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An Analysis of the Citrus Industry in Nueva Vizcaya, Philippines

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***Abstract*: The citrus industry in the Philippines was booming in the early 50s and 60s and citrus became one of the top high-value crops in the country. However, despite the surge the industry experienced in the earlier years, it has also faced issues that affected the growth and development of citrus in the country. Nueva Vizcaya, named as the Citrus Capital of the Philippines, is the main citrus producer in the country, and this study seeks to analyze the effects of different variables on the citrus industry in the province. This paper utilized the usage of Ordinary Least Squares (OLS) regression analysis to investigate the relationship between the citrus industry in Nueva Vizcaya and its related variables, covering data from 1992 - 2022. The findings in this study will provide a basis for policy recommendation focusing on the further development and recognition of the citrus industry in Nueva Vizcaya.**

***Keywords*: citrus industry, gross domestic product, agricultural land, temperature, precipitation, net export.**

1. Introduction

A. Background of the Study

The Food and Agriculture Organization of the United Nations defined citrus fruits as one of the world's top and widely grown crops. Its production and export have grown extensively over the past decades. Due to their refreshing flavors, nutritional benefits, and affordability, these fruits keep on thriving in terms of their economic impacts in the whole world, developing or developed countries (Tonogbanua et al., 2018). Citrus fruits' origins date back as early as 4,000 BC when they first emerged in Southeast Asia. Citrus fruits are grown in more than 140 countries globally, and oranges, lemons, and grapefruits are among the most grown citrus types. Aside from fresh fruits, citrus is also used for different purposes, such as juice, jam, jelly, squash, and marmalades (Ahmed & Saeid, 2021). The citrus industry (also known as citrus production) is home to the various production of citrus fruits known to many individuals across the globe as the highest-in-value fruit crop in the context of trade. The industry slowly spread to other regions due to increased demand and trade activity. These regions include Northern Africa and Southern Europe, specifically during the period of the Roman Empire. The citrus industry continued to move across various regions brought by explorers; thus, trade activity for citrus products continued expanding until it reached worldwide trade (Habermann & de Souza, 2014).

The Philippines is graced with a climate and fertile soil that enables year-round cultivation of fruits, and citrus is one of the most highly adaptable fruits in the country (Antonio et al., 2011). Habermann & de Souza (2014) stated that the primitive habitat of citrus plants is in the tropics, which is why the origin of these fruits is believed to be in Southeastern Asia - from Eastern Arabian to the Philippines and so on. As the Philippines is tropical, the citrus industry is in high demand in domestic and foreign markets. Due to this, the government has taken numerous steps to enhance and improve the production of the said industry, as studies point out that the citrus industry has been a significant contributor to the country's local economic growth (Ramel, 2023). It is undeniable that the citrus industry contributes to the overall economy of the Philippines; however, it is important to take note that the citrus industry in the country is considered a minor crop compared to other crops that the country exports, such as rice and corn.

Nueva Vizcaya, where Kasibu is located, was declared the Citrus Capital in Luzon on June 24, 2022. Kasibu (also known as the Town of Kasibu) is a 3rd class town located east of the province of Nueva Vizcaya with an area of approximately 318.8 square kilometers with 529 hectares of land devoted solely to cultivation of citrus (Inigo, 2022). Additionally, the town is very known for its citrus farms and orchards constituting its rich citrus agriculture and is said to be the source of calamandarin oranges, mandarin (satsuma and ponkan), and pomelos. The aforementioned town is one of the main producers and exporters of citrus fruits and products and the industry helped improve the quality of life of many people in the province.

In the province alone, 42 citrus varieties are being produced, specifically in Kasibu, Bayombong, Quezon, Villaverde, and Solano. In 2016, the province contributed approximately 70-80% of the total annual volume of citrus production in Region II and about 43% of the total Mandarin production in the Philippines (BAR, 2016). Nueva Vizcaya also houses the Nueva Vizcaya State University (NVSU), which leads research and development of the citrus industry. The NVSU Citrus Project is partnered with the Department of Science and Technology Philippines Council for Agriculture, Aquatic and Natural Resources Research and Development (DOST –

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PCAARRD). These institutions entered into a Memorandum of Agreement to look for ways to improve and increase the domestic supply of citrus, which is currently said to be insufficient to meet the demands of consumers (Ramel, 2023). Their website shows 67 collections and 14 species of citrus fruits scattered in 24 locations in the province alone.

Table 1
Citrus fruit collections in Nueva Vizcaya, Philippines

Fruit	Scientific Name	Location
Seedless Lemon	Citrus Limon	Cordon, Kasibu, Nueva Vizcaya
Robertson	Citrus Sinensis	
Posposok	Citrus Limon	
Perante	Citrus Sinesis	
Trovita	Citrus Sinesis	Bayombong, Nueva Vizcaya
Navalete	Citrus Sinesis	
Navelina	Citrus Sinesis	
Meyer	Citrus Meyeri	
Citron	Citrus Medica	
Calamandarin	Citrus Microcarpa	
Salustiana (B)	Citrus Sinesis	Malabing, Kasibu, Nueva Vizcaya
Salustiana (A)	Citrus Sinesis	
Robidoux	X Citroncirusspp	
Ponkan Californina	Citrus Reticulata	
Ponkan Taiwan	Citrus Reticulata	
Nova	Citrus Sinesis	
Imperial	Citrus Reticulata	
Gillete	Citrus Sinesis	
Fremont	Citrus Reticulata	
Fortune	Citrus Reticulata	
Eureka	Citrus Limon	
Carrizo	X Citroncirusspp	
Chinese Pomelo	Citrus Maxima	Pag-asa, Darubba, Quezon, Nueva Vizcaya
Tankan	Sinesis x Reticulata	Cabuluan, Villaverde, Nueva Vizcaya
Satsuma	Citrus Reticulata	
Clementine	Citrus Reticulata	
Citrumelo	X Citroncirusspp	
Variegated Lemon	Citrus Limon	San Luiz, Solano, Nueva Vizcaya
Lemon	Citrus Limon	
Citron	Citrus Medica	
Tankan	Sinesis x Reticulata	Maasin, Quezon, Nueva Vizcaya
Red Chandler	Citrus Maxima	
Davao Pummelo	Citrus Maxima	
Florida Red	Citrus Maxima	NVSU Field Genebank
Szinkom	Citrus Reticulata	Centro, Sawmill, Villaverde, Nueva Vizcaya
Key Lime	Citrus x Aurantifolia	
Kaburaw	Citrus Hystrix	
Lemon	Citrus Limon	Bagahabah, Solano, Nueva Vizcaya
Native White Pummelo	Citrus Maxima	NVSU, Bayombong, Nueva Vizcaya
Pummelo White	Citrus Maxima	Poblacion North, Solano, Nueva Vizcaya
Variegated Calamansi	Citrus Microcarpa	Nalubbunan, Quezon, Nueva Vizcaya
Washington Navel	Citrus Sinesis	Matutud, Binugawan, Kasibu, Nueva Vizcaya

In the 1950s and 60s, the citrus industry in the country was booming, and the demand in the domestic market was also expanding fast. (Antonio et. al., 2011). The development of the industry over the decades aided the improvement of both the production and quality of life of farmers in the province (Ramel, 2023). However, the citrus industry in the Philippines is facing various obstacles. Among these are the spread of citrus greening disease, high production expenses, inadequate access to funding, land loss due to soil erosion, climate change, and inappropriate use of fertilizers.

B. Statement of the Problem

This research has a chief concern regarding different factors that impact the performance of the citrus industry in Nueva Vizcaya, Philippines. To obtain all essential information and data, the paper sought to answer the following questions:

1. Does the availability of agricultural land devoted to citrus cultivation in Nueva Vizcaya affect the citrus industry?
2. Does the annual temperature in Nueva Vizcaya have a significant impact on the citrus industry?
3. Does the annual precipitation in Nueva Vizcaya have a significant impact on the citrus industry?
4. What has the country's citrus net export status been over the past few years?

C. Significance of the Study

This paper provided additional information and knowledge regarding the chosen topic from the secondary data obtained from related government agencies and research departments and from recent studies and theses with the aid of numerical data and economic analysis. The significance of the study lies in its potential to enhance people's knowledge and comprehension of the citrus industry in the Philippines. Moreover, this research paper was application-based. Therefore, it was expected to provide practical and valuable insights that could increase awareness and understanding of the industry, leading to further developments and improvements in the field. By providing a comprehensive analysis, it can help shed light on the importance of the citrus industry in the agricultural sector, its impact on society and the environment, and its overall contribution to the Philippine economy.

D. Research Aims and Objectives

1. To identify the impact of agricultural land availability devoted for citrus cultivation in Nueva Vizcaya.
2. To identify the underlying effect of annual temperature on the citrus industry in Nueva Vizcaya.
3. To identify the underlying effect of annual precipitation to the citrus industry in Nueva Vizcaya.
4. To analyze the performance of the net exports of citrus in the country and its effect on Nueva Vizcaya.

E. Scope and Limitation of the Study

This study focused on the analysis of the general recognition of the citrus industry in Nueva Vizcaya, Philippines through various factors that may affect the performance of the aforementioned industry. This study focused on the impact of the availability of agricultural land for citrus cultivation, namely Lemon, Pomelo, Orange, Calamansi, Lime, and Mandarin, in the entirety of Nueva Vizcaya. Alongside of this, the study also focused on analyzing the underlying effect of

climate change phenomenon through the analysis of the trend of the province's temperature and precipitation over the years. Lastly, the study focused on analyzing the growth in the country's citrus net exports.

This study will not extend to other factors that may affect the performance of the citrus industry, such as but not limited to, any scientific studies and/or observations of the citrus fruits, any primary data (e.g. interviews, firsthand experiences) gathered from relevant sources, and the agricultural land for other crops outside of Nueva Vizcaya, Philippines.

2. Literature

The Philippine citrus industry was known to be booming in the 1950s and 1960s, specifically when Alfonso Namujhe Jr, the man behind the inception of citrus farming in the province of Nueva Vizcaya, figured that the area's mountain soil and temperature are perfect for the cultivation of citrus and started planting within the area in 1966. As a pioneer of citrus production in the province, he adopted good management practices to improve the overall production of citrus on his farm which he later on shared with other citrus growers in Nueva Vizcaya (DOST - PCAARRD, 2017). The domestic market, as well as area expansion for citrus cultivation was in high demand during this time (Antonio et al., 2011). He also argued that the citrus industry has significantly contributed to local economic growth. The production process provided by the Philippine Statistics Authority typically involves breeding and planting citrus trees, fertilizing the soil, managing pests and diseases, cultivating and harvesting the fruit, and selling it to the local and international markets.

A. Agricultural Land Specific for Citrus Cultivation

Nueva Vizcaya has a land area of 3,903.90 square kilometers approximately. This is made up of 10.72% regional land area and 1.30% total land area of the Philippines. The province of As per the Administrative Order Number (No.) 18 as released by the Department of Agriculture, the Town of Kasibu, in the Province of Nueva Vizcaya has been a significant producer of different varieties of oranges, pomelos, lemons, and other fruits, all year-round. The Town of Kasibu in Nueva Vizcaya has 519 hectares planted for Citrus, with an additional expansion area of 495 hectares for citrus production. This amounts to a total physical area of 1,014 hectares for citrus production and a potential annual production of 30,240 MT.

According to Antonio et al. (2011), the town of Kasibu is one of the leading producers in the country. This land area is devoted to citrus cultivation primarily the Satsuma mandarin *(Citrus reticulate Blanco)*, Ponkan mandarin *(Citrus reticulate)*, pomelo *(Citrus maxima)*, and oranges such as Hamlin, Perante, and the Valencia varieties.

According to Quijano et. al (2021), for citrus variety: calamansi, for the past six years, there was a decreasing trend in production, average yield (MT/ha), and land area allocated for the citrus variety. The gold and copper mine of the Australian-Canadian OceanaGold in Nueva Vizcaya is causing problems such as water pollution, illegal expansion, and threats to the province's agricultural land, to name a few (Broad, R. et al., 2018). In 2017, it was reported that agricultural activity in the province declined by as much as 30%, which meant low agricultural product yields such as vegetables and citrus. The contaminated surface water in the irrigations destroyed the richness of the agricultural lands. Additionally, the mine claimed 27,000 hectares of land in 2021 and was reported to expand beyond the approved project area, and illegal conversions of land are still being observed (Lapniten, 2021; Broad, R. et al., 2018).

B. Annual Precipitation

The United Nations defines climate change as the long-term shifts in temperatures and weather patterns. This is interrelated with the processes and affects agriculture in many ways. Climate change, particularly drought and high temperature events collectively affect plant productivity and growth. (Shafqat et al., 2021). Same findings were found in the study of Ritchie (2021) stating that high precipitation levels and intense temperatures will prevent crop growth. Overall, changes in trends in the climate and weather can have many consequences on agriculture.

A study on the impact of climate change on agriculture in Saudi Arabia by Alam et. al (2011), found that a reduction of 30% in the yield of wheat, barley, date, vegetables, and citrus fruits is due to the change in temperature and rainfall. In the study of Olesen et. al. (2011), for European countries the effect of temperature differs per region. In Northern Europe, cool temperature is a major concern, while extreme temperature and low rainfall limit crop productivity in the southern part. Citrus plants are subject to a series of abiotic stresses that limit production; one that stands out among them is water deficit, mainly due to rainfall variability in principle-producing regions and the risk expected in the coming years of climate change. (Drielly et al., 2021). In a study done by Gil-Mora (2023), the Cusco Region is a territory highly affected by extreme climatic events due to the geographical, physical, and climatic properties of the aforementioned region. This is attested by higher average temperatures, increased levels of rainfall, as well as meteorological droughts. The region is heavily affected by climate change, which also heavily affects agriculture. Citrus crops are located in the regional Amazon, particularly in the La Convencion province, however, due to changes in temperature and low rainfall, citrus yields are said to have decreased in level. The same case study was conducted by Craig (2017) where he interviewed farmers of the communities of Nueva Vizcaya regarding awareness of climate conditions and their effect on production. They admitted that agricultural production activities are generally affected by the long drought wherein irrigation water is inadequate and the wet season with strong typhoons causing flooding. Moreover, according to them, the potable water supply continued to diminish despite improved forest cover. Water insufficiency was also evident, especially during the summer when inadequate irrigation caused a decline in productivity. The same was experienced by the citrus industry in Pakistan. According to the study of Siddique and Garnevska (2018), there was a great decrease in production due to unfavorable weather phenomena (e.g. hailstorm) and water

shortage. In the same study, an increase in area under citrus production was not found.

Intense precipitation occurrences might lead to destruction brought about by floods, whereas minimal rainfall for an extended period of time may result in drought stresses (Khan, 2016). In contrast with the climate in European and African regions, With the region in the north-central part of Luzon, Nueva Vizcaya experiences relatively dryness from November to April and relatively wet during the rest of the year. (Bangat, Patricio, and Tiongson, 2022).

C. Annual Temperature

Balfagon et. al., (2021), mentioned in the study that citrus trees are adjusting to different climates but their growth is affected due to low temperatures and frost. On the other hand, the vegetative growth of citrus plants is unaffected by high temperatures. (Pereira et. al, 2017). It is also mentioned by Balfagon et. al., (2021) that another climate factor that affects citrus cultivation is extreme weather events such as heatwave intensity and frequency, severe drought events, and flooding.

The increase in temperature affects citrus plants as it increases transpiration and photosynthesis, destabilizes their central membranes, and increases oxidative damage. environment. The ideal temperature for citrus cultivation is between 22 to 34 degrees Celsius. Temperatures above mentioned can lead to fruit abscission and smaller fruit size harvest. Although an increase in temperature is not a potential threat to the growth and development of citrus plants but harmful to the fruit formation and development. From a study conducted in Pakistan (Siddique and Garnevska (2018), for citrus fruit crops to ripen, it is required to have a low-temperature environment to achieve an increase in production.

According to a study in the Mediterranean region conducted by Davies, citrus fruits that are produced in low nighttime temperatures and relative humidity environments yield a relatively blemish-free and brightly colored fruit. A recent study by the Ministry of Environment Water and Agriculture results showed that crop temperature increase could adversely affect crop yields by 5-25% in Saudi Arabia (Mewa, 2017). A similar study done by Wang et. al., (2022) gathered that climate conditions that are suitable for cultivation positively affect the growth and yield of citrus fruits.

The change in climatic factors, especially temperature, affect the citrus growth, productivity, and fruit quality. These factors determine the quality and quantity yield of the cultivation process. The increase in temperature during the days close to harvest season results in a great loss in the ratio of total yield. Delayed fruit maturity, demolished peel color, and increased fruit splitting and creasing are some of the adverse effects of rising temperatures in this season. As per the temperature of the North-central part of Luzon, specifically in Nueva Vizcaya, the maximum temperature is 25 degrees Celsius, normally during the warmest months of April and May. December and January are the coldest months when temperatures fall to about 20 degrees Celsius. (Bangat, Patricio, and Tiongson, 2022).

In a study conducted by Abobatta (2019), similar to the conclusions of other studies, citrus fruits can adapt to different climatic zones and can grow in places with temperature ranges between 12 to 37 degrees Celsius. Low temperatures and frost are also among the determining factors due to its sensitivity to cool climates. High temperatures reduce the growth of citrus trees since they are exposed to chlorophyll deficiency and photosynthesis reduction.

The swift increase and decrease in temperature beyond a certain level will cause a hindrance in its metabolism and may affect the growth and development of the citrus, which leads to decreases in its production (Khalid et al., 2021). In the Philippines, the impact of climate change is evident. The country's experience with extreme climatic events such as severe drought, El Nino/La Nina occurrences, changes in rainfall patterns, a rise of surface air temperature, and frequent typhoons leads to reduced food crop production in the agricultural sector, resulting in food insecurity and a decline in health and nutritional status among local people (Penaflor and Gata, 2020).

According to the study of Strano et. al (2022), one of the causes of postharvest loss in citrus fruits is physiological disorders, mainly inappropriate storage temperatures that result in chilling injury and Membranosis. Chilling injury is a severe physiological disorder that occurs in fruit held in a thermal range above freezing point (0–8 ◦C) for an extended period. On the other hand, Membranosis is lemon-specific and can reach an incidence of up to 90% during cold storage. It develops on the inner membranes as reddish-brown and dark areas in the albedo. In the same study, it was found that this kind of disorder can be minimized by harvesting during dry conditions.

D. Net Exports

Among all citrus products available in the Philippines, *calamansi* is highly regarded as economically viable in the export market (Mopera, 2016). Philippine Lime or Calamansi is one of the major citrus fruits produced and exported by the Philippines. Quijano et al. (2021) stated that the fruit is indigenous to the Philippines and is then identified by the Department of Agriculture as "*one of the most important fruit crops grown in the country."* This fruit is widely cultivated in the Philippines and is available year-round, with a peak harvesting period from July to September (Quijano et al., 2021). The Country is the only major exporter of calamansi worldwide, and its juices cover a more significant portion of the exported products (Rodeo, 2016). Alongside of this, data from the Philippine Statistics Authority also shows that the country continuously exports citrus peels, wherein its value is a part of the Philippine agricultural exports top five commodity group.

In 2021, the Philippines exported $1.06M in Citrus, therefore making the country the 87th largest exporter of Citrus in the world. In the same year, Citrus was deemed the most exported product in the Philippines.

In the Philippines, imports of citrus fruits - mostly mandarin and orange - exceed the exports of locally grown and produced citrus products (Antonio et al., 2011). The study also denotes that there is an evident gap between the demand and supply, as the Philippines relied on the importation of citrus fruits to satisfy the growing demands of consumers in the market. In

2016, the Philippines accounted for 6.0% of Chinese mandarins/tangerines imports (Spreen et al., 2020). The United States Department of Agriculture's Foreign Agricultural Service in Manila reported that the exports of fruits, including citrus, to the Philippines increased by 36% or to $695 million in 2020 and are forecasted to grow by 5% in 2021 (DA, 2021). USDA - FAS Manila stated that despite the fruits being produced for export intentions, economic resources that are utilized affect the overall supply of fruits for the domestic market.

Between 2016 and 2018, the Philippines imported almost 117,000 tons of citrus. The market then will support the continued robust expansion of the local industry. With over 80,000 tons imported between 2016 and 2018, mandarins account for the Philippines' largest citrus imports; China supplied the majority (with 60%) of the mandarins, with Pakistan supplying the remaining 25%. Currently, Australia (2,000 tons, equating to 3% of the total), and Argentina (8,000 tons, or 10%) are the Southern Hemisphere's top exporters of mandarins to the Philippines. In the same years, oranges were the second citrus import, amounting to 28,000 tons. China accounted for 22% of the imports, while Australia accounted for 20%, making them the main sources. Lemon imports are also met with continued growth over the years, with the USA being the primary supplier.

According to Sanguyo (2004), Japan accounts for 36% of the total volume of calamansi juice exported, followed by the USA with 33%, Canada with 6%, Hong Kong with 5%, and the Republic of Korea with 5%. Opposing the study of Quijano et. al (2021), Sanguyo study presented an increasing trend in terms of production, land agricultural area, and volume and value of calamansi exports. Siddique and Garnevska (2018) mentions the varying preferences regarding the consumption of both fresh and convenience food results in an increase in the global demand for fresh fruits. FAOSTAT (2004), stated that although citrus varieties are grown all over the Philippines, its contribution to the value of agricultural exports is minimal. Significant amounts of citrus fruits and liquids need to be imported to meet the demand across the Philippines. Snelder et. al, (2007), study concluded that when it comes to fruit tree production, farmers preferred to plant Mango and Mandarin due to positive high yields, economic returns, and their strong growth compared to Coconut. Farmers also admit during the interview that they lack knowledge from planting fruit trees as compared to seasonal crops like rice and corn. Lastly, typhoon damages involving heavy winds and flooding poses a major risk for fruit tree production.

3. Method

A. Research Method

This study utilized quantitative analysis, which helped the researchers objectively understand and present results and helped us interpret the findings accurately. Additionally, quantitative analysis helped the researchers attain more excellent knowledge and understanding of the topic revolving around the citrus industry in the province of Nueva Vizcaya.

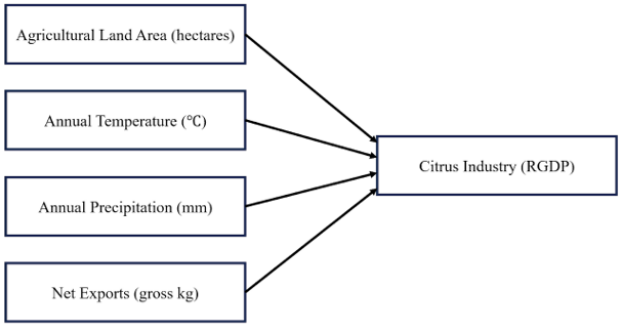

Fig. 1. Research Simulacrum

The study centered on the province of Nueva Vizcaya, covering 1992-2022. The rationale behind this choice is from the sense that Nueva Vizcaya is a top citrus producer and exporter and was then named the Citrus Capital of Luzon. To gather all necessary information and data needed in pursuing the paper, secondary data was utilized from government agencies such as the Department of Trade and Industry, Department of Agriculture in Region II, Philippine Atmospheric, Geophysical and Astronomical Services Administration Climatology and Agrometeorology Division (CAD PAG-ASA), and Philippine Statistics Authority.

$$CI = \beta_0 + \beta_1 AL + \beta_2 AT + \beta_3 AP + \beta_4 NX + \mu$$

where, CI is the citrus industry share in the real gross domestic product in Agriculture, Forestry, and Fishing in Region II, AL is the agricultural land specific for citrus production, AT is annual temperature, AP is annual precipitation, and NX is net exports of citrus products.

4. Results and Discussions

This study sought to analyze the relationship between the citrus related variables and the citrus industry in Nueva Vizcaya from 1992 to 2022.

Multiple regression analysis was utilized in the study to examine the relationship between the citrus industry measured by GDP and its four independent variables. Alongside this, individual representations were used to analyze the trend in all four independent variables:

1. A line graph was used to show the increase and decrease in agricultural land allocation in Nueva Vizcaya for specific citrus fruits: lemon, pomelo, orange, mandarin, calamansi, and lime.
2. A time series plot separated into two graphs was used to show the annual temperature and precipitation trend in the province.
3. Lastly, a clustered column line in the primary axis was used for trade analysis between the volume of citrus imports and exports in the country.

A. Agricultural Land Specific for Citrus Cultivation

Most of Nueva Vizcaya's agricultural land specifically for citrus cultivation is allotted for lemon, pomelo, orange, mandarin, calamansi, and lime. Figure 1 shows that the agricultural land allocation for Pomelo experienced a

significant increase in 1996, and lands allocated for Mandarins spiked in 2006. The expansion of citrus agricultural land for these fruits supports the trade statistics from the Philippine Statistics Authority, showing that pomelo and mandarin are the top citrus exports of the country. Alongside this, Lemon and Lime's agricultural land allotment in Nueva Vizcaya experienced sharp decreases in 2000. As for Orange, it has a fluctuating land allocation for cultivation where it spiked in 1998 and decreased in 2010. Calamansi, on the other hand, showed no significant changes in the allocation of land.

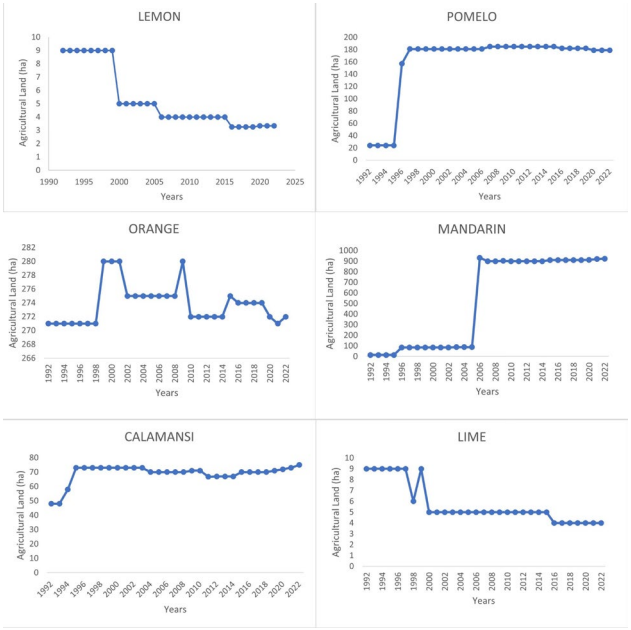

Fig. 2. Agricultural land specific for citrus cultivation

B. *Annual Precipitation and Annual Temperature*

Fig. 3. Annual temperature and annual precipitation in Nueva Vizcaya

Using a Time Series Plot presented in a separate graph demonstrates the observed annual precipitation and annual temperature in Nueva Vizcaya gathered from the dataset extracted from historical weather station information by Climatology and Agrometeorology Division (CAD) DOST-PAGASA, and Geodata US. The annual precipitation in Figure 2 ranged from 143.79 mm, the lowest record in 2021, to 364 mm, the highest record in 1999. In terms of temperature, Nueva Vizcaya is rarely above 27° and below 25°; hence the reason why the province produces citrus fruits abundantly as these fruits' ideal temperature lies between 15 to 32°, and the tropical and subtropical climate in the province helps the citrus fruits thrive and propagate.

C. *Net Exports*

Fig. 4. Trade analysis of citrus in the Philippines

Using a Clustered Column - Line on Primary Axis, Figure 4 shows the difference in the importation and exportation trend of citrus, indicating a citrus trade deficit in the Philippines. Trade deficit happens when the amount of goods or services a country imports is greater than what it exports. The formula, NX=X-M, shows that the net exports of the country since 1992 are negative. The deficit peaked in 2021 when the Philippines imported 159,394,658 gross kg of citrus goods and exported 6,959,467 gross kg; and stood at 114,706,299 gross kg imported citrus goods in 2022 - 28.04% lower than 2021; and exported 12,108,999 gross kg - 74% higher than the previous year.

D. *OLS Model*

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Model 1: OLS, using observations 1992-2022 (T = 31)
Dependent variable: GDP

              coefficient      std. error     t-ratio   p-value
  ------------------------------------------------------------
  const         1.26980e+08     3.16612e+07   4.011    0.0005   ***
  AL            41786.7         4568.39       9.147    1.31e-09 ***
  AT           -3.58194e+06     1.17865e+06  -3.039    0.0054   ***
  AP            1100.82         35742.2       0.03080  0.9757
  NX             -0.208184        0.0587789  -3.542    0.0015   ***

Mean dependent var   82820764   S.D. dependent var   24055147
Sum squared resid    1.47e+15   S.E. of regression    7530672
R-squared            0.915062   Adjusted R-squared   0.901994
F(4, 26)             70.02615   P-value(F)           1.54e-13
Log-likelihood      -532.1301   Akaike criterion     1074.260
Schwarz criterion    1081.430   Hannan-Quinn         1076.597
rho                  0.387020   Durbin-Watson        1.199793

Excluding the constant, p-value was highest for variable 5 (AP)
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Fig. 5. Ordinary Least Square, dependent variable: GDP

Figure 5 shows the results of the OLS multiple regression analysis, which evaluates the impact of agricultural land specific for citrus production (AL), annual temperature (AT), annual precipitation (AP), and net exports (NX) on the GDP share of the citrus industry in the province of Nueva Vizcaya.

From the OLS model, the p-values of AL, AT, and NX are all significant. The p-value of AP, on the other hand, was insignificant to the chosen level of alpha, which is 0.05. However, 2 independent variables (AT and NX) yielded a negative output, signifying a slight downward slope in its

impact on the GDP share of the citrus industry, while AL and AP yielded a positive impact.

The coefficient of 41786.7 of AL suggests that there will be a high increase in the citrus GDP of Region II for every percent increase in citrus agricultural land area. Iñigo (2022) has stated that citrus has been considered to be among the top high-value crops in the Philippines with Cagayan Valley – home to Kasibu, Nueva Vizcaya – as one of the major citrus-producing regions. Kasibu is known for its orange varieties which are available in the area, as well as being the source of calamandarin oranges, mandarin (Satsuma and Ponkan), and pomelos. In the peak season of orange and citrus products, it is highly expected that tons of citrus fruits are to be loaded in crates for distribution to other outlets outside the region. Given this scenario, Kasibu citrus producers are in for great earnings, since citrus fruits are in demand. Calata (2022) stated that Nueva Vizcaya reported increases in tourism as the province launched a citrus-based circuit, which opened citrus orchard visitations for agriculture-inclined activities such as expansion of citrus agricultural land which will then open up employment opportunities and increase household income in the province while increasing citrus production. Alongside this, Nueva Vizcaya's land area is suitable for citrus production; thus, giving focus on expanding and improving the citrus agricultural land in the province can increase annual yield, supporting the study conducted by Wu et. al in 2022, which produced a result showing a positive correlation between suitable agricultural land area and annual yield. In an article by Braganza (2023), the citrus industry in the Philippines is one of the fastest-growing agricultural sectors. According to the Philippine Statistics Authority, there was a 9% increase in the production of citrus crops in 2020 compared to the previous year. Such growth can be linked to the increased demand for citrus fruits as made by both local and international markets.

The coefficient of -3.58194e+06 of the independent variable, Annual temperature (AT) suggests that there will be a decrease in the citrus GDP of Region II for every percent increase in citrus annual temperature. In the same study done by Siddique and Garnerska (2018) in the citrus industry in Pakistan, critical low-temperature lead to a decline in the production of citrus fruit crops. Also, a study from Pakistan by Ahmad (2017) suggested that there is a very negative effect put by climatic variables such as variation in temperature in the citrus production in the country. According to Tejero (2009), an increase in temperature and water stress after pollination inhibits ovule fertilization, thus resulting in increased fruit drop and decreased yields. Supporting the results, evident extreme climatic events in the Philippines such as severe drought, El Nino and La Nina occurrences, a rise of surface air temperature leads to reduced food crop production in the agricultural sector (Penaflor and Gata, 2020).

Annual precipitation (AP) has also resulted in a positive coefficient (1100.82), which suggests that there will also be a high increase in the citrus GDP of Region II for every percent increase in precipitation in the province of Nueva Vizcaya. However, AP was the only one with an insignificant p-value level out of all four variables. With this result, it is safe to state that there is insufficient evidence to conclude that a significant linear relationship between AP and GDP exists. In a study done by Martinez et al. (2020), it was mentioned that the growth, development, and productivity of citrus plants are influenced by climatic factors such as tropical conditions, and rainfall. (Orduz-Rodríguez et. al. 2017; Agovino et. al. 2018). Citrus is also reported to grow well in tropical and subtropical climates. Particularly, citrus can thrive well in drier areas with rainfall up to 500 mm and hilly areas with 2500 mm of rainfall. Ramel (2023) also states that Nueva Vizcaya's tropical monsoon climate is ideal for agriculture and citrus production. With ample rain of about 1,591 mm annually, such climate and weather conditions make the area an ideal place for citrus cultivation.

Net exports of citrus yielded a negative coefficient of -0.208184 yet resulted in a significant p-value of 0.0011. Given that the Philippines has had a trade deficit in citrus since 1992, and if the deficit continuously persists in future years, it will reduce the GDP of Region II. In the study conducted by Lumabao et al. (2023), net exports are significant to GDP as the volume of exports and imports determines a country's economic development and growth. A study conducted by Thangavelu & Rajaguru (2004) regarding import-led growth in Asian countries including the Philippines, showed strong unidirectional relationship between imports to economic growth. According to Coe et. al (1993), importation offers developing countries to learn from developed countries especially efficient methods that can aid in the increase in productivity and national revenue levels. Results may differ if the ratio of agricultural exports to agricultural imports increases, and so will agriculture's percentage contribution to GDP (Sormeaux, 2011). In a study done by Bakari and Mabrouki (2018), they investigated the impact of agricultural exports and agricultural imports on economic growth. Empirical results show that agricultural trade positively correlates with economic growth but denote that agricultural exports and economic growth have a feeble relationship. Chen (2020) states that the relationship between agricultural productivity and agricultural imports is positive and significant, and there is no evidence of unidirectional causality from GDP per capita growth to agricultural imports.

The R-squared result of 0.915062 implies that about 91.52% of the variation in GDP can be explained collectively by the changes in AL, AT, AP, and NX. The p-value of 1.54e-13 is less than alpha 0.05. Hence, implying that the regression model is significant. Durbin-Watson of 1.199 signifies that the model is confident that there is no autocorrelation error. Hence, accepting the null hypothesis suggesting that there is no considerable autocorrelation in Model 1.

Given that the coefficients of some variables are large, the researchers ran the data for more tests supporting the claim that all independent variables and the dependent variable are significant to one another.

E. Heteroskedasticity

Using White's Test for Heteroskedasticity, the p-value of 0.061879, which is greater than the chosen level of alpha of

0.05, accepts the null hypothesis stating that there is no heteroskedasticity in Model 1. Alongside of this, the data used in the study is time series, marking it safe from heteroskedasticity.

```
White's test for heteroskedasticity
OLS, using observations 1992-2022 (T = 31)
Dependent variable: uhat^2

              coefficient        std. error     t-ratio  p-value
  ---------------------------------------------------------------
  const        -6.83880e+015      2.57315e+015  -2.658   0.0172  **
  AL            6.72594e+012      2.51611e+012   2.673   0.0167  **
  AT            5.01616e+014      1.96868e+014   2.548   0.0215  **
  AP           -8.28645e+012      8.91440e+012  -0.9296  0.3664
  NX            1.15318e+08       3.54676e+07    3.251   0.0050  ***
  sq_AL         1.30354e+08       1.73216e+08    0.7526  0.4626
  X2_X3        -2.29753e+011      9.05712e+010  -2.537   0.0220  **
  X2_X4        -2.24620e+09       1.21380e+09   -1.851   0.0828  *
  X2_X5        -8845.97           7628.75       -1.160   0.2632
  sq_AT        -8.68785e+012      4.45353e+012  -1.951   0.0688  *
  X3_X4         2.37751e+011      3.09392e+011   0.7684  0.4534
  X3_X5        -3.17095e+06       1.19868e+06   -2.645   0.0176  **
  sq_AP         4.26576e+09       6.07513e+09    0.7022  0.4927
  X4_X5        -38761.0           18700.1       -2.073   0.0547  *
  sq_NX         0.0413786         0.0162517      2.546   0.0216  **

  Unadjusted R-squared = 0.738782

Test statistic: TR^2 = 22.902237,
with p-value = P(Chi-square(14) > 22.902237) = 0.061879
```

Fig. 6. White's test for Heteroskedasticity

F. Normality of Residual

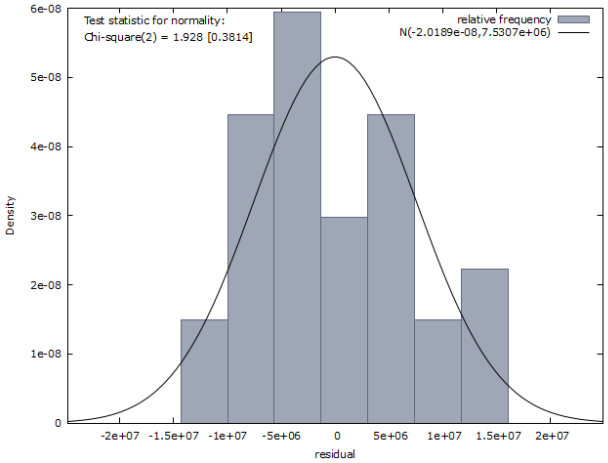

Fig. 7. Normality of residual

The histogram shows the graphic representation of the normality in the conditions of the residuals. The p-value of 0.3814 is greater than alpha 0.05 thus resulting in the acceptance of the null hypothesis stating that the residuals are normally distributed. Since the residuals are normal, both the model and the assumptions are presumed to be valid.

G. Chow Breakpoint & ARCH Test

```
Chow test for structural break at observation 2007
  F(5, 21) = 0.581227 with p-value 0.7140

Test for ARCH of order 1

             coefficient     std. error    t-ratio   p-value
  ------------------------------------------------------------
  alpha(0)   4.74210e+013    1.37099e+013   3.459     0.0018  ***
  alpha(1)   0.0112894       0.190074       0.05939   0.9531

  Null hypothesis: no ARCH effect is present
  Test statistic: LM = 0.00377924
  with p-value = P(Chi-square(1) > 0.00377924) = 0.95098
```

Fig. 8. Chow breakpoint and ARCH test

Both the Chow Breakpoint of 0.713992 and ARCH test of 0.95098 are greater than the alpha value of 0.05, proving that there is no heteroskedasticity in Model 1 and that there are no structural break observations in 1992 - 2022.

H. Q-Q Plot

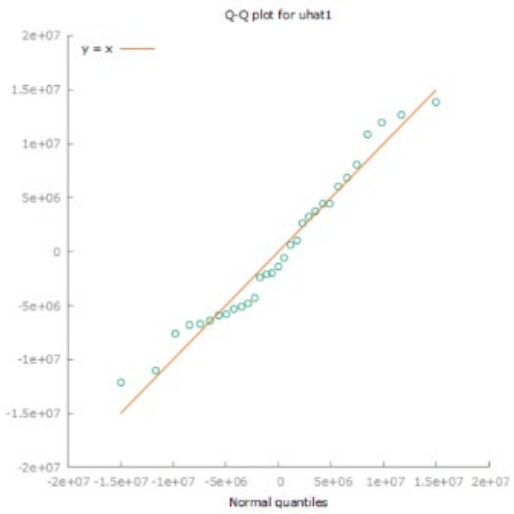

Fig. 9. Q-Q plot

Lastly, the Q-Q plot is also a useful tool in determining whether the identified outliers in the dataset are normally distributed. Given the demonstration in Figure 7, the dependent and independent variables used in the study have a normal distribution.

5. Conclusion

This paper aims to analyze and investigate how variables such as (but not limited to) agricultural land specific for citrus cultivation, temperature, precipitation, and citrus trade activity have affected the citrus industry in Nueva Vizcaya for the past 30 years.

The country was blessed with a terrain and tropical climate and due to this, the Philippines have been producing high-value crops, including citrus fruits. Nueva Vizcaya has been named the Citrus Capital of the Philippines due to the bountiful selection of citrus fruits available in the province. Past studies have shown that increases or decreases in agricultural land specific for citrus cultivation have effects on the citrus industry as it affects the volume of citrus production. Throughout this study, it was concluded that there is a positive relationship between the agricultural land area and yields of citrus cultivation.

On the other hand, changes in temperature patterns also impact the industry. Changes in heat, especially in the province of Nueva Vizcaya, will impact citrus harvests. Citrus fruits might have been said to be adaptable to different climatic conditions; however, despite being adaptable, changes in temperature can affect the growth and flowering of citrus trees and fruit yields. Therefore, this abiotic factor has adverse effects on citrus production.

Changes in precipitation pattern is also an abiotic factor that brings adverse effects on the citrus industry. Similar to changes

in temperature, changes in the water citrus trees receive can result in low survival of citrus trees, a decrease in fruit growth and size, low yields, and an increase in pre-harvest fruit drops.

Increasing economic growth and the country's GDP is the main target of most economies, especially those who belong in developing countries. Net exports are one of the determinants of economic growth. Along the study, it was found that there is a positive relationship between net exports and GDP. Given that the country imports more citrus, the trade deficit may continue to persist in the succeeding years.

6. Recommendations

The policy implications of this study suggest funding more in citrus related research. In the course duration of this study, there are limited studies available on the chosen topic. This shows that the citrus industry sector is neglected for further development and recognition in general. This has a potential for realization through collaborating with government agencies for additional funding for research and development, as well as equipment and infrastructures. This also includes providing agricultural education and training programs to citrus farmers in regard to new technology that would increase production efficiency and fruit quality and thus, keep pace with the demand locally and export more excess. Moreover, strengthening the advertisement of Nueva Vizcaya as the citrus capital of Luzon is suggested. The projects of the city Mayor especially, the Citrus Farm Tour and Citrus-Picking Experience, Farm-to-Market, Citrus Festival, and Agro-Trade Fair to name a few, have a limited audience reach. Lastly, encouraging more cooperatives to engage in the said industry to provide essential services and target the poorest of the poor farmers.

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