Impacts of El Nino and La Nina on Palm Oil Production: Evidence from Selected Palm Oil Producing Countries

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ABSTRACT

Palm oil is one of the most important edible oils commercialized in world oils and fats market. However, agriculture is highly vulnerable to climate change. For instance, El Nino is the warm phase of El Nino Southern Oscillation (ENSO) while La Nina is the opposite of El Nino, the cold phase of ENSO. Strong El Nino and La Nina events cause global changes especially in temperature and rainfall, subsequently affect agricultural areas and causing considerable economic losses. Therefore, the objective of this study is to explore the impacts of El Nino and La Nina on palm oil production in selected palm oil producing countries namely Indonesia, Malaysia and Thailand from 1980 to 2019 using the Ordinary Least Square (OLS) multiple regression analysis. The results revealed that area harvested and palm oil price affect palm oil production significantly in all palm oil producing countries. Nevertheless, the ENSO effects are not apparent. Only the El Nino dummy coefficients are negative and statistically significant in Thailand, suggesting that the occurrence of El Nino events is more pronounced than the La Nina events on palm oil production in Thailand. Hence, this study suggests that a good water management system is needed to allow the palm oil to achieve optimum production.

Keywords: *Palm oil production, El Nino, La Nina, Climate change, OLS*

1.0 INTRODUCTION

Palm oil is the most widely used edible oil on earth. The growth in palm oil production can be credited to the local demand and to the price that is affordable to purchase. The palm oil is used widely in a number of applications (including food, cosmetics and other industries) as well as biofuels, along with a lower selling price relative to its rivals, making it a more attractive commodity (Chuangchid, Wiboonpongse & Sriboonchitta, 2012). Moreover, palm oil contributed a significant amount of revenue to the economy (Wiebe et al., 2015). According to Malaysian Department of Statistics, in 2018, agriculture, forestry and fishing sectors accounted for 12.81% (Indonesia) and 7.48% (Thailand) of GDP; roughly 7.3% of GDP (RM99.5 billion) was generated by agriculture sector in Malaysia.
Table 1 presents the world's top ten of palm oil producing countries in 2019. Indonesia and its neighbouring countries (Malaysia and Thailand) rank among the top three global palm oil producers, with the total production of 42500 (1000MT), 19800 (1000MT) and 3000 (1000MT), respectively. Malaysia was once largest palm oil producer but starting from 2007, Indonesia appeared to be the largest producer of crude palm oil (CPO) worldwide resulting from a steady increase of palm oil plantation growth between 2000 and 2005 (Sulistyanto & Akyuwen, 2009).

Table 1: World's Top Ten of Palm Oil Producing Countries in 2019

No	Country	Production (1000MT)
1	Indonesia	42500
2	Malaysia	19800
3	Thailand	3000
4	Colombia	1680
5	Nigeria	1015
6	Guatemala	852
7	Ecuador	630
8	Honduras	580
9	Brazil	540
10	Cote D'ivoire	515

Sources: Index Mundi

However, agricultural sector is strongly influenced by climatic condition includes El Nino and La Nina phenomenon or El-Nino Southern Oscillation (ENSO) (Paterson & Lima, 2018). According to Rahman et al. (2013), El Nino event is linked to warming of the Central and Eastern tropical waters of the Pacific Ocean and an exceptionally warm ocean temperature in the Equatorial Pacific. On the other hand, La Nina is characterized in the Equatorial Pacific as extremely cold ocean temperatures (Limsakul, 2019; Rahman et al., 2013). These two events are caused by global warming and subsequently affect the palm oil productivity

(Kamil & Omar, 2017).

Palm oil is a tropical plant that demands a regularly distributed annual rainfall between 1500mm and 2000mm or minimum 5 hours per day of sun exposure (Abdullah, 2012; Casey et al., 2019). Shortage of rain or too much rainfall will affect palm oil productivity. Best palm oil yield can be obtained in the areas where the highest average temperature ranges 29oC - 33oC and the minimum average temperature ranges 22oC - 24oC (Zainal et al., 2012). Hence, the El Nino (prolonged hot and dry weather) or the La Nina (cooler temperature and associated with heavy rainfall) events will affect palm oil production in a country. During El Nino, high weather conditions and fewer rainfalls may lead to a poor yield of fresh fruit bunches output in future (Rahman et al., 2013). According to Rahman et al. (2012), heavy rains during La Nina cause flooding in certain planted areas and disrupt the harvesting and collecting activities of fresh fruit bunches (FFB). Therefore, the objective of this paper is to examine the effects of El Nino and La Nina on palm oil production in selected palm oil producing countries namely Indonesia, Malaysia and Thailand using Ordinary Least Square multiple regression models from 1980 to 2019. The rest of paper is outlined as follows: Section two provides the literature review while the next section presents the data and methodology. Section four discusses the empirical findings and the final part includes conclusions.

2.0 LITERATURE REVIEW

According to Whelan and Forrester (1996), supply is the amount of product and services that the suppliers are both willing and able to supply over a given period of time at a specific price. There exists a direct relationship between price and quantity supplied (Dormady, Henriquez, & Rose, 2019). Subsequently, producers will more likely to increase the production in order to generate more profits. As pointed by Braekkan (2014), factors that affect production between periods includes weather conditions on agricultural yields, input prices and productivity growth.

Rahman et al. (2012) found that planted area has a significant impact on palm oil production. The larger the oil palm planted area, the higher the production of crude palm oil (Noor, Simeh, Ismail & Latif, 2004). Moreover, Talib and Darawi (2002) examined the connection among palm oil production and planted area, export, import and CPO price. Sulistyanto and Akyuwen (2009) and Talib and Darawi (2002) reported that total planted area of palm oil has a direct infuence on the production of crude palm oil.

Alternatively, Rahman et al. (2012) and Basiron (2002) reported that crude palm oil fluctuation is determined by market forces, both demand and supply factors. Abdullah, Abas and Ayatollah (2007) indicated that palm oil price plays a significant role in affecting the palm oil production. The increase in palm oil price is mainly due to palm oil demand continues to grow (Abdullah et al., 2007). This could potentially push the production upward as producers want to increase profit from the increase in prices and to meet the rising demand of palm oil.

Aside from the planted area and price factors, changing climate such as strong El Nino and La Nina events are additional influencing factors that cause drought and floods, leading to a decline in palm oil production (Rahman et al., 2012). Kamil and Omar (2016) noted that climate variability has a major effect on the trend of palm oil production. Nevertheless, the influence of extreme weather patterns on crop productivity is subjected to the severity of the El Nino and La Nina events (Deng et al., 2010). A mild or weak El Nino and La Nina does not matter much for a country and its economy. According to Kamil and Omar (2017), the El Nino occurrence has been shown to influence weather patterns through the distribution of precipitation, which later affects the palm oil production significantly in Malaysia. They further highlighted that a strong El Nino will cause rainfall to be lower than normal and therefore affect oil palm trend.

On a similar note, Rahman et al. (2012) found an inverse connection between La Nina and palm oil production. Heavy rainfall during La Nina triggers floods to impact oil palm planted areas and subsequently leads to the disruption in cultivation and process of FFB. Ezechi and Muda (2019) also claimed that the decline in CPO production in 2010, 2012 and 2016 was attributed to adverse weather conditions induced by El Nino and La Nina. As reported by Rahman et al. (2013), CPO production in a certain year declined by about 3.37% during El Nino and La Nina events.

3.0 DATA AND METHODOLOGY

This study utilized annual time series data for three palm oil producing countries namely Indonesia, Malaysian and Thailand spanning from 1980 to 2019. Table 2 presents the variables description. Data for palm oil production, area harvested and CPO price were obtained from Index Mundi while El Nino and La Nina were collected from the Australian Government Bureau of Meteorology.

Table 2 : Variables Description

Variables		Units
Palm oil production	PO	MT
Area harvested	AREA	HA
CPO price	P	USD/T
El Nino	NINO	
La Nina	NINA	

According to supply determinants, other factors that affect supply are cost of production, technology and the number of sellers aside from its own price. The present study augments the effects of El Nino and La Nino on the palm oil production. The inclusion of these climate change variables can be specified in the following OLS regression models :

$$lnPO_t = \beta_0 + \beta_1 lnAREA_t + \beta_2 lnP_t + \beta_3 NINO_t + e_t \quad (1)$$
$$lnPO_t = \alpha_0 + \alpha_1 lnAREA_t + \alpha_2 lnP_t + \alpha_3 NINA_t + e_t \quad (2)$$
$$lnPO_t = \theta_0 + \theta_1 lnAREA_t + \theta_2 NINO_t + \theta_3 NINA_t + e_t \quad (3)$$

awhere t is time period, PO is the palm oil production, AREA is the area harvested, P is the CPO price, NINO and NINA are El Nino and La Nina, respectively, and e is the error term. β_0 to β_3, α_0 to α_3 and θ_0 to θ_3 are the parameter estimates. β_1, α_1 and θ_1 are expected to have a positive effect on palm oil production. Similarly, β_2 and α_2 are expected to have a significant and direct effect on palm oil, signifying that the price level will affect tha production of palm oil. β_3, α_3, θ_2 and θ_3 are expected to have a negative sign, reflecting that the palm oil production will be lowered during El Nino or La Nina events. This is because agriculture is among the most vulnerable to uncertain weather conditions. Extreme weather condition may affect the growth of fresh fruit bunches yield.

4.0 EMPIRICAL FINDINGS AND DISCUSSION

Table 3 provides the summary statistics. Indonesia was the largest palm oil producer with an average of 13429.47 (1000MT), followed by Malaysia 11610.95 (1000MT) and Thailand with 920.80 (1000MT). The largest planted area of palm oil located in Indonesia about 4058 (1000HA), Malaysia with 2913.6750 (1000HA) and Thailand, 308.0750 (1000HA). The average value crude palm oil price was 547.4852 (USD/T). The correlation coefficient is shown in Table 4. There exists a strong and positive correlation between AREA and P in Thailand with 0.7238. The correlation of 0.6945 and 0.6620 shows a moderate and positive correlation between AREA and P in Indonesia and Malaysia.

Table 3 : Descriptive Statistics

INDONESIA	PO	AREA	P
Mean	13429.4700	4058.0000	547.4852
Maximum	42500.0000	11750.0000	1125.4200
Minimum	752.0000	230.0000	212.3800
Std. Dev.	13245.1600	3788.6230	206.7608
MALAYSIA	**PO**	**AREA**	**P**
Mean	11610.9500	2913.6750	547.4852
Maximum	20800.0000	5350.0000	1125.4200
Minimum	2692.0000	777.0000	212.3800
Std. Dev.	6092.3780	1410.2180	223.1874
THAILAND	**PO**	**AREA**	**P**
Mean	920.8000	308.0750	547.4852
Maximum	3000.0000	810.0000	1125.4200
Minimum	19.0000	11.0000	212.3800
Std. Dev.	904.8445	260.6228	223.1874

Notes: PO – palm oil production, AREA - area harvested, P - Crude palm oil price.

Table 4 : Correlation Coefficient

	INDONESIA			MALAYSIA			THAILAND		
	lnPO	lnAREA	lnP	lnPO	lnAREA	lnP	lnPO	lnAREA	lnP
lnPO	1.0000	0.9963	0.6833	1.0000	0.9864	0.7045	1.0000	0.9813	0.6927
lnAREA	0.9963	1.0000	0.6945	0.9864	1.0000	0.6620	0.9813	1.0000	0.7238
lnP	0.6833	0.6945	1.0000	0.7045	0.6620	1.0000	0.6927	0.7238	1.0000

Notes: PO – palm oil production, AREA - area harvested, P - Crude palm oil price, NINO - El Nino and NINA - La Nina.

Table 5 presents the OLS multiple regression results. Three regression models (model1, model 2 and model 3) were estimated with different independent variables for each country. The findings can be split into following parts. First, the bottom panel of Table 5 reports various diagnostic for the estimated models used in this study. These diagnostic checks include, Durbin-Watson test for serial correlation, White's test for heteroscedasticity, Jarque-Bera (JB) test for errors normality and lastly RESET test for model specification. Most regression models in Indonesia suffered from the serial correlation, residuals are not normally distributed and model misspecification; while regression models in Malaysia and Thailand satisfied the classical assumptions except serial correlation in Malaysia.

Second, the *F*-statistics are statistically significant in all regression models, showing that the models are well fit in this study. The R2 values of around 0.9881 to 0.9933 for all countries. This suggests that the around 99.88% to 99.33% of variance explained by the regression models.

Third, area harvested (AREA) has a positive and significant influence on palm oil production in all countries. The coefficients of AREA ranged from a low of 0.9724 (model 1) in Indonesia to a high of 1.2298 (model 1) in Thailand. This implies that a one percent rise in AREA was associated with an increase between 0.9724%

and 1.2298% in the PO. This in line with Sulistyanto and Akyuwen (2009) and Talib and Darawi (2002) where they found a positive relationship between total oil palm planted area and palm oil production. As pointed by Rahman et al. (2012), production of palm oil is found to be significantly affected by area harvested. Several studies evidenced that expansion in oil palm planted area has attributed to the increase in palm oil production in Indonesia and Malaysia (Basiron, 2002; Ezechi & Muda, 2019). Additionally, Rahman et al. (2012) also supported that CPO production in 2013 is expected to increase moderately due to the increase in oil palm mature areas in Malaysia.

Fourth, the coefficients of crude palm oil price (P) follow the expected sign, implying that P has a positive and significant impact on PO in Indonesia and Malaysia. Model 2 in Malaysia has the lowest coefficient value of 0.0614 while the highest value is 0.1159 (model 2) in Indonesia. This suggest that as P increases by one percent, on average, palm oil production is expected to increase of about 0.0614% and 0.1159% in Indonesia and Malaysia. Rahman (2012) noted that palm oil price is one of the important factors in influencing the palm oil production.

Lastly, the ENSO effects are not apparent. The coefficients of El Nino (NINO) and La Nina (NINA) are negative but statistically insignificant in most regression models in Indonesia and Malaysia. Interestingly, the NINO dummies are statistically significant in Thailand. The NINO coefficients are -0.1021 (model 1) and -0.0977 (model 3), suggesting that the average palm oil production is lower by about 9.7061% (model 1) and 9.3079% (model 3) during El Nino[1] . This suggests that the El Nino events has more pronounce effect on palm oil production than La Nina events in Thailand. Palm oil production in the current year tends to be affected by the previous El Nino event (Rahman et al., 2012; Kamil & Omar, 2016). Hassan and Balu (2016) also evidenced that hot weather and less rainfall (El Nino) will cause a lower yield of palm oil production. In fact, palm oil needs to have at least 100mm rainfall per month. Rainfall below this level would interrupt the growth of the fresh fruit bunches and reduce the palm oil production (Harun et al., 2010; Kamil & Omar, 2017). On the contrary, the impact arising from extreme weather conditions on palm oil productivity is depending on the intensity of El Nino and La Nina events.

[1] To obtain a correct percentage change, we should take the antilog of the dummy coefficient, subtract 1 from it and multiply the difference by 100 (Gujarati & Porter, 2009).

Table 5: OLS Multiple Regression Results

		INDONESIA					
		Model 1		Model 2		Model 3	
C	Coefficient	0.7115		0.6364		1.9118	
	t-stat	2.4658	**	2.2227	**	10.2391	***
lnAREA	Coefficient	0.9724		0.9784		1.0014	
	t-stat	53.5513	***	53.4611	***	65.0539	***
lnP	Coefficient	0.1098		0.1159			
	t-stat	1.9186	*	2.0609	**		
NINO	Coefficient	-0.0188				-0.0229	
	t-stat	-0.5313				-0.6239	
NINA	Coefficient			-0.0531		-0.0492	
	t-stat			-1.3581		-1.1925	
R-Sq		0.9930		0.9933		0.9926	
Adjusted R-Sq		0.9924		0.9927		0.9920	
F-stat		1700.6850	***	1774.4290	***	1603.1900	***
Diagnostic tests							
BG		18.3396	***	17.3529	***	22.5404	***
P-value (Chi-Sq)		0.0000		0.0000		0.0000	
White		8.6733		5.5713		8.9674	
P-value (Chi-Sq)		0.3706		0.6951		0.2550	
JB		8.1376	**	12.4228	***	3.5998	
P-value		0.0170		0.0020		0.1653	
RESET		11.3550	***	10.4151	***	14.4953	***
P-value (*F*-Stat)		0.0018		0.0027		0.0005	

		MALAYSIA					
		Model 1		Model 2		Model 3	
C	Coefficient	0.3932		0.4595		0.6521	
	t-stat	2.1466	**	2.3518	**	3.9046	***
lnAREA	Coefficient	1.0725		1.0637		1.0900	
	t-stat	44.0296	***	41.7934	***	50.2987	***
lnP	Coefficient	0.0657		0.0614			
	t-stat	1.9387	*	1.7800	*		
NINO	Coefficient	-0.0362				-0.0330	
	t-stat	-1.6425				-1.4478	
NINA	Coefficient			0.0336		0.0338	
	t-stat			1.3309		1.3205	
R-Sq		0.9887		0.9884		0.9881	
Adjusted R-Sq		0.9877		0.9874		0.9871	
F-stat		1047.9730	***	1022.5900	***	994.2613	***
Diagnostic tests							
BG		7.7309	***	9.6973	***	8.1644	***
P-value (Chi-Sq)		0.0054		0.0018		0.0043	
White		9.7040		10.1335		6.3138	
P-value (Chi-Sq)		0.2864		0.2558		0.5036	
JB		1.0665		1.6122		1.1892	
P-value		0.5867		0.4466		0.5518	
RESET		0.5674		0.0334		0.1713	
P-value (*F*-Stat)		0.4564		0.8561		0.6815	

		THAILAND					
		Model 1		Model 2		Model 3	
C	**Coefficient**	-0.0342		-0.0433		-0.2073	
	***t*-stat**	-0.0965		-0.1140		-1.9752	*
lnAREA	**Coefficient**	1.2298		1.2208		1.2169	
	***t*-stat**	51.8187	***	46.9288	***	59.6145	***
lnP	**Coefficient**	-0.0365		-0.0384			
	***t*-stat**	-0.5502		-0.5429			
NINO	**Coefficient**	-0.1021				-0.0977	
	***t*-stat**	-2.3834	**			-2.2678	**
NINA	**Coefficient**			0.0492		0.0324	
	***t*-stat**			0.9567		0.6686	
R-Sq		0.9914		0.9903		0.9914	
Adjusted R-Sq		0.9907		0.9895		0.9907	
***F*-stat**		1381.7870	***	1222.4330	***	1387.3310	***
Diagnostic tests							
BG		0.1375		0.0031		0.1437	
***P*-value (Chi-Sq)**		0.7108		0.9556		0.7047	
White		7.9103		12.7577		5.6254	
***P*-value (Chi-Sq)**		0.4423		0.1205		0.5841	
JB		0.3813		0.0800		0.3483	
***P*-value**		0.8264		0.9608		0.8402	
RESET		0.1487		0.9394		0.0002	
***P*-value (*F*-Stat)**		0.7021		0.3391		0.9887	

Notes: AREA - area harvested, P - Crude palm oil price, NINO - El Nino and NINA - La Nina. BG - The Breusch-Godfrey Lagrange Multiplier test for serial correlation, White - The White's test for heteroscedasticity, JB - The Jarque-Bera test for normality and RESET - The Ramsey RESET test. ***, ** and * denote significant at 1%, 5% and 10% levels

5.0 CONCLUSIONS

The objective of this study is to examine the effects of El Nino and La Nina on palm oil production in selected palm oil producing countries namely Indonesia, Malaysia and Thailand using Ordinary Least Square multiple regression models from 1980 to 2019. The results suggested that oil palm planted area and price play a significant role in influencing the palm oil production. The ENSO effects are not apparent. The coefficients for El Nino are negative and statistically significant in Thailand only. This implies that the El Nino events has more pronounce effect on palm oil production than La Nina events in Thailand

Hence, better adaptation approaches need to be developed by relevant authorities to reduce the effects of El Nino in Thailand. To mitigate the impact of drought causing from El Nino, activities such as replanting need to be postponed as lack of rainfall will influence the formation and growth of seedlings. As the seeds should be moist and cool at all time, very hot and dry weather trigger seed damage. Apart from that, water conservation in the field should be strongly encouraged as oil palm yield requires a lot of water. To conclude, effective water management is important as it allows the palm to achieve optimum production.

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