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1           **Rice Price Transmission between Wholesalers and Retailers in the**  
2                           **Philippines: Are Prices Integrated in Local Markets?**

3  
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6  
7           **ABSTRACT**

8   Increasing attention has been given to raising commodity prices due to its negative effects  
9   on poverty and undernutrition. An example of this problem are the growing rice prices in  
10   Philippines, which are causing high living expenses to the population across the country.  
11   To assess the competitiveness of agro-food chains, price transmission has been used as an  
12   indicator of market integration. Using monthly data for the period 2000 to 2016, this study  
13   tests vertical price transmission between wholesale and retail prices and dynamic  
14   relationship between them in five local markets in Philippines. Results demonstrate that  
15   retail prices are granger caused by wholesale prices in all local markets. An autoregressive  
16   distributed lag (ARDL) model confirms that asymmetry in rice price transmission between  
17   wholesale and retail levels in Metro Manila and Davao. In addition, the ARDL model also  
18   confirms retail rice prices in all markets studied in Philippines depend on previous retail  
19   prices, contemporaneous wholesale prices and wholesale prices lagged one and two  
20   periods, depending on the location. Impulse Response Functions (IRFs) show the retail  
21   price response initiates almost immediately or at most one month later after shock, i.e.  
22   negative and positive change, on wholesale price, and the duration of full price adjustments

23 tend to be considerably longer in all five local markets in Philippines. [EconLit citations:  
24 C32, L11, Q13].

## 25 **1. INTRODUCTION**

26 Rice price in Philippines is higher in comparison with other major rice producing Asian  
27 countries such as Vietnam, Thailand and China. The largest sources of higher rice price in  
28 the Philippines are the costs for transportation, milling, packaging, working capital and  
29 import restriction (The Philippine Rice Research Institute (PhiRice), 2016). The PhiRice  
30 (2016) also said that the gross marketing margin (GMM) is higher at the different stages  
31 of rice supply chain in Philippines, and it is due to the high costs of marketing and the  
32 enormous returns to trade management. The rice prices in Philippines have fluctuated  
33 dramatically in the last decade, with consumers facing increasingly high prices that reached  
34 exceptional levels before falling during the financial crisis over the second half of 2007  
35 and first half of the 2008 (FAO, 2016). According to FAO (2011), Zorya, Townsend and  
36 Delgado (2012) and Morales (2018), imperfections in price transmission are factors that  
37 have contributed to exacerbate price fluctuations of food commodities due to the lack of  
38 incentives transmitted to chain actors for markets adjust to shocks in supply and demand.  
39 The degree of market integration in agro-food chains is affected by variations in magnitude,  
40 delays and asymmetries in price transmission between positive and negative price shocks  
41 (Bunte, 2006; Aramyan and Kuiper, 2009; Swinnen and Vandeplas, 2014). In this context,  
42 market prices could be imperfect signals sent to actors, which could allocate suboptimal  
43 resources to production. Under this scenario, the quantity and quality of products offered  
44 in the market could be affected, with negative consequences for consumers and actors  
45 across the chain (Norwood and Lusk, 2008).

46 According to Rapsomanikis and Muger (2011), imperfections in price transmission are  
47 considered as evidence of market failure and require policy interventions to control the  
48 level of market power of some actors in agro-food chains. Producers/wholesalers when  
49 increase prices, the retailers instantly and completely increase their prices to maintain their  
50 normal profit margins, but when producers/wholesalers decrease prices, the retailers keep  
51 constant their prices or takes time to reduce prices to capture higher profit margins  
52 (Schroeder, 1988; Vavra & Goodwin, 2005). Swinnen and Vandeplass (2014) argued that  
53 consumers in developing countries are hurt by increasing food prices, while producers are  
54 not benefiting from high prices for their products, increasing poverty and hunger. Meyer  
55 and von Cramon-Taubadel (2004) also claimed that the asymmetric price transmission  
56 (APT) possibly results on consumers not benefitting from price reductions at the producers'  
57 level, and producers might not benefit from price increases at the retail level. The  
58 asymmetric price transmission, in terms of magnitude and time delay in price adjustment  
59 mechanism, raised serious concerns in Philippines about market integration between  
60 wholesale and retail markets. Very few studies have been conducted on price transmission  
61 in the Philippines rice markets, and most of them were done before the global economic  
62 crisis in 2007-2008. Therefore, to our knowledge, this is the first study that investigates the  
63 dynamics of price adjustment and vertical price transmission between wholesale and retail  
64 prices of milled rice in local markets in Philippines. In this paper, we examine the causal  
65 relationships and empirically observe asymmetries in price transmission between  
66 wholesale and retail prices, and the dynamics of price adjustment in milled rice prices in  
67 rice markets in Philippines.

68 Market imperfections in agro-food markets are more prevalent in developing countries  
69 compared to developed countries (Morales, 2018). Imperfections in price transmission are  
70 due to several factors such as market power, processing and marketing costs, costs of  
71 transportation, government intervention, and product homogeneity and differentiation, in  
72 addition to market failure (Meyer and von Cramon-Taubadel, 2004). Frey and Manera  
73 (2005) stated that the main cause of imperfect transmission from wholesale to retail is that  
74 retailers allegedly try to maintain their “normal” profit margin by increasing retail prices  
75 when wholesale prices rise, but they try to capture the larger margins keeping constant the  
76 retail prices when wholesale prices fall, which results at least temporarily in APT. In the  
77 case of Philippines, in the context of a developing country, we expect market imperfections  
78 affecting rice markets.

79 Rice is the most consumed food across the Philippines, with a share of the total food  
80 consumption per person very high and increasing from 68.56% in 1999-2000 to 78.99% in  
81 2008-2009 (Philrice, 2016). Growing rice prices in the Philippines represent high living  
82 expenses to the population across the country and more adverse effects on poverty, because  
83 the share of rice in total food consumption is high for poor peoples in Philippines which  
84 increases the expenditure for food consumption (Philrice, 2016). The historical data on rice  
85 consumption rate shows that it tends to increase over time, though the rice price rise,  
86 causing the rice consumption rate is inelastic to its price in the Philippines (Philrice, 2016  
87 & FAO, 2016). The degree to which price shocks at one level of the rice chain are  
88 transmitted to other levels in local markets is often taken to be an important indicator of  
89 market power in supply chain. The high food prices to consumers and large marketing  
90 margins to traders at certain stages in supply chain, therefore the unbalanced marketing

91 margins among traders are most important issues facing policy makers. Thus, deeper  
92 understanding about magnitude, speed and asymmetry to which wholesale prices are being  
93 transmitted to retailer prices is a key factor in designing appropriate policy measures to  
94 reduce the level of living expenses to individuals. Thus, the imperfections in rice markets  
95 could have serious economic impacts to households in the Philippines. Policy initiatives in  
96 this country indicate that market reform in rice market can lead to a reduction in the number  
97 of poor people in the country as it helps to reduce the food expenses for individuals  
98 (Cororaton, 2004), and to achieve such kind of benefits perfect price relationships between  
99 various market levels in rice supply chain in markets is an essential condition.

100 Previous studies on rice markets in the Philippines such as Reyes et al. (2009) analyzed  
101 the impact of changes in rice prices on poverty; Pede et al. (2013) investigated dynamics  
102 on rice prices, i.e. monthly rice prices changes over the period of January 1990 to December  
103 2012 in 16 regions in Philippines at three market levels: farmgate, wholesale and retail;  
104 Jolejole-Foreman and Mallory (2011) analyzed the movement of Philippine rice price  
105 margins between farmgate and retail affected by government intervention measures; and  
106 Ramos, E. V. empirically tested the presence of seasonality in palay and rice price series  
107 from 1972 to 2008 and the speed of price transmission between farm, wholesale and retail  
108 levels on local markets in Philippines: Nueva Ecija, Illoilo and North Cotabato. But these  
109 above-mentioned studies did not conduct empirical test on asymmetries in price  
110 transmission between chain levels in local rice markets in the Philippines. Consequently,  
111 this study aims to explore whether there are price transmission imperfections in the  
112 Philippines rice markets and report its results and welfare implications to policy makers.  
113 Hence, this paper i) tests the causality directions of rice prices between wholesale and retail

114 levels; ii) examines asymmetries in price transmission between wholesale and retail prices  
115 in different rice markets; and 3) assesses the dynamic relationships between wholesale and  
116 retail rice prices.

117 The remaining of this paper is organized as follows: Section 2 briefly review relevant  
118 literature about vertical price transmission analysis, Section 3 introduces the data which is  
119 used for the analysis, Section 4 describes the econometric methods for the vertical price  
120 transmission analysis and dynamics of price series, Section 5 presents the main findings  
121 and its discussions, and Section 6 provides the conclusions.

## 122 **2. VERTICAL PRICE TRANSMISSION IN AGRO-FOOD CHAINS**

123 Vertical price transmission has been studied to better understand the nature of price  
124 movements from one level to other in agro-food chains. Several methods have been used  
125 in previous studies, including von Cramon-Taubadel (1997), Conforti (2004), Varga  
126 (2007) Acosta and Valdes (2014), and Ahn and Lee (2015), to analyze the direction,  
127 magnitude and speed with which price changes are transmitted along the various stages of  
128 the agro-food chain. The price variations may reveal different kinds of asymmetries in  
129 intensity and nature depending upon the direction of price transmission in supply chain.  
130 Research and Consulting in Economics (Areté) (2012) argued that in agro-food supply  
131 chains, the increase in input prices are more rapidly (and often fully) transmitted to  
132 downstream along supply chain, but the reduction in input prices do not transmit or may  
133 take more time to be transmitted to the final market levels. The assessment of magnitude  
134 and speed of price movement through supply chain is often used as an indicator of the

135 effectiveness and efficiency of the chain as well as the degree of competitiveness in food  
136 processing and distribution.

137 Vavra and Goodwin (2005), Commission of the European Communities (CEC) (2009)  
138 and Areté, (2012) stated that the assessment of vertical price transmission along the supply  
139 chain typically aims to address the issues: the magnitude, speed, and the asymmetry of  
140 price adjustment through the chain. In recent years, extensive studies have been done to  
141 examine market linkages among market levels such as: farm, wholesale and retail levels;  
142 and most of the literature on vertical price transmission refers to noncompetitive markets  
143 due to market imperfections, i.e. incomplete and time delay in price transmission (von  
144 Cramon-Taubadel & Loy, 1996; von Cramon-Taubadel, 1998; Conforti, 2004; Vavra &  
145 Goodwin, 2005; Capps & Sherwell, 2005; Acosta & Valdes, 2013; Ahn & Lee, 2015).

146 Developing appropriate models for analyzing price transmission and testing  
147 asymmetries is key to study market integration in agro-food chains. In the literature, there  
148 are econometric methods for testing APT in agricultural commodities markets which are  
149 still being used. In the very previous period, researchers have developed pre-cointegration  
150 approaches for testing APT. Tweeten and Quance (1969) introduced a dummy variable in  
151 the symmetric and linear price transmission model for estimating APT, and the dummy  
152 variables are split the prices into two parts: increasing and decreasing input prices.  
153 Wolffram (1971) proposed another empirical model that explicitly includes first  
154 differences of explanatory price series in the equation. Houck (1977) developed another  
155 model for testing APT, which is like Wolffram's model, and this model does not consider  
156 initial observations of price series data into account, because according to him the level of  
157 the first observation do not have power to cause dependent variable while considering



158 differential effects. Ward (1982) modified the Houck's specifications by considering time  
159 lags on the explanatory variables. Meyer and von Cramon-Taubadel (2004), Frey and  
160 Manera (2005), and Hassouneh et al. (2012) have reviewed the existing empirical models  
161 for testing APT.

162 Granger and Newbold (1974) discovered that there could be spuriously significant  
163 results between non-stationary and highly autocorrelated stationary time series. To avoid a  
164 potential spurious regression, tests have been developed to identify non-stationarity and  
165 models to account for co-integration between time series i.e. the time series variables share  
166 similar stochastic trends and they never diverge too far from each other. Granger and Lee  
167 (1989) proposed a modeling for estimating asymmetric price transmission between co-  
168 integrated variables using an error correction model (ECM). Von Cramon-Taubadel and  
169 Loy (1996) suggested the empirical specification by splitting the explanatory variable into  
170 positive and negative components to allow for more complex dynamic effects. According  
171 to Frey and Manera (2005) some researchers also assume that the dependent variable  
172 depends on its own lags and on vector of explanatory variables, both contemporaneous and  
173 lagged. Thus, they applied an *Autoregressive Distributed Lag (ARDL)* model to incorporate  
174 asymmetries in price transmission by assuming that the explanatory variables have a  
175 different impact on dependent variable, according to whether it is increasing or decreasing.

176 In addition, vectors can be used instead of single equational specifications, i.e.  
177 multivariate extension of the uni-equational specification for estimating asymmetries in  
178 price transmission. The vector models such as *Vector Auto Regressive (VAR)* and *Vector*  
179 *Error Correction Model (VECM)* models are generalized from the standard single equation  
180 analysis of price asymmetries to system of equations to take account the potential

181 interdependencies among time series data and other exogenous variables. Some studies  
182 such as Conforti (2004), Acosta and Valdés (2014), and Ahn and Lee (2015) among others,  
183 also tested the causality direction of price influences and lag distribution for adjustment of  
184 price transmission in agricultural commodity prices in different market levels.

185 Evidence of asymmetries in price transmission has been detected in several previous  
186 studies including producer and wholesaler pork prices in Northern Germany (von Cramon-  
187 Taubadel, 1998); producer, wholesaler and retailer for several agricultural product prices  
188 across Africa, Latin America and Asia (Conforti, 2004); beef, chicken and eggs in US  
189 farm (Vavra & Goodwin, 2005); farm and retail milk prices in US (Capps & Sherwell,  
190 2005); pork and dairy products in EU (CEC, 2009); producer and wholesale milk prices in  
191 Panama (Acosta & Valdés, 2014); and shipping and terminal prices of fresh apples, table  
192 grapes and fresh peaches within Washington and California (Ahn & Lee, 2015).

### 193 **3. DATA**

194 Monthly wholesale and retail price time series of milled rice for the period January 2000  
195 to March 2016 in five local markets in the Philippines were obtained from the “Food and  
196 Agriculture Organization of the United Nations – Food Price Monitoring and Analysis  
197 (FAO – FPMA) Tool”. The price series in Philippines pesos per kilogram (PHP/kg) were  
198 obtained for five selected local rice markets in the Philippines, including Metro Manila,  
199 Cebu, Davao, Iloilo and South Cotabato, which are indicated in Figure 1.

200 [Figure 1 about here]

201 The series were deflated to the base year 2000 using the consumer price index (CPI) for  
202 the Philippines (Index Mundi, 2016). Table 1 provides a summary of statistics of wholesale  
203 and retail rice price series for the five selected market locations, where the wholesale and  
204 retail prices reached highest levels in ‘Davao’ than other market locations with high  
205 standard deviations in both markets, wholesale and retail, implying a high price variation.  
206 In contrast, the standard deviations for both wholesale and retail market prices are smaller  
207 in ‘Metro Manila’ than other markets.

208 [Table 1 about here]

209 Figure 2 shows that wholesale and retail price series fluctuated during the period under  
210 analysis, and they reached a peak in all markets during 2008, which is related to the global  
211 financial crisis. Though Philippines is an eight largest rice producer, it is also a rice deficit  
212 country that imports around 10 percent of the rice consumption to meet its demand which  
213 makes it a single largest rice importer in the world (FAO, 2016; Philippines Ricepedia,  
214 2016). Being the largest rice importer, global rise in rice prices transmitted to the  
215 Philippines rice market and it caused high rice prices in domestic markets. After the peak  
216 value, the price series in all rice markets started to slightly decline. Figure 2 also  
217 demonstrates that the margin between wholesale and retail markets are comparatively  
218 higher in Metro Manila and Iloilo than the other three markets – Cebu, Davao and South  
219 Cotabato. This could be due the concretized relationship between large retailers and  
220 manufacturers in Metro Manila and Iloilo where manufacturers could deliver larger amount  
221 of product to the retailers’ own centralized warehouse (Dueñas-Caparas, 2005). The setup  
222 could help the retailer to internalize the wholesaling and transportation function into its  
223 own activities which could provide more market power to the retailers.

224 [Figure 2 about here]

#### 225 **4. ECONOMETRIC METHODS**

226 This research tests asymmetry in vertical price transmissions of milled rice, i.e.  
227 transmission of price shocks between wholesale and retail rice prices in different local  
228 markets to investigate the extent of impact of shocks at one market level (wholesale or  
229 retail) to the other market level (retail or wholesale). Before developing the appropriate  
230 empirical modeling for price transmission between price series, the characteristics of price  
231 series and the causal direction between them must be confirmed at first. Therefore, in this  
232 study the first step was to determine whether the price series have a unit root or not. The  
233 Augmented Dickey-Fuller (ADF) (1979) test is usually carried out for testing the  
234 stationarity characteristics of price series data (Dickey & Fuller 1979; Frey & Manera  
235 2005; Hill et al., 2012; Greb et al., 2012).

236 The reliability of unit root test is highly dependent on the inclusion of the intercept and  
237 time trend in the model equation. So, these terms are considered in the equation only if  
238 they appear significant in value. Sometimes ADF tests cannot capture the trend in time  
239 series data, therefore the Elliott, Rothenberg and Stock (ERS) (1996) and Ng-Perron (2001)  
240 tests were also performed to confirm the stationarity of time series price data. Rapach and  
241 Weber (2004) stated that ERS (1996) and Ng-Perron (2001) tests are more reliable because  
242 of its detrending data and size adjusted properties (Morales et al., 2017).

243 The tests found the price series do not contain unit root, so they are not cointegrated.  
244 The bivariate VAR model in matrix form, presented in equation (1), was used to determine

245 the optimal lag orders and Granger Causality to assess the possible direction of the price  
 246 transmission (Brooks 2014, p. 333; Ahn & Lee, 2015):

$$247 \quad (1) \quad \begin{bmatrix} P_{w,t} \\ P_{r,t} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \sum_{k=1}^n \begin{bmatrix} \beta_{11}(k) & \beta_{12}(k) \\ \beta_{21}(k) & \beta_{22}(k) \end{bmatrix} \begin{bmatrix} P_{w,t-k} \\ P_{r,t-k} \end{bmatrix} + \begin{bmatrix} \varepsilon_1(k) \\ \varepsilon_2(k) \end{bmatrix}$$

248 where  $P_{w,(t)}$  and  $P_{r,(t)}$  are rice price series at wholesale and retail levels, respectively,  $\beta_{ij}$   
 249 is the coefficient at  $k^{\text{th}}$  lag and  $\varepsilon_i(k)$  is a white noise residual with mean zero,  $k = 1, 2 \dots n$ ,  
 250 and ‘n’ is the optimal lags determined from equation (1). The optimal lag order is selected  
 251 based on the Schwartz Bayesian Information Criterion (SBIC), minimum value criteria.  
 252 *Granger causality* tests are performed based on the expressed individual equations from  
 253 equation (1), i.e.  $P_{w,t} = \alpha_1 + \sum_{k=1}^n \beta_{11}(k) P_{w,t-k} + \sum_{k=1}^n \beta_{12}(k) P_{r,t-k} + \varepsilon_1(k)$  and  
 254  $P_{r,t} = \alpha_2 + \sum_{k=1}^n \beta_{21}(k) P_{w,t-k} + \sum_{k=1}^n \beta_{22}(k) P_{r,t-k} + \varepsilon_2(k)$ , where the lags are  
 255 specified using the findings on optimal lags. Therefore, to determine the causal direction  
 256 between variables, all cross-lag coefficients or coefficient matrix,  $M = \begin{bmatrix} \beta_{11}(k) & \beta_{12}(k) \\ \beta_{21}(k) & \beta_{22}(k) \end{bmatrix}$   
 257 where  $k = 1, 2 \dots n$ , can be tested by Wald Statistics. From this Granger causality tests, we  
 258 can get four possible causal results between two price series  $P_{w,t}$  and  $P_{r,t}$ : i)  $P_{w,t}$  causes  
 259  $P_{r,t}$  but  $P_{r,t}$  does not cause  $P_{w,t}$ ; ii)  $P_{w,t}$  does not cause  $P_{r,t}$  but  $P_{r,t}$  causes  $P_{w,t}$ ; iii)  $P_{w,t}$   
 260 causes  $P_{r,t}$  and  $P_{r,t}$  also causes  $P_{w,t}$ ; and iv)  $P_{w,t}$  does not cause  $P_{r,t}$  and  $P_{r,t}$  also does not  
 261 cause  $P_{w,t}$ .

262 In this research the rice price series  $P_{w,t}$  and  $P_{r,t}$  are used for estimating asymmetries in  
 263 vertical price transmission between wholesale and retail levels in rice chains. The price  
 264 transmission analyses were conducted separately on five different local markets across the

265 Philippines. As the unit root tests identified the  $P_{r,t}$  and  $P_{w,t}$  are stationary, i.e.  $I(0)$ , in all  
 266 five markets, the Autoregressive Distributed Lag (ARDL) model with an  $n$  lag length  
 267 determined by Lag Order Choice based on SIC criteria, is applied for testing asymmetries  
 268 in price transmission between these price series. For model specification, we considered  
 269  $P_{r,t}$  depends on its own monthly lagged price and the current and monthly lagged of  $P_{w,t}$ ,  
 270 where the price series,  $P_{r,t}$  and  $P_{w,t}$ , are  $I(0)$ , and the ARDL model can be represented as:

$$271 \quad (2) \quad P_{r,t} = \alpha + \sum_{i=1}^n \beta_i^+ P_{r,t-i}^+ + \sum_{i=1}^n \beta_i^- P_{r,t-i}^- + \sum_{i=0}^n \gamma_i^+ P_{w,t-i}^+ + \sum_{i=0}^n \gamma_i^- P_{w,t-i}^- + e_t$$

$$272 \quad \text{where } P_{r,t} = \begin{cases} P_{r,t}^+ & \text{if } \Delta P_{r,t-1} \geq 0 \\ P_{r,t}^- & \text{Otherwise} \end{cases}, P_{w,t} = \begin{cases} P_{w,t}^+ & \text{if } \Delta P_{w,t-1} \geq 0 \\ P_{w,t}^- & \text{Otherwise} \end{cases}.$$

273 The tests of asymmetric price transmission are based on the parameter estimates,  
 274  $\beta_i^+, \beta_i^-, \gamma_i^+$ , and  $\gamma_i^-$  in equation (2). For example, the hypothesis  $H_0: \gamma_0^+ = \gamma_0^-$  provides an  
 275 immediate test of asymmetry between contemporaneous prices,  $P_{r,t}$  and  $P_{w,t}$ . If these  
 276 coefficients are significantly different from each other, contemporaneous asymmetry  
 277 exists. Estimating the effects of  $P_{r,t}$  and  $P_{w,t}$  is simple at the current period because of only  
 278 one explanatory variable,  $P_{w,t}$  exists. However, the period moves into the future, the  
 279 effects of  $P_{w,t}$  becomes less clear because the term  $P_{w,t}$  entered as lagged terms in equation  
 280 (2) at the future period which can influences the future  $P_{r,t}$  directly as a lagged wholesale  
 281 prices as well as indirectly through lagged retail prices. Thus, for the comprehensive  
 282 analysis of price transmission, the dynamic multiplier approach requires which captures  
 283 both the direct effects of  $P_{w,t}$  and indirect effects that are realized through lagged retail  
 284 prices over the multiple periods (Ahn & Lee, 2015). So, tracing all these effects, if

285  $\sum_{i=0}^n \gamma_i^+$  and  $\sum_{i=0}^n \gamma_i^-$  are significantly different, asymmetry exists between two price  
 286 series in long run.

287 In addition to usual test of asymmetry, the present study extends the test of asymmetry  
 288 to dynamic multiplier effects by performing Impulse Response Functions (IRFs) to  
 289 construct the dynamic relationships between wholesale and retail prices over the multiple  
 290 periods in five local markets. The pattern of dynamic multiplier effects for each successive  
 291 period gives insight about how the retail price adjusts in response to the initial shock in the  
 292 wholesale price. Therefore, the comprehensive effect of initial shock can be obtained by  
 293 summing up the dynamic multiplier effect at each period. These complete effects on retail  
 294 price under the  $n$ th lag order can be expressed algebraically. For instance, the positive  
 295 shock of wholesale price ( $P_{w,t}$ ) under the  $n$ th lag order can be expressed as:

296 (3a)  $\hat{P}_{r,t} = (\gamma_0^+ P_{w,t}),$

297 (3b)  $\hat{P}_{r,t+1} = (\gamma_1^+ P_{w,t}) + (\beta_1 \hat{P}_{r,t}),$

298 (3c)  $\hat{P}_{r,t+2} = (\gamma_2^+ P_{w,t}) + (\beta_2 \hat{P}_{r,t} + \beta_1 \hat{P}_{r,t+1}),$

299 ..... ,

300 (3d)  $\hat{P}_{r,t+n} = (\gamma_n^+ P_{w,t}) + (\beta_n \hat{P}_{r,t} + \beta_{n-1} \hat{P}_{r,t+1} + \dots + \beta_1 \hat{P}_{r,t+n-1}).$

301 The structural vector autoregressive (SVAR) model represented in equation (4) is also  
 302 applied in this study to test the contemporaneous relationships between these price series  
 303 in markets, where bi-directional causality found:

304 (4)  $AP_t = \gamma + BP_{t-1} + e_t$

305 where,  $P_t$  is a vector of prices at time t,  $P_{t-1}$  is first month lag term of prices, A and B are  
306  $2 \times 2$  square matrices, and  $\gamma$  and  $e_t$  are  $2 \times 1$  column vector matrices.

307 The price transmission between the contemporaneous prices is estimated by imposing  
308 short-run restriction on the SVAR model equation (4) by creating matrix ‘A’ as lower-case  
309 matrix and matrix ‘B’ as diagonal matrix, i.e.  $A = \begin{pmatrix} 1 & 0 \\ \alpha_{21} & 1 \end{pmatrix}$ ,  $B = \begin{pmatrix} \beta_{11} & 0 \\ 0 & \beta_{22} \end{pmatrix}$ . If  
310 the coefficients of contemporaneous price series (lower case in matrix A) are found  
311 significant, contemporaneous effects are existed in price transmission between price series.  
312 If the diagonal coefficients in matrix B are found significant, we can say that its lag term  
313 is significant in price transmission.

## 314 **5. RESULTS AND DISCUSSIONS**

### 315 **Unit-Root Tests**

316 The results of the unit root tests reported in Table 2, indicate that for the wholesale price  
317 ( $P_{w,t}$ ) and retail price ( $P_{r,t}$ ) there is sufficient evidence to reject the null hypothesis of unit  
318 roots, i.e. non-stationarity. The ADF (1979) tests show the sign of stationary for wholesale  
319 prices in markets – Cebu, Davao, Iloilo and South Cotabato, and for retail prices in markets  
320 – Cebu, Davao and South Cotabato. In contrast, the ADF (1979) test results indicate that  
321 both wholesale and retail prices in Metro Manila and retail price in Iloilo are non-  
322 stationary. Furthermore, the stronger unit root tests such as ERS (1996) and Ng-Perron  
323 (2001) tests result show the evidence of stationarity for wholesale and retail price series in  
324 all local markets. Therefore, the wholesale and retail price series in all local markets are  
325 stationary, i.e. integrated order zero  $I(0)$ . This is a similar outcome to those reported by



326 Ahn and Lee (2015). So, this study used the price series data at level for the model  
327 specification to estimate price transmission. But these unit root test results contrast with  
328 those reported by von Cramon-Taubadel (1998), Conforti (2004), Vavra and Goodwin  
329 (2005), Capps and Sherwell (2005), and Acosta and Valdés (2013), who identified unit  
330 roots in price series of agro-food products, and their first differences were stationary.  
331 Consequently, they used price series in first differences for estimating price transmission.

332 [Table 2 about here]

### 333 **Lag Order Choice and Causality Tests**

334 The test results of optimum lag order choice presented in Table 3, were based on the VAR  
335 model equation (1) and the optimum lag orders were selected using the Schwartz  
336 Information Criteria (SIC) – minimum value criteria.

337 [Table 3 about here]

338 The optimum lag orders were found one lag order for Cebu and Iloilo, and two lag orders  
339 for the Metro Manila, Davao and South Cotabato which are used for Granger Causality  
340 tests between  $P_{r,t}$  and  $P_{w,t}$  in all local markets. The price transmission models include two  
341 lags, as it is the length that is recommended in most of locations. The Granger Causality  
342 tests results shown in Table 4 confirmed the presence of causality between wholesale and  
343 retail prices in all five markets. In market locations – Metro Manila, Cebu and Iloilo, the  
344 results showed wholesale rice price granger causes retail rice price at the 1% level, but  
345 retail rice price do not granger cause wholesale rice price, i.e. there is uni-directional  
346 granger causality in these markets. This observed causality direction is comparable to that

347 identified by Ahn and Lee (2015), i.e. the upstream prices Granger-cause downstream  
348 prices. The results also indicated that the retail price granger cause wholesale price at the  
349 1% and 5% level in Davao and South Cotabato, respectively. Therefore, there is bi-  
350 directional causality between wholesale and retail prices in these markets. The Granger-  
351 causalities identified in this study are significant which are different from those reported  
352 by Conforti (2004), who found inconclusive Granger-causality within domestic markets in  
353 several agricultural products such as for pork meat in Costa Rica, wheat and bovine meat  
354 in Egypt, maize in Ethiopia, sorghum, palm oil and cassava in Ghana, and rice in Turkey.

355 [Table 4 about here]

### 356 **Estimation Results of Price Transmission**

357 We specified an ARDL model equation to assess the asymmetric relationship between the  
358 wholesale and retail price series in the five local markets. The results of the Granger  
359 causality test indicate that in the setting of ARDL, the current retail price series ( $P_{r,t}$ ) is  
360 dependent variable and should be on the left-hand side. The estimation results of ARDL  
361 tests presented in Table 5, indicate that the current wholesale price ( $P_{w,t}$ ) and one-month  
362 lagged retail price ( $P_{r,t-1}$ ) have positive effects on the  $P_{r,t}$ , and their impact is significant  
363 at the 1% level in all local markets. This implies that changes in  $P_{w,t}$  and  $P_{r,t-1}$  caused  
364 changes in  $P_{r,t}$  in same direction. In contrast, the one- month lagged wholesale price  
365 ( $P_{w,t-1}$ ) has negative effect on the  $P_{r,t}$ , and the impact was also significant at the 1% level  
366 in locations – Metro Manila, Cebu and Davao, and significant at the 5% level in South  
367 Cotabato. This result suggests the  $P_{r,t}$  changes in opposite direction with  $P_{w,t-1}$  which  
368 implies that when wholesale price increase (decrease) caused the retail price decrease

369 (increase) after one month. The ARDL outputs also suggests that the two-month lagged  
370 retail price ( $P_{r,t-2}$ ) do not have significant impact on  $P_{r,t}$  in all local markets implying that  
371 when shock comes on current retail price, it does not make any changes on retail price after  
372 two-months. But the two-month lagged wholesale price ( $P_{w,t-2}$ ) has significant positive  
373 effect on  $P_{r,t}$  in the markets Cebu and Davao at the 5% level, which means that the retail  
374 price increase (decrease) after two-months of wholesale price increase (decrease).

375 [Table 5 about here]

376 The vertical price transmission estimation results demonstrate that there is evidence of  
377 *asymmetry* in price transmission between wholesale and retail prices in the short and long  
378 run at 5% significance level in the markets, Metro Manila and Davao. This outcome  
379 indicates that rice price shocks at wholesale level do not fully transmit to the retail level in  
380 the short and long run. In contrast, the results corroborate that there is *symmetry* in price  
381 transmission between wholesale and retail prices in Iloilo and South Cotabato in the short  
382 and long run at 5% significance level. In Cebu, the estimated results demonstrate that there  
383 is *asymmetric price transmission* in the short run between wholesale and retail prices, but  
384 it is *symmetric* in the long run at 5% significance level. The vertical price transmission  
385 results in the rice markets of Cebu, Iloilo and South Cotabato in the Philippines are different  
386 than the results obtained in previous studies where asymmetry in price transmission was  
387 found in number of agro-food products along supply chains, including von Cramon-  
388 Taubadel (1998) for pork prices in northern Germany, Vavra and Goodwin (2005) for U.S.  
389 beef, chicken and egg markets, Acosta and Valdés (2014) for milk prices in Panama, Ahn  
390 and Lee (2015) for fresh fruits in the Western United States.

391 In addition, the results of the Granger causality tests indicated that there is bi-directional  
392 causality between wholesale and retail prices in Davao and South Cotabato. Hence, we  
393 estimated the contemporaneous relationships between these price series in these two  
394 markets using the SVAR model equations (4) imposing short-run restrictions.

395 The SVAR estimated results showed in Table 6 indicate the lower coefficients in matrix  
396  $A^{-1}$  are statistically significant at 1% level in both locations, Davao and South Cotabato,  
397 implying that there are contemporaneous effects between wholesale and retail prices. This  
398 could be due to a reduced concentration of market power, which could be the consequence  
399 of more competitive conditions in these markets. The results also show the diagonal  
400 coefficients in matrix B are significant in 1% level, which implies both price series depend  
401 on its own first month lagged terms in both markets.

402 [Table 6 about here]

### 403 **Dynamic Multiplier Effects**

404 Based on the expressions (3a) – (3d) the dynamic multiplier effects and parameter estimates  
405 presented in table 5, we derive the responses of the retail prices to positive and negative  
406 impulses on the wholesale prices. We use the absolute value of one standard deviation  
407 (S.D.) as a magnitude of initial shocks of wholesale prices to represent a typical change in  
408 monthly wholesale price. The positive and negative shocks are prescribed simply by taking  
409 positive and negative change values of these price series.

410 [Figure 3 about here]

411 Figure 3 presents the resulting dynamic multiplier effects of retail prices and the lines  
412 corresponds to the retail price responses to the positive and negative shocks, equivalent to  
413 one S.D., in wholesale price. IRFs presented in figure 3 shows responses of retail prices in  
414 all five markets seems similar in terms of magnitude and duration in price transmission.  
415 First, IRFs demonstrate the impacts to retail price in second month due to shocks in  
416 wholesale price in all five markets; the dynamic multiplier effect and the duration of the  
417 full adjustment are long in all markets. Second, the response and the price transmission  
418 effect tend to be most intense after several months and its tend to be tamper with time.  
419 Third, the dynamic multiplier effect to retail price becomes strong in second and third  
420 months due to negative and positive changes on wholesale price respectively in South  
421 Cotabato, and the adjustment process is faster in South Cotabato than other four markets.  
422 Fourth, the adjustment process extends over many periods till 21<sup>st</sup> month for negative  
423 change and 36<sup>th</sup> month for positive change in South Cotabato but it spreads over more than  
424 48 months for both negative and positive changes in Metro Manila, Cebu, Davao and Iloilo.

## 425 **6. CONCLUSION**

426 This study examines the asymmetry of price transmission between wholesale and retail  
427 monthly rice prices in five different markets in Philippines, Metro Manila, Cebu, Davao,  
428 Iloilo and South Cotabato. We tested the asymmetry by applying ARDL model and  
429 outlined the speed of adjustment of retail price response over multiperiod to a change in  
430 wholesale price that is differentiated by the direction of the change. This study also derived  
431 the dynamic multiplier effects of the retail price in response to the change in wholesale  
432 price based on IRFs.

433 The empirical results demonstrated asymmetry in price transmission between wholesale  
434 and retail prices in Metro Manila and Davao in long run, but the symmetric price  
435 transmission was found in Cebu, Iloilo and South Cotabato in long run. The price  
436 adjustment process was faster in South Cotabato than other markets, which took twenty-  
437 one months for full adjustment. But the IRFs showed the response for retail prices in Metro  
438 Manila, Cebu, Davao and Iloilo gradually tampered with time and it takes more than forty-  
439 eight months for full adjustment. Using monthly data enables us to find that the retail price  
440 response initiates almost immediately or at most one month later after the shock and that  
441 the full price adjustments tend to last a considerable time, more than forty-eight months  
442 except South Cotabato.

443 In this regard of price transmission, this study suggests that the different rice markets  
444 have distinct competitiveness in Philippines, and the policy makers require to pay close  
445 attention in designing mechanisms other than traditional transfer approaches from  
446 wholesale to retail level to increase the competitiveness in the rice markets in the supply  
447 chain. Therefore, it can reduce the food expenses to the all Filipinos and help to decrease  
448 a substantial number of poor peoples across the Philippines.

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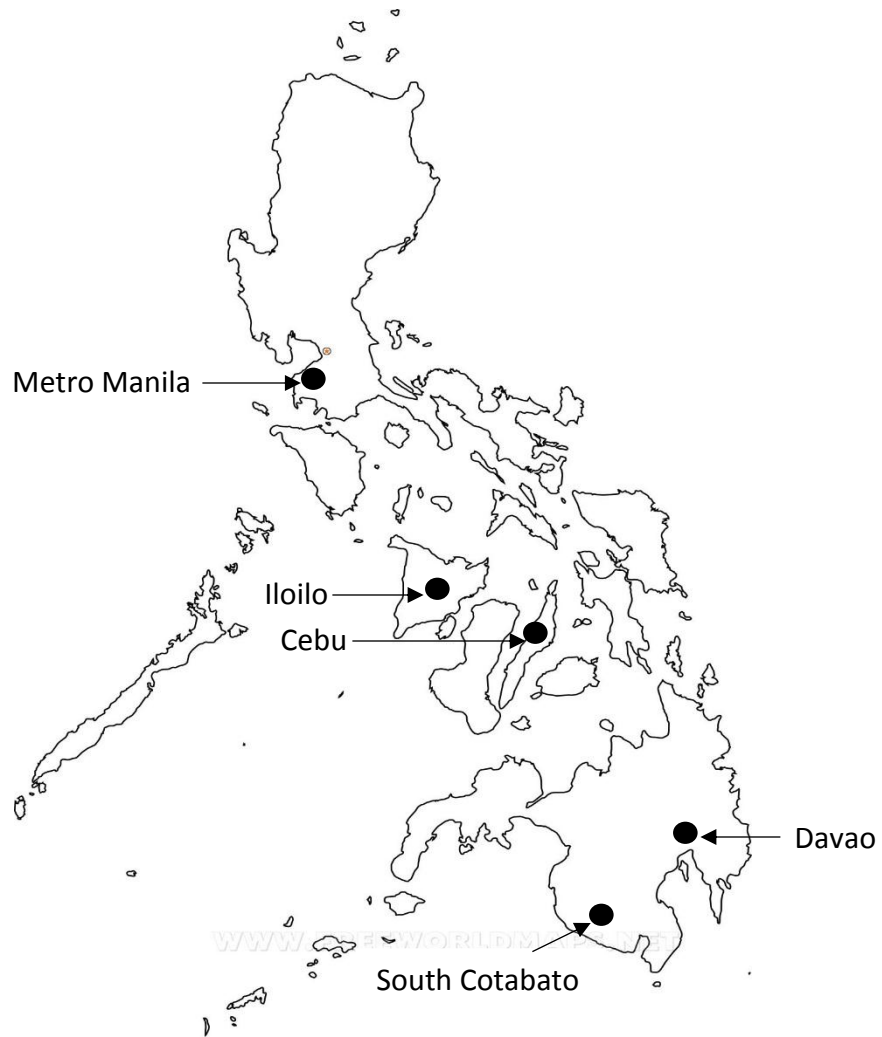
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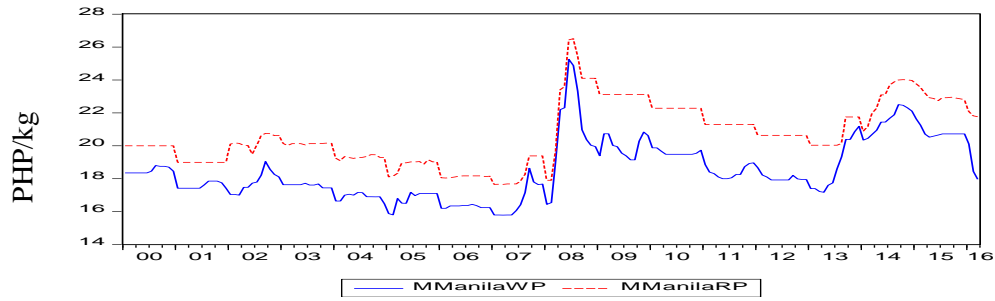
586 **FIGURE 1** Locations of selected rice markets in Philippines

587 Source: Google

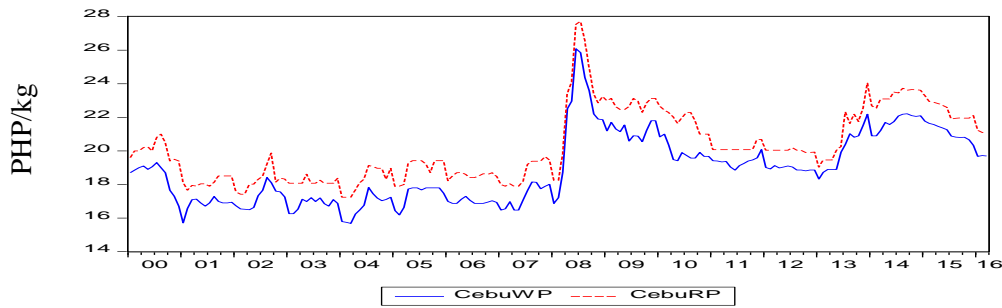
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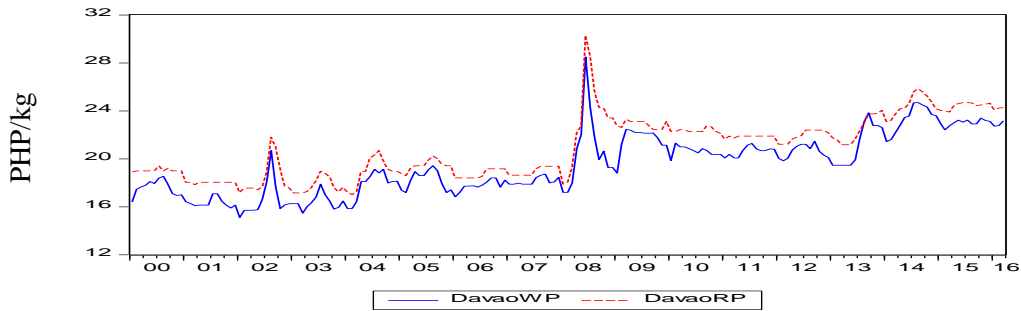
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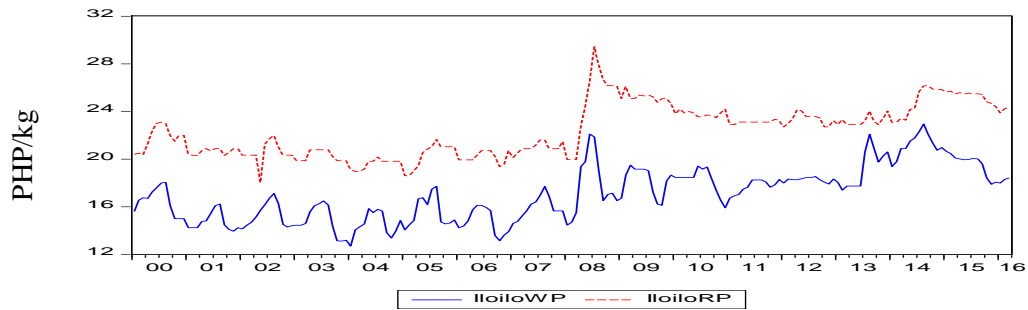
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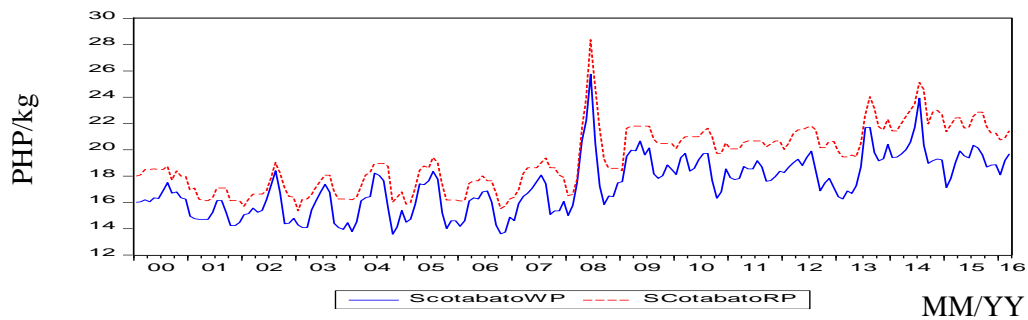
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596 **FIGURE 2** Wholesale (WP) and Retail (RP) monthly prices of milled rice in local  
 597 markets in the Philippines, measured ‘months’ in X-axis and ‘price (PHP/kg)’ in Y-axis.  
 598 Source: FAO – FPMA

599 **TABLE 1.** Descriptive statistics of wholesale/retail prices from January 2000 to March  
 600 2016 – Philippine pesos per kilogram (PHP/kg) in base year 2000.

601 Wholesale prices (WP) – (PHP/kg)						
602	Location	Mean	Median	SD	Min.	Max.
603	Metro Manila	18.52	18.05	1.80	15.78	25.25
604	Cebu	18.90	18.86	2.06	15.68	26.08
605	Davao	19.49	19.28	2.53	15.11	28.50
606	Iloilo	17.04	16.85	2.28	12.69	22.95
607	South Cotabato	17.30	17.33	2.13	13.58	25.75
608 Retail prices (RP) – (PHP/kg)						
609	Location	Mean	Median	SD.	Min.	Max.
610	Metro Manila	20.70	20.14	1.90	17.65	26.51
611	Cebu	20.27	19.93	2.12	17.24	27.71
612	Davao	20.87	21.02	2.57	17.02	30.29
613	Iloilo	22.38	22.70	2.20	18.02	29.43
614	South Cotabato	19.30	19.01	2.39	15.36	28.37

615 Source: FAO – FMPA

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623 **TABLE 2** Unit root test results of wholesale and retail rice prices in the Philippines

624	Variable	t-statistics		
625		ADF	ERS	Ng-Perron (MZt)
626	Metro Manila:			
627	Wholesale	- 1.79	- 3.07***	- 3.07***
628	Retail	- 2.34	- 2.21**	- 2.22**
629	Cebu:			
630	Wholesale	- 3.43*	- 2.85*	- 2.84*
631	Retail	- 3.30*	- 2.98**	- 2.95**
632	Davao:			
633	Wholesale	- 5.42***	- 4.74***	- 4.25***
634	Retail	- 4.60***	- 4.11***	- 4.02***
635	Iloilo:			
636	Wholesale	- 5.71***	- 5.11***	- 4.94***
637	Retail	- 2.96	- 2.93*	- 2.81*
638	South Cotabato:			
639	Wholesale	- 7.14***	- 6.72***	- 6.40***
640	Retail	- 6.45***	- 1.75	- 1.48

641 Null Hypothesis  $H_0$ : Series has unit root  $\rightarrow$  Non-Stationary.

642 ADF = Augmented Dickey-Fuller (1979); ERS = Elliott, Rothenberg, and Stock (1996); and Ng-Perron = Ng  
 643 and Perron (2001).

644 (\*\*\*) , (\*\*) and (\*) indicate statistical significant at the 1% , 5% and 10% level respectively.

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648 **TABLE 3** Lag order choice based on SIC – minimum value criteria

649	Location	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5
650	Metro Manila	2.1531	2.1451*	2.2307	2.2848	2.3626
651	Cebu	2.5320*	2.5369	2.6308	2.7305	2.8191
652	Davao	3.7643	3.7326*	3.8265	3.8968	3.9968
653	Iloilo	4.1945*	4.2034	4.2744	4.3262	4.3813
654	South Cotabato	4.1827	4.1636*	4.2684	4.3597	4.3525

655 \*Minimum value that determines the optimal Lag Order Choice.

656

657 **TABLE 4** VAR Granger Causality test results between wholesale and retail rice prices

658	Location	Causality	Chi <sup>2</sup> Test Statistics	d.f.	p-values
659	Metro Manila	H <sub>0</sub> : Wholesale do not cause Retail	13.88638***	2	0.0010
660		H <sub>0</sub> : Retail do not cause Wholesale	0.936402	2	0.6261
661	Cebu	H <sub>0</sub> : Wholesale do not cause Retail	29.59543***	1	0.0000
662		H <sub>0</sub> : Retail do not cause Wholesale	1.779629	1	0.1822
663	Davao	H <sub>0</sub> : Wholesale do not cause Retail	24.47100***	2	0.0000
664		H <sub>0</sub> : Retail do not cause Wholesale	12.78076***	2	0.0017
665	Iloilo	H <sub>0</sub> : Wholesale do not cause Retail	21.77164***	1	0.0000
666		H <sub>0</sub> : Retail do not cause Wholesale	1.091724	1	0.2961
667	South Cotabato	H <sub>0</sub> : Wholesale do not cause Retail	32.37150***	2	0.0000
668		H <sub>0</sub> : Retail do not cause Wholesale	7.612101**	2	0.0222

669 (\*\*\*), (\*\*) and (\*) indicate statistical significant at the 1%, 5% and 10% level respectively.

670 **TABLE 5** Estimation results for testing vertical price transmission in local markets in the Philippines

671			Metro Manila		Cebu		Davao		Iloilo		South Cotabato	
672	Regressor	Coefficient	Coeff. Est.	Std. Er.	Coeff. Est.	Std. Er.	Coeff. Est.	Std. Er.	Coeff. Est.	Std. Er.	Coeff. Est.	Std. Er.
673		$\alpha$	0.0107	0.2307	0.4084	0.2515	0.2842	0.2393	1.1837***	0.4338	-0.7522***	0.2772
674	$P_{r,t-1}^+$	$\beta_1^+$	0.8891***	0.0781	0.5190***	0.0790	0.9840***	0.0761	0.8776***	0.0828	0.6739***	0.0757
675	$P_{r,t-1}^-$	$\beta_1^-$	0.8891***	0.0790	0.5178***	0.0803	0.9854***	0.0769	0.8865***	0.0852	0.6796***	0.0770
676	$P_{r,t-2}^+$	$\beta_2^+$	-0.0507	0.0729	0.1362*	0.0836	-0.2131***	0.0750	-0.0728	0.0812	-0.0648	0.0657
677	$P_{r,t-2}^-$	$\beta_2^-$	-0.0502	0.0732	0.1395*	0.0837	-0.2121***	0.0746	-0.0664	0.0812	-0.0640	0.0653
678	$P_{w,t}^+$	$\gamma_0^+$	0.7759***	0.0444	0.8790***	0.0548	0.8242***	0.0381	0.3912***	0.0604	0.7136***	0.0404
679	$P_{w,t}^-$	$\gamma_0^-$	0.7833***	0.0459	0.8860***	0.0569	0.8386***	0.0402	0.3926***	0.0643	0.7204***	0.0442
680	$P_{w,t-1}^+$	$\gamma_1^+$	-0.6116***	0.0943	-0.2921***	0.1097	-0.6456***	0.0869	-0.1116	0.0963	-0.2026**	0.0797
681	$P_{w,t-1}^-$	$\gamma_1^-$	-0.6089***	0.0956	-0.2911***	0.1111	-0.6482***	0.0885	-0.1015	0.0986	-0.1989**	0.0815
682	$P_{w,t-2}^+$	$\gamma_2^+$	0.0111	0.0729	-0.2420**	0.0941	0.0460***	0.0722	-0.1041	0.0710	-0.0402	0.0646
683	$P_{w,t-2}^-$	$\gamma_2^-$	0.0142	0.0731	-0.2449**	0.0945	0.0475***	0.0728	-0.1012	0.0708	-0.0336	0.0651
684	Null Hypothesis		F- Stat.	Pr( F  > c)	F- Stat.	Pr( F  > c)	F- Stat.	Pr( F  > c)	F- Stat.	Pr( F  > c)	F- Stat.	Pr( F  > c)
685			(df)		(df)		(df)		(df)		(df)	
686	$\gamma_0^+ = \gamma_0^-$		6.5906	0.0111	4.3969	0.0374	16.2504	0.0001	0.0492	0.8246	1.6217	0.2045
687	$\sum_{i=0}^n \gamma_i^+ = \sum_{i=0}^n \gamma_i^-$		12.4591	0.0005	0.9018	0.3436	4.8975	0.0281	2.0945	0.1496	3.1117	0.0794
688			(1, 181)		(1, 181)		(1, 181)		(1, 181)		(1, 181)	

689 (\*\*\*), (\*\*) and (\*) indicate statistical significant at the 1%, 5% and 10% level respectively.

690 **Table 6. Coefficients Cholesky decomposition imposing short-run restrictions**

		Coefficients Matrix A <sup>-1</sup>		Coefficients Matrix B		
		Retail	Wholesale	Retail	Wholesale	
693	<b>Davao</b>	Retail	1.0000	0.0000	0.7467***	0.0000
694		Wholesale	0.9989***	1.0000	0.0000	0.4469***
695	<b>South</b>	Retail	1.0000	0.0000	0.8017***	0.0000
696	<b>Cotabato</b>	Wholesale	1.0835***	1.0000	0.0000	0.5179***

697 (\*\*\*), (\*\*) and (\*) indicate statistical significant at the 1%, 5% and 10% level respectively.

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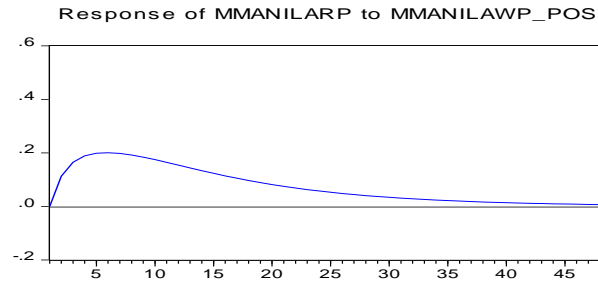
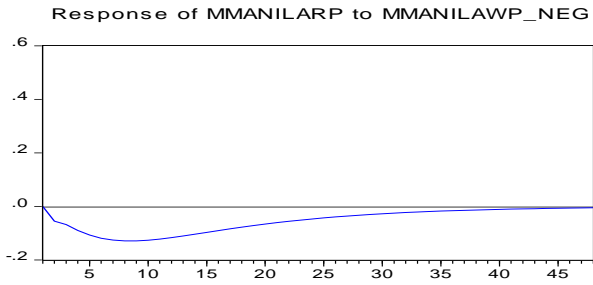
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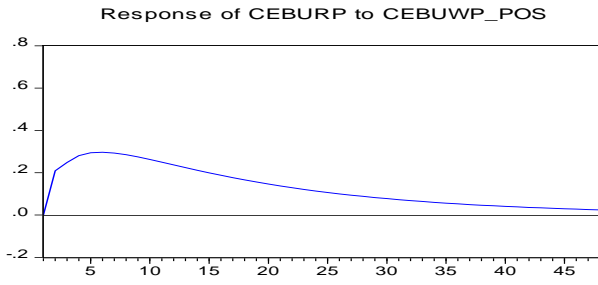
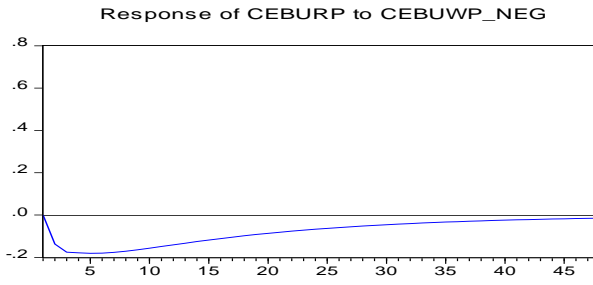
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### Response to Cholesky One S.D. Innovations

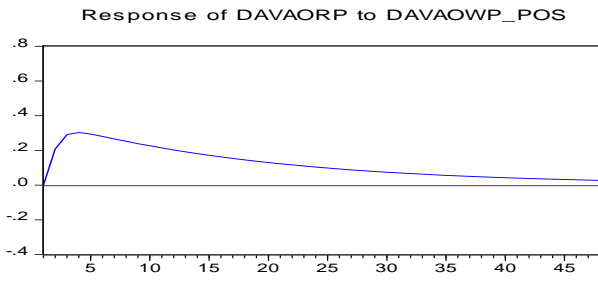
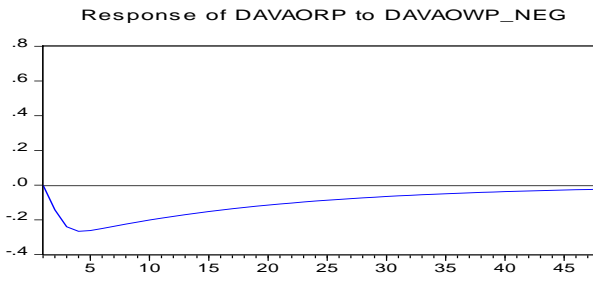
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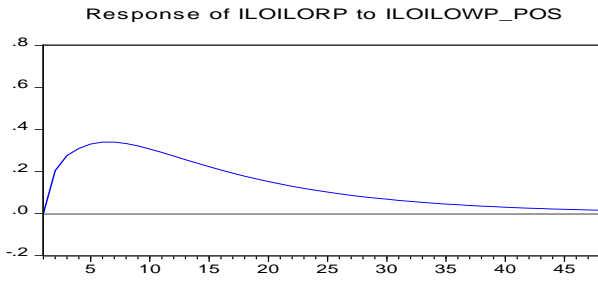
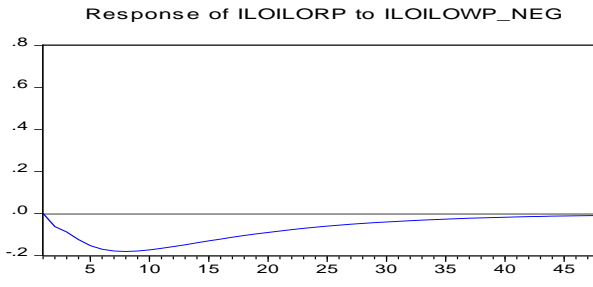
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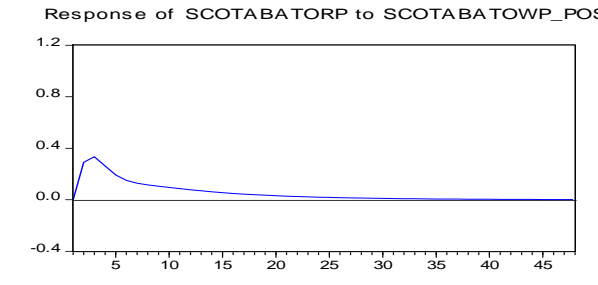
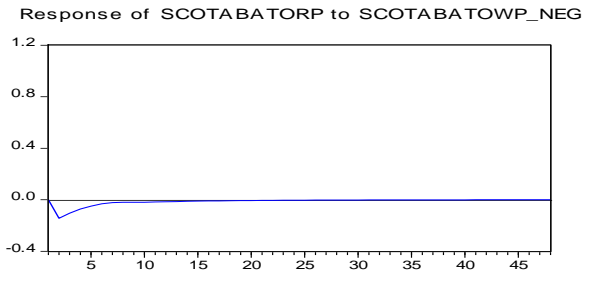
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721 **Figure 3** Responses of Retail Price to Positive and Negative Shocks in Wholesale Price by One Standard  
722 Deviation; measured 'month' in X-axis and 'price (PHP/kg)' in Y-axis.

723 Source: FAO – FPMA