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ENSO (El-Niño Southern Oscillation) AND CONSUMER PRICES IN SOUTHEAST ASIA

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Abstract: ENSO (El Niño–Southern Oscillation) affects agricultural productivity by altering rainfall patterns and temperatures, which subsequently influence agricultural prices and may even trigger the rise of consumer prices. This study aims to examine the correlation of ENSO as represented by Oceanic Niño Index (ONI) and rainfall, as well as to examine the differences in consumer prices across different ENSO events, i.e., El Niño and La Niña, in Southeast Asian countries. We utilized rainfall data from the World Bank, ONI from the National Oceanic and Atmospheric Administration (NOAA), and consumer price index data (both general and food) from the Food and Agriculture Organization (FAO). Spearman's rank correlation and the Mann-Whitney U test are used in this study. The results indicate Indonesia is the most affected country by ENSO, showing the strongest correlation (-0.7631) between ONI and rainfall, where El Niño reduces rainfall and La Niña otherwise. Additionally, consumer prices tend to differ noticeably between El Niño and when it does not happen. Timor Leste shows the largest gap (32.74), suggesting that strong El Niño are often associated with higher consumer prices. Similarly, the food prices in Lao PDR records the widest difference (61.60). In contrast, most countries do not show meaningful changes during La Niña. The results indicate that food prices react more strongly to El Niño than general prices which likely linked to lower agricultural yield, disruptions in supply chains, and greater price volatility in main food commodities. The need to strengthen climate-responsive food security policies are essential like prioritizing early warning system to integrate climate forecasts with agricultural planning, alongside the enhancement of food reserves and social protection as well to build resilience.

Keywords: ENSO, consumer prices, consumer food prices, inflation, Southeast Asia

Introduction

The El Niño–Southern Oscillation (ENSO) is a significant climatic phenomenon originating in the tropical Pacific that influences weather patterns on a global scale. ENSO consists of two primary phases: El Niño, the warm phase, and La Niña, the cold phase (Scaife et al., 2019). In Southeast Asia, El Niño events lead to a decrease in rainfall across the Maritime Continent and the Philippines, except in West Philippines and West Kalimantan. In contrast, La Niña events generally result in increased rainfall across most sub-regions. However, some areas, including West Philippines, parts of mainland Indochina, South Sumatra, West Kalimantan, and Papua, experience reduced rainfall during La Niña (Nguyen-Thanh et al., 2023).

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ENSO is one of the key forces behind global climate variability, influencing atmospheric circulation and contributing to various extreme weather events across the globe (Alizadeh, 2022; Yu et al., 2017). During El Niño, the intensity of rainfall decreases, often resulting in severe drought. For instance, strong El Niño in 2015 triggered drought in Southeast Asia (Kogan & Guo, 2017) and intensified by the high temperatures (Thirumalai et al., 2017). In contrast, La Niña usually bring heavier and persistent rainfall, which can intensify the risk of flooding (Sun et al., 2020) and trigger the landslides (Chen et al., 2024).

El Niño and La Niña can strongly influence agricultural production because they disrupt normal rainfall and temperatures patterns. During El Niño, drought often reduce crop yields, whereas La Niña's excessive rainfall can lead to flooding and crop damage (Varghese et al., 2024). Beyond agriculture, ENSO are also linked to broader economic impacts, including significant financial losses (Callahan & Mankin, 2023) and drive-up commodity prices (Cai & Sakemoto, 2022). In some cases, food prices can rise by 2% to 5% especially for agricultural commodities or food prices by 2% to 5%. ENSO-related shocks also lead to price variations by 30% (Ubilava, 2016). These disruptions feed into the global economy by driving up output prices, especially food prices, which adds pressure to inflation. The rise of food prices, in turn, becoming an important source of global economic vulnerability (Dufrénot et al., 2023).

Studies on the impact of ENSO on inflation revealed that the El Niño events contribute to rising inflation (Ahmad et al., 2019; Marpaung et al., 2019). El Niño causes droughts, leading to a decline in agricultural production in the short term, which results in food shortages, followed by rising food prices and inflation (Ahmad et al., 2019; Cevik & Jalles, 2023). As ENSO highly related with rainfall more studies on the impact of rainfall on inflation indicates that shocks of rainfall could increase agricultural or food inflation (Ichoku et al., 2023; Zouabi & Dimou, 2024) and headline inflation (Odongo et al., 2022). As a result, food inflation rises when rainfall reaches extremely low levels, which are associated with drought conditions. Food inflation can also happen due to excessively high rainfall level, which is linked to flood conditions (Moessner, 2022). The relationship between ENSO and inflation raises the question of whether ENSO can affect the inflation, especially in Southeast Asia that are highly vulnerable to ENSO events. Building on previous studies, this paper analyzes the ENSO and inflation in Indonesia by employing the Oceanic Niño Index (ONI) to represent ENSO variability and the Consumer Price Index (CPI) to represent inflation. The study investigates the link between ENSO and rainfall, as well as the behavior of consumer prices during ENSO events in Southeast Asia.

Materials and Methods

Understanding the level of ENSO's impact on Southeast Asian countries is essential because strong ENSO events influence rainfall patterns in a region. Similar to Malau et al. (2021), this paper also employs correlation analysis to assess the correlation magnitude of ENSO and rainfall in Southeast Asian countries. We used Oceanic Nino Index (ONI), representing ENSO obtained from the National Oceanic and Atmospheric Administration (NOAA), rainfall data World Bank Climate Change Knowledge Portal from 1950 to 2023. Since the ONI data is monthly, we transformed the data into ordinal from the year associated with ENSO events data with the classification as follows.

Table 1: Classification of ENSO Events

Classification	El Niño	La Niña
Weak	$+0.5 \leq$ ONI $< +1.0$	$-0.5 \geq$ ONI > -1.0
Moderate	$+1.00 \leq$ ONI $< +1.5$	$-1.0 \geq$ ONI > -1.5
Strong	ONI $\geq +1.5$	ONI ≤ -1.5

Source: Cherian et al. (2021)

Spearman's rank correlation analysis is employed to assess the magnitude and direction of a monotonic correlation between ONI and rainfall. The resulting correlation coefficient ranges from -1 to +1, where a lower negative value indicates that when ONI positive, corresponding to El Niño events, rainfall tend to decrease.

We used the Mann-Whitney U test to assess whether consumer prices, both overall and food prices to show significant differences between periods with ENSO events and periods without them. The null hypothesis assumes that there is no difference in consumer prices between ENSO and non-ENSO events, while the alternative hypothesis assumes that such differences exist. ENSO events are identified using monthly Oceanic Niño Index (ONI) data obtained from NOAA. To assess inflationary pressure, the analysis utilizes monthly Consumer Price Index (CPI) data (January 2000–December 2023) and Consumer Food Price Index (CFPI) data (January 2000–March 2024) sourced from the FAO, both indexed to the 2015 base year. Myanmar is excluded from the study as the required data for consistent analysis were incomplete.

Results and Discussions

ENSO and Rainfall Relationship

Understanding the relationship of ENSO and regional climatic conditions is essential to assess the broader socioeconomic and environmental impacts across Southeast Asia. Figure 3.1 shows the correlation coefficients between ONI and rainfall across Southeast Asian countries. Since the rainfall data are annual, the ONI values were aggregated and matched to the corresponding years associated with ENSO events. Overall, the correlation coefficients are negative, indicating that rainfall intensity tends to be lower during El Niño events, as indicated by the high ONI. Notably, Indonesia exhibited the

highest correlation coefficient among all observed countries for both El Niño and strong El Niño, suggesting a strong relationship of El Niño events and rainfall variability in Indonesia. For instance, Indonesia experienced the most severe drought, which led to widespread fires (Trenberth, 2013). Moreover, strong El Niño in 2015 further intensified fire activity in Indonesia that sensitive to dry conditions, with less than 4 mm/day of rainfall increase fire susceptibility (Field et al., 2016). Interestingly, Philippines had experienced drought and negative effect on marine fisheries resources during strong El Niño events (Damatac & Santos, 2016).

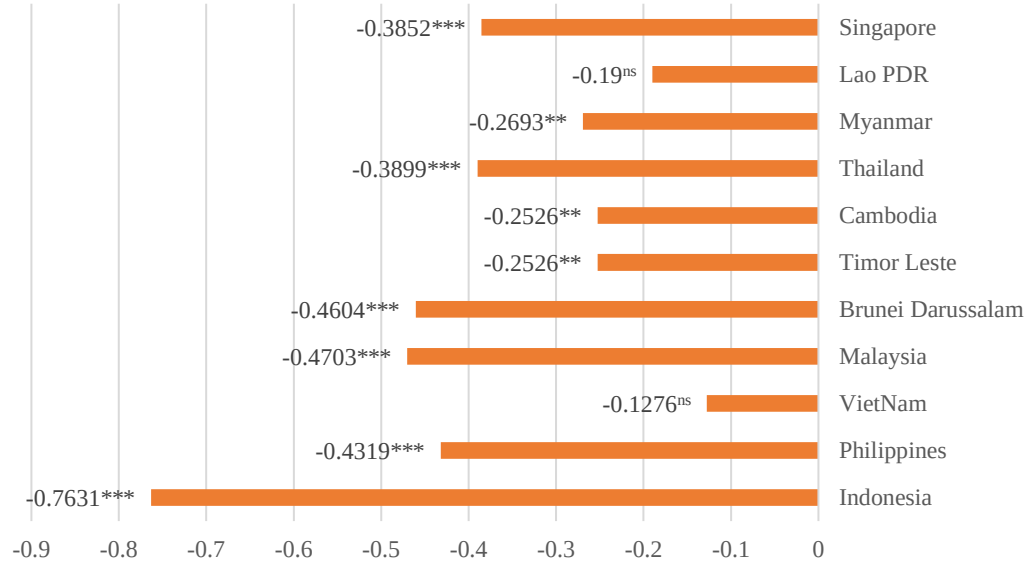

Figure 1: Spearman's rank correlation coefficient between ENSO and rainfall across Southeast Asian countries
Notes:
*) significant at α=10%; **) significant at α=5%; ***) significant at α=1%; ns) not significant

In addition to the strong correlation between ONI and rainfall in Indonesia, La Niña events are associated with positive rainfall anomalies of up to 200 mm/month during La Niña events. In DJF (December-January-February) period, several regions of Sumatera, Kalimantan, and Eastern Indonesia experienced negative rainfall anomalies (Hidayat et al., 2018). In Indonesia, flooding is caused by several factors, with La Niña events contributing to the increases in flood occurrences through extreme rainfall variability (Rodysill et al., 2019).

ENSO and General Consumer Prices

This section examines the differences of general consumer prices during ENSO across Southeast Asian countries, using the Mann-Whitney U Test. The analysis focuses on identifying significant differences in a country's general consumer prices during ENSO events compared to periods when ENSO events do not occur (e.g., during El Niño events versus non-El Niño periods). Figure 2 presents Z-value of the Mann-Whitney U Test result on general consumer prices during ENSO events. The result shows that there is no statistical difference of general consumer prices during El Niño and non-El Niño events.

However, Timor Leste experienced the statistically difference of general inflation at the same time. In addition, the analysis shows a statistically significant distinction in general consumer prices when comparing strong El Niño with non-strong El Niño in Southeast Asia. This indicate that when strong El Niño events take places, consumer prices tend to be higher. This outcome is driven by the influence of strong El Niño conditions on agriculture, the sector most heavily affected. For instance, during strong El Niño events, they cause drought and reduce agricultural productivity (Ahmad et al., 2019).

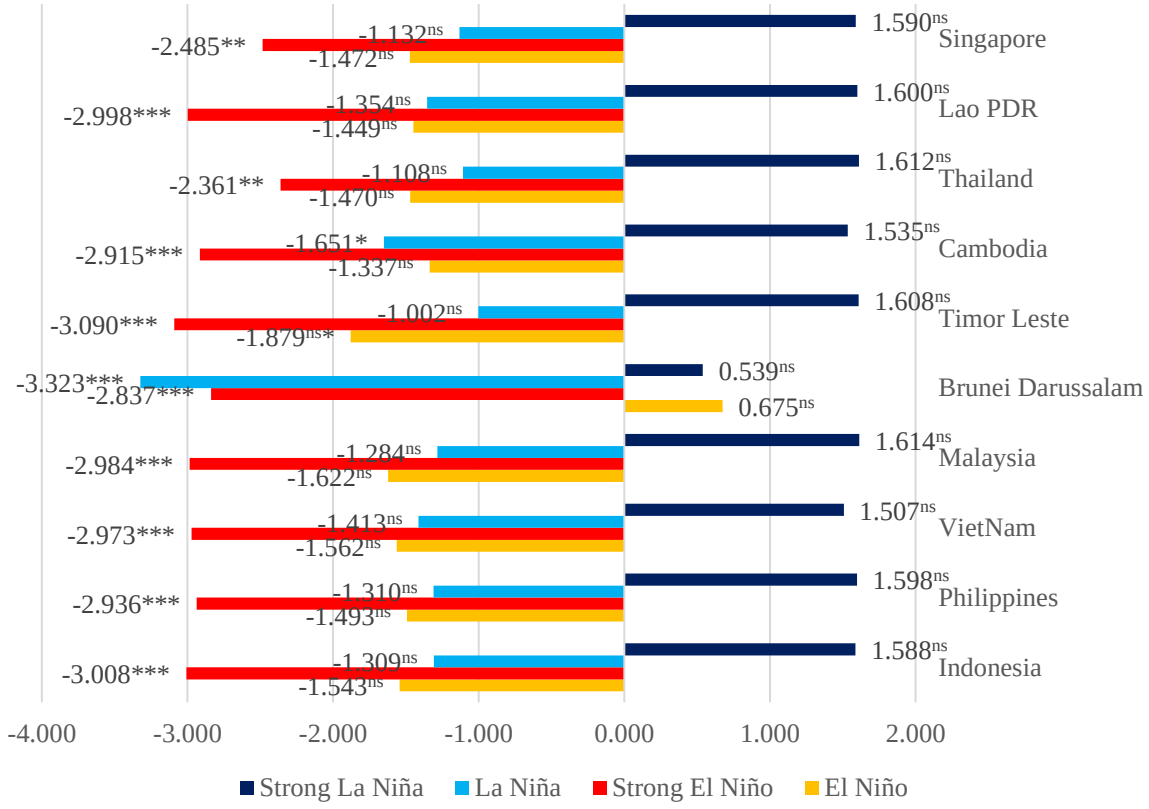

Figure 2: Z-value of Mann-Whitney U Test for general consumer prices during ENSO events
*, **, ***denote the p value at 10, 5, and 1% significance, while "ns" denotes not significant

In Cambodia, there is a statistically significant difference of general consumer prices during La Niña events with non-La Niña, while other countries, there is no significant difference. La Niña leads to inflationary pressure as a second-round effect (Dufrénot et al., 2023). Furthermore, general consumer prices in all countries across the Southeast Asian region shows no statistically significant difference between strong La Niña and non-strong La Niña events. Smith & Ubilava (2017) stated that El Niño events significantly reduce economic growth, and the impact of La Niña events are much less noticeable.

ENSO and Food Prices

Food inflation or food consumer prices in this study is a critical economic measure that tracks changes in the food prices. Food consumer prices are accounted for 42.7% of the commodity basket in consumer price index or headline inflation (Ismaya & Anugrah, 2018). In Indonesia, the increase of food prices

has been the primary driver of inflation. For instance, in 2023 the food inflation rate reached 5.83% surpassing the general inflation rate of 5.51%, making it the largest contributor to general inflation. Climate anomaly, such as irregular rainfall patterns and natural disasters significantly impact the agricultural production, leading to price increases in essential commodity such as rice, vegetables, and meat (Badan Pusat Statistik, 2024).

The difference in food consumer prices during ENSO events and non-ENSO events is more pronounced. Figure 3 shows the differences between food consumer prices during El Niño and non-El Niño events for both strong and all El Niño events. As El Niño causes increased rainfall in South America, it simultaneously leads to droughts in Indonesia and Australia. These dry conditions endanger water resources, as reservoirs shrink, and river levels drop. As a result, agriculture, which relies on water for irrigation, faces significant risks (National Geographic Education, 2024), which often leads to a decline in production, ultimately resulting in higher food prices (Ahmad et al., 2019).

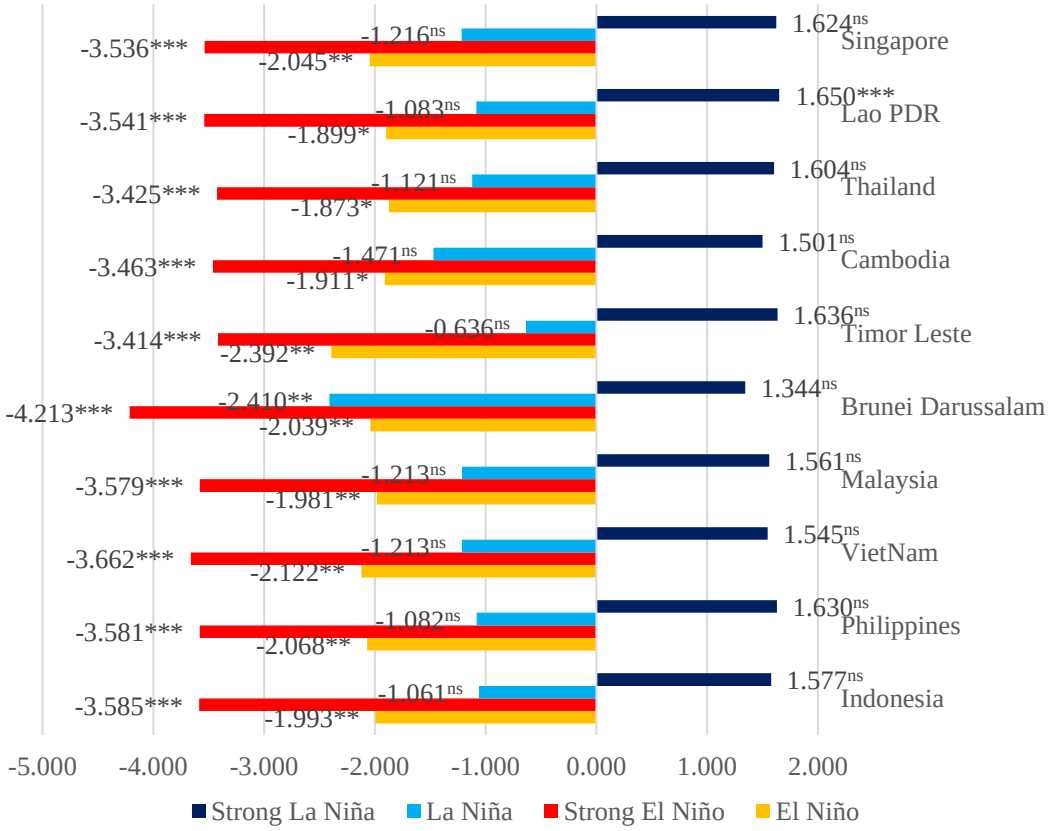

Figure 3: Z-value of Mann-Whitney U Test for food consumer prices during ENSO events
Notes:
*, **, ***denote the p value at 10, 5, and 1% significance, while "ns" denotes not significant

Food consumer prices in most Southeast Asian countries do not differ in a statistically meaningful way between La Niña and times when La Niña is absent, regardless of whether all events or only strong episodes are considered. La Niña events tend to have a positive impact on food productivity, especially grain production (Li et al., 2020). As production increases, food prices tend to decrease. Overall, El

Niño events have a greater impact on price changes than La Niña events (Fajri et al., 2019). In contrast, food consumer price in Lao People's Democratic Republic is statistically different during strong La Niña and non-strong La Niña events In keeping with the overall findings, Brunei Darussalam displays a statistically significant difference in food consumer prices between La Niña and times when La Niña does not occur. In Southeast Asia and Australia, La Niña can cause heavy rainfall, raising the risk of flooding and landslides, particularly between October and March (FAO, 2024).

Finally, based on the data presented in the appendix 1, the mean differences of food consumer prices between ENSO events and non-ENSO events are notably higher than the corresponding difference in general consumer prices. This discrepancy is particularly pronounced when comparing periods of strong El Niño events with those of non-strong El Niño events. The findings suggest that consumer food prices are more vulnerable to external shocks triggered by ENSO events, with the most significant impact occurring during periods of strong El Niño. These differences may reflect interruptions in agricultural production, weaknesses in supply chain continuity, and increased volatility in the prices of main food commodities.

Conclusion

The purpose of this study is to analyze the correlation between ENSO activity and changes in rainfall level across Southeast Asian countries and analyze the difference of consumer prices during ENSO events. By using the spearman's rank correlation, we found that Indonesia is most affected by ENSO, as shown by its strong correlation coefficient. Moreover, the Mann-Whitney U test revealed that there is statistical difference between consumer prices during El Niño with the periods when its absent, with food consumer prices shows a significant different in both El Niño and strong El Niño. Nevertheless, consumer prices appear largely unchanged when comparing periods of La Niña with periods when its absent.

Given these findings, ENSO events, particularly El Niño that have significant implications for both rainfall variability and food consumer prices in Southeast Asia, especially in Indonesia. These finding highlight the vulnerability of the agriculture and the need for proactive policy responses. Enhancing the use of climate-smart agricultural approaches is necessary to bolster the sector's capacity to withstand ENSO shocks, ensuring stable agricultural production. Additionally, food diversification is also crucial to reducing the dependence on a single food commodity. Moreover, the government needs to develop an early warning system to help mitigate inflationary pressures caused by ENSO events, such as food stock management and financial support during ENSO events. Further work is needed to clarify how ENSO influences inflation, with special attention to the mediating role of the agricultural sector.

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Declaration of Interest Statement

The authors declare that they have no conflict of interests.

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Appendix

Appendix 1: Mean differences of consumer prices

Countries	El Niño		Strong El Niño		La Niña		Strong La Niña	
	General Consumer Prices	Food Consumer Prices	General Consumer Prices	Food Consumer Prices	General Consumer Prices	Food Consumer Prices	General Consumer Prices	Food Consumer Prices
Indonesia	6.677527	10.13542	24.75169	35.55636	4.374656	4.687509	-15.20092	-20.95072
Philippines	4.645922	7.876234	18.52089	26.32558	4.182995	4.128926	-11.85418	-14.78749
Viet Nam	5.477168	7.363334	26.22752	32.55226	4.895149	5.713045	-20.63715	-22.28101
Malaysia	2.985697	5.646862	11.75906	20.06282	2.242305	3.015038	-7.806686	-12.78175
Brunei Darussalam	0.41328	1.230473	3.049018	6.380598	1.530438	1.926011	-0.562307	-1.819217
Timor Leste	5.651688	7.818651	32.73678	28.95524	1.137171	0.6746491	-16.91113	-18.41078
Cambodia	3.586683	6.558446	19.86812	27.78155	6.090758	6.902663	-9.996692	-13.36252
Thailand	1.949809	4.863036	10.28776	19.78791	1.994353	2.458246	-5.138196	-12.0292
Lao PDR	10.58126	19.24198	39.5406	61.59721	3.177679	1.354693	-16.62039	-25.08135
Singapore	2.246885	4.345958	11.41344	16.17388	1.507522	2.498966	-6.848662	-8.914659