the data was collected from the economic sites and it was from across the past thirty years. The data was collected and was exposed to analytical testing techniques. After this, the data analysis was used to perform detailed discussion and draw results from that. The results concluded that AES, ARD and CY have insignificant impacts on ALP in the long run and significant impacts in the short run.

Implications of the study

This study has its wide implications in the literature section. ARD is the variable consisting of the least amount of data and discussion on its importance and on its impact that it casts on

any of the other variables. This research has highlighted and increased the literature material about this variable and about the important of ALP as well. In light of this research, the important factors for ALP can be applied practically. It can be seen in a significant way that what things are important for ALP and what should be implemented in order to improve ALP. This research has provided the important aspects of ARD, AES and CY that are important to be applied and included in the agricultural sector in order to improve ALP.

Limitations and future research indications

This study was conducted by collecting data about the ASEAN countries and collecting data from the World Bank reports on ASEAN countries only. While, the problem of Labour inefficiency is worldwide in different percentages so the same study can be conducted by targeting other countries and sectors as well. Moreover, control variables like, agricultural land and Labour motivation can also be included in the future studies.

REFERENCES

Anderson, K. (2016). Projecting International Trade to 2030. In *Agricultural Trade, Policy Reforms, and Global Food Security* (pp. 259-306). Palgrave Macmillan, New York.

Barlett, P. F. (2016). *Agricultural decision making: Anthropological contributions to rural development*: Academic Press.

Birkhaeuser, D., Evenson, R. E., and Feder, G. (1991). The economic impact of agricultural extension: A review. *Economic development and cultural change, 39*(3), 607-650.

Birthal, P. S., Joshi, P. K., Roy, D., and Pandey, G. (2019). *Transformation and sources of growth in Southeast Asian agriculture* (Vol. 1834). Intl Food Policy Res Inst.

Bustos, P., Caprettini, B., and Ponticelli, J. (2016). Agricultural productivity and structural transformation: Evidence from Brazil. *American Economic Review, 106*(6), 1320-1365.

Cannan, E. (2016). *A review of economic theory*: Routledge.

Capalbo, S. M., and Antle, J. M. (2015). *Agricultural productivity: measurement and explanation*: Routledge.

Charlton, D., Taylor, J. E., Vougioukas, S., and Rutledge, Z. (2019). Innovations for a Shrinking Agricultural Workforce. *Choices*, *34*(316-2019-1865), 1-8.

Clark, M., and Tilman, D. (2017). Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice. *Environmental Research Letters, 12*(6), 064016.

De Santis, R., and Jona Lasinio, C. (2016). Environmental Policies, Innovation and Productivity in the EU. *Global Economy Journal, 16*(4), 615-635.

Dong, L., Liang, H., Zhang, L., Liu, Z., Gao, Z., and Hu, M. (2017). Highlighting regional eco-industrial development: Life cycle benefits of an urban industrial symbiosis and implications in China. *Ecological Modelling, 361*, 164-176.

Elias, A., Nohmi, M., and Yasunobu, K. (2016). Farmers' Satisfaction with Agricultural Extension Service and Its Influencing Factors: A Case Study in North West Ethiopia. *Journal of Agricultural Science and Technology, 18*(1).

Evenson, R. E. (2001). Economic impacts of agricultural research and extension. *Handbook of agricultural economics, 1*, 573-628.

FitzSimmons, M. (2017). The new industrial agriculture: The regional integration of specialty crop production *The Rural* (pp. 3-22): Routledge.

Fukugawa, N. (2019). Determinants and impacts of public agricultural research: product-level evidence from agricultural Kohsetsushi in Japan. *Scientometrics*, 1-24.

Gago, J., Douthe, C., Coopman, R., Gallego, P., Ribas-Carbo, M., Flexas, J., . . . Medrano, H. (2015). UAVs challenge to assess water stress for sustainable agriculture. *Agricultural water management, 153*, 9-19.

Greenville, J., and Kawasaki, K. (2018). Agro-food trade, GVCs and agricultural development in ASEAN.

Gurr, G. M., Lu, Z., Zheng, X., Xu, H., Zhu, P., Chen, G., . . . Catindig, J. L. (2016). Multi-country evidence that crop diversification promotes ecological intensification of agriculture. *Nature Plants, 2*(3), 16014.

Heisey, P. W., and Fuglie, K. O. (2018). Public agricultural R and D in high-income countries: Old and new roles in a new funding environment. *Global food security*, *17*, 92-102.

Hoang, H., and Bui, D. (2015). Determinants of foreign direct investment in ASEAN: A panel approach. *Management Science Letters, 5*(2), 213-222.

King, K. W., Williams, M. R., Macrae, M. L., Fausey, N. R., Frankenberger, J., Smith, D. R., . . . Brown, L. C. (2015). Phosphorus transport in agricultural subsurface drainage: A review. *Journal of environmental quality, 44*(2), 467-485.

Lawrence, D., and Vandecar, K. (2015). Effects of tropical deforestation on climate and agriculture. *Nature climate change, 5*(1), 27.

Lee, C., and Narjoko, D. (2015). Escaping the Middle-Income Trap in S outheast A sia: Micro Evidence on Innovation, Productivity, and Globalization. *Asian Economic Policy Review, 10*(1), 124-147.

Noi, H. (2018). ASEAN MULTI-SECTORAL FRAMEWORK FOR CLIMATE CHANGE: AGRICULTURE AND FORESTRY TOWARDS FOOD AND NUTRITION SECURITY AND ACHIEVEMENT OF SDGs (Proposed Integrated Framework for AFCC Component 4).

Paini, D. R., Sheppard, A. W., Cook, D. C., De Barro, P. J., Worner, S. P., and Thomas, M. B. (2016). Global threat to agriculture from invasive species. *Proceedings of the National Academy of Sciences, 113*(27), 7575-7579.

Paudel, M. N. (2016). Prospects and limitations of agriculture industrialization in Nepal. *Agronomy Journal of Nepal*, *4*, 38-63.

Powlson, D. S., Stirling, C. M., Thierfelder, C., White, R. P., and Jat, M. L. (2016). Does conservation agriculture deliver climate change mitigation through soil carbon sequestration in tropical agro-ecosystems? *Agriculture, Ecosystems and Environment, 220*, 164-174.

Rada, N. E., and Fuglie, K. O. (2019). New perspectives on farm size and productivity. *Food Policy, 84*, 147-152.

Ragasa, C., and Mazunda, J. (2018). The impact of agricultural extension services in the context of a heavily subsidized input system: The case of Malawi. *World Development, 105*, 25-47.

Rusch, A., Chaplin-Kramer, R., Gardiner, M. M., Hawro, V., Holland, J., Landis, D., . . . Winqvist, C. (2016). Agricultural landscape simplification reduces natural pest control: A quantitative synthesis. *Agriculture, Ecosystems and Environment, 221*, 198-204.

Snapp, S., and Pound, B. (2017). *Agricultural systems: agroecology and rural innovation for development: agroecology and rural innovation for development*: Academic Press.

Suphannachart, W. (2017). What Drives Labour Productivity in the Ageing Agriculture of Thailand?. *Advances in Management and Applied Economics*, *7*(1), 89.

Takeshima, H., and Joshi, P. K. (2019). *Overview of the agricultural modernization in Southeast Asia* (Vol. 1819). Intl Food Policy Res Inst.

Tsiafouli, M. A., Thébault, E., Sgardelis, S. P., De Ruiter, P. C., Van Der Putten, W. H., Birkhofer, K., . . . Brady, M. V. (2015). Intensive agriculture reduces soil biodiversity across Europe. *Global change biology, 21*(2), 973-985.

Tsuji, M., Ueki, Y., Shigeno, H., Idota, H., and Bunno, T. (2018). R and D and non-R and D in the innovation process among firms in ASEAN countries: Based on firm-level survey data. *European Journal of Management and Business Economics*, *27*(2), 198-214.

Wang, J., Chen, K. Z., Das Gupta, S., and Huang, Z. (2015). Is small still beautiful? A comparative study of rice farm size and productivity in China and India. *China Agricultural Economic Review, 7*(3), 484-509.

Wang, S. L., Heisey, P., Schimmelpfennig, D., and Ball, V. E. (2015). Agricultural productivity growth in the United States: Measurement, trends, and drivers. *Economic Research Service, Paper No. ERR-189*.

Wharton, J. (2017). *Subsistence agriculture and economic development*: Routledge.

Wossen, T., Abdoulaye, T., Alene, A., Haile, M. G., Feleke, S., Olanrewaju, A., and Manyong, V. (2017). Impacts of extension access and cooperative membership on technology adoption and household welfare. *Journal of rural studies, 54*, 223-233.

Zaidi, S., and Saidi, K. (2018). Environmental pollution, health expenditure and economic growth in the Sub-Saharan Africa countries: Panel ARDL approach. *Sustainable Cities and Society, 41*, 833-840.

Zhang, W.-B. (2018). *Economic Growth Theory: Capital, Knowledge, and Economic Stuctures*: Routledge.