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Agriculture Technology Adoption in Malaysia: The Extension Service's Role, Rural Financing, and the Lender's Institutional Context

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There has been an increase on the incorporation of technology in the agricultural industry. The present research addresses the effect of the extension services, institutional lender context and rural financing in Malaysia and the degree to which these practices influence the agricultural technological adoption within the country. The country has been promoting microfinance institutions and education in agriculture to support the agricultural development as major revenue is driven from the industry. Thus, the present study was developed to study the relationship between the extension services, institutional lender context and rural financing and agricultural technological adoption in Malaysia. The present study used the novel approach of the ARDL to study the long run and short run relationships between the extension services, institutional lender context and rural financing and agricultural technological adoption of Malaysia. The data for the last 3 decades was used to study the variation and association between the research variables. The ARDL bounds test informed of significant cointegration among the research variables. The estimation indicated that there are direct associations between the extension services, institutional lender context and rural financing and ATA both in the long and short run. The extension services, institutional lender context and rural financing in Malaysia represent significant affluence over the dependency for the adoption for technological advancements in the agricultural industry. This study presents a new vision for Malaysia to develop its agricultural and economic policies.

Keywords: Extension services, institutional lender context and rural financing, agricultural technology adoption, farming households.

1. INTRODUCTION

To help the farmers in agriculture, they must be provided with some incentives and funds to enhance productivity with effective processes. Increased rural credits provided to farmers would have a productive impact on their agriculture practices. Various competitive industries have also been working in providing incentives to farmers so that they can work for such organizations and supply them with efficient crops that are rich in nutrients and grown with new techniques to grab the attention of consumers as well as increase the business profitability by signing contracts with professional farmers. Agricultural technology adoption has increased in the recent decade in Malaysia as crop quality is the main product of agriculture to increase the business processes and the economic stability of farmers (Verma & Sinha, 2018).

In the context of Malaysia, it has been reported that various institutions have been lending loans to the farmers to enhance the production of crops with effective practices that have been guided to the farmers through agriculture extension services. In addition, many insurance organizations have been helping the poor farmers that need to acquire some financial resources to increase their income by enhancing new techniques in agriculture. In such a way, the farmers can be helped to increase the productivity of crops as new technology equipment are quite expensive to afford for poor farmers (Utami, Indrianto, & Pratama, 2019).

The financial support provided to farmers as per agriculture credit, or rural financing can be done through various means. In some ways, the farmers can get loans from banks and insurance organizations to increase the quality of fields and crop yields. In other ways, the farmers can contact the government agencies to lend them some amount for upgrading their agriculture business and enhance the living standards. The farmers can also attain the funds in the form of a mortgage. This method has also been proved effective in Malaysia's rural regions that farmers have the assistance by keeping something worthy under mortgage regulations.

The study is based on utilization of new techniques in agriculture department of Malaysia and increasing the need of agriculture extension services as well as providing rural financing to farmers for better crop productivity. The problem statement in the current study is to enlighten the aspects and influence of rural financing on the agriculture department and providing incentives to farmers so that they can earn better and improve their farm level income. In various developed and developing countries the need of rural financing is increasing and farmers are now aware of new policies that have been added in the agriculture sector to enhance the farming career with extensive services.

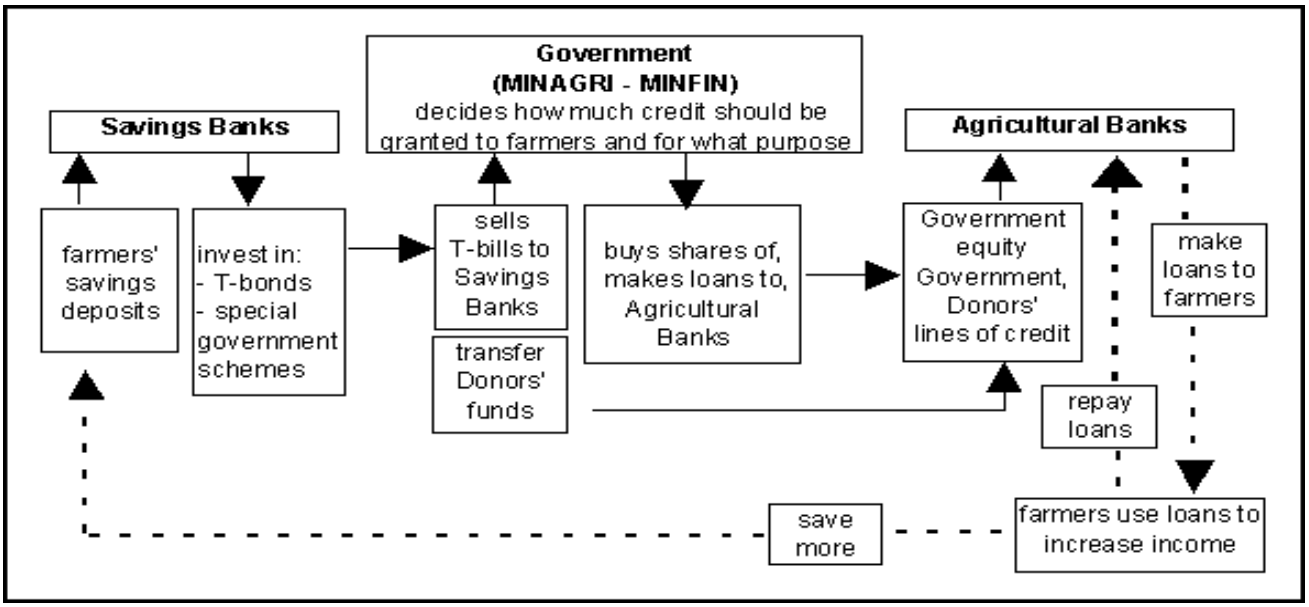
The current research fulfils the concerns of adopting agriculture practices with advanced technology tools and equipment that would be beneficent for development of crops yields. Rural financing as a supportive initiative of agricultural needs is required to be promoted in Malaysia for providing farmers with financial support to increase their

lifestyle standards. The different aspects of extension services are illuminated in the following research to solve the issues of institutional context and providing financial aid to farmers with extension services to adapt new techniques introduced in agriculture for increasing profitability.

In previous studies the significant need for rural financing was not known and the farmers were not provided with adequate incentives specifically in rural areas to enhance their crop productivity and to promote the institutional context of lenders. Such financing policies were considered useless for upgradation of farming practices as farmers at rural areas were not aware of financial support from government to enhance the agriculture productivity. The current study fulfils such gaps and highlights various rural credit institutions in Malaysia that have been working to support the farmers in their agriculture progress. Such institutions and organizations have provided millions of financial support to farmers and increased their market share to 16.1% to 18%. The current study promotes the need to provide the farmers with loans and rural financing to upgrade their career opportunities in the agriculture sector of Malaysia (Ujang & Noor, 2020).

In accordance to above information provided in background of study the specific objectives can be formulated. It is obvious that new technology utilized in farming practices will increase the soil fertility and make a rapid evolution in the agriculture perspectives with efficient rewards to farmers. Specific objectives for the study are initiated below:

- To explore new techniques in order to generate agricultural productivity.
- To study different aspects of rural financing and to promote legal perspectives of lending financial support to farmers.
- To study the new skills and farming behaviors in rural areas and establish awareness for new technology adoption in farmers.



In the agriculture extension services provided to farmers in Malaysia, a lot of awareness is required to be provided for enhancing innovative measures. The scope of study is vast as it is based on using different equipment to enrich the crops with more fertile soil and usage of compost in a considerable quantity so that the crops are produced rich in nutrients. The farmers can also be provided with harvesting equipment to learn new techniques for using such favourable tools in agriculture. In addition, various irrigation techniques are also guided to farmers to minimize water wastage and use required quantity of fertilizers to cultivate the land (Jin, Seong, & Khin, 2019).

The current study has immense Significance because it is going to provide ample data regarding financing resources for rural farers specifically and providing incentives in order to help them in adopting new techniques according to the needs of modern era. It is seen in various studies that a lot of insurance companies have been emerging to provide incentives to framers to make their crop productivity better. The current study has the importance to illuminate the need of agriculture extension services for farmers so that they can work for upgrading their agriculture practices with innovative measures. The use of new technology tools will support farmers to enhance farming techniques (Lakhan, Channa, Magsi, Koondher et al., 2020).

The current study structure is ordered as initial introduction then literature review is discussed in accordance with past studies for the selected topic. The third chapter defines methodology for the research being conducted followed by results and findings gathered from methodology. The last part is based on discussion and conclusion that explain the topic further.

2. LITERATURE REVIEW

2.1. Agricultural technology adoption" and the "Theory of Planned Behavior"

The studies conducted in the field of agriculture especially related to the adoption of technology as well as its diffusion showed that the farmers are in control of making

decisions regarding the implementation or use of such technology. Many agricultural sectors of different countries around the globe practice this theory. However, it was initially practiced in the US and less involvement of the government was observed in the decision-making processes of the farmers. Later on as the increased use of pesticides and fertilizers caused an alarming condition, the US government took control of the agricultural field (Adnan, Nordin, Bahruddin, & Tareq, 2019). Thus, different standards of technology were maintained for better outcomes. For this purpose, the behavior of both adopters as well non-adopters is observed by different scholars. Even the "Theory of Reasoned Action" is also controlled by the "Theory of Planned Behavior". However, along with the behavior of the individuals, the financial resources are also considered to have an important impact on the action of the individuals (Beaman, BenYishay, Magruder, & Mobarak, 2021).

However, different external as well as internal factors are found to have an impact on the action of the individuals. The impact of "financial variables" is considered to be very essential for this purpose. Thus, the "Theory of Planned Behavior" is found to have a substantial impact on the decision making processes of the farmers thus encouraging them or demotivating them to adopt the newly available technologies for improving their incomes (Jayashankar, Nilakanta, Johnston, Gill et al., 2018). Different extension services also play an important role in molding the behavioral attitude of the farmers (especially from the rural areas of the developing countries) towards the technology adoption. Whereas, the lender is also found to play an important role as the financial variables are directly linked to it. This helps in encouraging the farmers to opt for more technologies in order to earn more profit (Ugochukwu & Phillips, 2018). This is an essential practice especially in the agricultural sectors of the developing countries leading to more positive outcomes in the form of great profit as well as credibility. Many different new technologies are being introduced in the agricultural sectors these days. This has encouraged the farmers to adopt them more efficiently and the extension services play a huge part in this context which encourages the farmers to go for better net profit revenue (Zhang, Sun, Ma, & Valentinov, 2020).

2.2. Agricultural extension service and Agricultural technology adoption

Many research studies have played an important role in determining the impact of agricultural extension services on adoption of technology by the farmers. According to Danso-Abbeam, Ehiakpor, and Aidoo (2018), the programs are introduced by the public sectors for different extension services. This helped in promoting the use of technologies by the farmers. It has been observed that the farmers who have extension services, are more likely to adopt the technology (He, Kim, & Zhang, 2020). Different others studies have also shown that the farmers who adopt more of the technologies, gain more profitability in terms of crop productivity and utilization of natural resources (Pan, Smith, & Sulaiman, 2018). Many policies as well as educational programs are also introduced by the governments to promote the agricultural extension services which ultimately leads to better agricultural technology adoption by the farmers. It has been observed by different projects, that the well-educated farmers were more likely to adopt the technologies which lead to better production of the crops whereas, the non-educated farmers followed the old school methods and were not able to obtain the required outcomes as required (Takahashi, Muraoka, & Otsuka, 2020). This showed the significance of the agricultural extension services for the adoption of agricultural technology by the farmers especially of the rural areas in the developing countries.

With the passing time, many new technologies have emerged also in the field of agriculture. These technologies have helped in providing a helping hand for the farmers to obtain their desired goals in a time limited frame. Many governments of different countries have also introduced different extension services for increasing the adoption of the farmers towards the agricultural technology (Verma & Sinha, 2018). This is the most effective method used by the farmers in order to obtain better crop production. New technologies acceptance has become more common with the implementation of extension services. According to Norton and Alwang (2020), the use of chemical fertilizers was not common in Ghana. However, the implementation of extension services in the agricultural sectors of Ghana promoted their interests towards new innovations for improving the crop productivity and the use of fertilizers gradually increased for effective outcomes. This helped the agriculture sectors to boom thus promoting the sustainable development. However, the sustainable performance in such areas in also considered to be effective for this purpose. Thus, such explanation leads to the formulation of following hypothesis:

H1: Agricultural extension services has a significant impact on the Agricultural technology adoption.

2.3. Rural financing and Agricultural technology adoption

Different countries around the globe are more concerned about their agricultural sectors due to the increased awareness of the sustainable development. This has also encouraged the baking systems of such countries especially the developing countries to promote agricultural credit for the agricultural sectors in order to increase the crop productivity ultimately leading towards the security of the food. This also helps the rural farmers to maintain a better household by financing it properly after the gain through the agricultural production (Yajid M.S.A., 2020). According to AlBar and Hoque (2019), the credit given to the agricultural sectors in Africa, helped in improving their production by adopting new technologies. The female workers in the field were more likely to adopt these technologies. This not only proved to be effective for increasing the crop production but it also helped in improving the household of such farmers. This is considered to be very useful by many other scholars such as (Gebregziabher, 2019) and (Mariyono, 2019).

However, the education was also found to play an important role in this regard. Even though the credit has been given to the agricultural sectors especially in the rural areas. But if the farmers are not capable enough to utilize this credit properly, they might not be able to earn the desired incomes (Zheng, Wang, & Wachenheim, 2019). Education along with different training programs also help in improving the technical efficiency of the farmers that help them to adopt the new technologies more efficiently. This not only increases the total output of the put efforts but it also help in providing awareness to the farmers for better acceptability (Mutyasira, Hoag, & Pendell, 2018). According to Ejemeyovwi and Osabuohien (2020), the acceptability of the new technologies is very important for the farmers and the rural financing by the governments also support the adoption of agricultural technology by these farmers. This encourages them to take risk as they are provided with the needed support and this could help in increasing the economic growth above an expected range that could be beneficial for both the rural farmers as well as the country itself. This explanation leads to the formulation of following hypothesis for this research study:

H2: Rural financing has a significant impact on the Agricultural technology adoption

2.4. Institutional context of lender and Agricultural technology adoption

The use of agricultural technologies is being promoted by different policies of the developing world. Such policies help in promoting their use for an effective outcome. According to (Bridle, Magruder, McIntosh, & Suri, 2020), both macro as well as micro institutions, are considered to have an important impact on the performance of the agricultural sectors especially in the developing countries. For this purpose, the "Institutional theory" was also taken into account to understand the impact of institutional behavior on the action of the individuals. However, according to (Kebebe, 2019), the lender plays an important role in providing the desired capital to the farmers especially for the promotion of adoption of agricultural technology.

Many developing countries such as Ghana, Malaysia and many others, contain many "farmer-based organizations (FBOs)" which help the farmers to become a member of such organizations in order to have an easy access to the agricultural credit. According to Kumar, Engle, and Tucker (2018), the credit helps in promoting the behaviors of the farmers to adopt to the agricultural technology. Such groups help in saving the farms as they help in providing investments to the farmers. This in return helps in improving the welfare of the farmers. The capital investments made by such groups as well as farmers help in getting new technologies for improving the work. Many such technologies include: water irrigation technology, different fertilizers as well as pesticides and UAV technology and many others. With the continuously progressing world, the developing countries are also needed to work harder to obtain the desired results (Magruder, 2018). The provided loans, credit, investments boost the farmers in putting their full effort to increase the rate of production. The technical efficiency of farmers is considered to be beneficial for them in this process. When the new technologies are entered in the field, different training sessions are held for the rural farmers especially for the developing countries in order to understand the proper working of the technologies in order to obtain better results. According to Vinholis, Saes, Carrer, and de Souza Filho (2021), different instruments related to policies as well as other extension services also promote the adoption of the agricultural technology by the farmers. This not promotes the economic growth of the country but it also helps in improving the households of the rural farmers. This explanation leads to the formulation of following hypothesis for this research study:

H3: Institutional context of lender has a significant impact on the Agricultural technology adoption

3. METHOD

3.1. Data

The framework of the present paper is based on the framework of theory of planned behavior and correlates with technological adoption. The present study is focused on evaluating the relationship between the agricultural extension services, institutional context of lender, and rural financing in the context of technological adoption within the context of Malaysia. The population of the current study is the Malaysian agricultural industry. The study is being developed based on the time series methodology. The study required the collection of secondary data for the factors. The data was collected from Malaysian agricultural agencies, World bank group and Bank Negara Malaysia.

The table indicates of the primary variables and their descriptions

Table 1: Variable Description

			Description
Dependent	TA	Technological adoption	Technological adoption refers to the integration, application, and usage of new technology in the society or some industry. In the present study it refers to the application of technology within the agricultural sector.
Independent	RF	Rural financing	Refers to the line of credit distinguished by the government and other private vendors for completion of requirements of the agricultural sector.
	ICL	Institutional context of lender	Institutional lenders refer to the savings or commercial banks, loan agencies, trusts or any other financial institution that extends credit.
	AES	Agricultural extension services	Refers to the access to technical systems that assist the farmer or agricultural households through educational processes aimed at improving the farming methods and mechanisms.
Control	AF	Access to financial education	Measures the degree to which the population of Malaysia has access to financial education or literacy.

The study is based in Malaysia and thus all data was collected from secondary sources within the context of Malaysia. The data was collected for the period between 1980-2020, because the economy and agricultural industry of Malaysia has grown significantly during this period.

3.2. Model specification

To evaluate the impact of the associations present between the agricultural extension services, institutional context of lender, and rural financing and technological adoption, the present study is employing the usage of the Autoregressive distributed lag. Through the application of this technique the short run and long run associations between the factors of interest will be presented.

The main objective of the present study was to evaluate the degree to which factors like rural financing, extension services and institutional context of lender predict the technological adoption in the agricultural industry of Malaysia. For this purpose, the determinants under consideration for the evaluation have been specified and the economic model is specified as follows:

$$ATA = f(AES, RF, ICL, AFE,) \quad (1)$$

where ATA represents the agricultural technological adoption, AES refers to the agricultural extension services, RF refers to rural financing, ICL refers to the institutional context of lender and AFE refers to the access to financial education. The equation one is transformed into econometric models as follows:

$$ATA_t = \theta_0 + \theta_1 AES + \theta_2 RF + \theta_3 ICL + \theta_4 AFE + e_t \quad (2)$$

In the above expression the term θ_0 represents the intercept term and the $\theta_{1\text{-}4}$ are indicative of the associated parameters of the dependent and control variables. The estimation process of the ARDL technique will be used to predict the association in the short and long run for computing the variable dependencies.

3.3. Unit Root Tests

It has been discussed in the previous studies that unit root tests provide information about whether the collected data is affected by its own previous values or not. Apart from that, the stochastic properties of data and variables can also be found out by using these tests. These tests are based on the null hypothesis and its alternate hypothesis. The null hypothesis shows that unit root is present in the data and it is non stationary in nature. On the contrary, the alternate hypothesis shows that there is no unit root and the data is completely stationary. On the basis of these two types of hypotheses, the results are derived from unit root tests. As author has applied ADF unit root test in this particular study, the equation for this test can be written as follows:

$$\Delta y_{i,t} = a_i + \rho y_{i,t} - 1 + \sum_{J=1}^{pi} a_J \Delta y_{i,t-J} + \varepsilon_{i,t}$$

Here $\Delta y_{i,t}$ is the difference that $\Delta y_{i,t}$shows for ith country for the specific time period of t

3.4. ARDL Bounds Test

The study has used the ARDL bounds test developed by Pesaran, Shin, and Smith (1996) for detention of long run properties through the evaluation of cointegration among the variables. The bounds test has precedence over other cointegration techniques; it can be used even when the variables are integrated at mixed orders, provides robust results for smaller samples, and it can be used for impartial evaluation of the long-term framework. Also, if the value of the F-statistic is greater than the upper and lower bounds, it confirms the presence the long-term association among the variables. The ARDL bounds test is depicted through the following equations:

$$\begin{aligned}\Delta ATA_t = \theta_0 &+ \sum_{i=1}^{t} \theta_1 \Delta ATA_{t-i} + \sum_{i=1}^{t} \theta_2 \Delta RF_{t-i} \\ &+ \sum_{i=1}^{t} \theta_3 \Delta AES_{t-i} + \sum_{i=1}^{t} \theta_4 \Delta ICL_{t-i} \\ &+ \sum_{i=1}^{t} \theta_5 \Delta AFE_{t-i} + \beta_1 ATA_{t-1} \\ &+ \beta_2 RF_{t-1} + \beta_3 AES_{t-1} + \beta_4 ICL_{t-1} \\ &+ \beta_5 AFE_{t-1} + e_t\end{aligned}$$

In the above equations $\boldsymbol{\theta}_i$ is the coefficient of the long run multiplier and the β_i is the coefficient of the short run multiplier, where i=1,2,3,4, and 5.

3.5. Long-Run Elasticities

In the present study first the cointegration of the factors was evaluated to evaluate the long-term association. Once the cointegration is confirmed, multiple econometric models are applied for exploring the long-run association among the variables. The following equation was used for the estimation of the long run elasticity of the variables:

$$\begin{aligned}ATA_t = \beta_0 &+ \beta_1 ATA_{t-1} + \beta_2 RF_{t-1} + \beta_3 AES_{t-1} \\ &+ \beta_4 ICL_{t-1} + \beta_5 AFE_{t-1} + e_t\end{aligned}$$

Short-Run Elasticities

Whereas the short run equation includes the error correction term which evaluates the propensity of attaining equilibrium in the model:

$$\begin{aligned}ATA_t = \theta_0 &+ ECT \\ &+ \sum_{i=1}^{t} \theta_1 \Delta ATA_{t-i} + \sum_{i=1}^{t} \theta_2 \Delta RF_{t-i} \\ &+ \sum_{i=1}^{t} \theta_3 \Delta AES_{t-i} + \sum_{i=1}^{t} \theta_4 \Delta ICL_{t-i} \\ &+ \sum_{i=1}^{t} \theta_5 \Delta AFE_{t-i} + e_t\end{aligned}$$

4. RESULTS

4.1. Descriptive statistics

The table 2 represents the descriptive summary of the variables that have been targeted in the study. The table values show that the mean value for access to extension services is 1.4, mean value for agricultural technological adoption is 3.5, rural financing is 4, institutional context of lender's average value is 3.4, and access t0o financial education is 2.38. The values for standard deviation are small and indicate that the measure of dispersion was low in the data. The table values also indicate of the normality of the variables. From table 2, it can be confirmed that all

the variables are distributed normally. To evaluation of the normality, skewness, kurtosis and the results indicate that all five variables, agricultural technological adoption, agricultural extension services, rural financing, institutional context of lender, and access to financial education are distributed normally.

Table 2: Descriptive summary.

	ATA	AES	RF	ICL	AFE
Mean	3.58000	1.400000	4.000000	3.400000	2.380394
Median	3.50000	1.000000	4.000000	3.500000	2.408482
Maximum	4.50000	2.000000	5.000000	4.500000	2.698389
Minimum	2.500000	1.000000	3.000000	2.500000	1.998242
Std. Dev.	0.606905	0.500000	0.577350	0.577350	0.209201
Skewness	-0.31921	0.408248	0.331456	0.232019	-0.22444
Kurtosis	2.217824	1.166667	1.953125	2.246094	2.04754

4.2. Unit root test

To avoid the issue of spurious regressions, the stationary properties of the variables are evaluated through the application of the unit root test. In time series data, the occurrence of the spurious regressions is a commonality and thus the data needs to be studied. The ADF test is applied to study the stationary properties of the data i.e., whether the variance and mean are constant over time and if any trending behavior is present. The results are indicated in the table 3. From the table 3 it can be seen that the five variables i.e., ATA AES, RF, ICL and AFE are non-stationary, but their first order differences are all stationary. This shows that agricultural technological adoption, agricultural extension services, rural financing, and access to education are all integrated at the order one. The stationary properties and process of the first-order differences in the variables indicate that there has been no major shift in the basic characteristics of Malaysia's agricultural processes, change in the technological practices and adoption of education and technology in the industry within the previous 3 decades.

Table 2: unit root test

Variables	ADF		KPSS	
	At level	First diff	At level	First diff
ATA	-0.16**	-6.17 ***	8.1129**	-1.7009**
AES	0.52 **	-7.78 ***	33.1385**	0.1343
RF	1.18 *	-6.12 **	30.4290**	0.2878
ICL	1.19 *	-6.12 **	23.1788**	0.3404
AFE	1.08 *	-5.09 **	13.5863**	-0.2152

4.3. Lag order

After the preliminary testing, the researcher proceeded with the lag order selection of the model. The Log L, BIC, HQ and AIC lag tests are used for the selection of the appropriate lag order for the model. The study is based on annual data and thus the process was initiated with three lags and then it was reduced to one and zero (Altintas & Taban, 2011). The AIC, HQ and SC are very important for lag selection and are renowned for choosing the best lag for all types of variables in the times series data. The table 3 is presenting the values for the lag order tests. One of the characteristics of the ARDL model is that it allows the usage of different lags for the independent variables and the dependent variable. According to the results displayed in the model the value of AIC, SQ and HQ for lag 6 is the lowest. As indicated by the table, the lag 6 will be selected for application in the model.

Table 3: Lag order selection

Lag	AIC	SIC	FPE	HQ	LOG L	LR
1	-2.110	-1.492	3.43	-2.101	-1.467	3.16
2	-2.131	-1.310	3.59	-2.110	-1.287	3.33
3	-2.110	-1.362	2.90	-1.993	-1.299	2.54
4	-2.172	-1.289	3.87	-2.167	-1.210	3.61
5	-2.103	-1.391	3.98	-2.100	-1.387	3.77
6	**-3.143**	**-1.689**	**5.91***	**-3.130**	**-1.691**	**5.88****
7	-2.732	-1.391	0.78	-2.693	-1.386	0.84

4.4. F-Bounds test

Once the optimal lag for the model is selected. The researcher used the F-Bounds test for evaluating the cointegration of the variables. The variables can only be specified as cointegrating if they show evidence of having similar stochastic trends that lead them to cancel the effects of each other (Hendry & Juselius, 2000). The literature theoretically and empirically proves the importance of testing the cointegration of data in time series models studies (Granger, 2004; Hatemi-J, 2020; Hendry & Clements, 2003; Hendry & Juselius, 2000, 2001) and, hence, cointegration analysis is important as it allows avoidance of spurious results in the regression model steps (Hendry & Clements, 2003; Hendry & Juselius, 2001). The main assumption of the model is that the rural financing, institutional context of lender and the agricultural extension services influence the adoption of agricultural technology in the farm households of Malaysia. Thus, the measures of the rural financing, institutional context of lender and the agricultural extension services will be able to predict the dependence on the adoption of technological resources. Thus, it is probable that these variables may be cointegrated which can lead to the estimation of a stationary variable. The unit root test revealed that the variables are stationary at the first difference. The table below presents the results for the ARDL bounds test. The null hypothesis for the test is of no cointegration and it can be rejected as indicated by the table values. The results in the table below clearly indicate that the calculated F-statistic is greater than the critical higher and lower bound values. This shows that there is a stable long-term association between the n the rural financing, institutional context of lender and the agricultural extension services and the agricultural technological adoption.

Table 4: Cointegration

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	4.807447	10%	3.2	3.08
K	4	5%	1.56	3.48
		2.5%	2.78	4.86
		1%	2.29	4.36

4.5. ARDL model

The results of the initial estimation are presented in the table 5. The values for the table and the parameter coefficients inform of the significance and insignificance among the variables. The results are indicating that the influence of the agricultural extension services is insignificant on the agricultural technological adoption.

However, the impact of the lagged version of AES shows a positive and significant impact on the adoption of agricultural technology in Malaysian farmers. Thus, a percentage increase in the AES will result in the 0.38 percent increase in the agricultural technological adoption among the Malaysian farmers. The impact and effect of rural financing is found to be significant as well. A percentage increase in the rural financing indicates an increase of 16 percent in the agricultural technological adoption. Rural financing is an essential facet for the development of the agricultural industry (Lakhan et al., 2020; Utami et al., 2019). The agricultural countries are promoting the usage of microfinance institutions for facilitating the smallholder farmers and farmers in general so that constraints to credit access can be minimized. The findings of the present study are comparable to Abate, Rashid, Borzaga, and Getnet (2016) who found a positive association between the access to institutional and rural finance and agricultural technology adoption. The association between the institutional context of lender and ATA is negative and significant. Thus, a percentage increase in the ICL will result in 44% decrease in the agricultural technology adoption. The R-squared value for the model is 0.87, indicating that overall, the selected variables are responsible for 87% of the variation in the model.

Table 5: ARDL model

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
AES	0.201153	0.163632	1.229301	0.2425
AES(-1)	0.381867	0.143437	2.662270	0.0207
RF	0.167933	0.199871	2.840207	0.0172
ICL	-0.445211	0.193054	-2.306151	0.0398
AFE	1.534732	1.599899	0.959268	0.3564
AFE(-1)	2.990921	1.463072	2.044274	0.0435
C	7.886581	99.16247	-2.499818	0.0279
R-squared	0.874578	Mean dependent var		3.625000
Adjusted R-squared	0.759609	S.D. dependent var		0.575779
S.E. of regression	0.282303	Akaike info criterion		0.615180
Sum squared reside	0.956339	Schwarz criterion		1.204207
Log likelihood	4.617836	Hannan-Quinn criterion		0.771449
F-statistic	7.607034	Durbin-Watson stat		2.360805
Prob(F-statistic)	0.000738			

4.6. Long run and short run

The table 6 is presenting the long run and short run associations for the regressed model. The results from table 6 indicate that AES has a direct and significant impact on agricultural technological adoption. Similarly, rural financing and institutional context of the lender have a significant and positive impact on the agricultural technological adoption in the long and short run.

Table 6: long run and short run estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
	Long-term Equation			
AES	0.095432	1.965434	1.785443	0.0543
RF	0.231356	1.032145	2.053533	0.0031
ICL	0.132134	0.997642	3.635322	0.0000
AFE	3.153222	1.094322	3.642111	0.0000
	Short Term Equation			
COINTEQ01	2.216123	1.645522	2.064662	0.0421
D(AES)	0.317243	0.946611	2.563661	0.0000
D(RF)	0.241115	2.643243	3.842321	0.0000
D(ICL)	2.074552	3.163551	0.734422	0.3846
D(AFE)	0.533663	1.936553	1.999362	0.0283
C	1.2413	1.366361	2.144742	0.0103

4.7. Heteroscedasticity

The results from the table indicate that the heteroscedasticity is absent from the model as indicated by the results below.

Table 7: heteroscedasticity

F-statistic	0.627143	Prob. F(6,18)	0.7067
Obs*R-squared	4.322567	Prob. Chi-Square(6)	0.6331
Scaled explained SS	0.912357	Prob. Chi-Square(6)	0.9887

5. DISCUSSION

The adoption of agricultural technology is becoming very important in today's era due to high competition as well as different risk factors. Such technology helps in improving the production of the crops as well as to reduce the workload of the farmers. Different internal as well as external factors are found to have an impact on the "agricultural technology adoption". This research study was conducted to determine the impact of different variables including: agricultural extension services, rural financing and institutional context of lender on the agricultural technology adoption. For this purpose, a model was developed to determine the significance of the hypotheses. This study showed three important results.

Firstly, the agricultural extension services were found to have a significant impact on the adoption of agricultural technology by the farmers. Such services has a good impact on the overall attitude as well as behavior of the farmers and they become more prone towards adopting new technologies for effective outcomes. According to Emerick and Dar (2021), the "Information and Communication Technology" mechanisms should be promoted to spread awareness about the significance of technology to the farmers so that they could be encouraged enough to make their decisions for implementing such technologies. According to Kassem, Alotaibi, Muddassir, and Herab (2021), as the male farmers are considered to be the feeding tubes for the households in the rural areas of developing countries, their adoption to the agricultural technology in considered to be essential than the adoption of the female farmers. This shows the significance impact

of the agricultural extension services on adopting new technologies (Nyarko & Kozári, 2021). The technical efficiencies of the farmers are also improved by holding different training sessions as well as educational programs.

Secondly, the relationship between rural financing and agricultural technology adoption, was found to be significant. According to Nakano, Tsusaka, Aida, and Pede (2018), the investments play an important role on encouraging the farmers to go for the agricultural technology. Many scholars have observed that the promoted wealth in the rural areas of the developing countries, encourage farmers to opt the new technologies. Even though they are provided with the necessary capital to go for this option. According to Ugochukwu and Phillips (2018), the increase in "rural incomes" provide the opportunity for the rural farmers to increase the production. Globally the rural areas are found to be in crisis due to the shortage of the investments so, different countries have taken initiatives to provide the necessary capitals to the rural farmers to improve this situation.

Thirdly, the institutional context of lender was also found have a positive impact on the agricultural technology adoption by the farmers. Different strategies are being used around the globe to improve the households of rural farmers in developing countries. According to Chavali, Kishore, and Narayana (2020), different organizations are formed in different developing countries for this purpose. Such organizations help in reforming the policies as well as regulations and also provide needed investments or credits to the rural farmers for their effective growth. According to Kumar, Engle, and Tucker (2018), the credit helps in promoting the behaviors of the farmers to adopt to the agricultural technology. This improves the overall production activity of the farmers thus leading them to a better household and increased incomes.

6. CONCLUSION

As the development in technology is being progressed day by day. It is being used in different fields of the work around the globe. Even in the agricultural field, the new technologies are being introduced for improving the production as well as reducing the prices. This also helps in improving the income of the farmers especially in the rural areas of the developing countries. Different factors are found to have an impact on the attitude as well behavior of the rural farmers towards adopting the agricultural technologies. Many studies have been conducted in the past to determine the impact of internal as well as external variables on the adoption of agricultural technology by the farmers. The current study is also conducted for this purpose. However, the main focus of this research study to determine the impact of different variables such as agricultural extension services, rural financing and institutional context of lender on the agricultural technology adoption. For this purpose, the time-series method was used to collect the data. A model was developed by considering the impact of all these variables on the adoption of the agricultural technology by the farmers. The findings from this research study showed that all of the above mentioned variables have significant impact on the agricultural technology adoption by the farmers. Such mobility not only helps in improving the crop production but it ultimately leads to better households of the rural farmers (Ouattara, Xiong, Traoré, Turvey et al., 2020). Thus, it was concluded that with proper provided investments and trainings as well as awareness, the agricultural system of the developing countries could be improved.

7. LIMITATIONS AND FUTURE RESEARCH INDICATIONS

For this research study, limited literature review was available as almost no such study was conducted in the past. However, the current study will help the future researchers in order to have a better understanding of the needs for the adopting of agricultural technology.

The impact of only few variables (including: agricultural extension services, rural financing and institutional context of lender) on the adoption of agricultural technology, was considered for this research study. However, many other variables are also found to have a substantial impact on the agricultural technology adoption such as education, bank finance and many others. So, such variables should be considered by other scholars while conducting a research.

The secondary data is used for this study. However, other such studies should also be conducted using the primary data in order to have a better analysis as well as comparison with other such conducted studies to improve the information needed to opt for the agriculture technologies by the farmers. However, as the current study was conducted in the context of Malaysia using the time-series data. The cross-sectional studies should be promoted to have a detailed and better knowledge about the topic. Even though the rural areas of the developing countries are considered to be the hot spots for such studies, the agricultural sectors of the developed countries should also be studied in order to fill the gap.

8. IMPLICATIONS

This research study helped in providing the literature review for future studies. It helped in determining the significance of adoption of agricultural technology by the rural farmers. Different extension services are promoted for improving the behavior as well as attitude of the rural farmers towards the adoption of agricultural technology. Different organizations are formed to support the rural farmers by providing them with the required capitals and supporting them to make initial investments for effective outcomes. This not only helped in improving the productivity of the crops but it also helped in the betterment of the households of the rural farmers by increasing their incomes. Different educational programs as well as training sessions are held to promote the technical efficiencies of such farmers encouraging them to adopt the agricultural technologies. Most importantly different policies were developed which helped in promoting the use of agricultural technology especially in the rural areas of the country by introducing their benefits and productivity. Such policies were not only significant for the farmers of Malaysia. But they were also found to have an impact on the farmers around the globe.

REFERENCE

Abate, G. T., Rashid, S., Borzaga, C., & Getnet, K. (2016). Rural Finance and Agricultural Technology Adoption in Ethiopia: Does the Institutional Design of Lending Organizations Matter? *World Development*, *84*, 235-253. doi:https://doi.org/10.1016/j.worlddev.2016.03.003

Adnan, N., Nordin, S. M., Bahruddin, M. A., & Tareq, A. H. (2019). A state-of-the-art review on facilitating sustainable agriculture through green fertilizer technology adoption: Assessing farmers behavior. *Trends in Food Science & Technology*, *86*, 439-452. doi:https://doi.org/10.1016/j.tifs.2019.02.040

AlBar, A. M., & Hoque, M. R. (2019). Factors affecting the adoption of information and communication technology in small and medium enterprises: A perspective from rural Saudi Arabia. *Information Technology for Development*, *25*(4), 715-738. doi:https://doi.org/10.1080/02681102.2017.1390437

Altintas, H., & Taban, S. (2011). Twin deficit problem and Feldstein-Horioka hypothesis in Turkey: ARDL bound testing approach and investigation of causality. *International Research Journal of Finance and Economics*, *74*, 30-45. Retrieved from https://www.researchgate.net/publication/279892734

Beaman, L., BenYishay, A., Magruder, J., & Mobarak, A. M. (2021). Can network theory-based targeting increase technology adoption? *American Economic Review*, *111*(6), 1918-1943. doi:https://doi.org/10.1257/aer.20200295

Bridle, L., Magruder, J., McIntosh, C., & Suri, T. (2020). Experimental insights on the constraints to agricultural technology adoption. *UC Berkeley: Center for Effective Global Action*. Retrieved from https://escholarship.org/uc/item/79w3t4ds

Chavali, L., Kishore, P., & Narayana, P. L. (2020). Role of IoT and its Adoption in Smart Farming. *Current Trends in Biotechnology & Pharmacy*, *14*(4), 439-447. doi:http://dx.doi.org/10.5530/ctbp.2020.4.47

Danso-Abbeam, G., Ehiakpor, D. S., & Aidoo, R. (2018). Agricultural extension and its effects on farm productivity and income: insight from Northern Ghana. *Agriculture & Food Security*, *7*(1), 1-10. doi:https://doi.org/10.1186/s40066-018-0225-x

Ejemeyovwi, J. O., & Osabuohien, E. S. (2020). Investigating the relevance of mobile technology adoption on inclusive growth in West Africa. *Contemporary Social Science*, *15*(1), 48-61. doi:https://doi.org/10.1080/21582041.2018.1503320

Emerick, K., & Dar, M. H. (2021). Farmer field days and demonstrator selection for increasing technology adoption. *Review of Economics and Statistics*, *103*(4), 680-693. doi:https://doi.org/10.1162/rest_a_00917

Gebregziabher, G. (2019). Water lifting irrigation technology adoption in Ethiopia: challenges and opportunities. *Gates Open Res*, *3*(952), 952. doi:https://doi.org/10.21955/gatesopenres.1115841.1

Granger, C. W. (2004). Time series analysis, cointegration, and applications. *American Economic Review*, *94*(3), 421-425. doi:https://doi.org/10.1257/0002828041464669

Hatemi-J, A. (2020). Hidden panel cointegration. *Journal of King Saud University-Science*, *32*(1), 507-510. doi:https://doi.org/10.1016/j.jksus.2018.07.011

He, L., Kim, I., & Zhang, Z. G. (2020). Vertical Cooperative Advertising: A Manufacturer's Perspective. *International J. of Opers. and Quant. Management*, *26*(3), 163-182. Retrieved from https://www.ijoqm.org/papers/26-3-1-p.pdf

Hendry, D. F., & Clements, M. P. (2003). Economic forecasting: Some lessons from recent research. *Economic Modelling*, *20*(2), 301-329. doi:https://doi.org/10.1016/S0264-9993(02)00055-X

Hendry, D. F., & Juselius, K. (2000). Explaining cointegration analysis: Part 1. *The Energy Journal*, *21*(1). doi:https://doi.org/10.5547/ISSN0195-6574-EJ-Vol21-No1-1

Hendry, D. F., & Juselius, K. (2001). Explaining cointegration analysis: Part II. *The Energy Journal*, *22*(1). doi:https://doi.org/10.5547/ISSN0195-6574-EJ-Vol22-No1-4

Jayashankar, P., Nilakanta, S., Johnston, W. J., Gill, P., & Burres, R. (2018). IoT adoption in agriculture: the role of trust, perceived value and risk. *The Journal of Business and Industrial Marketing*, *33*(6), 804-821. doi:https://doi.org/10.1108/JBIM-01-2018-0023

Jin, C. C., Seong, L. C., & Khin, A. A. (2019). Factors affecting the consumer acceptance towards fintech products and services in Malaysia. *International Journal of Asian Social Science*, *9*(1), 59-65. doi:https://doi.org/10.18488/journal.1.2019.91.59.65

Kassem, H. S., Alotaibi, B. A., Muddassir, M., & Herab, A. (2021). Factors influencing farmers' satisfaction with the quality of agricultural extension services. *Evaluation and Program Planning*, *85*, 101912. doi:https://doi.org/10.1016/j.evalprogplan.2021.101912

Kebebe, E. (2019). Bridging technology adoption gaps in livestock sector in Ethiopia: A innovation system perspective. *Technology in Society*, *57*, 30-37. doi:https://doi.org/10.1016/j.techsoc.2018.12.002

Kumar, G., Engle, C., & Tucker, C. (2018). Factors driving aquaculture technology adoption. *Journal of the world aquaculture society*, *49*(3), 447-476. doi:https://doi.org/10.1111/jwas.12514

Lakhan, G. R., Channa, S. A., Magsi, H., Koondher, M. A., Wang, J., & Channa, N. A. (2020). Credit constraints and rural farmers' welfare in an agrarian economy. *Heliyon*, *6*(10), e05252. doi:https://doi.org/10.1016/j.heliyon.2020.e05252

Magruder, J. R. (2018). An assessment of experimental evidence on agricultural technology adoption in developing countries. *Annual Review of Resource Economics*, *10*, 299-316. doi:https://dx.doi.org/10.1146/annurev-resource-100517-023202

Mariyono, J. (2019). Microcredit and technology adoption: Sustained pathways to improve farmers' prosperity in Indonesia. *Agricultural Finance Review*, *79*(1), 85-106. doi:https://doi.org/10.1108/AFR-05-2017-0033

Mutyasira, V., Hoag, D., & Pendell, D. (2018). The adoption of sustainable agricultural practices by smallholder farmers in Ethiopian highlands: An integrative approach. *Cogent Food & Agriculture*, *4*(1), 1552439. doi:https://doi.org/10.1080/23311932.2018.1552439

Nakano, Y., Tsusaka, T. W., Aida, T., & Pede, V. O. (2018). Is farmer-to-farmer extension effective? The impact of training on technology adoption and rice farming productivity in Tanzania. *World Development*, *105*, 336-351. doi:https://doi.org/10.1016/j.worlddev.2017.12.013

Norton, G. W., & Alwang, J. (2020). Changes in agricultural extension and implications for farmer adoption of new practices. *Applied Economic Perspectives and Policy*, *42*(1), 8-20. doi:https://doi.org/10.1002/aepp.13008

Nyarko, D. A., & Kozári, J. (2021). Information and communication technologies (ICTs) usage among agricultural extension officers and its impact on extension delivery in Ghana. *Journal of the Saudi Society of Agricultural Sciences*, *20*(3), 164-172. doi:https://doi.org/10.1016/j.jssas.2021.01.002

Ouattara, N. B., Xiong, X., Traoré, L., Turvey, C. G., Sun, R., Ali, A., & Ballo, Z. (2020). Does Credit Influence Fertilizer Intensification in Rice Farming? Empirical Evidence from Côte D'Ivoire. *Agronomy*, *10*(8), 1063. doi:https://doi.org/10.3390/agronomy10081063

Pan, Y., Smith, S. C., & Sulaiman, M. (2018). Agricultural extension and technology adoption for food security: Evidence from Uganda. *American Journal of Agricultural Economics*, *100*(4), 1012-1031. doi:https://doi.org/10.1093/ajae/aay012

Pesaran, M. H., Shin, Y., & Smith, R. J. (1996). *Testing for the'Existence of a Long-run Relationship'*. Retrieved from https://ideas.repec.org/p/cam/camdae/9622.html

Takahashi, K., Muraoka, R., & Otsuka, K. (2020). Technology adoption, impact, and extension in developing countries' agriculture: A review of the recent literature. *Agricultural Economics*, *51*(1), 31-45. doi:https://doi.org/10.1111/agec.12539

Ugochukwu, A. I., & Phillips, P. W. B. (2018). Technology Adoption by Agricultural Producers: A Review of the Literature. In N. Kalaitzandonakes, E. G. Carayannis, E. Grigoroudis, & S. Rozakis (Eds.), *From Agriscience to Agribusiness: Theories, Policies and Practices in Technology Transfer and Commercialization* (pp. 361-377). Cham: Springer International Publishing. doi:https://doi.org/10.1007/978-3-319-67958-7_17

Ujang, S., & Noor, Y. L. (2020). Factors Encouraging the Use of Peer-To-Peer Lending By Farmers. *Russian Journal of Agricultural and Socio-Economic Sciences*, *7*(103), 72-81. doi:https://doi.org/10.18551/rjoas.2020-07.10

Utami, C. W., Indrianto, A. T. L., & Pratama, I. (2019). Agricultural Technology Adoption in Indonesia: The Role of the Agriculture Extension Service, the Rural Financing and the Institutional Context of the Lender. *International Journal of Innovation, Creativity and Change*, *7*(7), 258-276. Retrieved from http://dspace.uc.ac.id/handle/123456789/2111

Verma, P., & Sinha, N. (2018). Integrating perceived economic wellbeing to technology acceptance model: The case of mobile based agricultural extension service. *Technological forecasting and social change*, *126*, 207-216. doi:https://doi.org/10.1016/j.techfore.2017.08.013

Vinholis, M. d. M. B., Saes, M. S. M., Carrer, M. J., & de Souza Filho, H. M. (2021). The effect of meso-institutions on adoption of sustainable agricultural technology: A case study of the Brazilian Low Carbon Agriculture Plan. *Journal of Cleaner Production*, *280*, 124334. doi:https://doi.org/10.1016/j.jclepro.2020.124334

Yajid M.S.A., S. S., Khatibi A. (2020). How China United telecommunication markets? *Systematic Reviews in Pharmacy*, *11*(1), 785-790. Retrieved from https://www.sysrevpharm.org/articles/how-china-united-telecommunication-markets.pdf

Zhang, S., Sun, Z., Ma, W., & Valentinov, V. (2020). The effect of cooperative membership on agricultural technology adoption in Sichuan, China. *China Economic Review*, *62*, 101334. doi:https://doi.org/10.1016/j.chieco.2019.101334

Zheng, S., Wang, Z., & Wachenheim, C. J. (2019). Technology adoption among farmers in Jilin Province, China: The case of aerial pesticide application. *China Agricultural Economic Review*, *11*(1), 206-216. doi:https://doi.org/10.1108/CAER-11-2017-0216