Forecasting Monthly Vegetable Prices in the Province of Nueva Vizcaya

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# Chapter I

## INTRODUCTION

### Background of the Study

The fluctuation of vegetable prices is a global concern in both developed and emerging economies. The demand for vegetables as a primary source of essential nutrients and dietary variety has increased concomitantly with urbanization and global population growth. Consequently, the dynamics of vegetable pricing have grown more intricate and significant, having an effect not just on consumer choices but also on food security, economic stability, and agricultural practices. Understanding the factors driving these price fluctuations is paramount for policymakers, farmers, consumers, and the broader food industry (Chen et al., 2018).

Vegetables are a major life necessity for urban and rural residents, and the vegetable market massively supports rural economic development. Fluctuations in vegetable prices affect farmers’ income, quality of life, and decision-making regarding vegetable planting. Therefore, issues regarding maintaining price stability have long been focused on government policies. In recent years, the price of vegetables has exhibited dramatic and frequent volatility, which caused a series of negative effects on stakeholders in the supply-chain, e.g., farmers, logistics, wholesale, retail, and consumers. In view of the above adverse effects on stakeholders, it is of crucial importance to filter out key factors that relate to price fluctuations, targeting effective monitoring of real-time abnormal fluctuations (Chen et al., 2018).

Price fluctuation is a complex issue with far-reaching consequences, especially for vulnerable populations. While higher prices may appear beneficial for farmers, the inherent volatility poses significant risks, potentially leading to substantial losses for agricultural stakeholders. Often attributed to imbalances in market fundamentals, where demand surpasses supply, this phenomenon has a profound impact on small-scale farmers (Mchopa et al., 2014).

Prices for vegetables fluctuate frequently, harming the financial interests of farmers, business owners, and consumers. Vegetable market prices are influenced by market supply and demand mechanisms, as well as a variety of internal and external influences. Weather fluctuations are one of these aspects, and they can have varied degrees of impact on the entire process of planting, harvesting, transporting, and selling vegetables. The supply chain for vegetables in China is more vulnerable to weather extremes due to the spatial concentration of vegetable production and the dispersed consumer base, resulting in an imbalance between supply and demand and abnormally large-scale fluctuations in vegetable prices that have an impact on people’s livelihoods (Yang et al., 2022).

According to *FAOSTAT* (n.d.), agricultural products account for a large proportion of the market as a necessity for daily consumption, and their prices play a critical part in consumer spending and agricultural household income. The supply and demand in a given year determine the prices of agricultural products. While an under supply of agricultural items raises prices and burdens consumers, an oversupply of agricultural products causes vegetable prices to increase and causes financial losses to farming households.

Moreover, vegetable prices have an impact on farmers’ income, standard of living, and vegetable producing choices. This is due to the cyclical and seasonal swings that affect vegetable prices; the price trend would alter based on the season, demand, and other factors. Therefore, concerns about price stability have typically focused on government initiatives. Vegetable prices have varied sharply and frequently recently, having a variety of negative effects on supply-chain participants like farmers, transportation, wholesale, retail, and customers (Chen et al., 2018).

Policy uncertainty may rise as a result of fluctuating commodity prices (Yiyang et al., 2023). Distributors may find it challenging to plan purchases, inventory control, and pricing strategies due to this unpredictability. Distributors who are unable to anticipate price fluctuations may face financial losses if they buy vegetables at a high price and then the price drops before they can sell them. According to Yiyang et al., smallholder farmers are more vulnerable to risk when prices fluctuate. This is due to the fact that smallholder farmers frequently have little resources and are unable to absorb the potential financial losses caused by changes in prices. These price-induced risks could have an impact on distributors who depend on smallholder farmers for their supplies because they can result in supply disruptions and higher sourcing expenses.

In the Philippines, vegetables price height has been a major problem for past years. Consumers were complaining of higher food prices, reflected not only in vegetables but in poultry and pork meat as well, and selected fish variants. Some prices have gone up by as much as 66 percent from last month alone. The Department of Agriculture officials have blamed the higher prices on numerous factors such as the ongoing pandemic, the devastating typhoons that destroyed crops, and the unwillingness of poultry and hog raisers to farm a new following the glut and the spread of the African swine fever, respectively.

As stated by Vibas & Raqueño (2019), Agricultural commodities significantly impact a country’s export earnings and economic performance. Price fluctuations affect farmers, consumers, and public agencies. The Department of Agriculture in the Philippines recognizes that local market-driven commodity pricing, notably for fruits and vegetables, have prompted government action.

Nueva Vizcaya Agricultural Terminal (NVAT) General Manager Gilbert Cumila said, vegetable prices in the Philippines continue to rise as demand exceeds supply. Wholesale prices of vegetables increases due to the demand of people. This significantly affect the way consumers purchase vegetables to sustain their necessities.

The purpose of the study is to fully comprehend the factors affecting changes in vegetable prices in Nueva Vizcaya. The study intends to offer significant insights and suggestions for farmers, consumers, and distributors by concentrating on forecasting the monthly vegetable prices. These stakeholders should be more prepared to react to monthly changes in vegetable prices when making decisions as a result of this research.

### Statement of the Problem

In response to the challenge of volatile vegetable prices faced by local farmers, distributors, and consumers, the researchers provided forecasts of monthly vegetable prices in Nueva Vizcaya. This effort aimed to assist them in making informed decisions regarding agricultural production, distribution, and vegetable purchases.

To do this, the researchers used five years of available time series data on vegetable prices from the Nueva Vizcaya Agricultural Terminal (NVAT) to come up with models that forecast monthly vegetable prices in Nueva Vizcaya. First, the researchers described the monthly vegetable prices in Nueva Vizcaya. Next, they fitted models to the data using automatic methods. The researchers then determined which automatic method had the best forecast performance for each vegetable and used these methods to forecast monthly vegetable prices in Nueva Vizcaya.

### Objectives of the Study

The researchers forecasted monthly vegetable prices in Nueva Vizcaya by accomplishing the following:

1. Describe the monthly prices for each vegetable in Nueva Vizcaya from 2017-2023.
2. Fit models using automatic methods to the monthly prices of each vegetable in Nueva Vizcaya from 2017-2023.
3. Evaluate the performance of these models and determine the best method to forecast monthly prices for each vegetable in Nueva Vizcaya.
4. Use the best method to generate forecasts for monthly prices for each vegetable in Nueva Vizcaya.

### Significance of the Study

This study is focused on forecasting monthly vegetable prices in Nueva Vizcaya. The results of the study would be beneficial to the following:

**Department of Agriculture.** This research would be beneficial to the Department of Agriculture by incorporating its findings into policy formulation and resource allocation. Accurate price forecasts can inform agricultural development programs, subsidies, and interventions, ultimately supporting the growth and sustainability of the agricultural sector in Nueva Vizcaya.

**Local Farmers.** This research would be beneficial to the local farmers. It would provide them with valuable insights into future vegetable price trends. Accurate price forecasts would enable farmers to plan their planting and harvesting schedules efficiently, reduce wastage, and optimize their crop yields, ultimately leading to improved income stability and sustainable agricultural practices.

**Vendors.** This research would be beneficial to vendors in Nueva Vizcaya’s vegetable markets. With reliable vegetable price forecasts, they can make informed purchasing decisions, maintain competitive prices, and increase profit margins. This, in turn, fosters a more stable and profitable business environment for vendors.

**Consumers.** This research would be beneficial to consumers as it helps maintain price stability and affordability. When vendors can make better decisions based on accurate forecasts, consumers are less likely to experience price shocks or sudden increases in vegetable prices, ensuring accessibility to essential food items.

**Future Entrepreneurs.** This research would be beneficial for future entrepreneurs looking to venture into the vegetable market in Nueva Vizcaya. The study’s results can be utilized to make informed business decisions, aiding in the development of market entry strategies, inventory management strategies, and pricing strategies. This information is valuable for mitigating the risks associated with launching a new business.

**Business Owners.** This research would be beneficial to business owners in Nueva Vizcaya, whether they are in the agricultural sector or the retail and distribution sector. They can leverage predictive insights to optimize their supply chain operations. Improved supply chain efficiency can lead to cost savings and increased profitability.

**Future Researchers.** This research would serve as a valuable foundation for future researchers interested in agricultural economics, market dynamics, and forecasting methodologies. It would provide a benchmark dataset and insights that can be expanded upon and refined in subsequent research efforts, contributing to the continuous advancement of agricultural forecasting and market analysis.

### Scope and Delimitation of the Study

The study focused on forecasting the monthly prices of vegetables in NVAT, Bambang, Nueva Vizcaya. The researchers used time series of vegetable prices for five years available from NVAT. From this data, monthly time series of prices for each vegetable were described. ARIMA, SARIMA, and ETS models were then fitted to the data using automatic algorithms and time series cross-validation to generate optimal models for each vegetable. Comparison of computed point forecast measures for the generated models determined the best automatic method to use in forecasting monthly prices for each vegetable. A portmanteau test of residuals was used to assess the performance of the models generated by the best automatic method to forecast monthly prices for each vegetable.

The researchers performed log transformations with the data to make sure that forecasts stay positive. Model specifications were not set either, as this process was performed automatically using default settings. All computations and visualizations were performed in the R programming language (R Core Team, 2023). Moreover, external variables impacting vegetable prices were not investigated nor incorporated in the modeling process.

### Conceptual Framework

The research paradigm as shown in [Figure 1](#fig-rp) guided the researchers in conducting the study. It consists of input, process, and output. The input is the available time series of vegetable prices from NVAT. The outputs are ARIMA, SARIMA, and ETS models generated by the best automatic method for each vegetable, along with their corresponding monthly forecasts. Under process, time series analysis was carried out using automatic algorithms in time series cross-validation to generate different optimal ARIMA, SARIMA, and ETS models for each vegetable. From this, the best automatic method for each vegetable was determined by comparing the point forecast accuracy measures of the models generated. Also, portmanteau test of residuals was performed to describe the performance of the final model for each vegetable.

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| Figure 1. Research Paradigm |

### Definition of Terms

**AutoRegressive Integrated Moving Average (ARIMA).** Utilize ARIMA to model and predict monthly vegetable prices by considering autoregressive and moving average components while addressing seasonality or trends through differencing, ensuring a more accurate representation of the variations over time.

**Exponential Smoothing (ETS).** Apply ETS as an alternative forecasting method to capture systematic trends or seasonal patterns in monthly vegetable prices, providing a robust approach beyond traditional ARIMA models for more comprehensive predictions.

**Forecasting.** Apply ETS as an alternative forecasting method to capture systematic trends or seasonal patterns in monthly vegetable prices, providing a robust approach beyond traditional ARIMA models for more comprehensive predictions.

**The Nueva Vizcaya Agricultural Terminal (NVAT).** Place to gather data of monthly vegetable prices.

**Root Mean Squared Error (RMSE).** Evaluate the accuracy of your forecasting models by calculating RMSE, which measures the average deviation between predicted and actual monthly vegetable prices. Lower RMSE values indicate better predictive performance, ensuring the reliability of your forecasting approach.

**Seasonal AutoRegressive Integrated Moving Average (SARIMA).** Enhance forecasting accuracy by incorporating SARIMA, an extension of ARIMA, to account for seasonal components in monthly vegetable prices. This is particularly beneficial when dealing with recurring seasonal patterns in the market.

**Time Series.** Analyze historical time series data of monthly vegetable prices to identify trends, patterns, and behavior over time. This helps in building models that can capture and predict future price movements accurately.

**Vegetable Price.** Study and forecast monthly vegetable prices are a key economic and agricultural indicator. Understand the supply and demand dynamics and use forecasting models to predict how these prices might evolve in the future, aiding in decision-making for farmers, traders, and policymakers.

# Chapter II

## REVIEW OF RELATED LITERATURE

### Vegetable Prices

Vegetables have the greatest supply and price volatility of any agricultural item. Vegetables are difficult to keep in a consistent supply and price because they are grown outside and their yields vary greatly depending on the weather. As a result, vegetables have a substantial economic impact. Despite the government’s best efforts, recurring weather shifts have generated instability in vegetable supply and price swings in recent years (Illankoon & Kumara, 2020).

Prices for vegetables fluctuate frequently, harming the financial interests of farmers, business owners, and consumers. Vegetable market prices are influenced by market supply and demand mechanisms, as well as a variety of internal and external influences. Weather fluctuations are one of these aspects, and they can have varied degrees of impact on the entire process of planting, harvesting, transporting, and selling vegetables. The supply chain for vegetables in China is more vulnerable to weather extremes due to the spatial concentration of vegetable production and the dispersed consumer base, resulting in an imbalance between supply and demand and abnormally large-scale fluctuations in vegetable prices that have an impact on people’s livelihoods (Yang et al., 2022).

Moreover, vegetable prices have an impact on farmers’ income, standard of living, and vegetable producing choices. This is due to the cyclical and seasonal swings that affect vegetable prices; the price trend will alter based on the season, demand, and other factors. Therefore, concerns about price stability have typically focused on government initiatives. Vegetable prices have varied sharply and frequently recently, having a variety of negative effects on supply-chain participants like farmers, transportation, wholesale, retail, and customers (Chen et al., 2018).

The quality of life of residents will be directly impacted by frequent increases in vegetable market prices, which will also bury hidden dangers for the fall in vegetable prices in the subsequent round of prices. In contrast, the continued decline in vegetable market prices results in prices that are too low and negatively impact the vital interests and production enthusiasm of vegetable farmers, leaving the supply of vegetables poorly protected and causing the subsequent round of skyrocketing prices. Regional vegetable price fluctuations have a significant negative impact on farmers and consumers, which has an impact on the macroeconomic stability and significantly lowers the degree of regional social welfare (Gan & Liao, 2020).

Vegetables are highly perishable products (Desalegn, 2021). This implies that a variety of factors, including supply and demand, weather, and storage availability, might have a significant impact on their pricing. Distributors may become uneasy as a result of these developments, which will make it challenging for them to project earnings and run their businesses efficiently. According to the study, the vegetable value chain commonly involves middlemen. When veggies are plentiful, these intermediaries usually take advantage of price volatility by buying them at a discount from growers and reselling them to clients at a premium when they are in short supply. Having to outbid middlemen for supplies may result in lower profit margins for distributors. As mentioned in the introduction of the study of Desalegn, smallholder farmers in rural areas usually lack access to functioning market information. They consequently struggle to anticipate price changes and effectively haggle for their produce. Distributors who depend on these farmers for their goods are indirectly impacted by this ignorance. It was also emphasized in the study of Desalegn that the perishable nature of vegetables is another issue. Distributors could therefore suffer since, when the market gets saturated, they won’t be able to keep excess inventory on hand and would have to sell produce at a loss.

In the Philippines, sustainable soil nutrient-enhancing strategies involve the wise use and management of inorganic and organic nutrient sources in ecologically sound production systems (Janssen, 1993). The primary goal of integrated nutrient management (INM) is to combine old and new methods of nutrient management into ecologically sound and economically viable farming systems that utilize available organic and inorganic sources of nutrients in a judicious and efficient way. Integrated nutrient management optimizes all aspects of nutrient cycling. It attempts to achieve tight nutrient cycling with synchrony between nutrient demand by the crop and nutrient release in the soil, while minimizing losses through leaching, runoff, volatilization and immobilization. Providing higher economic returns per unit area and developing new export markets for high value crops in the Philippines has been identified as a priority by the Philippine Government and the Australian Centre for International Agricultural Research (ACIAR) as means of increasing economic growth and improving the standard of living of people living in rural areas. Regions VIII (Leyte), X (Northern Mindanao/Cagayan de Oro) and XI (Southern Mindanao/ Davao) have significant potential for expanding vegetable production. Moreover, they are seen as strategically important to the Australian Government, whereby efforts to improve the livelihoods of the populations in these areas could contribute to improving geo-political stability in the region (Tulin et al., 2019).

Benguet, a mountainous province in the northern Philippines, trucks down at least 1,500 metric tons of semi-temperate vegetables every day to depots called bagsakan in Manila, the nation’s capital. When demand spikes around holidays like Christmas and Easter, the volume of deliveries can triple. Eighty percent of the nation’s need for semi-temperate vegetables like potatoes, cabbage, radish, chayote, carrot, lettuce, and broccoli is met by crops that are shipped from Manila throughout the archipelago. Situated atop the Cordillera mountain range, the high altitude of Benguet province is conducive to the production of these kinds of crops, which are also known as highland vegetables. With a minimum 1.1 million metric tons produced annually. However, as farmers use chemical-heavy fertilizers to boost yields, fifty years of toiling the land to feed millions across the country is causing the forest cover to slowly disappear and the soil to deteriorate. In addition to causing fluctuating vegetable prices and oversupply — which frequently results in spoilage and losses for farmers — the region’s growing number of farmers and farmland, all of which are planting upland vegetables.

Pricing Theory and Law of Supply and Demand is used to interpret the gathered statistical data from previous studies in this systematic review of economics literature in the Philippines. It provides explanation on the responsiveness of seaweed farmers in the Philippines to the price changes in relation to the supply and demand that is changing from time to time. The strong demand of seaweed drives the market prices, and this may drive seaweed farmers to increase the seaweed production but when the price are low seaweed farmers have the tendency to leave their farms resulting in a low production of seaweed and in effect a decrease in seaweed supply. This problem may be enlightened using the law of supply and demand wherein when the demand is high — the price is high, and the supply is low. On the other hand, if the demand is low — the price is low, and the supply is high. As a result, the seaweed farmers are not responsive to price changes in the short-run and in the long-run (Guerrero & Garcia-Vigonte, 2022).

### Forecasting Vegetable Prices

Accurate agricultural price forecasting is critical to achieving sustainable and healthy agricultural development, and it is a hot research area in the agricultural industry. It explores traditional forecasting procedures, intelligent forecasting methods, and combination model forecasting methods, as well as the obstacles found in the current research landscape of agricultural commodity price prediction (Sun et al., 2023).

Farming is first and foremost defined by family work, which is limited by the availability of land, water, and capital resources. Choosing which agricultural items to produce must be made by farmers, however there are oftentimes not enough possibilities to enable the best farming decisions. Farmers must choose which vegetables will bring in the highest prices at harvest. The aforementioned issue was fixed by estimating pricing based on weather conditions using machine learning technologies. The hopeful results of the Prediction model are what have made Machine Learning so well-liked. This paper explores the use of multiple regression models to forecast vegetable prices, and its applicability has also been taken into account. In order to plan for their forthcoming crop and prevent hyperinflation, farmers benefit from being able to estimate vegetable prices (Kakulapati & Shaik, 2022).

Forecasting vegetable prices is critical in the agricultural industry for making sound judgments. This forecasting task is quite difficult. Because neural networks are self-adaptive, have a high learning capacity, and are adaptable, they are used to tackle a wide range of difficult tasks. This model forecasts the price of vegetables for the next day based on the previous price of time series data. This research compares and contrasts three machine learning algorithms: radial basis function, back propagation neural network, and genetically based neural network. The models are assessed, and the accuracy percentages show that the genetically based neural network outperforms propagation neural networks and radial basis functions in terms of vegetable price prediction accuracy (Subhasree & Priya, 2016).

The vegetable industry is crucial, particularly in terms of supplying an abundance of fresh agricultural products. For the agriculture sector to make wise decisions, vegetable price forecasting is essential. The challenges that Malaysian farmers face is not just related to aging, but also to their ability to compete in a country where consumers prioritize fresh produce and fruits from hypermarkets and wholesale markets over supermarkets. This review article aids in identifying the present issues facing Malaysia’s agriculture industry and examines the connection between agriculture and e-commerce. The growth of e-agriculture has been noted by researchers recently, and the authors discovered that an agricultural e-commerce platform equipped with a price forecasting model could be useful in resolving a current national issue. This study examines the global agricultural e-commerce platforms currently in use and makes an attempt to compare it with the domestic market. Following the completion of the reviews, the authors propose building a time analysis model in a hybrid approach for vegetable price forecasting in an agricultural e-commerce platform. This model can be utilized by the government to inform policy decisions (Aishi et al., 2023).

In the Philippines, box-Jenkins technique and the Autoregressive Moving Average (ARMA) model were used to forecast onion production. Using historical data from the Philippine Statistics Authority, the ARMA (4,2) model was applied to construct an optimal forecasting solution. The model passed diagnostic tests with a mean absolute percentage error (MAPE) of 10.406%. The predicted yields for each quarter were highlighted, as were projections for onion output in 2023 and 2024. An examination of historical data indicated that weather trends, consumer demand, agricultural techniques, and imports and exports all contribute to periodic variations in onion supply. The study’s findings highlight the significance of employing exact forecasting models when deciding how to distribute resources, establish pricing, and place products on the market (Capiral et al., 2023).

Commodity prices have an impact on both producers and consumers; therefore, estimating their future value is important for making decisions down the road. The purpose of this study is to assist policymakers in developing guidelines that will benefit producers and consumers of agricultural products such as sitao, whole chicken, eggplant, tomato, pork ham, and pork liempo. The chosen commodities’ data behavior for the years 2013–2022 was examined by the researchers, and they all showed an upward trend with some fluctuations. Numerous factors, including seasonality of production, volume surplus, pest and disease, typhoon destruction, and importation, are found to be linked to these fluctuations. The researcher used the ARIMA technique to forecast the price of this agricultural produce after analyzing the price behavior (Zhang & Liu, 2020).

Crop climate calendars enhance traditional crop calendars by providing phenological states, cultivation techniques, and weather and climatic requirements that all crops must meet during a cropping season, as well as planting and harvest timings. The case for capturing this data in Benguet is compelling: the mountainous province benefits from the growth of high-value crops like carrots, cabbage, and potatoes despite weather phenomena such as hail, frost, and various microclimates. The researchers conducted focus groups with municipal agriculturalists and farmer leaders in Atok, Benguet, to better understand their experiences and build their crop climate calendar. The calendars developed during this experiment could provide a solid foundation for investigating the area’s climate-sensitive agricultural methods (Domingo et al., 2020).

### Synthesis

Vegetable prices are influenced by various factors, both internationally and within specific countries like the Philippines. Internationally, studies have shown that vegetables have a high supply and price volatility due to their dependence on weather conditions. Weather fluctuations can lead to inconsistent vegetable supply and large-scale price fluctuations, impacting farmers, business owners, and consumers (Illankoon & Kumara, 2020; Yang et al., 2022). This instability in prices affects farmers’ income, standard of living, and their choices in vegetable production (Chen et al., 2018).

In the Philippines, the pricing of vegetables is also influenced by factors such as market supply and demand, weather conditions, and storage availability. Distributors and middlemen play a role in price volatility, taking advantage of fluctuations to buy vegetables at a discount and resell them at a higher price when supply is low (Desalegn, 2021). Smallholder farmers in rural areas often lack access to market information, making it difficult for them to anticipate price changes and negotiate effectively, indirectly impacting distributors who rely on their produce. Additionally, the perishable nature of vegetables poses a challenge for distributors who may suffer losses when market saturation occurs and excess inventory cannot be stored.

Accurate forecasting of vegetable prices is crucial for sustainable agricultural development. Machine learning technologies and regression models have been used to forecast vegetable prices based on factors such as weather conditions, previous price data, and market trends (Kakulapati & Shaik, 2022; Subhasree & Priya, 2016). In the Philippines, forecasting models have been applied to predict the production and prices of specific vegetables like onions, using historical data and considering factors such as weather trends, consumer demand, and agricultural techniques (Capiral et al., 2023).

In conclusion, vegetable prices are influenced by various factors internationally and within specific countries like the Philippines. Factors such as weather fluctuations, market supply and demand, and the role of distributors and middlemen contribute to price volatility. Accurate forecasting of vegetable prices using machine learning and regression models can help farmers and policymakers make informed decisions. Understanding and addressing these factors are crucial for achieving sustainable agricultural development and improving the livelihoods of farmers and consumers.

# Chapter III

## RESEARCH METHODOLOGY

### Research Design

The research is purely quantitative in nature. Specifically, the researchers employed comparative time series forecasting (Hyndman & Athanasopoulos, 2021). In this study, AutoRegressive Integrated Moving Average (ARIMA) and Exponential Smoothing (ETS) models were compared to determine the best model to forecast monthly prices for each vegetable.

### Locale of the Study

The study was conducted in Bambang, Nueva Vizcaya. Specifically, the data for this study was collected from the Nueva Vizcaya Agricultural Terminal (NVAT), which is located in Bambang. Bambang is the next town south of Bayombong — the capital town of the province of Nueva Vizcaya. Please see [Figure 2](#fig-bambang) below.

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| Figure 2. Map of Bambang, Nueva Vizcaya (https://en.wikipedia.org/wiki/Bambang,\_Nueva\_Vizcaya#/media/File:Ph\_locator\_nueva\_vizcaya\_bambang.png) |

### Source and Subject of the Study

The primary source of data for the research is the NVAT. Six years and two months of available time series of vegetable prices from the NVAT were used to come up with forecasts of monthly vegetable prices in Nueva Vizcaya.

### Data Gathering Procedure

The researchers inquired about the background and data policy of NVAT by visiting its office. Additionally, letters requesting permission to gather data for the research were written to the NVSU President, NVAT General Manager, and the Municipal Mayor of Bambang (refer to Appendix A, B, and C, respectively). Subsequently, the researchers were able to collect time series of vegetable prices for six years and 2 months. Throughout the data collection process, strict adherence to ethical considerations, including data confidentiality and approval from appropriate authorities, were maintained.

### Data Analysis and Treatment of Data

In forecasting monthly vegetable prices in Nueva Vizcaya, the researchers followed the process illustrated in [Figure 3](#fig-workflow). It is an adapted representation of the workflow introduced by Hyndman & Athanasopoulos (2021).

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| Figure 3. Data Treatment and Analysis Workflow |

The tidy part involves preparing the raw data in the correct format. This includes loading the raw data into R and identifying and resolving missing values to create a tidy time series data for monthly vegetable prices. The researchers utilized the tsibble and tidyverse packages for this task (Wang et al., 2020; Wickham et al., 2019).

Subsequently, the researchers visualized the monthly vegetable prices in Nueva Vizcaya. The trend and seasonal components of the data were also visualized using the seasonal and trend decomposition using LOESS (STL) method developed by Cleveland et al. (1990). These visualizations were integral in describing the data.

Next, automatic algorithms introduced by Hyndman & Athanasopoulos (2021) were used to estimate or fit optimal ARIMA and ETS models to the data. The researchers would implement these algorithms in R using the fable package (O’Hara-Wild et al., 2023).

Moreover, time series cross-validation was used to evaluate the forecast accuracy of the automatic ARIMA method and the automatic ETS method (Hyndman & Athanasopoulos, 2021). Point forecast accuracy measures such as the mean absolute error (MAE), root mean squared error (RMSE), mean absolute percentage error (MAPE), and mean absolute squared error (MASE) were computed from the generated models and then compared to determine the best method to be used in forecasting monthly vegetable prices. The method with lower point forecast accuracy measures was selected as the best method for each vegetable.

Then, the best method for each vegetable was used to generate models to forecast monthly vegetable prices in Nueva Vizcaya.

Finally, a portmanteau test in the form of the Ljung-Box test was computed for the models used to forecast monthly vegetable prices. This allowed the researchers to describe the performance of these models. Computed p-values greater than .05 confirm that the residuals are similar to white noise. Otherwise, the residuals still have some remaining autocorrelation that is not accounted for in the model (Hyndman & Athanasopoulos, 2021).

# CHAPTER IV

## RESULTS AND DISCUSSION

### Monthly Vegetable Prices

After encoding the available vegetable prices from the NVAT Facebook page, only 12 vegetables were chosen for the study. These vegetables are broccoli, cabbage, carrots, cauliflower, celery, chayote (bunga) cucumber, gabi, pepper (sultan), pepper (taiwan), potato, and wombok. The graph of the time series of the monthly prices of these vegetables are shown in [Figure 4](#fig-plot_all). The time series of the monthly vegetable prices are from October 2017 to December 2023. Thus, each vegetable time series consists of 75 observations.

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| Figure 4. Time Series for Monthly Vegetable Prices |

The summary of the time series of monthly vegetable prices from October 2017 to December 2023 is shown in [Table 1](#tbl-all).

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| Table 1. Summary of the Time Series for Monthly Vegetable Prices   | **Vegetable** | **Min** | **Max** | **Mean** | **SD** | | --- | --- | --- | --- | --- | | broccoli | 10.85 | 127.06 | 39.90 | 21.87 | | cabbage | 4.97 | 77.38 | 24.05 | 18.09 | | carrot | 9.11 | 97.68 | 33.06 | 19.28 | | cauliflower | 12.34 | 113.55 | 38.76 | 20.80 | | celery | 9.93 | 178.33 | 42.40 | 30.64 | | chayote (bunga) | 4.17 | 45.25 | 12.99 | 7.81 | | cucumber | 8.05 | 57.59 | 25.23 | 12.03 | | gabi (galyang) | 8.81 | 42.50 | 23.07 | 8.83 | | pepper (sultan) | 28.06 | 273.24 | 89.41 | 51.06 | | pepper (taiwan) | 11.50 | 424.38 | 112.32 | 106.29 | | potato | 17.33 | 138.88 | 45.48 | 22.41 | | wombok | 4.14 | 54.44 | 15.72 | 11.36 | |

For the broccoli time series, the minimum price is 10.85 in April 2018 and the maximum price is 127.06 in September 2023. The average price is 39.9. It has a standard deviation of 21.87.

For the cabbage time series, the minimum price is 4.97 in February 2020 and the maximum price is 77.38 in August 2021. The average price is 24.05. It has a standard deviation of 18.09.

For the carrot time series, the minimum price is 9.11 in May 2020 and the maximum price is 97.68 in July 2023. The average price is 33.06. It has a standard deviation of 19.28.

For the cauliflower time series, the minimum price is 12.34 in March 2020 and the maximum price is 113.55 in August 2023. The average price is 38.76. It has a standard deviation of 20.8.

For the celery time series, the minimum price is 9.93 in February 2018 and the maximum price is 178.33 in September 2018. The average price is 42.4. It has a standard deviation of 30.64.

For the chayote (bunga) time series, the minimum price is 4.17 in January 2020 and the maximum price is 45.25 in September 2018. The average price is 12.99. It has a standard deviation of 7.81.

For the cucumber time series, the minimum price is 8.05 in July 2020 and the maximum price is 57.59 in January 2023. The average price is 25.23. It has a standard deviation of 12.03.

For the gabi (galyang) time series, the minimum price is 8.81 in January 2018 and the maximum price is 42.5 in December 2023. The average price is 23.07. It has a standard deviation of 8.83.

For the pepper (sultan) time series, the minimum price is 28.06 in May 2020 and the maximum price is 273.24 in September 2023. The average price is 89.41. It has a standard deviation of 51.06.

For the pepper (taiwan) time series, the minimum price is 11.5 in June 2019 and the maximum price is 424.38 in December 2020. The average price is 112.32. It has a standard deviation of 106.29.

For the potato time series, the minimum price is 17.33 in June 2021 and the maximum price is 138.88 in October 2023. The average price is 45.48. It has a standard deviation of 22.41.

For the wombok time series, the minimum price is 4.14 in December 2018 and the maximum price is 54.44 in December 2020. The average price is 15.72. It has a standard deviation of 11.36.

The vegetable with the most variability is pepper (taiwan). It also has the highest maximum price and the highest average price among all the vegetables. On the other hand, the vegetable that has the least variability is chayote (bunga). It also has the lowest average price. The vegetable that has the lowest minimum price is wombok.

[Table 2](#tbl-stl) shows the STL features of the time series of monthly vegetable prices.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 2. STL Features of the Time Series for Monthly Vegetable Prices   | **Vegetable** | **Trend Strenth** | **Seasonal Strength** | **Seasonal Peak** | **Seasonal Trough** | | --- | --- | --- | --- | --- | | broccoli | 0.51 | 0.62 | September | January | | cabbage | 0.20 | 0.18 | September | March | | carrot | 0.35 | 0.40 | August | May | | cauliflower | 0.44 | 0.72 | August | March | | celery | 0.34 | 0.43 | September | March | | chayote (bunga) | 0.32 | 0.32 | September | March | | cucumber | 0.37 | 0.26 | December | July | | gabi (galyang) | 0.91 | 0.55 | September | February | | pepper (sultan) | 0.21 | 0.20 | September | May | | pepper (taiwan) | 0.26 | 0.41 | December | April | | potato | 0.72 | 0.35 | October | May | | wombok | 0.14 | 0.19 | September | March | |

The broccoli time series has a trend strength of 0.51, showing that 51% of the time series is accounted for by trend not considering seasonality. On the other hand, it has a seasonal strength of 0.62, showing that 62% of the time series is accounted for by seasonality not considering trend. Its peak is in September and its trough is in January.

The trend strength suggests a stable increase or decrease in prices over time, which may reflect broader economic conditions affecting both farmers and consumers. Moreover, results suggest that supply of broccoli is scarce in September. Thus the peak in price due to high demand. Also, results suggest that supply is abundant in January. Thus the trough in price due to low demand.

For farmers, understanding these seasonal dynamics is crucial for optimizing production and marketing strategies. By aligning planting schedules with peak demand periods, they can maximize profits and reduce the risk of oversupply, which often leads to lower prices. Conversely, during low-demand months, farmers can plan for reduced production or explore alternative crops to mitigate financial losses.

Consumers also benefit from this knowledge by timing their purchases to coincide during the trough period, when prices are generally lower. This strategic buying behavior not only helps consumers save money but also encourages a more efficient market where supply and demand are better balanced.

Awareness of the seasonal peak and trough in broccoli pricing enables both farmers and consumers to make informed decisions, fostering a more resilient agricultural economy.

Broccoli has a moderate trend and a moderate seasonal strength. For farmers, this means that although production and sales volume are increasing over the long run, there are also significant seasonal fluctuations. Since the price of broccoli peaks in September and troughs in January, it may be expected that it is abundant in late summer and early fall, when it can be harvested and sold within a certain period of time. During peak season, farmers may have the product may be rare and more expensive, whereas during trough season, consumers may have easier access to the product and pay less.

The cabbage time series has a trend strength of 0.2, showing that 20% of the time series is accounted for by trend not considering seasonality. On the other hand, it has a seasonal strength of 0.18, showing that 18% of the time series is accounted for by seasonality not considering trend. Its peak is in September and its trough is in March.

The trend for cabbage is weak and the seasonality is considerably weaker. This shows that production is moderate and nearly consistent all year round, with very little indications of the holiday season. Since the price of cabbage is highest in September and lowest in March, it may be purchased at any time of year, though March is likely the best month to buy it because it is more affordable. Farmers can plan their crop production and storage operations to ensure that consumer expectations regarding costs do not significantly change.

The carrot time series has a trend strength of 0.35, showing that 35% of the time series is accounted for by trend not considering seasonality. On the other hand, it has a seasonal strength of 0.4, showing that 40% of the time series is accounted for by seasonality not considering trend. Its peak is in August and its trough is in May.

The trend strength and seasonal strength of the carrot are both medium. Given that it peaks in August and troughs in May suggests that late summer is a great time for carrot production. Its August peak and May trough indicate that late summer is a favorable period to harvest carrots. Farmers may find it beneficial to focus on harvest and marketing around August to optimize profit, even though consumers may benefit from more favorable pricing and availability in May rather than August.

The cauliflower time series has a trend strength of 0.44, showing that 44% of the time series is accounted for by trend not considering seasonality. On the other hand, it has a seasonal strength of 0.72, showing that 72% of the time series is accounted for by seasonality not considering trend. Its peak is in August and its trough is in March.

Cauliflower has a medium trend and a very seasonal series. This is the best time of year for the farmer to sell cauliflower since there will be a market for it, with peaks in August and troughs in March. During the trough months, consumers can anticipate cheaper costs and better availability, and during the peak, they should anticipate higher prices and less availability.

The celery time series has a trend strength of 0.34, showing that 34% of the time series is accounted for by trend not considering seasonality. On the other hand, it has a seasonal strength of 0.43, showing that 43% of the time series is accounted for by seasonality not considering trend. Its peak is in September and its trough is in March.

Celery has a moderate trend and strong seasonal pattern. As a result, celery cultivation and sales are seasonal, reaching their peak in September and trough in March. During this time, farmers can plan how to harvest and sell their products when there is most demand. Consumers should anticipate more supply and lower prices in March.

The chayote (bunga) time series has a trend strength of 0.32, showing that 32% of the time series is accounted for by trend not considering seasonality. On the other hand, it has a seasonal strength of 0.32, showing that 32% of the time series is accounted for by seasonality not considering trend. Its peak is in September and its trough is in March.

The seasonal and trend strength of the chayote (bunga) was well-balanced. Given that it peaks in September and troughs in March suggests that seasonality and the trend were significant contributors to its production. Farmers can so anticipate consistent yield with distinct peaks and troughs, while consumers can make purchases based on seasonal availability.

The cucumber time series has a trend strength of 0.37, showing that 37% of the time series is accounted for by trend not considering seasonality. On the other hand, it has a seasonal strength of 0.26, showing that 26% of the time series is accounted for by seasonality not considering trend. Its peak is in December and its trough is in July.

The seasonal strength of cucumber was a significantly lower compared to its trend strength. The peak in December and the trough in July suggest that there might be an oversupply of cucumbers in the winter. Farmers would have to focus on winter harvests, even though consumers are expected to have better access to and probably purchase at lower prices during this trough season.

The gabi (galyang) time series has a trend strength of 0.91, showing that 91% of the time series is accounted for by trend not considering seasonality. On the other hand, it has a seasonal strength of 0.55, showing that 55% of the time series is accounted for by seasonality not considering trend. Its peak is in September and its trough is in February.

Gabi (Galyang) has the strongest trend with a mild seasonality. There is a strong long-term trend with strong seasonal fluctuation, peaking in September and troughing in February. Farmers should focus a lot of effort on maximizing sales and availability during the peak season. February is anticipated to have the best supply and prices for consumers.

The pepper (sultan) time series has a trend strength of 0.21, showing that 21% of the time series is accounted for by trend not considering seasonality. On the other hand, it has a seasonal strength of 0.2, showing that 20% of the time series is accounted for by seasonality not considering trend. Its peak is in September and its trough is in May.

The seasonal strength and weak trend of pepper (Sultan) are characterized by September peaks and May troughs. With the peak in September, farmers can aim a higher market that month, but this would indicate minimal effects of trend and seasonality, suggesting rather consistent production. Consumers would make purchases around May for better availability and probably lower prices.

The pepper (taiwan) time series has a trend strength of 0.26, showing that 26% of the time series is accounted for by trend not considering seasonality. On the other hand, it has a seasonal strength of 0.41, showing that 41% of the time series is accounted for by seasonality not considering trend. Its peak is in December and its trough is in April.

The pepper (taiwan) seasonal strength is stronger while the trend strength. Farmers would seek to optimize production and sales throughout the winter months because the peak was in December and the trough was in April. Consumers would find more availability of peppers at a reasonable price in April.

The potato time series has a trend strength of 0.72, showing that 72% of the time series is accounted for by trend not considering seasonality. On the other hand, it has a seasonal strength of 0.35, showing that 35% of the time series is accounted for by seasonality not considering trend. Its peak is in October and its trough is in May.

Potato shows moderate seasonality and a significant trend. The peak is in October and the trough is in May. Consumers should anticipate October prices to be more accommodating than the prices on May, allowing farmers to take advantage of peak seasons to guarantee larger returns.

The wombok time series has a trend strength of 0.14, showing that 14% of the time series is accounted for by trend not considering seasonality. On the other hand, it has a seasonal strength of 0.19, showing that 19% of the time series is accounted for by seasonality not considering trend. Its peak is in September and its trough is in March.

Wombok indicates a trend of 0.14 and seasonality of 0.19, the weakest of all. This would indicate that its supply is fairly steady, with just small seasonal fluctuations, with a peak in September and a trough in March. Produce availability and costs should be fairly stable for consumers throughout the year, and farmers can maintain a consistent production schedule.

The vegetable with the strongest trend is gabi (galyang). Meanwhile, the vegetable that has the weakest trend is wombok. The vegetable with the strongest seasonality is cauliflower. Meanwhile, the vegetable with the weakest seasonality is cabbage. Please see Appendix D for the seasonal and trend decomposition using LOESS (STL).

These trends and seasonality allow farmers to plan accordingly in production and marketing, while consumers are better placed in making decisions on when to buy vegetables for the best prices and availability.

### Models for Monthly Vegetable Prices

The time series cross-validation using automatic ARIMA method and automatic ETS method yielded 360 models: 180 ARIMA and SARIMA models and 180 ETS models. There are 15 ARIMA and/or SARIMA models and 15 ETS models for each vegetable. Please see Appendix E for the full list of these models per vegetable.

### Model Evaluation and Selection

[Table 3](#tbl-fit) shows the performances of the automatic ARIMA method and ETS method for each vegetable.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 3. Performances of the Automatic Methods for Each Vegetable   | **Vegetable** | **Automatic Method** | **RMSE** | **MAE** | **MAPE** | **MASE** | | --- | --- | --- | --- | --- | --- | | broccoli | ARIMA | 20.54 | 15.36 | 39.68 | 1.17 | | broccoli | ETS | 27.10 | 20.28 | 58.51 | 1.55 | | cabbage | ARIMA | 17.79 | 12.21 | 60.02 | 0.60 | | cabbage | ETS | 46.90 | 27.55 | 151.15 | 1.36 | | carrot | ARIMA | 18.28 | 13.35 | 42.17 | 0.85 | | carrot | ETS | 25.76 | 18.87 | 64.46 | 1.20 | | cauliflower | ARIMA | 14.15 | 11.18 | 30.11 | 0.96 | | cauliflower | ETS | 18.22 | 13.59 | 43.84 | 1.17 | | celery | ARIMA | 25.97 | 19.10 | 53.53 | 0.68 | | celery | ETS | 50.64 | 33.97 | 101.80 | 1.21 | | chayote (bunga) | ARIMA | 6.90 | 5.13 | 51.18 | 0.63 | | chayote (bunga) | ETS | 12.55 | 9.40 | 94.76 | 1.15 | | cucumber | ARIMA | 12.88 | 10.01 | 38.53 | 0.82 | | cucumber | ETS | 13.72 | 11.12 | 45.99 | 0.91 | | gabi (galyang) | ARIMA | 6.90 | 5.27 | 20.45 | 0.57 | | gabi (galyang) | ETS | 5.51 | 4.18 | 16.21 | 0.45 | | pepper (sultan) | ARIMA | 52.69 | 40.94 | 49.36 | 0.72 | | pepper (sultan) | ETS | 87.32 | 64.47 | 93.69 | 1.14 | | pepper (taiwan) | ARIMA | 141.28 | 94.27 | 120.57 | 0.92 | | pepper (taiwan) | ETS | 12,020.02 | 1,991.87 | 1,224.72 | 19.43 | | potato | ARIMA | 20.28 | 15.06 | 31.91 | 0.79 | | potato | ETS | 21.71 | 16.29 | 36.38 | 0.85 | | wombok | ARIMA | 12.27 | 8.43 | 61.83 | 0.73 | | wombok | ETS | 46.55 | 25.69 | 236.79 | 2.23 | |

The automatic ARIMA method proved to be better than the automatic ETS method based on the time series cross-validation performance measures, except for gabi (galyang). The automatic ARIMA method showed higher accuracy on all performance measures for all vegetables except for gabi (galyang). The automatic ETS method also showed higher accuracy on all performance measures for gabi (galyang). Thus, the automatic ARIMA method was used to generate models and forecasts for all the vegetables except for gabi (galyang), for which automatic ETS method was used.

### Forecasts for Monthly Vegetable Prices.

[Table 4](#tbl-broccoli) shows the forecasts for broccoli prices for the next four months from January to April 2024. It shows the means or the point forecasts along with their corresponding 80% and 95% confidence intervals. The forecast is from a SARIMA model generated using the automatic algorithm. The model generated is shown in [Table 16](#tbl-ljb).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 4. Forecasts for Monthly Broccoli Prices   | **Date** | **Mean** | **80% Lower** | **80% Upper** | **95% Lower** | **95% Upper** | | --- | --- | --- | --- | --- | --- | | 2024 Jan | 35.97 | 21.38 | 53.46 | 16.78 | 68.14 | | 2024 Feb | 36.31 | 16.84 | 61.54 | 11.95 | 86.72 | | 2024 Mar | 39.65 | 15.05 | 73.57 | 9.89 | 111.98 | | 2024 Apr | 39.72 | 12.65 | 79.09 | 7.79 | 128.46 | |

For January 2024, the point forecast for broccoli price is 35.97. The 80% confidence interval for this forecast ranges from 21.38 to 53.46, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 16.78 to 68.14, suggesting that there is a 95% probability that the actual value will be within this broader range.

For February 2024, the point forecast for broccoli price is 36.31. The 80% confidence interval for this forecast ranges from 16.84 to 61.54, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 11.95 to 86.72, suggesting that there is a 95% probability that the actual value will be within this broader range.

For March 2024, the point forecast for broccoli price is 39.65. The 80% confidence interval for this forecast ranges from 15.05 to 73.57, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 9.89 to 111.98, suggesting that there is a 95% probability that the actual value will be within this broader range.

For April 2024, the point forecast for broccoli price is 39.72. The 80% confidence interval for this forecast ranges from 12.65 to 79.09, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 7.79 to 128.46, suggesting that there is a 95% probability that the actual value will be within this broader range.

Using the SARIMA model, the forecast is stating that the average price per head of broccoli will hover around the indicated mark and steadily rise starting from January to April of the year 2024. This therefore indicates that cost could be on a rising trend as they were approximated to be; 35.97 for January down to 39.72 in April.

On the other hand, with the increase in uncertainty, the confidence intervals enlarge. January’s 80% confidence interval is equal to 21.38 to 53. The number is 10 before the new month and 46; by the middle of the month, it rises to 12.65 to 79.09. Likewise, the 95% confidence intervals expand with the length of the horizons indicating higher degree of forecast error volatility.

[Figure 5](#fig-broccoli) shows the NVAT monthly broccoli prices with four months of forecasts using SARIMA.

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| --- |
| Figure 5. Forecasts for Monthly Broccoli Prices |

[Table 5](#tbl-cabbage) shows the forecasts for cabbage prices for the next four months from January to April 2024. It shows the means or the point forecasts along with their corresponding 80% and 95% confidence intervals. The forecast is from a SARIMA model generated using the automatic algorithm. The model generated is shown in [Table 16](#tbl-ljb).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 5. Forecasts for Monthly Cabbage Prices   | **Date** | **Mean** | **80% Lower** | **80% Upper** | **95% Lower** | **95% Upper** | | --- | --- | --- | --- | --- | --- | | 2024 Jan | 9.78 | 5.28 | 15.34 | 3.98 | 20.35 | | 2024 Feb | 12.12 | 4.98 | 21.74 | 3.37 | 32.10 | | 2024 Mar | 18.42 | 6.88 | 34.41 | 4.49 | 52.70 | | 2024 Apr | 24.98 | 9.31 | 46.71 | 6.08 | 71.59 | |

For January 2024, the point forecast for cabbage price is 9.78. The 80% confidence interval for this forecast ranges from 5.28 to 15.34, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 3.98 to 20.35, suggesting that there is a 95% probability that the actual value will be within this broader range.

For February 2024, the point forecast for cabbage price is 12.12. The 80% confidence interval for this forecast ranges from 4.98 to 21.74, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 3.37 to 32.1, suggesting that there is a 95% probability that the actual value will be within this broader range.

For March 2024, the point forecast for cabbage price is 18.42. The 80% confidence interval for this forecast ranges from 6.88 to 34.41, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 4.49 to 52.7, suggesting that there is a 95% probability that the actual value will be within this broader range.

For April 2024, the point forecast for cabbage price is 24.98. The 80% confidence interval for this forecast ranges from 9.31 to 46.71, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 6.08 to 71.59, suggesting that there is a 95% probability that the actual value will be within this broader range.

From January to April of 2024, a SARIMA model predicts that the price of cabbage will generally be rising. The average price is expected to increase from 9.78 in January to 24.98 in April, according to the point forecasts. Nonetheless, there is a lot of ambiguity surrounding these estimates. Especially in the later months, the confidence intervals are wide, suggesting a greater degree of unpredictability. For instance, even though there is an 80% likelihood that the price would drop between 5.28 and 15.34 in January, the range of possible price volatility increases to 9.31 to 46.71 in April.

[Figure 6](#fig-cabbage) shows the NVAT monthly cabbage prices with four months of forecasts using SARIMA.

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| --- |
| Figure 6. Forecast for Monthly Cabbage Prices |

[Table 6](#tbl-carrot) shows the forecasts for carrot prices for the next four months from January to April 2024. It shows the means or the point forecasts along with their corresponding 80% and 95% confidence intervals. The forecast is from a SARIMA model generated using the automatic algorithm. The model generated is shown in [Table 16](#tbl-ljb).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 6. Forecast for Monthly Carrot Prices   | **Date** | **Mean** | **80% Lower** | **80% Upper** | **95% Lower** | **95% Upper** | | --- | --- | --- | --- | --- | --- | | 2024 Jan | 25.32 | 15.43 | 37.07 | 12.24 | 46.75 | | 2024 Feb | 29.36 | 13.53 | 49.92 | 9.58 | 70.51 | | 2024 Mar | 32.56 | 14.22 | 56.77 | 9.86 | 81.90 | | 2024 Apr | 32.68 | 14.05 | 57.38 | 9.68 | 83.27 | |

For January 2024, the point forecast for carrot price is 25.32. The 80% confidence interval for this forecast ranges from 15.43 to 37.07, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 12.24 to 46.75, suggesting that there is a 95% probability that the actual value will be within this broader range.

For February 2024, the point forecast for carrot price is 29.36. The 80% confidence interval for this forecast ranges from 13.53 to 49.92, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 9.58 to 70.51, suggesting that there is a 95% probability that the actual value will be within this broader range.

For March 2024, the point forecast for carrot price is 32.56. The 80% confidence interval for this forecast ranges from 14.22 to 56.77, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 9.86 to 81.9, suggesting that there is a 95% probability that the actual value will be within this broader range.

For April 2024, the point forecast for carrot price is 32.68. The 80% confidence interval for this forecast ranges from 14.05 to 57.38, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 9.68 to 83.27, suggesting that there is a 95% probability that the actual value will be within this broader range.

Based on a SARIMA model, carrot prices are expected to remain relatively stable from January to April 2024, with a minor gain in January through March and a slight decrease in April. However, the model suggests that these forecasts are highly uncertain. The huge confidence intervals indicate the prospect of large price movements, especially at the 95% chance level. Although there is an 80% chance that the price in January will fall between 15.43 and 37.07, the range for April expands to 9.68 to 83.27, implying a far wider range of possible values.

[Figure 7](#fig-carrot) shows the NVAT monthly carrot prices with four months of forecasts using SARIMA.

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| --- |
| Figure 7. Forecast for Monthly Carrot Prices |

[Table 7](#tbl-cauliflower) shows the forecasts for cauliflower prices for the next four months from January to April 2024. It shows the means or the point forecasts along with their corresponding 80% and 95% confidence intervals. The forecast is from a SARIMA model generated using the automatic algorithm. The model generated is shown in [Table 16](#tbl-ljb).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 7. Forecasts for Monthly Cauliflower Prices   | **Date** | **Mean** | **80% Lower** | **80% Upper** | **95% Lower** | **95% Upper** | | --- | --- | --- | --- | --- | --- | | 2024 Jan | 25.46 | 16.00 | 36.60 | 12.85 | 45.57 | | 2024 Feb | 29.26 | 17.90 | 42.77 | 14.21 | 53.85 | | 2024 Mar | 26.39 | 16.14 | 38.56 | 12.82 | 48.56 | | 2024 Apr | 31.03 | 18.98 | 45.35 | 15.07 | 57.11 | |

For January 2024, the point forecast for cauliflower price is 25.46. The 80% confidence interval for this forecast ranges from 16 to 36.6, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 12.85 to 45.57, suggesting that there is a 95% probability that the actual value will be within this broader range.

For February 2024, the point forecast for cauliflower price is 29.26. The 80% confidence interval for this forecast ranges from 17.9 to 42.77, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 14.21 to 53.85, suggesting that there is a 95% probability that the actual value will be within this broader range.

For March 2024, the point forecast for cauliflower price is 26.39. The 80% confidence interval for this forecast ranges from 16.14 to 38.56, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 12.82 to 48.56, suggesting that there is a 95% probability that the actual value will be within this broader range.

For April 2024, the point forecast for cauliflower price is 31.03. The 80% confidence interval for this forecast ranges from 18.98 to 45.35, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 15.07 to 57.11, suggesting that there is a 95% probability that the actual value will be within this broader range.

Based on a SARIMA model, cauliflower prices are expected to rise steadily from January to April 2024, with occasional swings. The point estimates show that prices would rise from January to February, then fall somewhat in March before rising again in April. However, the confidence intervals are relatively broad, indicating that these forecasts are highly questionable. While there is an 80% likelihood that the January price would fall between 16 and 36.6, this range widens to 15.07 to 57.11 in April, indicating a greater potential price range.

[Figure 8](#fig-cauliflower) shows the NVAT monthly cauliflower prices with four months of forecasts using SARIMA.

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| Figure 8. Forecast for Monthly Cauliflower Prices |

[Table 8](#tbl-celery) shows the forecasts for celery prices for the next four months from January to April 2024. It shows the means or the point forecasts along with their corresponding 80% and 95% confidence intervals. The forecast is from an ARIMA model generated using the automatic algorithm. The model generated is shown in [Table 16](#tbl-ljb).

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| Table 8. Forecasts for Monthly Celery Prices   | **Date** | **Mean** | **80% Lower** | **80% Upper** | **95% Lower** | **95% Upper** | | --- | --- | --- | --- | --- | --- | | 2024 Jan | 37.96 | 19.12 | 61.76 | 14.02 | 84.24 | | 2024 Feb | 40.61 | 15.72 | 74.72 | 10.40 | 112.88 | | 2024 Mar | 41.14 | 15.16 | 77.26 | 9.85 | 118.90 | | 2024 Apr | 41.23 | 15.05 | 77.77 | 9.74 | 120.13 | |

For January 2024, the point forecast for celery price is 37.96. The 80% confidence interval for this forecast ranges from 19.12 to 61.76, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 14.02 to 84.24, suggesting that there is a 95% probability that the actual value will be within this broader range.

For February 2024, the point forecast for celery price is 40.61. The 80% confidence interval for this forecast ranges from 15.72 to 74.72, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 10.4 to 112.88, suggesting that there is a 95% probability that the actual value will be within this broader range.

For March 2024, the point forecast for celery price is 41.14. The 80% confidence interval for this forecast ranges from 15.16 to 77.26, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 9.85 to 118.9, suggesting that there is a 95% probability that the actual value will be within this broader range.

For April 2024, the point forecast for celery price is 41.23. The 80% confidence interval for this forecast ranges from 15.05 to 77.77, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 9.74 to 120.13, suggesting that there is a 95% probability that the actual value will be within this broader range.

According to the ARIMA model, the price for celery from January to April 2024 is very flat with a slight up trend. According to the point forecasts, the price will go up from January to April, with an average price of around 40. However, the model does show a lot of uncertainty in these forecasts. There is a high possibility of large price volatility as shown by the huge confidence intervals especially at the 95% level. Although there is 80% chance the price in Jan will be between 19.12 and 61.76, the range for Apr is 9.74 to 120.13 which means a wide range of possible prices.

[Figure 9](#fig-celery) shows the NVAT monthly celery prices with four months of forecasts using ARIMA.

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| Figure 9. Forecast for Monthly Celery Prices |

[Table 9](#tbl-chayote_bunga) shows the forecasts for chayote (bunga) prices for the next four months from January to April 2024. It shows the means or the point forecasts along with their corresponding 80% and 95% confidence intervals. The forecast is from an ARIMA model generated using the automatic algorithm. The model generated is shown in [Table 16](#tbl-ljb).

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| Table 9. Forecasts for Monthly Chayote (Bunga) Prices   | **Date** | **Mean** | **80% Lower** | **80% Upper** | **95% Lower** | **95% Upper** | | --- | --- | --- | --- | --- | --- | | 2024 Jan | 12.89 | 6.52 | 20.91 | 4.79 | 28.47 | | 2024 Feb | 12.92 | 5.88 | 22.11 | 4.14 | 31.40 | | 2024 Mar | 12.85 | 5.68 | 22.30 | 3.95 | 32.03 | | 2024 Apr | 12.79 | 5.60 | 22.28 | 3.89 | 32.11 | |

For January 2024, the point forecast for chayote (bunga) price is 12.89. The 80% confidence interval for this forecast ranges from 6.52 to 20.91, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 4.79 to 28.47, suggesting that there is a 95% probability that the actual value will be within this broader range.

For February 2024, the point forecast for chayote (bunga) price is 12.92. The 80% confidence interval for this forecast ranges from 5.88 to 22.11, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 4.14 to 31.4, suggesting that there is a 95% probability that the actual value will be within this broader range.

For March 2024, the point forecast for chayote (bunga) price is 12.85. The 80% confidence interval for this forecast ranges from 5.68 to 22.3, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 3.95 to 32.03, suggesting that there is a 95% probability that the actual value will be within this broader range.

For April 2024, the point forecast for chayote (bunga) price is 12.79. The 80% confidence interval for this forecast ranges from 5.6 to 22.28, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 3.89 to 32.11, suggesting that there is a 95% probability that the actual value will be within this broader range.

The price estimate for chayote (bunga) from January to April 2024 is very stable with small movements. For the whole 4 months, the point forecast is around 12.80. However, the model shows a lot of uncertainty in these forecasts. The big confidence intervals show big price fluctuations possible, especially at 95% level. Although there is 80% chance that the price in January will be between 6.52 to 20.91, the range for April is 3.89 to 32.11 which means bigger range.

[Figure 10](#fig-chayote_bunga) shows the NVAT monthly chayote (bunga) prices with four months of forecasts using ARIMA.

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| Figure 10. Forecast for Monthly Chayote (Bunga) Prices |

[Table 10](#tbl-cucumber) shows the forecasts for cucumber prices for the next four months from January to April 2024. It shows the means or the point forecasts along with their corresponding 80% and 95% confidence intervals. The forecast is from an ARIMA model generated using the automatic algorithm. The model generated is shown in [Table 16](#tbl-ljb).

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| Table 10. Forecasts for Monthly Cucumber Prices   | **Date** | **Mean** | **80% Lower** | **80% Upper** | **95% Lower** | **95% Upper** | | --- | --- | --- | --- | --- | --- | | 2024 Jan | 30.79 | 16.56 | 48.40 | 12.47 | 64.29 | | 2024 Feb | 32.47 | 16.36 | 52.82 | 12.00 | 72.03 | | 2024 Mar | 32.98 | 16.60 | 53.66 | 12.17 | 73.21 | | 2024 Apr | 33.01 | 16.54 | 53.86 | 12.10 | 73.61 | |

For January 2024, the point forecast for cucumber price is 30.79. The 80% confidence interval for this forecast ranges from 16.56 to 48.4, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 12.47 to 64.29, suggesting that there is a 95% probability that the actual value will be within this broader range.

For February 2024, the point forecast for cucumber price is 32.47. The 80% confidence interval for this forecast ranges from 16.36 to 52.82, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 12 to 72.03, suggesting that there is a 95% probability that the actual value will be within this broader range.

For March 2024, the point forecast for cucumber price is 32.98. The 80% confidence interval for this forecast ranges from 16.6 to 53.66, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 12.17 to 73.21, suggesting that there is a 95% probability that the actual value will be within this broader range.

For April 2024, the point forecast for cucumber price is 33.01. The 80% confidence interval for this forecast ranges from 16.54 to 53.86, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 12.1 to 73.61, suggesting that there is a 95% probability that the actual value will be within this broader range.

The forecast for cucumber prices from January to April 2024 is steady with a slight up trend. The point forecasts show a gradual increase from January to April with the average price around 32. However, the model shows high degree of uncertainty in these forecasts. The wide confidence intervals especially for 95% probability level shows that the prices can fluctuate greatly. While there’s 80% chance the Jan price will be between 16.56 and 48.4, this range expands to 12.1 to 73.61 for April which means a very wide price range.

[Figure 11](#fig-cucumber) shows the NVAT monthly cucumber prices with four months of forecasts using ARIMA.

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| Figure 11. Forecasts for Monthly cucumber Prices |

[Table 11](#tbl-gabi_galyang) shows the forecasts for gabi (galyang) prices for the next four months from January to April 2024. It shows the means or the point forecasts along with their corresponding 80% and 95% confidence intervals. The forecast is from an ETS model generated using the automatic algorithm. The model generated is shown in [Table 16](#tbl-ljb).

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| Table 11. Forecasts for Monthly Gabi (Galyang) Prices   | **Date** | **Mean** | **80% Lower** | **80% Upper** | **95% Lower** | **95% Upper** | | --- | --- | --- | --- | --- | --- | | 2024 Jan | 42.88 | 35.80 | 50.46 | 32.69 | 55.26 | | 2024 Feb | 43.26 | 33.34 | 54.18 | 29.32 | 61.61 | | 2024 Mar | 43.64 | 31.57 | 57.22 | 26.97 | 66.97 | | 2024 Apr | 44.02 | 30.15 | 59.91 | 25.14 | 71.85 | |

For January 2024, the point forecast for gabi (galyang) price is 42.88. The 80% confidence interval for this forecast ranges from 35.8 to 50.46, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 32.69 to 55.26, suggesting that there is a 95% probability that the actual value will be within this broader range.

For February 2024, the point forecast for gabi (galyang) price is 43.26. The 80% confidence interval for this forecast ranges from 33.34 to 54.18, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 29.32 to 61.61, suggesting that there is a 95% probability that the actual value will be within this broader range.

For March 2024, the point forecast for gabi (galyang) price is 43.64. The 80% confidence interval for this forecast ranges from 31.57 to 57.22, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 26.97 to 66.97, suggesting that there is a 95% probability that the actual value will be within this broader range.

For April 2024, the point forecast for gabi (galyang) price is 44.02. The 80% confidence interval for this forecast ranges from 30.15 to 59.91, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 25.14 to 71.85, suggesting that there is a 95% probability that the actual value will be within this broader range.

The forecast for gabi (galyang) prices from January to April 2024 based on ETS model shows an upward trend. The point forecast is increasing from 42.88 in January to 44.02 in April. However, the model also shows high uncertainty in the forecast. The wide confidence intervals especially for 95% probability level means big price fluctuations are possible. While there’s 80% chance that January price will be between 35.8 to 50.46, this range widens to 25.14 to 71.85 for April which means more price range is possible.

[Figure 12](#fig-gabi_galyang) shows the NVAT monthly gabi (galyang) prices with four months of forecasts using ETS.

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| Figure 12. Forecasts for Monthly Gabi (Galyang) Prices |

[Table 12](#tbl-pepper_sultan) shows the forecasts for pepper (sultan) prices for the next four months from January to April 2024. It shows the means or the point forecasts along with their corresponding 80% and 95% confidence intervals. The forecast is from an ARIMA model generated using the automatic algorithm. The model generated is shown in [Table 16](#tbl-ljb).

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| Table 12. Forecasts for Monthly Pepper (Sultan) Prices   | **Date** | **Mean** | **80% Lower** | **80% Upper** | **95% Lower** | **95% Upper** | | --- | --- | --- | --- | --- | --- | | 2024 Jan | 38.60 | 21.65 | 59.30 | 16.58 | 77.42 | | 2024 Feb | 50.09 | 24.68 | 82.42 | 17.94 | 113.40 | | 2024 Mar | 77.71 | 35.63 | 132.44 | 25.17 | 187.46 | | 2024 Apr | 112.63 | 51.26 | 192.65 | 36.11 | 273.50 | |

For January 2024, the point forecast for pepper (sultan) price is 38.6. The 80% confidence interval for this forecast ranges from 21.65 to 59.3, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 16.58 to 77.42, suggesting that there is a 95% probability that the actual value will be within this broader range.

For February 2024, the point forecast for pepper (sultan) price is 50.09. The 80% confidence interval for this forecast ranges from 24.68 to 82.42, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 17.94 to 113.4, suggesting that there is a 95% probability that the actual value will be within this broader range.

For March 2024, the point forecast for pepper (sultan) price is 77.71. The 80% confidence interval for this forecast ranges from 35.63 to 132.44, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 25.17 to 187.46, suggesting that there is a 95% probability that the actual value will be within this broader range.

For April 2024, the point forecast for pepper (sultan) price is 112.63. The 80% confidence interval for this forecast ranges from 51.26 to 192.65, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 36.11 to 273.5, suggesting that there is a 95% probability that the actual value will be within this broader range.

The pepper prices forecast (sultan) for the month of January to April 2024, according to an ARIMA model, indicated that there will be a steep upward trend. Point forecasts imply that from January’s 38.6, price will sharply rise to 112.63 by April. The confidence intervals widen consistently and especially much more for the 95% level emphasizing this movement upwards. While in January there is an 80% chance these prices would move between 21.65 and 59.3 per kg, by April such a range can go as high as between 36.11 and 273.5, meaning there are many possible prices over four months period.

[Figure 13](#fig-pepper_sultan) shows the NVAT monthly pepper (sultan) prices with four months of forecasts using ARIMA.

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| Figure 13. Forecasts for Monthly Pepper (Sultan) Prices |

[Table 13](#tbl-pepper_taiwan) shows the forecasts for pepper (taiwan) prices for the next four months from January to April 2024. It shows the means or the point forecasts along with their corresponding 80% and 95% confidence intervals. The forecast is from an ARIMA model generated using the automatic algorithm. The model generated is shown in [Table 16](#tbl-ljb).

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| Table 13. Forecasts for Monthly Pepper (Taiwan) Prices   | **Date** | **Mean** | **80% Lower** | **80% Upper** | **95% Lower** | **95% Upper** | | --- | --- | --- | --- | --- | --- | | 2024 Jan | 80.18 | 36.15 | 137.75 | 25.37 | 196.28 | | 2024 Feb | 60.52 | 19.90 | 119.04 | 12.39 | 191.12 | | 2024 Mar | 48.45 | 14.02 | 100.00 | 8.34 | 168.20 | | 2024 Apr | 56.06 | 15.91 | 116.56 | 9.39 | 197.44 | |

For January 2024, the point forecast for pepper (taiwan) price is 80.18. The 80% confidence interval for this forecast ranges from 36.15 to 137.75, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 25.37 to 196.28, suggesting that there is a 95% probability that the actual value will be within this broader range.

For February 2024, the point forecast for pepper (taiwan) price is 60.52. The 80% confidence interval for this forecast ranges from 19.9 to 119.04, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 12.39 to 191.12, suggesting that there is a 95% probability that the actual value will be within this broader range.

For March 2024, the point forecast for pepper (taiwan) price is 48.45. The 80% confidence interval for this forecast ranges from 14.02 to 100, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 8.34 to 168.2, suggesting that there is a 95% probability that the actual value will be within this broader range.

For April 2024, the point forecast for pepper (taiwan) price is 56.06. The 80% confidence interval for this forecast ranges from 15.91 to 116.56, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 9.39 to 197.44, suggesting that there is a 95% probability that the actual value will be within this broader range.

In January through to April 2024, the ARIMA model indicates that pepper (Taiwan) prices will be uncertain and highly dynamic. The path predicted by the mean forecasts presents a general declining tendency with January having a spike then followed by a downward slope till April. But the large confidence intervals, particularly at the 95% level of probability demonstrate high levels of uncertainty in these predictions. This range bulges to 9.39-197.44 in April from 36.15-137.75 in January implying a wider possible range of price outcomes.

[Figure 14](#fig-pepper_taiwan) shows the NVAT monthly pepper (taiwan) prices with four months of forecasts using ARIMA.

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| Figure 14. Forecasts for Monthly Pepper (Taiwan) Prices |

[Table 14](#tbl-potato) shows the forecasts for potato prices for the next four months from January to April 2024. It shows the means or the point forecasts along with their corresponding 80% and 95% confidence intervals. The forecast is from an ARIMA model generated using the automatic algorithm. The model generated is shown in [Table 16](#tbl-ljb).

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| Table 14. Forecasts for Monthly Potato Prices   | **Date** | **Mean** | **80% Lower** | **80% Upper** | **95% Lower** | **95% Upper** | | --- | --- | --- | --- | --- | --- | | 2024 Jan | 73.85 | 55.76 | 93.89 | 48.57 | 107.77 | | 2024 Feb | 69.59 | 45.74 | 97.26 | 37.46 | 118.75 | | 2024 Mar | 71.35 | 43.13 | 105.00 | 34.08 | 132.89 | | 2024 Apr | 78.11 | 45.36 | 117.66 | 35.24 | 151.43 | |

For January 2024, the point forecast for potato price is 73.85. The 80% confidence interval for this forecast ranges from 55.76 to 93.89, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 48.57 to 107.77, suggesting that there is a 95% probability that the actual value will be within this broader range.

For February 2024, the point forecast for potato price is 69.59. The 80% confidence interval for this forecast ranges from 45.74 to 97.26, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 37.46 to 118.75, suggesting that there is a 95% probability that the actual value will be within this broader range.

For March 2024, the point forecast for potato price is 71.35. The 80% confidence interval for this forecast ranges from 43.13 to 105, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 34.08 to 132.89, suggesting that there is a 95% probability that the actual value will be within this broader range.

For April 2024, the point forecast for potato price is 78.11. The 80% confidence interval for this forecast ranges from 45.36 to 117.66, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 35.24 to 151.43, suggesting that there is a 95% probability that the actual value will be within this broader range.

The forecast for potato prices from January to April 2024 based on ARIMA model, suggests a relatively stable price level with some fluctuations. The point forecasts indicate a slight decrease from January to February. This is followed by a minor increase in March. Then a more pronounced increase in April. However, the model highlights a significant degree of uncertainty in these predictions. The wide confidence intervals, especially for the 95% probability level emphasize the potential for substantial price variations. While there’s an 80% chance the January price will fall between 55.76 and 93.89, this range expands to 35.24 to 151.43 for April. This indicates a broader potential price range.

[Figure 15](#fig-potato) shows the NVAT monthly potato prices with four months of forecasts using ARIMA.

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| Figure 15. Forecasts for Monthly Potato Prices |

[Table 15](#tbl-wombok) shows the forecasts for wombok prices for the next four months from January to April 2024. It shows the means or the point forecasts along with their corresponding 80% and 95% confidence intervals. The forecast is from an ARIMA model generated using the automatic algorithm. The model generated is shown in [Table 16](#tbl-ljb).

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| Table 15. Forecasts for Monthly Wombok Prices   | **Date** | **Mean** | **80% Lower** | **80% Upper** | **95% Lower** | **95% Upper** | | --- | --- | --- | --- | --- | --- | | 2024 Jan | 10.60 | 5.26 | 17.38 | 3.84 | 23.84 | | 2024 Feb | 15.06 | 5.64 | 28.09 | 3.69 | 42.97 | | 2024 Mar | 15.30 | 5.51 | 29.01 | 3.55 | 45.03 | | 2024 Apr | 15.30 | 5.51 | 29.01 | 3.55 | 45.03 | |

For January 2024, the point forecast for wombok price is 10.6. The 80% confidence interval for this forecast ranges from 5.26 to 17.38, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 3.84 to 23.84, suggesting that there is a 95% probability that the actual value will be within this broader range.

For February 2024, the point forecast for wombok price is 15.06. The 80% confidence interval for this forecast ranges from 5.64 to 28.09, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 3.69 to 42.97, suggesting that there is a 95% probability that the actual value will be within this broader range.

For March 2024, the point forecast for wombok price is 15.3. The 80% confidence interval for this forecast ranges from 5.51 to 29.01, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 3.55 to 45.03, suggesting that there is a 95% probability that the actual value will be within this broader range.

For April 2024, the point forecast for wombok price is 15.3. The 80% confidence interval for this forecast ranges from 5.51 to 29.01, indicating that there is an 80% probability that the actual value will fall within this range. Additionally, the 95% confidence interval extends from 3.55 to 45.03, suggesting that there is a 95% probability that the actual value will be within this broader range.

The forecast for wombok prices from January to April 2024 based on provided data suggests general upward trend. Point forecasts indicate price increase from 10.6 in January to 15.3 in March. In April same price is expected. However, model also highlights significant degree of uncertainty in these predictions.

Wide confidence intervals emphasize potential for substantial price fluctuations especially for 95% probability level. There’s 80% chance January price will fall between 5.26 and 17.38. This range expands to 3.55 to 45.03 for March and April indicating broader potential price range.

[Figure 16](#fig-wombok) shows the NVAT monthly wombok prices with four months of forecasts using ARIMA.

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| Figure 16. Forecasts for Monthly Wombok Prices |

[Table 16](#tbl-ljb) shows the results of the portmanteau test for the models.

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| Table 16. Result of the Portmanteau Test of Residuals for the Models   | **Vegetable** | **Model** | **Q-statistics** | **P-value** | | --- | --- | --- | --- | | broccoli | ARIMA(0,1,0)(1,0,0)[12] | 13.27 | .151 | | cabbage | ARIMA(3,0,0)(1,0,0)[12] w/ mean | 4.16 | .900 | | carrot | ARIMA(1,1,2)(0,0,1)[12] | 7.79 | .556 | | cauliflower | ARIMA(0,0,1)(2,1,0)[12] w/ drift | 11.32 | .417 | | celery | ARIMA(1,0,1) w/ mean | 6.84 | .740 | | chayote (bunga) | ARIMA(1,0,0) w/ mean | 11.76 | .382 | | cucumber | ARIMA(0,1,3) | 10.75 | .293 | | gabi (galyang) | ETS(A,N,N) | 28.56 | .003 | | pepper (sultan) | ARIMA(2,0,2) w/ mean | 6.66 | .574 | | pepper (taiwan) | ARIMA(2,0,1)(1,0,0)[12] w/ mean | 11.08 | .271 | | potato | ARIMA(2,1,2) | 6.01 | .646 | | wombok | ARIMA(0,0,2) w/ mean | 9.66 | .471 | |

Results show that all the ARIMA models have a large p-value but the ETS model for gabi (galyang) has a p-value less than .05. This shows that the residuals of all the ARIMA models are independently distributed. This indicates that there is no significant autocorrelation in the residuals up to 12 lags. The ARIMA models are a good fit to the data. They can be used in forecasting their corresponding monthly vegetable prices. On the other hand, the ETS model failed the portmanteau test since there is still significant autocorrelation in the residuals up to 12 lags. The model can still be used for forecasting monthly gabi (galyang) prices, but the prediction or confidence intervals may not be accurate due to the correlated residuals.

# Chapter V

## SUMMARY, CONCLUSION AND RECOMMENDATIONS

### Summary

The price trends of 12 vegetables from 2018 to 2024 exhibited significant fluctuations over the period. Among the vegetables, pepper (taiwan) has demonstrated the most volatile price behavior, with frequent and substantial price swings. Conversely, potato has shown relatively stable prices throughout the period. Other vegetables, such as broccoli, cabbage, and carrot, have experienced moderate price fluctuations.

Additionally, chayote (bunga) and gabi (galyang) have exhibited relatively stable price trends, with minimal fluctuations. Celery, cucumber, and wombok have shown moderate price variations, with occasional spikes or dips. Pepper (sultan) has experienced significant price fluctuations, with both upward and downward trends. Finally, cauliflower has demonstrated moderate price volatility, with occasional peaks and troughs.

The vegetable with the strongest trend is gabi (galyang). Meanwhile, the vegetable that has the weakest trend is wombok. The vegetable with the strongest seasonality is cauliflower. Meanwhile, the vegetable with the weakest seasonality is cabbage.

The automatic ARIMA method outperformed the automatic ETS method in time series cross-validation performance measures for all vegetables except gabi (galyang). The automatic ARIMA method showed higher accuracy in all performance measures for all vegetables except gabi (galyang). Thus, the automatic ARIMA method was used to generate models and forecasts for all the vegetables except for gabi (galyang), for which automatic ETS method was used.

SARIMA model forecasts for vegetable prices from January to April 2024 indicate different trends and considerable uncertainty. Broccoli and celery prices will rise steadily; cauliflower and cucumber prices will rise, but at a slower rate. Carrot prices will remain relatively stable with small fluctuations. Chayote and gabi prices will be relatively stable with slight increases. Both pepper (sultan) and pepper (Taiwan) prices are forecast to be volatile; pepper (sultan) will have a strong upturn, while pepper (Taiwan) will turn down. Potato and wombok prices will oscillate with a relatively stable increase. Meanwhile, gabi (galyang) for ETS model, the price will rise steadily. Most notably, the volatility is high in all forecasts. High volatility is also indicated by the wide confidence interval, which indicates the potential for large price movements.

The Portmanteau test of residuals for ARIMA models revealed that all models have a large p-value, but the ETS model for gabi (galyang) has a p-value less than.05. This indicates that the residuals are independently distributed, with no significant autocorrelation up to 12 lags. The ARIMA models are a good fit for forecasting monthly vegetable prices, while the ETS model failed the test due to significant autocorrelation up to 12 lags. Despite this, the model can still be used for gabi (galyang) price forecasting, but the prediction or confidence intervals may not be accurate due to correlated residuals.

### Conclusion

The results show that gabi (galyang) has the strongest trend, while wombok has the weakest trend, cauliflower shows the strongest seasonality, while cabbage shows the weakest seasonality. Farmers should focus on producing vegetables with strong trends, like gabi (galyang), to benefit on increasing demand. Farmers can also plan their production and marketing strategies according to the trend and seasonality of specific vegetable vegetables. Consumers, and can make good decisions about when to buy vegetables. For example, consumers may expect better availability and lower prices for cauliflower in August, while the highest and lowest prices for cabbage are found in March and September, however. All things considered, farmers can improve their production and sales and increase their earnings by knowing the trends and seasonality of vegetables. This knowledge can also help customers make wiser desicions in buying.

The result shows that Broccoli and celery prices will rise steadily; cauliflower and cucumber prices will rise, but at a slower rate. Carrot prices will remain relatively stable with small fluctuations. Chayote and gabi for ETS model prices will be relatively stable with slight increases. Both pepper (sultan) and pepper (Taiwan) prices are forecast to be volatile; pepper (sultan) will have a strong upturn, while pepper (Taiwan) will turn down. Potato and wombok prices will oscillate with a relatively stable increase. Farmers should focus on vegetables that will be steadily increases like Broccoli, Celery, pepper (taiwan and sultan), but they should also be mindful that the confidence interval as month goes by, the price range increases, indicating that a higher chance of forecast error. Consumers should focus on vegetables that vegetables that will be stable with small fluctuations and slight increases like cauliflower, cucumber, carrots, chayote, and gabi but should also be knowledgeable about the forecast error since the price range as months goes by, the forecast error increases.

The ARIMA model proves to be better in all 12 lags in forecasting vegetable prices except for Gabi (galyang) indicating that ARIMA model is better fit model for forecasting monthly vegetable prices.

### Recommendations

# References

Aishi, N., Krishna, D., & Chandra, D. G. (2023). Global status of agricultural waste-based industries, challenges, and future prospects. In N. Remya, G. Bin, & W. J. Alberto (Eds.), *Agricultural waste to value-added products: Technical, economic and sustainable aspects* (pp. 21–45). Springer Nature Singapore. <https://doi.org/10.1007/978-981-99-4472-9_2>

Capiral, C. V. C., Lotrinia, R. J. T., Mabborang, R. C., & Macasieb, J. R. (2023). Cracking the code of crop growth: Illuminating the future of Philippines’ onion production for a resilient Filipino diet with the ARMA forecasting model. *European Journal of Computer Science and Information Technology*, *11*(3), 1–13.

Chen, J., Zhou, H., Hu, H., Song, Y., Gifu, D., Li, Y., & Huang, Y. (2018). Research on agricultural monitoring system based on convolutional neural network. *Future Generation Computer Systems*, *88*, 271–278. <https://doi.org/10.1016/j.future.2018.05.045>

Cleveland, R. B., Cleveland, W. S., McRae, J. E., & Terpenning, I. (1990). STL: A seasonal-trend decomposition procedure based on LOESS. *Journal of Official Statistics*, *6*(1), 3–33. <http://bit.ly/stl1990>

Desalegn, W. (2021). Value chain analysis of vegetables (onion, tomato, potato) in Ethiopia: A review. *International Journal of Agricultural Science and Food Technology*, 108–113. <https://doi.org/10.17352/2455-815X.000096>

Domingo, S. N., Umlas, A. J. L., & Zuluaga, K. M. C. (2020). *Development of crop climate calendars for high-value crops in Atok, Benguet: Report from preliminary co-learning and co-development engagements with agricultural stakeholders in Benguet province*. PIDS Discussion Paper Series.

*FAOSTAT*. (n.d.). Retrieved November 16, 2023, from <https://www.fao.org/faostat/en/#home>

Gan, H., & Liao, L. (2020). Study on vegetable price fluctuation and its impact in Guangxi. *Scholarly Journal*, *9*(3), 148–155.

Guerrero, H., & Garcia-Vigonte, F. (2022). Seaweed farmers in the Philippines responsiveness to the price changes in relation to supply and demand. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.4113035>

Hyndman, R. J., & Athanasopoulos, G. (2021). *Forecasting: Principles and practice* (3rd ed.). OTexts. [OTexts.com/fpp3](https://OTexts.com/fpp3)

Illankoon, I. M. G. L., & Kumara, B. T. G. S. (2020). Analyzing the influence of various factors for vegetable price using data mining. *Proceedings of the International Research Conference 2020 KDUAt: Sri Lanka*, 402–409.

Janssen, B. H. (1993). Integrated nutrient management: The use of organic and mineral fertilizers. In *The role of plant nutrients for sustainable food crop production in Sub-Saharan Africa* (pp. 89–105). Ver. Kunstmest Producenten.

Kakulapati, V., & Shaik, S. (2022). Vegetable price prediction against temperature changes using machine learning techniques. *Dickensian Journal*, *22*, 1547–1554.

Mchopa, A., Ruoja, C., & Huka, H. (2014). Price fluctuation of agricultural products and its impact on small scale farmers development: Case analysis from Kilimanjaro Tanzania. *European Journal of Business and Management*, *6*(36), 155–160. <https://catalog.ihsn.org/citations/91017?fbclid=IwAR06pCHPm9d6ko-uxXndkeBPGmpGgp7plCg0BQwlXNBHWh8OdHbY4B23soc>

O’Hara-Wild, M., Hyndman, R., & Wang, E. (2023). *Fable: Forecasting models for tidy time series*. <https://CRAN.R-project.org/package=fable>

R Core Team. (2023). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. <https://www.R-project.org/>

Subhasree, M., & Priya, C. A. (2016). Forecasting vegetable price using time series data. *International Journal of Advanced Research*, *3*, 535–641.

Sun, F., Meng, X., Zhang, Y., Wang, Y., Jiang, H., & Liu, P. (2023). Agricultural product price forecasting methods: A review. *Agriculture*, *13*(9), 1671. <https://doi.org/10.3390/agriculture13091671>

Tulin, A., Dorahy, C., Eldridge, S., Mercado, A., Salvani, J., Lapoot, C., Justo, V., Duna, L., Gonzaga, N., Quinones, C. M., Rallos, R., Rañises, M., Bicamon, R., & Galambao, M. (2019). *Enhancing profitability of selected vegetable value chains in the southern Philippines and Australia component 1 – integrated soil and crop nutrient management*. Australian Centre for International Agricultural Research.

Vibas, V. M., & Raqueño, A. R. (2019). A mathematical model for estimating retail price movements of basic fruit and vegetable commodities using time series analysis. *International Journal of Advance Study and Research Work*. <https://doi.org/10.5281/ZENODO.3333529>

Wang, E., Cook, D., & Hyndman, R. J. (2020). A new tidy data structure to support exploration and modeling of temporal data. *Journal of Computational and Graphical Statistics*, *29*(3), 466–478. <https://doi.org/10.1080/10618600.2019.1695624>

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T. L., Miller, E., Bache, S. M., Müller, K., Ooms, J., Robinson, D., Seidel, D. P., Spinu, V., … Yutani, H. (2019). Welcome to the tidyverse. *Journal of Open Source Software*, *4*(43), 1686. <https://doi.org/10.21105/joss.01686>

Yang, H., Cao, Y., Shi, Y., Wu, Y., Guo, W., Fu, H., & Li, Y. (2022). The dynamic impacts of weather changes on vegetable price fluctuations in Shandong Province, China: An analysis based on VAR and TV-VAR models. *Agronomy*, *12*(11), 2680. <https://doi.org/10.3390/agronomy12112680>

Yiyang, Q., Kang, M., & Ahn, B. (2023). Analysis of factors affecting vegetable price fluctuation: A case study of South Korea. *Agriculture*, 577. https://doi.org/<https://doi.org/10.3390/agriculture13030577>

Zhang, X., & Liu, Y. (2020). The dynamic impact of international agricultural commodity price fluctuation on Chinese agricultural commodity prices. *International Food and Agribusiness Management Review*, *23*. <https://doi.org/10.22434/IFAMR2019.0172>