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# Price dispersion and domestic banana market response in the Philippines

Rosario Silbano Lodovice [a], Yoonsuk Lee [b,*]

[a] Philippine Statistics Authority, Statistical Specialist II, Philippines
[b] Department of Agricultural and Resources Economics, Kangwon National University, Philippines

**Abstract**

This study investigated the vertical price transmission of banana in the domestic market of the Philippines. Banana, as one of the governments' priority crops under the Department of Agriculture's 'High-value Crops Development Program', has given priority to sustainability and global competitiveness. However, the domestic banana market consists of several marketing channels. Such complex characteristics of marketing channels can negatively affect market efficiency. In addition to such issues within a banana market, there are other issues that arise outside the market that can also affect market efficiency. This study considered both internal and external factors affecting market efficiency and analysed the price transmission of upstream and downstream banana markets in the Philippines. The nonlinear autoregressive distributed lag (NARDL) model is used to estimate asymmetric relationships among vertical banana markets. Following the NARDL model, the Granger causality test is applied to determine the direction between market prices. Results showed that the price dispersion and response depend on varieties of banana such as Lakatan and Saba, and market levels from farmgate, wholesale and retail. Lakatan banana is less inefficient than Saba banana in the Philippine domestic market. Based on the findings of the study, it is suggested that banana market stakeholders need to develop different strategies depending on the banana variety in order to improve the efficiency of the domestic banana market. To improve the complex distribution structure, the government needs to design medium- and long-term projects.

*Keywords:* Asymmetry, banana, Lakatan, nonlinear autoregressive distributed model, price transmission, Saba

## 1 Introduction

Information on prices of agricultural products is important for understanding the functioning of markets. Vertical price transmission can analyse the relation among interrelated markets that produce value-added goods (Ahn & Lee, 2015). Viewed along the vertical direction of the price spectrum, prices change as they move from one market to another.

Price transmission across regions and along market channels in traditional studies is assumed to be symmetric. The simultaneous-movement of farmgate, wholesale and retail prices means symmetric market information, as the price is transmitted vertically from the lower level to the higher level without distortion (Morales *et al.*, 2015). However, when price shocks occur in a market, prices in the farmgate, wholesale and retail markets may not move in parallel. By analysing vertical price transmission, we can identify asymmetric features between upstream and downstream market levels. Asymmetric prices are often associated with government intervention (Qui & Goodwin, 2013) and the market power of actors along the marketing chain. At one hand, government interventions such as policy impositions and/or abolishment of policies could lead to price movements leaning towards one direction (Goodwin, 2006; Oskenbayev & Turabayev, 2014). In addition, the market power is exploited to hinder the full transmission of price decreases in the market chain, while perfectly transmitting the price increases, so that information may be distorted and create asymmetry which lead to market inefficiency (Muazo *et al.*, 2014; Morales *et al.*, 2015). Moreover, according to various studies, product perishability (Ward, 1982; Ahn and Lee, 2015; Santeramo & von Cramon-Taubadel, 2016), transportation costs (FAO, 2004; Surbakti *et al.*, 2022), and high transaction costs (Balke & Fombe, 1997; Balcombe *et al.*, 2007;

* Corresponding author: yoonsuklee@kangwon.ac.kr

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Shikur, 2020) are also causes of asymmetric price transmission.

This study focuses on the features of vertical markets for banana in the Philippines. How is the price information transmitted across market channels? Is it symmetric or asymmetric? In the Philippines, banana has been included in the list of priority commodities by the Department of Agriculture under the 'Food Staples Sufficiency Program' and classified as a high value crop (Briones, 2014). The banana industry in the Philippines comprises of farmers, cooperatives, traders, exporters, and manufacturers. However, in terms of export it is dominated by large multinational companies (MNC). According to the Department of Science and Technology – Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (DOST-PCAARRD), there are several varieties of banana grown locally, but Cavendish, Lakatan and Saba are the most important varieties in the markets. Cavendish is for export, while Lakatan and Saba are for the domestic market as cooking, desserts and processed products. In terms of production, Cavendish banana accounts for 52.4 % of the total volume of banana production and this variety is contracted by multinational companies (MNCs), while Saba and Lakatan varieties follow with corresponding shares of 27.7 % and 10.2 %, respectively, and most of the farmers of these two varieties are small-scale farmers (PSA, 2021). In this study, the Saba and Lakatan varieties are selected to analyse the domestic banana markets.

The marketing channel of banana in the Philippines has five layers of traders in the supply chain before the product reaches the final consumers (Fig. 1). Supermarket chains, groceries, online retailers, hotels, and other institutional consumers usually get their supplies from wholesale traders. On the other hand, processed banana like chips distributed by processors in the local market deal directly with traditional retailers and institutional retailers like supermarkets, hypermarkets (Boquiren *et al.*, 2007), and the emerging online markets. The existence of multiple layers of key players in the domestic banana market can lead to asymmetric price transmission (Surbakti *et al.*, 2022; Goodwin, 2006; Elitzak, 1999; Funke, 2006).

In addition, asymmetric price transmission can be investigated when the impacts of price shocks distort information flaws within the marketing system (Jha & Nagarajan, 1998). In 2013 the country recorded a sharp decline of banana production mainly due to the devastation of Typhoon Pablo in 2012, where the large production area in Mindanao was badly hit (Department of Agriculture, 2018). The damaging effect was expanded to the following years in addition with the other factors like pests and diseases and changing weather patterns like long drought which affect the recovery. Despite the negative effect of natural calamities to the banana industry, this commodity accounted 8.2 % share to the gross value-added (GVA) in agriculture from 2010 to 2020.

This study estimates the asymmetric price responses between farmgate and wholesale, between wholesale and retail, and between farmgate and retail to examine the inefficiency of domestic banana markets in the Philippines. In particular, the causes of asymmetry are considered, focusing on internal structural problems such as complex marketing channels and external factors such as natural disasters. The study uses a nonlinear autoregressive distributed lag (NARDL) model to analyse the long- and short-term relationships between farmgate, wholesale and retail markets, and to identify the extent, direction, and nature of price asymmetry. Finally, the study also analyses the causal relationships between market levels.

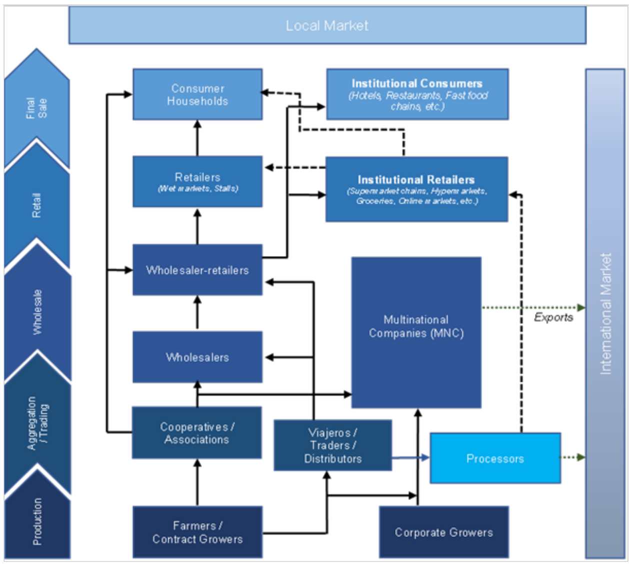


**Fig. 1:** *Supply chain map and marketing channels of banana. Source: Authors' summary.*

## 2 Materials and methods

### 2.1 Data

This research used monthly banana prices at farmgate, wholesale, and retail markets for Lakatan and Saba varieties in the Philippines from 1991 to 2021. The data was collected by the Philippine Statistics Authority (PSA). According to Farmgate Price Survey User's Manual (2018), the farmgate prices are the actual transaction during the reference month minus the actual marketing cost such as transport, labour, and any other cost incurred in marketing the product.

Recently, the farmgate, wholesale, and retail prices for bananas have diverged more and more over time. A large divergence was observed between farmgate and wholesale prices, and wholesale and retail prices showed a similar pattern of price divergence, albeit to a lesser extent (Fig. 2). From 1990 to 1998, banana at domestic market showed fairly stable prices, until a sharp price shock occurred in 1999. Since the late period of 1999 to 2008 the farmgate price of banana is relatively stable while wholesale and retail prices started to incline dramatically away from the producer price. Wholesale prices became more erratic started in 2011 and the price gaps have expanded wider.

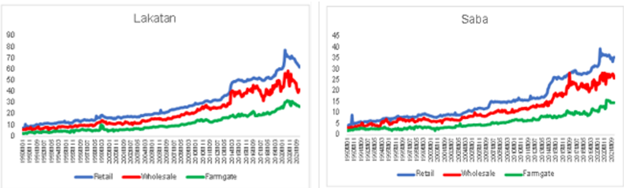


**Fig. 2:** *Monthly average prices of the Lakatan and Saba banana variety in the Philippines: 1990-2021 (in Philippine Peso). Source: Philippine Statistics Authority.*

According to the FAO (2014), import prices of banana fluctuated since early 2012 driven by a stronger US dollar against the Euro and higher demand which creates upward pressure on prices. The average prices of banana in domestic markets had started to decline after it peaked in April 2020 when the country had started its series of lockdowns due to the onset of COVID-19. PSA recorded volume of production for banana about 9 million metric tons in 2020 (PSA-AIS, 2021). Though, in 2013 the country recorded a sharp decline of banana production mainly due to the devastation of Typhoon Pablo in 2012, where the large production area in Mindanao was badly hit (Department of Agriculture, 2018). This natural disaster affected the production in the following years in addition to other factors such as pests and diseases, and changing weather patterns such as prolonged drought, which affect recovery. The price fluctuations of banana over time can be an indication of asymmetric price transmission. In one-way or another, a fall in farmgate prices may not be passed on equally to retailers, or the percentage of the fall may be different, do that consumers do not benefit from the fall in farmgate prices or producers do not benefit from the increase in retail prices (Elitzak, 1999; Meyer & von Cramon-Taubadel, 2004). This imperfect price transmission creates the problem of price asymmetry along the supply chain where shocks, for example, elicit different responses across the downward and upward directions.

## 2.2 *Nonlinear autoregressive distributed lag model.*

The first step of the analysis is to conduct an optimal lag selection and a stationarity test for each time series variable. The Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC) are used for selection of the optimal lags. Then the Augmented Dickey-Fuller (ADF) test for stationarity is used to determine whether price series is stationary at I(0) or I(1) (Deluna *et al*, 2021).

Based on the stationarity, the nonlinear autoregressive distributed lag (NARDL) model (Shin *et al.*, 2014) is utilised to analyse the asymmetric relation among farmgate, wholesale and retail of domestic banana markets. The NARDL model reflects the asymmetric stochastic trend of integrated prices, by decomposing the positive and negative components (CHO *et al.*, 2020). Further, the NARDL model can be integrated into an error correction model (ECM) to form a dynamic nonlinear ECM. As with the linear ECM, the integration of short-term dynamics and long-term equilibrium is carried out to avoid false regressions without losing information from the long-term equilibrium (Shrestha & Bhatta, 2018).

Moreover, the ECM corrected the short-term dynamics by adjusting the short-term imbalances towards the long-term equilibrium. With this, by separating the positive and negative error correction term (ECT) and the changes in the increases and decreases of independent variables it will result to an asymmetric price transmission model (Cramon, 1996). The generalised equation of NARDL model for pairs of farmgate-wholesale, farmgate-retail, wholesale-retail is as follows:

$$\Delta P^f_t = \alpha_0 + \alpha_1 P^f_{t-i} + \alpha_2^+ P^{w+}_{t-i} + \alpha_2^- P^{w-}_{t-i} + \sum_{j=1}^{q} \lambda_j \Delta P^f_{t-j} + \sum_{j=1}^{q} \delta_j^+ \Delta P^{w+}_{t-j} + \sum_{j=1}^{q} \delta_j^- \Delta P^{w-}_{t-j} + e_t \quad (1)$$

$$\Delta P^f_t = \beta_0 + \beta_1 P^f_{t-i} + \beta_2^+ P^{r+}_{t-i} + \beta_2^- P^{r-}_{t-i} + \sum_{j=1}^{q} \theta_j \Delta P^f_{t-j} + \sum_{j=1}^{q} \tau_j^+ \Delta P^{r+}_{t-j} + \sum_{j=1}^{q} \tau_j^- \Delta P^{r-}_{t-j} + \varepsilon_t \quad (2)$$

$$\Delta P^w_t = \gamma_0 + \gamma_1 P^w_{t-i} + \gamma_2^+ P^{r+}_{t-i} + \gamma_2^- P^{r-}_{t-i} + \sum_{j=1}^{q} \rho_j \Delta P^w_{t-j} + \sum_{j=1}^{q} \sigma_j^+ \Delta P^{r+}_{t-j} + \sum_{j=1}^{q} \sigma_j^- \Delta P^{r-}_{t-j} + \mu_t \quad (3)$$

where $P^f$, $P^w$ and, $P^r$ refer to farmgate price, wholesale price, and retail price, respectively, and the terms with $\alpha$, $\beta$

and $\gamma$ coefficients are associated with the long-term relationship. $\sum_{j=1}^{q}\hat{\delta}_j^+ \neq \sum_{j=1}^{q}\hat{\delta}_j^-$ and $\sum_{j=1}^{q}\hat{\theta}_j^+ \neq \sum_{j=1}^{q}\hat{\theta}_j^-$ represents the lagged dependent variables where $q$ is the optimal lags for each pair of prices. The $\delta$, $\tau$ and $\tau$ are short-term dynamics of the model, (+) and (–) corresponds to price increase and decrease, respectively.

The NARDL model allows to test the asymmetric impact of wholesale and retail to farmgate price and also the asymmetric adjustments of the latter to short-term dynamics from the equilibrium. In addition, obtaining different lag lengths for positive and negative partial sums in equation (1) indicate an asymmetric short-term adjustment to farmgate prices. For example, if $\sum_{j=1}^{q}\hat{\delta}_j^+ \neq \sum_{j=1}^{q}\hat{\delta}_j^-$ and $\sum_{j=1}^{q}\hat{\theta}_j^+ \neq \sum_{j=1}^{q}\hat{\theta}_j^-$ these imply that in the short-term the impacts of wholesale and retail prices to farmgate price is asymmetric. Specifically, if $\hat{\delta}_j^+ \neq \hat{\delta}_j^-$ and $\hat{\theta}_j^+ \neq \hat{\theta}_j^-$ these show asymmetric effect of wholesale price and retail price, respectively, into farmgate price. In other words, if the null hypothesis of $\sum_{j=1}^{q}\hat{\delta}_j^+ = \sum_{j=1}^{q}\hat{\delta}_j^-$ for testing the symmetry of price transmission is rejected by the Wald test, then short-term asymmetric effect will be established. Furthermore, the $\beta$ coefficients in equation (1) used to detect the nonlinear cointegration between farmgate and wholesale and it can be investigated how the previous farmgate prices and wholesale prices affect the long-term farmgate prices. The ECM is used to analyse the long-term relationships while the partial sums represent the short-term dynamics between farmgate and wholesale markets. According to Surbakti *et al.* (2022), the existence of cointegration among nonstationary time series implies the possibility of imbalances in the short-term, but has a long-term effect. Likewise, if the null hypotheses for long-term coefficients, $\hat{\beta}_2^+ = \hat{\beta}_2^-$, are rejected, then there is asymmetric effect of wholesale to farmgate price in the long-term. The equation (2) and (3) of farmegate-retail and wholesale-retail followed the same estimation procedures.

## 3 Results

### *3.1 Optimal lag selection and unit root test*

First, the optimal lag selection for each series is determined by the Schwarz Information Criterion (SIC) selection criteria. Lag selection is important for structuring a time series model when inappropriate lags cause biased results. The SIC criterion performs better with smaller data sets (Weakliem, 1999). Table 1 shows the results of the optimal lag selection. The optimal lag length of the Lakatan model was 3 lags for farmgate, wholesale, and retail, and in the Saba model 4 lags for farmgate, 3 lags for wholesale and retail.

**Table 1:** *Optimal lag selection for Lakatan and Saba banana varieties.*

| *Variables* | *Lakatan* | *Saba* |
|---|---|---|
| Farmgate | 2-lags | 4-lags |
| Wholesale | 2-lags | 3-lags |
| Retail | 2-lags | 3-lags |

Based on the selection of optimal lags, the unit root test was conducted. All price series of the Lakatan and Saba varieties were stationary at first difference, i.e., of first order or I(1), which satisfies the requirement of NARDL analysis (Deluna *et al.*, 2021).

**Table 2:** *Optimal lag selection for Lakatan and Saba banana varieties.*

| *Varieties* | *Prices* | *Status* | *Conclusion* |
|---|---|---|---|
| Lakatan | Farmgate | I(0) | Non-stationary |
| | Wholesale | I(0) | Non-Stationary |
| | Retail | I(0) | Non-stationary |
| | ΔFarmgate | I(1) | Stationary |
| | ΔWholesale | I(1) | stationary |
| | ΔRetail | I(1) | Stationary |
| Saba | Farmgate | I(0) | Non-stationary |
| | Wholesale | I(0) | Non-Stationary |
| | Retail | I(0) | Non-stationary |
| | ΔFarmgate | I(1) | Stationary |
| | ΔWholesale | I(1) | stationary |
| | ΔRetail | I(1) | Stationary |

### *3.2 NARDL estimation on vertical price transmission of banana*

One of the reasons for using the NARDL model in this study is that banana prices have non-linear characteristics. The results of the test showed that all variables are nonlinear, which is an indication that NARDL modelling should be used. In addition, the bounds test for nonlinear cointegration was necessary to know whether the model should include the short-term and long-term relationships. Table 3 shows the bounds test results for bivariate models with their corresponding dependent variables. Bounds test results indicated that both wholesale and retail prices for the Lakatan variety are vertically cointegrated with the farmgate price at 5 % level of significance. Likewise, its retail price is cointegrated with the wholesale price. Therefore, the short-run and long-run components are estimated on the NARDL model for Lakatan. Similarly, the NARDL model was estimated for

**Table 3:** *Bounds test for nonlinear cointegration.*

| *Dependent* | *Independent* | *F-statistic* | *k* | *Critical values* (5%) *I(0)* | *I(1)* | *Conclusion* |
|---|---|---|---|---|---|---|
| Lakatan_f | Lakatan_w | 6.4465** | 3 | Apr 94 | Mai 73 | Cointegrated |
| Lakatan_f | Lakatan_r | 7.0731** | 3 | Apr 94 | Mai 73 | Cointegrated |
| Lakatan_w | Lakatan_r | 7.1479** | 3 | Apr 94 | Mai 73 | Cointegrated |
| Saba_f | Saba_w | 45.460 | 4 | Apr 94 | Mai 73 | No cointegration |
| Saba_f | Saba_r | 5.0068* | 3 | 04. Apr | Apr 78 | Cointegrated |
| Saba_w | Saba_r | 11.7471*** | 3 | Apr 94 | Mai 73 | Cointegrated |

Note: (***) represents 1 % significance, (**) represents 5 %, (*) represents 10 %.
The suffix _f, _w, and _r means farmgate, wholesale, and retail prices, respectively.

the cointegrating relations that exist for the Saba varieties. However, those pairs of prices that did not show significant cointegrating relationships were excluded from the NARDL estimation.

Based on the results of the bounds test, the components of NARDL model for Lakatan variety was estimated using the long-run and short-run components. Table 4 displays the output for the NARDL estimates for the Lakatan variety. Three models were fitted to represent the bivariate relationships, namely; farmgate-wholesale, farmgate-retail, and wholesale-retail. The results showed that the estimated adjustment coefficients for all three equations were negative and statistically significant at the 1 % level. This indicates a reverse adjustment mechanism, that is, the short-term price deviations were corrected in the long-run.

For instance, the long-run coefficient of −0.1431 for farmgate-wholesale equation implies that the previous months' errors will adjust at 0.143 % in the long-run. Moreover, in the long-run a 1 % increase in wholesale price of Lakatan will increase the farmgate by 0.05 %, while a 1 % decrease of wholesale will reduce the farmgate by 0.04 %. The two values were significantly different at the 1 % significance level, indicating a long-term price asymmetry between farmgate prices and wholesale prices for the Lakatan banana. In the short-run, however, the model showed that the increase in the wholesale price in the previous month had a positive effect 0.074 % on the current farmgate price, while the decrease in the wholesale price in the previous month had no effect on the farmgate price, indicating asymmetric price transmission.

Meanwhile, the farmgate-retail model showed a −0.1468 coefficient, indicating an adjustment of 0.147 % in the long-run. The long-term model stated that a 1 % increase in retail price will influence an upward adjustment of farmgate at 0.05 %, whereas a reduction of 1 % in retail price will decrease the farmgate by 0.04 %. Though, these long-run coefficients showed a weak price asymmetry that is only significant at the 10 % level. In this model, the short-run component indicated that the increase in retail prices in the current and previous month positively influenced the current farmgate price with a combined effect of 0.432 %. When considering the wholesale price as the outcome variable, as shown in the wholesale-retail equation, the adjustment was faster than for the other two price pairs, namely by 0.206 %. The long-run model implied that increases and decreases in retail prices had the same impact to wholesale prices, indicating symmetry in price transmission in the long-run. However, the short-run model found that retail price increases in the current and previous months had a positive impact on the pass-through of the current wholesale price, with a combined effect of 1.23 %, while a retail price decrease in the current month reduced the wholesale price by around 1.08 %.

The estimates for the Saba variety are presented in Table 5. Based on the result, the coefficient of adjustment for the farmgate-retail model is −0.1071 and highly significant at the 1 % level. The short-run deviations between farmgate and retail prices are corrected in the long-run at an average rate of 0.107 %. Furthermore, a 1 % increase in the retail price of Saba in the long-run led to a 0.03 % increase in the farmgate price, while a decrease in the retail price is not absorbed by the farmgate price as it is insignificant at the 5 % level. The short-run dynamics showed that positive retail price shocks in the current and previous months can lead to an upward adjustment of the farmgate price with a total impact of 0.24 %. On the other hand, when negative retail price shocks occurred for the Saba variety, only the current month led to a 0.16 % decrease in the producer price. This result indicates that there is an asymmetric transmission of prices in the short-run.

The wholesale-retail model, on the other hand, showed a faster speed of adjustment to equilibrium of about 0.268 % and is highly significant at the 1 % level. The long-run model showed no asymmetric price transmission. In contrast, the short-run model showed that the wholesale price ($\Delta retail_t^+ =$

**Table 4:** *Short-run and long-run estimates of NARDL model for the Lakatan banana variety.*

| *Farmgate-Wholesale* | | | *Farmgate-Retail* | | | *Wholesale-Retail* | | |
|---|---|---|---|---|---|---|---|---|
| *Regressor* | *Coefficients* | *Std. dev.* | *Regressor* | *Coefficients* | *Std. dev.* | *Regressor* | *Coefficients* | *Std. dev.* |
| | | | Long-run | | | | | |
| $farm_{t-1}$ | $-0.1431^{***}$ | 0.0333 | $farm_{t-1}$ | $-0.1468^{***}$ | 0.0320 | $whole_{t-1}$ | $-0.2060^{***}$ | 0.0477 |
| $whole^{+}_{t-1}$ | $0.0488^{***}$ | 0.0131 | $retail^{+}_{t-1}$ | $0.0540^{***}$ | 0.0129 | $retail^{+}_{t-1}$ | $0.1552^{***}$ | 0.0405 |
| $whole^{-}_{t-1}$ | $0.0365^{**}$ | 0.0127 | $retail^{-}_{t-1}$ | $0.0439^{***}$ | 0.0140 | $retail^{-}_{t-1}$ | $0.1530^{***}$ | 0.0466 |
| | | | Short-run | | | | | |
| $\Delta farm_{t-1}$ | −0.0369 | 0.0536 | $\Delta farm_{t-1}$ | $-0.1093^{**}$ | 0.0531 | $\Delta whole_{t-1}$ | $-0.2654^{***}$ | 0.0590 |
| $\Delta farm_{t-2}$ | −0.0586 | 0.0519 | $\Delta farm_{t-2}$ | $-0.1112^{**}$ | 0.0516 | $\Delta whole_{t-2}$ | $-0.2200^{***}$ | 0.0546 |
| $\Delta whole^{+}_{t}$ | 0.0497 | 0.0338 | $\Delta retail^{+}_{t}$ | $0.2087^{***}$ | 0.0518 | $\Delta retail^{+}_{t}$ | $0.5838^{***}$ | 0.1209 |
| $\Delta whole^{+}_{t-1}$ | $0.0740^{**}$ | 0.0356 | $\Delta retail^{+}_{t-1}$ | $0.2233^{***}$ | 0.0758 | $\Delta retail^{+}_{t-1}$ | $0.6459^{***}$ | 0.1822 |
| $\Delta whole^{+}_{t-2}$ | −0.0025 | 0.0348 | $\Delta retail^{+}_{t-2}$ | 0.0367 | 0.0685 | $\Delta retail^{+}_{t-2}$ | 0.1891 | 0.1681 |
| $\Delta whole^{-}_{t}$ | −0.0141 | 0.0410 | $\Delta reail^{-}_{t}$ | $0.3187^{***}$ | 0.1061 | $\Delta retail^{-}_{t}$ | $1.0779^{***}$ | 0.2610 |
| $\Delta whole^{-}_{t-1}$ | 0.0234 | 0.0424 | $\Delta retail^{-}_{t-1}$ | 0.1178 | 0.1071 | $\Delta retail^{-}_{t-1}$ | 0.2459 | 0.2586 |
| $\Delta whole^{-}_{t-2}$ | $0.1365^{***}$ | 0.0411 | $\Delta retail^{-}_{t-2}$ | −0.1943** | 0.0751 | $\Delta retail^{-}_{t-2}$ | $0.4004^{**}$ | 0.1735 |
| $\alpha_0$ | $0.4179^{***}$ | 0.1041 | $\beta_0$ | $0.2523^{**}$ | 0.1026 | $\gamma_0$ | $1.0516^{***}$ | 0.3309 |

Note: (***) 1 % significance, (**) 5 % significance, probability based on one-tailed t-test.

**Table 5:** *Short-run and long-run estimates of NARDL model for the Saba banana variety.*

| *Farmgate-Retail* | | | *Wholesale-Retail* | | |
|---|---|---|---|---|---|
| *Regressor* | *Coefficients* | *Std. dev.* | *Regressor* | *Coefficients* | *Std. dev.* |
| | | | Long-run | | |
| $farm_{t-1}$ | $-0.1071^{***}$ | 0.0294 | $whole_{t-1}$ | $-0.2678^{***}$ | 0.0460 |
| $retail^{+}_{t-1}$ | $0.0297^{***}$ | 0.0100 | $retail^{+}_{t-1}$ | $0.2089^{***}$ | 0.0364 |
| $retail^{-}_{t-1}$ | 0.0183 | 0.0140 | $retail^{-}_{t-1}$ | $0.2129^{***}$ | 0.0431 |
| | | | Short-run | | |
| $\Delta farm_{t-1}$ | −0.0245 | 0.0528 | $\Delta whole_{t-1}$ | $-0.3445^{***}$ | 0.0572 |
| $\Delta farm_{t-2}$ | $-0.1365^{**}$ | 0.0512 | $\Delta whole_{t-2}$ | $-0.2150^{***}$ | 0.0556 |
| $\Delta farm_{t-3}$ | $-0.1080^{**}$ | 0.0510 | $\Delta whole_{t-3}$ | $-0.0931^{**}$ | 0.0493 |
| $\Delta retail^{+}_{t}$ | $0.0838^{**}$ | 0.0440 | $\Delta retail^{+}_{t}$ | $0.2713^{***}$ | 0.0932 |
| $\Delta retail^{+}_{t-1}$ | $0.1563^{**}$ | 0.0622 | $\Delta retail^{+}_{t-1}$ | 0.0775 | 0.1401 |
| $\Delta retail^{-}_{t}$ | $0.1609^{**}$ | 0.0831 | $\Delta reail^{-}_{t}$ | 0.1027 | 0.1781 |
| $\Delta retail^{-}_{t-1}$ | 0.0282 | 0.0575 | $\Delta retail^{-}_{t-1}$ | $0.2243^{**}$ | 0.1227 |
| $\alpha_0$ | $0.1170^{*}$ | 0.0671 | $\alpha_1$ | $0.9078^{***}$ | 0.1885 |

Note: (***) 1 % significance, (**) 5 % significance, probability based on one-tailed t-test.

0.2713) increased by 0.271 % in an upward direction when the difference between the current retail price and the previous retail price of Saba banana is increased by 1 %.

### *3.3 Asymmetry statistics on prices of banana*

Table 4 and 5 report the results of asymmetry from each lagged parameter in the long-run and short-run, while table 6 displays the tests for long-run effect and asymmetries for all models discussed. Looking at the short-run asymmetry statistics, there exist no significant asymmetry in all models. This implies that, in the short-run, prices of the two banana varieties tend to have a symmetric vertical price transmission along the supply chain. However, in the long-run, there was a highly significant asymmetric price transmission between farmgate-wholesale for the Lakatan variety. Although farmgate-retail also showed asymmetry in price

**Table 6:** *Asymmetry statistics of NARDL models for Lakatan and Saba banana varieties.*

| *Variables* | | *Long-run effect [+]* | | | *Long-run effect [-]* | | | *Long-run asymmetry* | | *Short-run asymmetry* | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Dep.* | *Indep.* | *Coeff.* | *F-Stat* | *P-Value* | *Coeff.* | *F-Stat.* | *P-Value.* | *F-Stat* | *P-Value* | *F-Stat* | *P-Value* |
| lakf | lakw | 0.341 | 48.59 | 0.000 | −0.255 | 14.73 | 0.000 | 19.86 | 0.000 | 0.068 | 0.794 |
| lakf | lakr | 0.368 | 157.80 | 0.000 | −0.299 | 22.19 | 0.000 | 3.60 | 0.058 | 2.747 | 0.098 |
| lakw | lakr | 0.753 | 221.10 | 0.000 | −0.742 | 47.16 | 0.000 | 0.03 | 0.859 | 0.766 | 0.382 |
| sabf | sabr | 0.277 | 19.21 | 0.000 | −0.171 | 1.89 | 0.170 | 2.86 | 0.092 | 0.281 | 0.596 |
| sabw | sabr | 0.780 | 203.60 | 0.000 | −0.795 | 54.63 | 0.000 | 0.08 | 0.781 | 0.011 | 0.917 |

Note: lakw means wholesale price for Lakatan banana, lakr means retail price for Lakatan banana, sabw means wholesale price for Saba banana, and sabr means retail price for Saba banana.
Dep. = Dependent, Indep. = Independent, Coeff. = Coefficients

**Table 7:** *Results of Granger causality test for banana varieties.*

| *Dependent* | | *Independent* | *Direction* | *Relationships* |
|---|---|---|---|---|
| | | *Lakatan* | | |
| Farmgate | ⟷ | Wholesale | Bidirectional | wholesale influences farmgate and vice versa |
| Farmgate | ⟵ | Retail | Unidirectional | retail influences farmgate |
| Wholesale | ⟷ | Retail | Bidirectional | wholesale influences retail and vice versa |
| | | *Saba* | | |
| Farmgate | ⟵ | Retail | Unidirectional | retail influences farmgate |
| Wholesale | ⟵ | Retail | Unidirectional | retail influences wholesale |

transmission for Lakatan, it was weakly significant at the 10 % level.

### 3.4 Granger causality tests

The pairwise Granger causality test was used to determine the direction of price relationships along the vertical supply chain of banana. As shown in Table 7, for Lakatan variety it shows bi-directional relations among pairs of prices, particularly, the farmgate-wholesale and the wholesale-retail. This means that wholesale price dominated the formations of farmgate and retail prices and vice versa. Whereas, the farmgate-retail combination displayed unidirectional relations, that is, retail price of Lakatan influenced the farmgate price. The Saba variety had unidirectional relations among retail price to farmgate price and retail price to wholesale price. In general, the causalities between the price pairs for bananas showed mixed directional relationships for the two banana varieties. Bidirectional causal relationships were found between farmgate and wholesale prices for the Lakatan variety. However, an asymmetric long-run relationship was found between farmgate and wholesale prices. This implies that although farmgate and wholesale prices influence each other, the degree of influence between them is different. The Saba variety showed that retail prices influenced farmgate and wholesale prices, respectively, but not vice versa.

Based on the causality tests, the Lakatan and Saba varieties had different causal directions at each market level. Comparing the two varieties, the role of wholesale prices is more important for the Lakatan variety than for the Saba variety.

## 4 Discussion

The main objective of this study was to determine the symmetry of the vertical price transmission of bananas in the domestic market. That is, based on the law of one price the movement of farmgate, wholesale, and retail prices should be parallel and therefore any shocks from the downstream or upstream market are assumed to be perfectly transmitted leading to an equilibrium condition. However, given the complex structure of the banana market in the country, there is a suspicion of inefficient price transmission along the vertical market due to factors such as higher transaction and transport costs, and the possible market power of large distributors. In addition, price shocks may or may not be fully transmitted vertically and may be absorbed within the chain of market actors.

Based on the results, Lakatan and Saba banana showed different market responses and directions. Lakatan banana showed asymmetric transmission between farmgate and wholesale prices, between farmgate and retail prices in the long-run, however, in the short-run, there exist no asymmetric transmission between all pairs of market levels. This implies that the existence of external shocks can trigger long-run adjustment toward the long-run equilibrium. That is, the effects of some external shocks on the market of Lakatan banana market can be quickly recovered in the short-run but, the effects of other shocks permanently remain in the market and make the market inefficient in the long-run. The results for Saba banana showed that there is no asymmetric transmission between all pairs of market levels, both in the long-run and in the short-run. This implies that there is a little possibility of responding to external shocks. Comparing the price behaviour of Saba and Lakatan, the Saba banana market was relatively efficient. In addition, the size of response to a given price shock differs according the direction of origin. In general, the results showed that positive shocks occurring at one level of the market had a greater impact on prices at other levels than negative shocks. Such results may reflect the complicated marketing channel of the domestic banana market in the Philippines (Fig. 1). The complicated marketing channel negatively affects farmgate prices because the farmgate level is more vulnerable compared to prices at other levels Lakatan and Saba bananas are for domestic consumption, and most farmers who grow both varieties are smallholders. Smallholder banana farmers do not usually have market power over marketing intermediaries such as traders, distributors and wholesalers, and may be deprived of perfect information from the upstream market. To ensure transparency in the domestic banana market in the Philippines, the government needs to establish a public market information system. One implication drawn from Goodwin (2006) is that when the market price falls, the purchase price also falls. However, if the market price rises, the purchase price remains the same or rises to varying degrees. In fact, price decreases at the wholesale level can be passed on to the farmgate level, whereas price increases at the wholesale level may not be passed on to the farmer level because there is a hierarchy of actors who could control a price adjustment of the farmgate price and are reluctant to do so.

From these set of findings, this study draws some recommendations that could lead to policy implications with regards to market expansion of domestic banana. Firstly, given the archipelagic geography of the country where transportation is a high factor cost when it comes to product transfer, government could devise programs that enhance transport connectivity and improve technology to keep bananas fresh. The poor conditions of farm-to-market transport infrastructure in some parts of the country might be the reason why some wholesalers do not have direct encounter with banana farmers, and because of this, other mediators exist on their behalf. In 2018, the Department of Public Works Road (DPWH) in the Philippines carried out a road improvement project to reduce transportation costs for banana producers in the Barangay and Ilagan regions of Ilagan. Infrastructure projects such as road construction must be planned for the long-term in terms of overall industrial development because the effects are difficult to appear in a short period of time. Secondly, the existence of multi-layer channels along the domestic market chain for bananas leads to a price asymmetry problem, where positive price adjustments coming from the wholesale level are passed on with a much greater delay than negative price adjustments. Although the banana market appears to be efficient in the short-run, the long-run effect is unfavourable to banana producers. A policy that directly or indirectly reduces the number of market actors between the existing marketing levels could lead to a more efficient marketing system. The government must create a market environment in which the direct transaction market can be activated. A direct transaction system can have the positive effect of improving distribution by saving distribution costs. It can also diversify sales channels from the producer's perspective.

Thirdly, since the market power is in favour of the wholesalers, the creation or existence of banana farmers' associations (or cooperatives) could alleviate the situation, so that small-scale growers could pool their products and have countervailing power against wholesalers and other market intermediaries such as traders and distributors. More recently, the role of producer organisations has expanded to include not only specialisation, uniformity of quality and marketing, but also the management of supply and demand. By organising banana producers, the Philippine government can increase its commercial bargaining power in the market and achieve management stability through increased income. To address these issues, the government can leverage various local resources. One approach is to activate village cooperatives, enabling them to conduct the role of market players like Maragusan Dole banana Growers Multi-Purpose Cooperative (Tila, 2021).

Fourth, based on the estimation results for Lakatan and Saba bananas, different strategies are needed to expand both markets. Lakatan banana is popular for dessert and Saba banana is commonly used for cuisine in the Philippines. In order to expand the market for Lakatan and saba, stakeholders in the banana industry can consider improving the quality such as taste, nutrition, appearance and so on. According to the study about consumer demand for domestic banana in Philippines (Basan et al, 2021), quality is most important factor to attract consumers. To enhance the quality (taste, appearance, etc.) of bananas, cooperation among farmers, cooperatives, and the government is necessary. The government should provide various training programs, either directly or through cooperatives, to help banana farmers learn improved farming techniques. For such programs to succeed, the government must also provide appropriate financial support. There is no doubt that it is important to assess the efficiency of a domestic banana market in the Philippines. However, this study is limited in its ability to draw various conclusions because it only used market prices. For further study, it is necessary to collect different factors such as the social and economic characteristics of banana farms, the existence and impact of arbitrage across regions, consumer behaviour towards banana varieties and so on, and then analyse them from different aspects to strengthen the banana market and especially the banana producers. In addition,

*Conflict of interest*

The authors declare that they have no conflict of interest.

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