

Article history:

Submitted : March 5th, 2021

Revised : May 25th, 2021

Accepted : May 28th, 2021

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Malaysia's Agricultural Production Dropped and the Impact of Climate Change: Applying and Extending the Theory of Cobb Douglas Production

DOI: <https://doi.org/10.18196/agraris.v7i2.11274>

ABSTRACT

Under climate change, Malaysia's agricultural production showed decreasing in recent decades. This study tries to fill in the gaps to applying and extending the Cobb Douglas production function theory to examine the impact of climate change and economic factors on Malaysia's agricultural production. Using Engle-Granger (EG) test with 37 years of data from 1980 to 2016. The findings showed that the long-run estimated coefficients for rainfall, temperature, and interest rate were -0.338, -0.024, and -0.029, respectively. This indicates that each additional percent in rainfall, temperature, and interest rate will be affected the agricultural production, on average, to decrease by 0.338%, 0.024%, and 0.029%, respectively, holding others constant. Besides that, the long-run elasticity of real GDP per capita, employment, and Trend showed 0.509, 0.513, and 0.119, respectively. Increase 1% of real GDP per capita will lead to the agricultural production to increase about 0.509%, *ceteris paribus*. The elasticity of employment showed that each 10% increase in agricultural employment will increase the agricultural production on average 5.13%, *ceteris paribus*. Furthermore, the trend estimated coefficient showed that the agricultural production will have a constant growth rate which is 0.119% per year. All variables were statistically significant to explain the long-run agricultural production. The short-run rainfall, temperature, employment, and Trend were statistically significant to determine the short-run production growth. Therefore, advanced technology and the latest information on climate change are relevant to boost agricultural production growth. In addition, policymakers also suggested establishing lower interest rate loan facilities and no labor shortage in this industry.

Keywords: agriculture, climate change, global warming, economics, co-integration

INTRODUCTION

In Malaysia, the agricultural sector contributed 8.6% of the national Gross Domestic Product (GDP) and about 12.1% of the total labor force in 2016. However, the contribution of this sector in national GDP has declined gradually from 23.03% in 1980 to about 10.09% in 2010. On the other hand, the employment in this sector has declined from about 1.78 million in 1980 to 1.42 million in 2011. Even the percentage of agriculture contribution to national

income and the percentage share of total employment have declined (Figure 1). The agriculture sector's contribution remains a crucial sector to the Malaysian GDP (Ahmed *et al.*, 2016; Akhtar, Masud, & Afroz, 2019; Kadir & Tunggal, 2015).

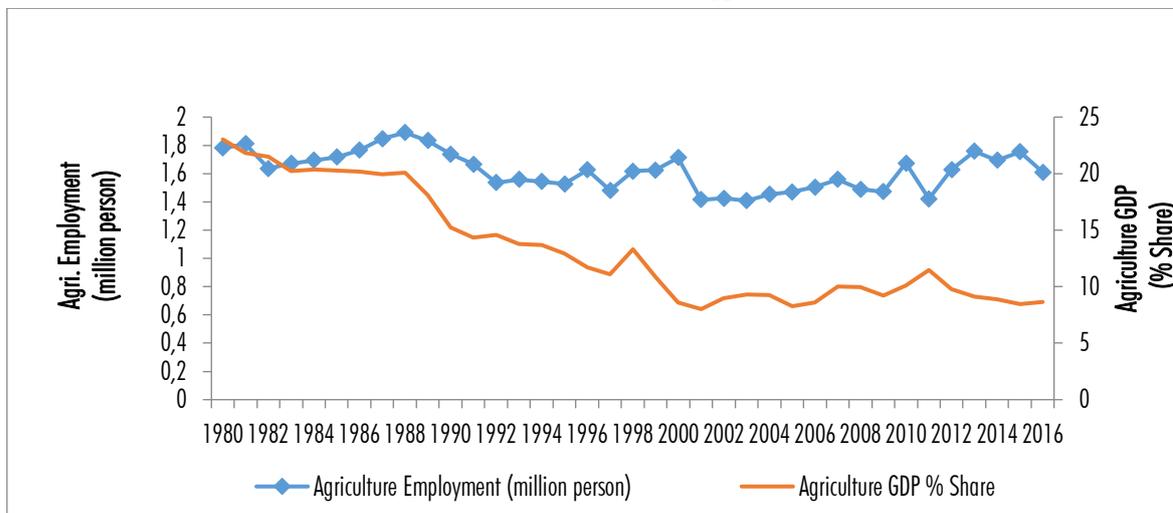


FIGURE 1. MALAYSIA'S AGRICULTURE EMPLOYMENT AND GDP (% SHARE IN TOTAL GDP), 1980 – 2016
SOURCE: DEPARTMENT OF STATISTICS MALAYSIA, (2019A, 2019B)

The production system in the agriculture sector is entirely different from other economic sectors such as the manufacturing and services sectors. Agricultural production growth is strongly related to labor and capital productivity, but the climate variables (rainfall and temperature) also critical to determine production growth. Hence, climate change will directly harm agricultural production, and this sector is affected biophysically by climate factors such as rainfall and temperature more than other economic sectors. Biologically speaking, agricultural products such as crops and plantations need sufficient rainfall and appropriate temperature to grow. Numerous researchers have claimed the negative effects of climate change on the world's agricultural production (Aydinalp & Cresser, 2008; Calzadilla, Zhu, Rehdanz, Tol, & Ringler, 2014) as well as some non-government organization (NGOs) such as the Food and Agriculture Organization (Alexandratos & Bruinsma, 2012; IPCC, 2014).

Studies have shown that climate change substantially reduces agricultural production in low latitude (tropical and semitropical) regions (Adams *et al.*, 1998; Fujimori *et al.*, 2018; Nashwan *et al.*, 2019; and Rosenzweig & Parry, 1994). It mainly a threat to most world developing communities (Huong *et al.*, 2019; and Laux *et al.*, 2010). Climate change is a general problem and that Malaysia would not be excluded as it is a developing country located in lower latitude. According to N'zué (2018) and Sinha & Bhatt (2017), greenhouse gases (GHGs) are the main cause of climate change, and it is estimated that more than 60% of climate change is caused by carbon dioxide. The increase in carbon dioxide in the atmosphere harms the agricultural sector through temperature rises and changes in rainfall patterns, leading to climate disasters. Most importantly, it interferes with the crop nutrition system and increases the susceptibility to pests and diseases that ultimately reduce crop productivity. In Malaysia, the emissions of greenhouse gas carbon dioxide (CO₂) and

temperature recorded an increasing trend (Figure 2), indicating that climate change is also happening in Malaysia, thereby warning the risk of shortage in future agricultural production as well as food production.

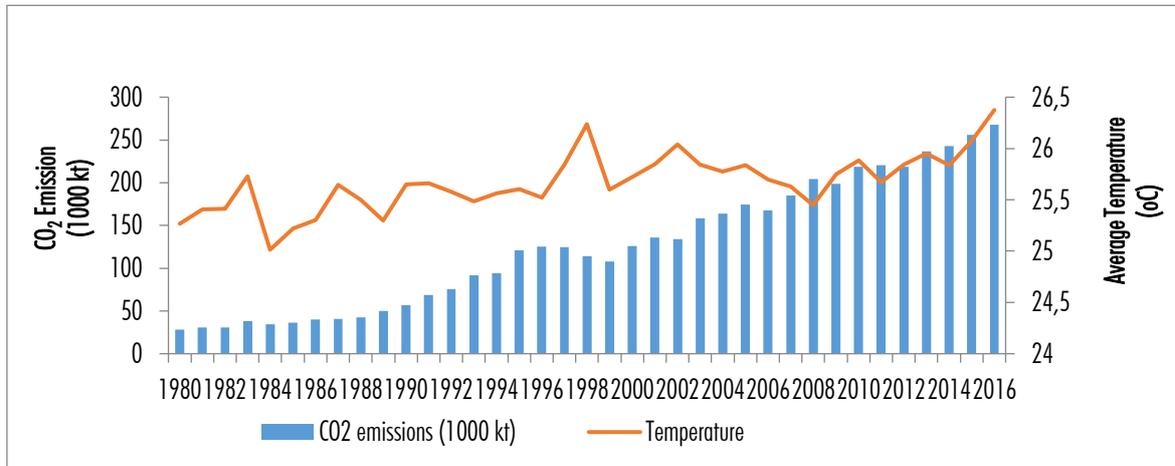


FIGURE 2. MALAYSIA'S CO₂ EMISSION (KT) AND AVERAGE TEMPERATURE (°C), 1980 – 2016
 SOURCE: THE WORLD BANK, WORLD BANK INDICATORS (2019)

Aside from the climatic factors, Malaysia's agriculture sector is facing the restriction from the economic side too (Ali *et al.*, 2010). For instance, agricultural land in Malaysia has increased at a slower growth rate which is about 2.7% from 1980 to 2016 and the agricultural land size remained at 70 thousand km² from 1990 to 2016 (World Bank Group, 2019). Furthermore, considering that agriculture is one of the labor-intensive sectors, a decreased in employment poses a major problem faced by the agriculture sector in Malaysia. The agriculture sector, particularly crop production, is influenced by labor and capital and climatic factors such as temperature and rainfall. Under climate change, assess the factors that lead to the failure of agricultural production is very important.

Choe (1989) and Adekunle & Ndukwe (2018) found that interest rates have a negative impact on agricultural output. These authors stated that an increase in interest rate will raise the cost of capital (cost of borrowing the money), which ultimately results in reduced investment and then a decrease in agricultural output. Besides that, the negative relationship between interest rate and agricultural production was confirmed by (Ali *et al.* 2010; Baek & Koo, 2010; and Onakoya *et al.* 2018).

The employment rate is a commonly used representative variable used to represent labor in a production function. Consistent with the postulation of Okun's law (Okun, 1962) on the relationship between employment and output, employment has a positive relationship with agricultural output. Increasing labor productivity or labor quantity will increase total output. Abbas *et al.* (2015), Barrios *et al.* (2008), Belloumi (2014), Odhiambo *et al.* (2004), Onakoya *et al.* (2018), and Udah & Nwachukwu (2015) found employment has a positive related to the agricultural production, an increase in employment in the agriculture sector will able to increase the agricultural output. Since the agriculture sector is a labor-intensive market, employment will play an important role in this industry.

Additionally, economic growth or national income is also known as one of the key economic factors that have a significant impact on agricultural production (Baek & Koo, 2010; Brownson *et al.*, 2012). According to Baek & Koo (2010), national income is positively related to agricultural production. When the economic growth, producers will intent to produce more of the outputs because they will expect that market demand will increase.

In terms of the impact of agricultural climate change, numerous studies have been conducted to investigate the impact of climate change on agricultural production in various regions across the globe which used temperature and rainfall as climate change factors and found a negative impact of climate change on the agriculture sector (Adams *et al.*, 1998; Laux *et al.*, 2010; Liu *et al.*, 2004; Rosenzweig & Parry, 1994; Tang, 2019).

In Malaysia, there are many studies have investigated the impact of climate change on crop production and showed that climate change negatively influenced agricultural sector (Al-Amin *et al.*, 2011; Alam *et al.*, 2012; Ali *et al.*, 2017; Herath *et al.*, 2020 ; Masud *et al.*, 2014; Siwar *et al.*, 2009; Tang, 2019; Vaghefi *et al.*, 2011). According to Tang (2019), climate change in Malaysia has harmed the agricultural sector due to rising temperatures and unexpected rainfall variability every year. Extreme weather may damage agricultural products such as paddy during the flood or drought (Akhtar *et al.*, 2019; Alam *et al.*, 2011). For instance, Alam *et al.* (2017), and Herath *et al.* (2020) used mean temperature and rainfall to determine the impact of climate change on paddy production in Malaysia. They found that both temperature and rainfall harm paddy production.

There are limited studies that combined climate change and economic variables to explain agricultural production. Cobb Douglas's production function theory widely in the past studies explains the physical output determine by the physical inputs use. However, agricultural production such as crops and livestock is different than manufacturing production. The factors used to explain agricultural production should not limit to either climate change variables (rainfall and temperature) or economic variables. As mentioned before, climate factors are important to justify agricultural production and they should be included in the Cobb Douglas production function. Therefore, this study tries to fill in the gaps to applying and extending the Cobb Douglas production function theory to examine the impact of climate change and economic factors on Malaysia's agricultural production.

RESEARCH METHOD

Cobb Douglas' production function (Cobb and Douglas, 1928) is a popular economic theory that widely adopted to explain specific physical products that can generate by two or more physical inputs (such as labor and capital) quantity (Equation 1).

$$Y = f(A, L, K) = AL^{\alpha}K^{\beta} \quad (1)$$

where, Y represents the physical output; A, L, and K denotes total input productivity, physical labor, and physical capital, respectively; then α and β implies the constant output elasticity of capital input and labor input. However, Cobb Douglas' production function

does not take climate impact as one of the important determinants of agricultural production. Hence, additional climate change variables are crucial to extending the Cobb Douglas production theory in this study.

Based on the general Equation 1, the long-run agricultural production regression can be written as Equations 2:

$$\ln \text{AGRI}_t = \beta_0 + \beta_1 \ln \text{INT}_t + \beta_2 \ln \text{EMP}_t + \beta_3 \ln \text{RGDPPC}_t + \beta_4 \ln \text{TEMP}_t + \beta_5 \ln \text{RAIN}_t + \beta_6 \text{TREND}_t + u_t \quad (2)$$

where, \ln denotes as natural logarithmic and the β_0 represents the constant total productivity of Malaysia's agricultural production. In addition, β_1 , β_2 , β_3 , β_4 , β_5 , and β_6 have represented the long-run elasticity for interest rate (INT) which is a proxy for the physical capital, employment (EMP) is proxy for labor input, real GDP per capita (RGDPPC) as a proxy for the national economic performances, temperature (TEMP) and rainfall (RAIN) both represents the climate change variables and the technology time trend (TREND), respectively. The u_t denotes the estimated residual of the model and error correction term (ECT).

Regarding the signs of the coefficients in Equation 2, the previous expectations of theoretically determining the signs of the parameters of economic relations are discussed in the literature review section. It is expected that $\beta_1 < 0$ because a rise in interest rates would increase the borrowing costs which will subsequently lead to a decrease in agricultural production as a consequence of reduced investment in physical capital. As to the effect of employment, it is expected that $\beta_2 > 0$, which is consistent with the postulation of Okun's law that typically in an economy the production of more goods and services would require more labor and employment to promote the output. Similarly, concerning the impact of real per capita GDP (income), since an increase in real GDP per capita will increase purchasing power, which will lead to a rise in output, it is expected that $\beta_3 > 0$. Finally, it is foreseeable that due to the increase of temperature and rainfall, both β_4 and $\beta_5 < 0$ will cause climatic disasters such as floods and droughts, which will lead to soil erosion and leaching, and ultimately lead to reduced agricultural production due to depletion of soil nutrients.

Based on the classical linear regression model (CLRM) assumptions, the ECT in long-run regression must be stationary to avoid the spurious regression problem. Hence, Engle & Granger (1987) proposed a co-integration test and using Augmented Dickey-Fuller (ADF) test to confirm the ECT in the stationary process. The EG co-integration test obtains the ECT from Equation 2 and re-estimate in the following regression form:

$$\Delta \hat{u}_t = (p - 1) \hat{u}_{t-1} + \sum_{j=1}^k \theta_j \Delta \hat{u}_{t-j} + e_t \quad (3)$$

Where, $\Delta \hat{u}_t$ is the first difference of the residual (u_t) obtained from Equation 2. k denotes the number of lags, θ_j is the coefficient of the lagged difference of the estimated residuals, \hat{u}_{t-j} the lag of estimated residual from the long-run regression, and e_t is the error term for the ADF test. If the null hypothesis of the $p-1 = 0$ is rejected in this test, indicating a long-run co-integration relationship and there is no spurious regression problem.

If there is a long-term co-integration relationship between the regression variables, the error correction model (ECM) will take the lagged one ECT as a relevant variable to explain the impact of short-term changes. The short-run ECM will show as the Equation 4:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^n \beta_i \Delta y_{t-i} + \sum_{k=1}^m \delta_k \Delta x_{jt-k} + \lambda ECT_{t-1} + u_t \quad (4)$$

Where, β and δ are the short-run dynamic coefficient of the model. ECT_{t-1} is the lagged one of the residual from Equation 2 and λ is the coefficient of the error correction term ($-1 < \lambda < 0$) which represents the speed of adjustment. If the market has a self-adjustment from disequilibrium back to the equilibrium point, the coefficient of the ECT_{t-1} is estimated to be negative and statistically significant (Engle & Granger, 1987; Gujarati, 1995).

Based on the general Equation 4, the ECM model for variables in this study can be written as Equation 5:

$$\begin{aligned} \Delta \ln AGRI_t = & \delta_0 + \theta ECT_{t-1} + \sum_{i=1}^p \alpha_i \Delta \ln AGRI_{t-i} + \sum_{j=0}^q \beta_j \Delta INT_{t-j} + \sum_{k=0}^r \beta_k \Delta \ln EMP_{t-k} + \\ & \sum_{m=0}^s \beta_m \Delta \ln RGDP_{t-m} + \sum_{n=0}^u \beta_n \Delta \ln RAIN_{t-n} + \sum_{f=0}^v \beta_f \Delta \ln TEMP_{t-f} + \\ & \delta_1 \Delta \ln TREND_t + u_t \end{aligned} \quad (5)$$

Where, δ_0 is constant, θ is coefficient for ECT and it is expected to be negative and significant; $\sum_{j=0}^q \beta_j$, $\sum_{k=0}^r \beta_k$, $\sum_{m=0}^s \beta_m$, $\sum_{n=0}^u \beta_n$, and $\sum_{f=0}^v \beta_f$ are the magnitude of the short-run changes for AGRI, INT, EMP, RGDP, RAIN, TEMP, and TRND, respectively.

The annual time series data from 1980 to 2016 is used in this study. Real agricultural GDP (AGRI) and lending interest rate for the capital were collected from World Bank Indicators (www.worldbank.org/indicator). Annual data on the number of employees in the agricultural sector (EMP) and Malaysia's real GDP per capita (RGDP) collected from the Food and Agriculture Organization (www.fao.org) each year, as well as data on climatic factors (rainfall and rainfall) can be accessed from the World Bank Group's Climate Knowledge Portal (<https://climateknowledgeportal.worldbank.org>).

RESULT AND DISCUSSIONS

The findings of Augmented Dicky Fuller (ADF) and Phillip-Perron (PP) tests were summarized in Table 1. The ADF and PP tests showed that all variables were significant at 1% of significance level which after transformed it into the first difference. This indicates that these variables were considered as integrated at order one or I (1) variable.

The result of the Engle-Granger co-integration test was presented in Table 2. It showed that the residual of the estimated co-integration regression ($\widehat{u}_t = -5.218$) was less than the critical value (-4.07) at 1% of the significance level. Therefore, the null hypothesis that there is no co-integration relationship was rejected, indicating that all estimated variables (INT, EMP, RGDP, RAIN, and TEMP) had a strong long-term co-integration relationship with agricultural production. The long-run regression result showed that all the independent variables followed the expected sign in the model. The $\ln TEMP$ was found significant at 5% significance level and other variables were statistically significant at 1% of the significance

level. The interest rate (INT), rainfall (RAIN), and temperature (TEMP) had negative relationships with agricultural production, whereas employment (EMP) and real GDP per capita (RGDPPC) had a strong positive relationship with agricultural production in Malaysia. A linear time trend (TREND) was included in the EG long-run model to take into account the constant technology change effect on agricultural production. The TREND showed statistically positive significance to explain the agricultural production at 1% significance level. This indicates that the constant increase in technology in the agricultural sector will able to increase agricultural production.

TABLE 1. SUMMARY OF STATIONARY TEST RESULTS (ADF AND PP TESTS)

Variables	ADF		PP	
	I(0)	I(1)	I(0)	I(1)
lnAGRI	-1.159 (0)	-5.955*** (1)	-1.172 (4)	-5.792*** (6)
lnINT	-0.649 (0)	-5.375*** (0)	-0.480 (6)	-9.114*** (21)
lnEMP	-2.821 (0)	-8.449*** (0)	-2.740 (2)	-8.486*** (2)
lnRGDPC	-0.683 (0)	-4.997*** (0)	-0.677 (1)	-4.997*** (0)
lnTEMP	-2.616 (0)	-6.486*** (1)	-2.616 (0)	-15.890*** (34)
lnRAIN	-2.041 (0)	-6.983*** (0)	-2.079 (3)	-14.021*** (24)

Note: *** and ** denotes the significance level at 1% and 5% respectively.
 The value of parenthesis (...) represents the optimum lag selected based on the SIC criteria.

TABLE 2. FINDING OF ENGLE-GRANGER CO-INTEGRATION TEST AND LONG-RUN REGRESSION

lnAGRI	C	lnINT	lnEMP	lnRGDPPC	lnRAIN	lnTEMP	TREND
	β_0	β_1	β_2	β_3	β_4	β_6	β_7
	27.974***	-0.029***	0.513***	0.509***	-0.338***	-3.024**	0.119***
	(4.034)	(0.006)	(0.108)	(0.060)	(0.094)	(1.211)	(0.035)
	[0.000]	[0.001]	[0.000]	[0.000]	[0.001]	[0.018]	[0.002]
Engle-Granger Co-integration test:							
$\Delta \hat{u}_i = (\rho - 1) \hat{u}_{i-1} + \sum_{j=1}^k \theta_j \Delta \hat{u}_{i-j} + \epsilon_i$				-5.218***			
Critical Value		1%	5%	10%			
		-4.07	-3.37	-3.03			
R ²	0.966	Durbin Watson Stat		1.624			

Note: *** and ** indicated the significance level at 1% and 5%, respectively.
 The value in the parenthesis (...) denotes standard error while the value in the [...] represents the P-value.

The estimated elasticity of INT is -0.029 which indicates that a 1% increase in the interest rate will result in a decline in long-run agricultural production by 0.029%, holding other factors constant. The finding accords with the result of Adekunle, Wasiu & Ndukwe (2018), Ali *et al.* (2010), Baek & Koo (2010), and Odior (2014) where an ascent in the interest rate would lower agricultural production as a consequence of diminishing investment due to the increase in the capital cost and the cost of production.

The long-run coefficient elasticity for EMP is 0.513, indicating that a 10% increase in agricultural employment would increase agricultural production by about 5.13%, *ceteris paribus*. The finding corresponds with the results of Abbas *et al.* (2015), Onakoya *et al.*

(2018), and Udah & Nwachukwu (2015), stating that the labor force is one of the most important contributors to agricultural production. Researchers believe that employment and agricultural production have a direct and important relationship. Also, the estimated coefficient for RGDPPC is 0.509, which implies a direct and significant relationship between national income and agricultural production. In other words, agricultural growth will increase by 5.09% for every 10% increase in national income. Similar results were found by Brownson *et al.* (2012), Dlamini *et al.* (2015), and Baek & Koo (2010) that, an increase in income will increase production by increasing the purchase power demand for production.

However, there is a negative relationship between climate factors (rainfall and temperature) and agricultural production (Chizari *et al.*, 2017 and Herath *et al.*, 2020). The estimated elasticity for RAIN was -0.34, indicating that at a 1% increase in rainfall, the agricultural production will decline by about 0.34%, holding other factors constant. This result is consistent with those observed by Alam *et al.*, (2014), Ali *et al.* (2017), Chizari *et al.* (2017), and Herath *et al.* (2020) that, rainfall harms agricultural production. The long-run elasticity coefficient for TEMP is -3.024, which means that a 1% increase in temperature will lead to a decline in total agricultural output by 3.024% in the long run. A similar finding is also reported by Alam *et al.* (2014) that, 1% increase in temperature would decrease rice production by about 3.4%.

The results of the ECM model for short-run analysis are presented in Table 3. It shows that all the estimated variables followed the expected sign even in the short run. The lag one of Error Correction Term (ECT_{t-1}) represents the speed of adjustment, which is -0.456 and significant at 1% of the significance level. It indicates that the short-run disequilibrium in agricultural production would require a moderate speed of adjustment to recover the state of equilibrium.

TABLE 3. ESTIMATED RESULT OF ERROR CORRECTION MODEL

	Coefficient	Standard Error	P-Value
C	0.007	0.009	0.422
ECT_{t-1}	-0.456***	0.163	0.009
$\Delta AGRI_{t-1}$	0.341**	0.160	0.042
ΔINT_t	-0.004	0.007	0.576
ΔEMP_t	0.427***	0.103	0.000
$\Delta RGDPPC_t$	0.253	0.170	0.149
$\Delta RAIN_t$	-0.179***	0.057	0.004
$\Delta TEMP_t$	-2.703***	0.767	0.002
TREND _t	0.041**	0.018	0.027

Note: *** and ** indicated the significance level at 1% and 5%, respectively.

Based on the estimated result of the ECM model for short-run analysis, the slope coefficient of lag one of the dependent variable ($AGRI_{t-1}$) was statistically significant at 5% of the significance level. EMP was the only significant variable from the economic factors, which was statistically significant at 1% of the significance level. He estimated that the elasticity of short-term employment was within a reasonable range of 0.427, which indicates that the increase in labor demand in this industry will increase labor productivity and then

increase agricultural production in the short term (Onakoya *et al.*, 2018). However, INT and RGDPPC had an insignificant positive causal impact on agricultural production. The estimated elasticity for climate factors of both rainfall and temperature were negative and statistically significant at a 1% level, indicating that climate change has a strong negative relationship with agricultural production even in the short run. These findings were supported by Talib & Darawi (2002), and rainfall has an important impact on production.

In this study, several keys diagnostic tests were used to confirm that the long-term and short-term estimated models are the Best Linear Unbiased Estimators (BLUE). The results were reported in Table 4. The R-squared of the long-term model is 0.966, indicating that all independent variables (INT, EMP, RGDPPC, RAIN, and TEMP) in the model explain about 96.6% of the variation in agricultural production. However, the R² in the short-term estimation model was 0.606, which indicates that about 60.6% of the changes in agricultural output were explained by the changes in the independent variables, while there was no explanation for about 39.4% in the model. The F-statistic in the long-run and short-run model were statistically significant at 1% of significance level, which indicates that the models were fit, and all independent variables used in the models jointly affected the agricultural output.

TABLE 4. DIAGNOSTIC CHECKING TESTS

Test Statistics	OLS Estimation	ECM Estimation
R ²	0.966	0.606
Adj R ²	0.959	0.485
F- Statistics	139.241*** [0.000]	4.998*** [0.001]
LM test	1.166 [0.558]	0.269 [0.874]
Jarque-Bera	0.620 [0.733]	1.414 [0.235]
ARCH	0.071 [0.790]	3.746 [0.154]

Note: *** and ** indicated the significance level at 1% and 5%, respectively. The value in the parenthesis [...] represents the P-value.

Also, the auto-serial correlation test (LM-test) was employed to confirm the estimated regressions were not suffering from a serial correlation problem. The result showed that the p-value was insignificant and failed to reject the null hypothesis and that the residual was serially correlated. In addition, the Jarque-Bera test and ARCH test were insignificant and failed to reject the null hypothesis, thereby confirming that the residuals of the regression models were normally distributed, and the variance of the residual was constant over time. Hence, the model has fulfilled the homoscedasticity assumption in the Classical Linear Regression Method (CLRM). Finally, the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of recursive residuals (CUSUMSQ) statistical graphs move within the critical range (significantly 5%), indicating that the stability estimates all variables' coefficient and not cause any structural damage (Figure 3).

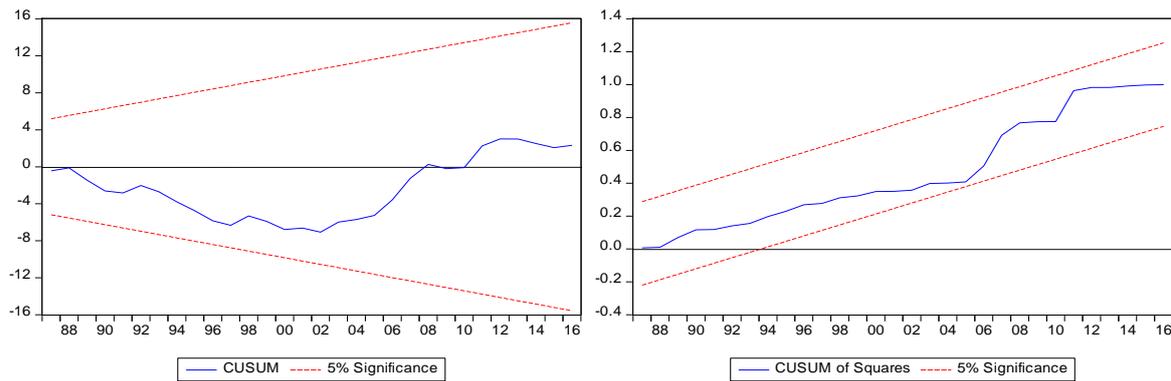


FIGURE 3: CUSUM AND CUSUMSQ TESTS FOR ESTIMATED PARAMETER STABILITY

CONCLUSION AND RECOMMENDATION

Conclusion

In recent decades, the agriculture GDP has a lower growth rate, which has drastically fallen since 2010. This study employed the co-integration method and utilized annual data spanning a period of 37 years (1980 - 2016). The co-integration test showed that there is a long-run co-integration between agricultural production and all explanatory variables (TREND, INT, EMP, RGDPPC, TEMP, and RAIN). The results further showed that all the variables followed the expected signs, both in the long run and short run. In the long run, interest rate, rainfall, and temperature have negative and significant effects on agricultural production, while national income and employment have positive significant effects. In the short run, rainfall and temperature have negative and significant effects on agricultural production while employment has a positive and significant effect. Meanwhile, interest rate and income do not have significant effects on agricultural production in the short run. Also, the negative and significant ECT_{t-1} indicated that the short-run disequilibrium in agricultural production would require a moderate speed to recover the state of equilibrium.

Therefore, the findings highlighted that an accurate forecast of the weather changed is important to reduce the farmers' losses. The perfect information sharing i.e the changes of rainfall and temperature between the meteorology department and farmers is important. According to the accurate weather forecast of the meteorological department, farmers can make good agricultural production plans. Moreover, time to receive the information of weather also an important element especially before the flood and drought happens.

From the economic point of view, policymakers or governments can establish lower interest or special interest loan facilities to encourage farmers to adopt advanced technology or increase their investment in their agricultural production. Besides that, the local authorities also have to make sure that there is no labor shortage in this industry. Because when the sector is facing larger excess labor demand, the agricultural sector may face shortage at the end. Since the upstream sector shortage, the downstream sector such as the food sector may face increasing food import bills or food shortage. This indicates that the problem of labor shortage may increase the nation's food insecure issues.

Recommendation

Based on the finding of this study, several relevant policy recommendations are proposed to help better coping with the impact of climate change. However, some adaptation strategies, such as growing drought-resistant crops, changing the planting date, and managing the irrigation and technology use, are recommended to afford the farmers a cushion against further anticipated adverse climatic conditions. Nevertheless, the government as an authority for policy and law-making must play the most influential role in ensuring climate mitigation and adaptation at all levels. First and foremost, climate change factors harm agricultural production. To overcome the negative effect of climate change, the government and policymakers should provide policies on providing advanced technology to overcome the climate change problem and ensure that the producers receive up-to-date information in anticipation of severe climate change variations. This is to enable the farmers to make well-informed decisions on their productions. Another important policy message based on the finding of the study that pertains to the negative influence of interest rate on agricultural production is to offer a special lower interest rate for the farmers to reduce production costs and increase their investment in their physical capital. Additionally, given the fact that agriculture is a labor-intensive sector and an increase in the number of employments has a significant impact on increasing agricultural production, appropriate authorities have to make sure there is no labor shortage in this industry. Finally, policymakers and economists need to consider adaptation barriers, namely financial, ecological, technical, and institutional barriers, to define government incentive plans, because agricultural policies need to be more strategic and must respond to possible be fully prepared for the impact.

ACKNOWLEDGEMENT

This work was supported by the Ministry of Higher Education (MOHE)/Higher Education Development Program (HEDP) of Afghanistan and funded by the World Bank scholarship.

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