Inefficiency in Agricultural Markets: Asymmetric Rice Price Transmission in Thailand

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Abstract

Farm output markets of developing countries are usually tied to foreign markets. Although Thailand is a major agricultural exporter of many farm commodities and products, Thai farmers have often encountered economic loss due to output price fluctuations. In the international trade domain, it is believed that farmers in exporting countries not only get no benefit from rising prices but also are in a disadvantageous position when prices decline. This paper has two objectives. First, we analyze the efficiency of markets by investigating the backward and forward transmissions of prices from export and from wholesale markets to and from the farm level. Second, we compare the market efficiency of price transmission in the situations of increasing and decreasing prices. This study utilizes the annual time series during 1983–2004 for rice exports and the farm price relationship and monthly data during 2001–2008 for domestic markets.

The findings from applying quantile regression models suggest that there is a need for investigating the asymmetry between positive and negative price changes and between backward and forward transmissions. The wholesale market of white rice ought to be monitored closely because it is significant for reaping benefits from both domestic price rises and falls from farmers and consumers.

Key Words: Price transmission, Quantile regression, Agricultural markets, Rice, Thailand

1. Introduction

Agriculture has constantly been vital in the overall national economic sector, despite its declining GDP share over the last three decades, from 20 per cent in 1980 to 10 per cent in 2008 (National Economic and Social Development Board, 2009) with the continuing growth of the industrial and service sectors. The persistency of its economic significance is attributable to its roles as the largest labour absorption sector, major raw material supplier to the domestic agro-industries, market outlet for manufactured products, and the way of life of the populace at large. Furthermore, agriculture has enabled Thailand to become a world-leading exporter of

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many food products and farm commodities including rice, sheet-rubber, poultry, sugar and cassava. As a consequence, Thai governments under various administrations have determined to promote the country as the “Kitchen of the World”. For the foreseeable future of Thai agriculture, it is the vision of the government “to transform Thailand to become a country with food and energy security, capacity to export high quality and high value agricultural commodities and food products as well as tourism services, and development status as a pleasant society.” (Wiboonpongse et al., 2009: 6.11)

Although Thailand has so far performed quite well in its agriculturally related affairs, according to the background introduced above, a detailed investigation disclosed certain alarming symptoms when the effort to build the “Kitchen of the World” was found to come, in part, from the cost burden of some 32.1–35.2 million farmers. Wiboonpongse, et al. (2009) found that, by participating more in the operation of the “Kitchen of the World”, farming households incurred greater average debt from 43,415 baht in the 2001/02 crop year to 67,762 baht in 2003/04, without a corresponding increase in productive assets. The deepening indebtedness was caused primarily by the realized product prices that left no profit margins for the farmers. Farmers protested several times against the state’s actions related to the problem commodities and pleaded for the government’s help. Similar actions are likely to occur in the near future with other farm products if the state cannot find solutions to the undesirable outcomes from the operation of existing price and market structures. The measures of various governments to deal with the problems due to low farm prices have been the minimum price and commodity loan programs. The latter program, in particular, has been applied to such major economic crops as rice and longan, but has never achieved the policy goals due to management difficulties. The present administration relies mainly on price guarantees to minimize the distortion from market mechanism effects.

Problems of severe farm price fluctuations can arise from uncontrollable demand and supply conditions that are due partly to farmers who plan without adequate information. Economists, thus, assign primary importance to the functioning of market mechanisms to transmit new information to both producers and buyers. There is evidence that the terminal market in the supply chain of farm commodity markets such as world rice exports is characterized as monopsonistic. Few buyers in market structures in the industrial sector may have less implications compared with the agricultural sector in which the monopsonistic or monopolistic effects can be felt at the level of producers along the supply chain up to the final consumers.
Efficiency of the marketing of agricultural products has always been an issue of interest on the presumption that middle agents are primarily responsible for any inefficient market practice and depressed farm prices in a country due to their market power. One way to prove the concentration of market power is by analysis of the efficiency of the market system addressing market integration and perfect price transmission among various sub-markets. Study of market integration is, therefore, useful for forecasting prices at different market levels; for example, for estimating the magnitude of the effect of urban market price movements on the rural market price patterns (Okoh and Egbon, 2002; Khang, Ndifon, and Odok, 2007).

Furthermore, an efficient market can help prevent problems in arbitrage trade from business losses. Knowledge about the state of integration in the domestic market can also help middle agents in their selection of markets by arbitrage measures to reduce business risk (Falsafian and Moghaddasi, 2008). Market integration is fundamental for economic growth by enabling efficient resource allocation (Khang, Ndifon, and Odok, 2007) and leading to specialization in production because of the principle of comparative advantage and, eventually, to production expansion, economies of scale, market competitiveness, and market efficiency.

**Rice Policy Measures**

Rice is of primary economic importance for Thailand as a staple food, major agricultural income source (66 per cent of farming households grow rice) and a predominant export item (40-45 per cent of domestic rice outputs are exported), Thailand being world number one exporter of rice since 1981. In the recent five years (2004–2008), Thai rice exports have been on a rising trend. However, problems in the Thai rice sector have increased over the more than 30 years of efforts by the state to assist farmers through intervention in the rice market. The overly high floor prices for the loan or rice mortgaging program since 2000, particularly in the 2004/5 crop year when the floor prices were 20-30 per cent above the market levels, have led to the problem of non-redemption of the collaterized rice (Agricultural Futures Exchange of Thailand, 2009). The accumulated problems in the quite lengthy time span have rendered the state a heavy burden to shoulder in terms of capital for running the rice mortgaging. Rice has been used as collateral in the loan program during 1986–1996 to reduce effective supply but this was not followed by increases in the market price because, at the same time, the traders delayed their purchase schedules (Sriboonchitta, 2000). The Siam Intelligence Unit (2009) cited that the Thailand Development Research Institute found that
about 40 per cent of the benefit of the rice collateral credit policy was received by farmers, especially those better-off cultivators in the irrigated areas. Among middle agents, the exporters enjoyed the highest benefit, being about 24 per cent, while rice millers and warehouse owners received about 14 and 4 per cent, respectively.

Although the rice mortgaging scheme is a government measure intended for dealing with rice price fluctuations and increasing farm incomes, it has been regarded as market price intervention and action to distort the market mechanism, so that farm prices do not reflect the actual functioning of the market. These policy actions are designed to ensure more reasonable prices for farmers. In international trade, the gap between the rice export price for Thailand and Vietnam in the last couple of years widened from US$10-20 to US$100-200 per ton. Furthermore, the compliance with the WTO agreements to open markets for free trade in rice in early 2010 will be a factor to cause Thailand to revise its rice market intervention measure because the high domestic price from the rice mortgaging program has invited enormous rice movements from its neighbouring countries. The Thai government had to increase its budget substantially to meet the demand for rice mortgaging.

The undesirable outcomes led to a major policy change when the cabinet passed a resolution in its meeting on 21 July 2009 to replace the rice mortgaging program with a price guarantee scheme as a rice price support measure which has been effective since November 2009 from the 2009/10 crop year onward. The underlying principles that the National Rice Policy Board has established to aid farmers by this price support measure are that farmers will be assured the minimum price or target price and they will be compensated for the difference between the market price and the target price when the former is lower. The crucial issue is to determine the appropriate and acceptable target price level, especially in the light of world price dynamics. The decision by the policy authority must be based on the right knowledge and understanding about price behaviour and its relationship in various markets to ensure the most efficient and effective price guarantee program. Along with the price guarantee scheme, the government encourages trading in agricultural futures exchange so as to promote competitive environment and efficient pricing signals.

To enable a better understanding of the price system, Figure 1 presents a diagram of marketing channels from the levels of local paddy (rice grain) procurers to rice millers, retailers and exporters. The two subsectors of paddy and rice markets are closely integrated. Local traders serve as assemblers as well as brokers (acting on behalf of millers). Prior to the rice mortgage scheme, both types of assemblers handle approximately 80% of paddy before delivery to rice mills. (Most rice millers are located in producing areas but large rice millers
usually operate on a regional scale while some rice milling businesses also export their rice products. The flow of paddy had changed substantially after implementation of the mortgage scheme. Figure 1 reveals the most recent picture of the paddy and rice marketing channels (only some statistics were available). In 2009, 33.7% was mortgaged to the Bank of Agriculture and Agricultural Cooperatives or BAAC (Department of Internal Trade, 2010). Most paddy then was stored by millers under contracts with the government. Before the new harvest, the government opened an auction for the stored paddy. Rice millers, exporters and large traders were involved in the auction for the paddy. Apparently, the final auction prices were far below desired levels. The prices were determined by prevailing market conditions and the traders’ price expectations. Once the mortgaged paddy was sold, it was milled mostly by large millers. In the milled rice subsystem, commission agents took an important role in matching supply from millers to wholesalers’ and exporters’ demand whereas the international brokers conducted the same function for exporters and overseas importers. At the final stage in the marketing system, 54% of the rice was stocked and consumed domestically, and 46% was for export. As can be seen from Figure 1, the rice marketing system in Thailand is quite complex, with the private sector having a key role in both export and domestic markets. The pricing system was inevitably influenced by export and wholesale markets, despite the price support measure and the presence of farmers’ organizations and government agencies.

Several methods of market integration and efficiency have been employed. For any pairs of markets, the popular method of cointegration (Engle and Granger, 1987) can be used to investigate the extent to which price shocks are transmitted from one spatial market to another or one vertical market to another. Subsequently, the error correction model is applied to measure the speed of adjustment of price changes. In the case of multi-markets, where the causal direction of effects is unknown, the vector error correction model, developed by Sims (1980) and Johansen and Juselius (1990), is more appropriate. More recently, researchers have applied new methods such as threshold autoregressive models and variants such as the exponential smoothing threshold autoregressive model (Enders and Granger, 1998). These new methods clearly identify the influences of transaction costs on spatial (or vertical) price linkages. The threshold autoregressive models take into account thresholds caused by transaction costs that result in non-linear patterns of price adjustment (Falsofian and Moghaddari, 2008). These non-linear patterns are caused by price differences being below or

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3 Moreover, the impulse response function, suggested by Enders (2004), can be applied to investigate effects of shocks in any variable.
above the transaction costs between any two markets which make arbitrage unprofitable or profitable, respectively. However, a limitation of the threshold autoregressive model is the assumption of constant transaction costs in proportional terms, which implies a fixed neutral band over the period of study (but may not be constant in the long run and may be nonstationary).

This paper has the objective to determine the degree of market integration for rice, the major economic crop of Thailand. We use the quantile regression technique and cointegration analysis of farm-gate and export prices (based on annual data) to understand the forward and backward linkages between the two different levels of the market and the asymmetry in forward and backward price transmissions. The price data are used in two forms, namely, the logarithm of price and the logarithm of the rate of price change. We study the asymmetry of prices at different levels (high, medium, or low) or when different price levels have different growth rates.

This study is concerned with determining the degree of transmission at the different price ranges and at different rates of price changes using quantile regression models, first introduced by Koenker and Bassett (1978). The quantile regression model allows variation of price transmission within a price range to be observed. According to Coad and Rao (2006), advantages of this model over least-squares regression are fourfold: (1) The quantile regression model does not require the assumption of normality of the error terms, and, hence, the quantile regression estimates are robust to outliers and heavy-tailed distributions; (2) The quantile regression estimates are invariant to outliers of the dependent variable tending toward $\pm \infty$ (Buchinsky, 1994, cited by Coad and Rao, 2006). Thus, a quantile regression model is able to describe the entire range of a dependent variable; (3) Individual quantiles contain valuable information and their comparison provides asymmetric behaviour of commodity markets from one extreme to the other; and (4) The quantile regression model does not require that the error terms be identically distributed. Thus, heterogeneity can be accounted for, so that the slope coefficients can vary at different quantiles.
Figure 1: Marketing System of Thai Rice in 2005

Local market

- Local trader
- Broker
- Paddy Central market
- Government agency
- Rice mill
- Farmers’ organization
- Farmers' or organization
- BAAC* 33.74%
- Auction
- Mortgage
- Farmer 100%

Regional – terminal market

- Government agency
- Wholesaler
- Retailer
- Consumer 3 54.03%
- Commission agent
- International broker
- Exporter
- Exporter 41.17%

Notes: (*) % mortgaged paddy to total production (in crop year 2008/09), G to G = government to government

Source: 1. Department of Internal Trade (2010)
2. Isawilanon (2009)
3. Department of Custom
4. Interview with traders
2. Data and Methodology

2.1 Data

This study uses multiple listing data. For farm and export prices in Bangkok, annual data are obtained from three sources, namely, the Office of Agricultural Economics, the Food and Agriculture Organization of the United Nations and the ASEAN Food Security Information System during 1983-2004. Monthly data are available for farm prices and wholesale prices during January 2001 to December 2008. The study chooses the longest time series available for each pair of markets. The ranges of the data are clearly indicated under the tables presented for the analysis below.

2.2 Empirical model

The quantile regression model used is outlined below.

Farm price is a random variable \( P \) with probability distribution function

\[
F(p) = \Pr(P \leq p). \tag{1}
\]

The \( \tau \)-th quantile of \( P \) (where \( 0 < \tau < 1 \)) is defined as the smallest \( p \) satisfying \( F(p) \geq \tau \):

\[
Q(\tau) = \inf \{ p : F(p) \geq \tau \}. \tag{2}
\]

Given a set of \( n \) observations on \( P \), the empirical distribution function is given by:

\[
F_n(p) = \frac{1}{n} \sum_{i=1}^{n} I(P_i \leq p) \tag{3}
\]

where \( I(z) \) is an indicator function that takes the value 1 if the argument \( z \) is true and 0 otherwise. The associated empirical quantile is given by:

\[
Q_n(\tau) = \inf \{ p : F_n(p) \geq \tau \}. \tag{4}
\]

As is well known in the literature, an equivalent form is the optimization problem:

\[
Q_n(\tau) = \arg\min_{\xi} \left\{ \sum_{i: P_i \geq \xi} \tau |P_i - \xi_i| + \sum_{i: P_i < \xi} (1 - \tau) |P_i - \xi_i| \right\} \tag{5}
\]

\[
= \arg\min_{\xi} \left\{ \sum_{i} \rho_i(P_i - \xi_i) \right\} \tag{6}
\]

where \( \rho_i(u) = u(\tau - I(u < 0)) \) is the so-called check function that weights positive and negative values asymmetrically.
For a multivariate model, and assuming a linear specification for the conditional quantile of the response variable, \( P \), given values of a vector of explanatory variables such as export price \((X)\), we have:

\[
Q(x|\beta(\tau)) = x'_i \beta(\tau)
\]  

(7)

where \( \beta(\tau) \) is the vector of coefficients associated with the \( \tau \)-th quantile.

Then the unconditional quantile minimization above yields the conditional quantile regression estimator:

\[
\hat{\beta}_n(\tau) = \arg \min_{\beta(\tau)} \left\{ \sum_i \rho(\tau) \left( P_i - x'_i \beta(\tau) \right) \right\}.
\]

(8)

The price transmission models for the original prices are as follows:

**Forward transmission:**  
\( \ln P_1 = \alpha_0 + \alpha_1 \ln P_2 + \epsilon_1 \)  
(9.1)

**Backward transmission:**  
\( \ln P_2 = \alpha_3 + \alpha_4 \ln P_1 + \epsilon_2 \)  
(9.2)

where \( P_1, P_2 \) are prices (e.g., baht/100 kg.) for upstream and downstream/terminal markets;  
for farm-export linkage: \( P_1 = \) farm price, and \( P_2 = \) export price; and  
for the domestic market: \( P_1 = \) farm price, and \( P_2 = \) wholesale price of products.

The models using the price ratios are:

**Forward transmission:**  
\( \ln r_1 = \beta_0 + \beta_1 \ln r_2 + \mid w_1 \)  
(10.1)

**Backward transmission:**  
\( \ln r_2 = \beta_3 + \beta_4 \ln r_1 + \mid w_2 \)  
(10.2)

where \( r_1 \) and \( r_2 \) are the price ratios, e.g., \( r_{1t} = \frac{P_1}{P_{1,t+1}} \).

Since models (9.1) and (9.2) use untransformed time-series data, the regressions may suffer from a spurious relationship. We take a step further to ensure that \( P_1 \) and \( P_2 \) cointegrate by applying the Augmented Dickey-Fuller (ADF) test to examine non-stationarity of the estimated residuals. The null hypothesis is that \( P_1, P_2 \) has a unit root and the MacKinnon (1996) one-sided p-value is used for the test procedure.

The models (9.1) to (10.2) are estimated using the conditional quantile regression estimator in equation (8). The standard errors of the coefficients are estimated using
bootstrapping (based on $P_1, P_2$). These standard errors are less sensitive to heteroscedasticity as compared with nonquantile methods.

3. Empirical Results

3.1 World/local market integration

We estimate quantiles at 0.15, 0.25, 0.75 and 0.95 to capture differences in the effect of changes in prices and (price ratios) under consideration. The basic statistics of the prices are presented in Appendix 1.

The empirical results for rice market associations are presented in Tables 1 and 2. Table 1 (A and B) reveal that the models for all quantiles are statistically significant at the 1% level, with high pseudo $R^2$-values (ranging from 0.499 to 0.613). The coefficients of transmission ($\beta$) in both sections (A and B) are highly significant at the 1% level (except for q.95 in Section A). This indicates that the farm price of paddy significantly relates to export price. The ADF tests for the residuals are highly significant, at least at probability 0.01, and so indicate that there is a long-term relationship for these prices in both the backward and forward models. At q.95, markets tend to have no long-term relationship when prices (of paddy or export rice) are very low and very high (q.15, q.95), as indicated by a higher probability of the MacKinnon and ADF tests. This is a very interesting finding showing that, in the normal situation, both farm and export markets tend to move closely together. The slope coefficients confirm this observation. As shown in Table 1, Section A at q.25 and q.75, a one per cent change in export price is estimated to bring about 0.95 per cent change in the farm price while at the extremes, q.15 and q.95, the changes are 0.87 per cent and 0.78 per cent, respectively. Surprisingly, the coefficients of price transmission do not statistically differ among quantiles (slope equality test using the Wald test). This means that, although the point estimates ($\beta$) are different, when their standard errors are taken into account, the differences are not significant (see Figures 2 and 3).

Similarly for the forward transmission, the results of the slope equality and symmetric quantile tests support the null hypothesis. The coefficient at the median can represent the degree of transmission of price changes from farm to export markets. The elasticity (0.81) is almost identical to that for the backward transmission.
Table 1: Backward and forward price transmission of paddy and export price (5% white rice) (1983-2004) (Annual data)

<table>
<thead>
<tr>
<th>Variable</th>
<th>0.15</th>
<th>0.25</th>
<th>0.50</th>
<th>0.75</th>
<th>0.95</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Backward transmission</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>constant</td>
<td>-0.078</td>
<td>-0.51</td>
<td>0.14</td>
<td>-0.33</td>
<td>0.67</td>
</tr>
<tr>
<td>Log of Export Price (PE)</td>
<td>0.87***</td>
<td>0.95***</td>
<td>0.85***</td>
<td>0.95***</td>
<td>0.78***</td>
</tr>
<tr>
<td>Standard errors</td>
<td>0.16</td>
<td>0.18</td>
<td>0.17</td>
<td>0.14</td>
<td>0.33</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.581</td>
<td>0.570</td>
<td>0.570</td>
<td>0.511</td>
<td>0.499</td>
</tr>
<tr>
<td>Prob (Quasi-LR statistic)</td>
<td>-</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>-</td>
</tr>
<tr>
<td>ADF test of residuals</td>
<td>-1.796*</td>
<td>-2.126**</td>
<td>-3.199***</td>
<td>-2.776***</td>
<td>-1.751*</td>
</tr>
<tr>
<td>Quantile slope equality test</td>
<td>0.558</td>
<td>0.763</td>
<td>1.360</td>
<td>0.476</td>
<td>0.703</td>
</tr>
<tr>
<td>Symmetric quantiles test</td>
<td>1.545</td>
<td>2.831</td>
<td>1.557</td>
<td>2.330</td>
<td>1.777</td>
</tr>
<tr>
<td>(B) Forward transmission</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>constant</td>
<td>1.36</td>
<td>0.86</td>
<td>1.63**</td>
<td>1.65***</td>
<td>0.98</td>
</tr>
<tr>
<td>Log of Farm Price (PF)</td>
<td>0.84***</td>
<td>0.95***</td>
<td>0.81***</td>
<td>0.82***</td>
<td>0.97***</td>
</tr>
<tr>
<td>Standard errors</td>
<td>0.16</td>
<td>0.15</td>
<td>0.14</td>
<td>0.14</td>
<td>0.15</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.542</td>
<td>0.553</td>
<td>0.563</td>
<td>0.565</td>
<td>0.613</td>
</tr>
<tr>
<td>Prob (Quasi-LR statistic)</td>
<td>-</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>-</td>
</tr>
<tr>
<td>ADF test of residuals</td>
<td>-1.876*</td>
<td>-2.808***</td>
<td>-2.820***</td>
<td>-2.158**</td>
<td>-1.226</td>
</tr>
<tr>
<td>Quantile slope equality test</td>
<td>1.644</td>
<td>1.528</td>
<td>2.154</td>
<td>1.755</td>
<td>1.601</td>
</tr>
<tr>
<td>Symmetric quantiles test</td>
<td>1.078</td>
<td>1.032</td>
<td>0.700</td>
<td>1.245</td>
<td>0.837</td>
</tr>
</tbody>
</table>

Note: ***, ** and * indicate statistically significant at the 1%, 5% and 10% levels, respectively.

The symmetric quantile tests that are used in EViews 6.1 perform tests for conditional symmetry. The tests indicate that the null hypothesis of symmetry cannot be rejected for all quantiles. This implies that the average value of two sets of coefficients (any pair of quantiles, e.g., 0.25 and 0.75) for symmetric quantiles around the median equals the value of the coefficient at the median. Thus, the coefficient at the median equals that of the mean. This suggests that there is no need for the use of quantile regression for investigation of the price association between farm and export markets given that the farm prices range from 438.40 baht/100 kg to 1,325.92 bath/100 kg (for the annual price series). The median elasticity of transmission is 0.85, indicating that 100% of the export price changes is estimated to induce 85 per cent change in the farm price.
**Figure 2:** Quantile regression estimates with 95% confident bounds for backward rice price transmission (export to farm)

**Figure 3:** Quantile regression estimates with 95% confident bounds for forward rice price transmission (farm to export)

The data in Table 2 are for the natural logarithms of price ratios for paddy and the export price (Appendix 2) and quantile regression analyses are performed in the same manner as described above. The results that are shown in Table 2, Sections A and B, depict backward and forward rate of change, respectively. Section A in Table 2 suggests that when the export price declines (at q.15 and q.25) changes are fully transmitted from the export market to the farm (the elasticities are 1.01 and 1.08, respectively). On the contrary, when the export price increases, only 83-87 per cent of the changes go to farmers. However, the test for the equality
of quantile slopes cannot be rejected, implying that there is symmetry in the price transmission between price increases and decreases (see Figures 4 and 5).

### Table 2: Backward and forward price transmission of paddy and export rate of change in price (5% white rice) (1984-2004) (Annual data)

<table>
<thead>
<tr>
<th>Variable</th>
<th>0.15</th>
<th>0.25</th>
<th>0.50</th>
<th>0.75</th>
<th>0.95</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(A) Backward transmission</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.119**</td>
<td>-0.082*</td>
<td>0.011</td>
<td>0.083†</td>
<td>0.18***</td>
</tr>
<tr>
<td>Log of Export Price Ratio (PE)</td>
<td>1.01***</td>
<td>1.08***</td>
<td>0.69**</td>
<td>0.88***</td>
<td>0.84***</td>
</tr>
<tr>
<td>Standard errors</td>
<td>0.34</td>
<td>0.34</td>
<td>0.29</td>
<td>0.28</td>
<td>0.25</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.264</td>
<td>0.264</td>
<td>0.331</td>
<td>0.315</td>
<td>0.538</td>
</tr>
<tr>
<td>Prob (Quasi-LR stat)</td>
<td>-</td>
<td>0.020</td>
<td>0.003</td>
<td>0.009</td>
<td>-</td>
</tr>
<tr>
<td>ADF test of residuals</td>
<td>-3.036***</td>
<td>-3.956***</td>
<td>-5.415***</td>
<td>-3.714***</td>
<td>-1.898*</td>
</tr>
<tr>
<td>Quantile slope equality test</td>
<td>0.374</td>
<td>0.453</td>
<td>1.828</td>
<td>0.393</td>
<td>0.356</td>
</tr>
<tr>
<td><strong>(B) Forward transmission</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.14***</td>
<td>-0.073*</td>
<td>0.019</td>
<td>0.050†</td>
<td>0.15***</td>
</tr>
<tr>
<td>Log of Farmer Price Ratio (PF)</td>
<td>0.72***</td>
<td>0.84***</td>
<td>0.63***</td>
<td>0.52***</td>
<td>0.57***</td>
</tr>
<tr>
<td>Standard errors</td>
<td>0.24</td>
<td>0.29</td>
<td>0.21</td>
<td>0.15</td>
<td>0.21</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.312</td>
<td>0.233</td>
<td>0.330</td>
<td>0.377</td>
<td>0.371</td>
</tr>
<tr>
<td>Prob (Quasi-LR stat)</td>
<td>-</td>
<td>0.028</td>
<td>0.004</td>
<td>0.002</td>
<td>-</td>
</tr>
<tr>
<td>Quantile slope equality test</td>
<td>1.014</td>
<td>1.178</td>
<td>1.472</td>
<td>1.281</td>
<td>1.212</td>
</tr>
<tr>
<td>Symmetric quantiles test</td>
<td>2.683</td>
<td>4.080</td>
<td>2.174</td>
<td>3.095</td>
<td>2.798</td>
</tr>
</tbody>
</table>

Note: ***, ** and * indicate statistically significant at the 1%, 5% and 10% levels, respectively.

Because Thailand is the largest rice exporter, it is expected that the changes in rice production would have an impact on prices of all market levels along the distribution channel. The export price may be influenced by the price occurring in the production area. In Section B of Table 2, the transmission seems much stronger when the farm price falls (q.15 and q.25) than when the farm price increases (q.75 and q.95).

In brief, the annual data reveal a long-term relationship between export and farm prices in both directions. The backward price transmission from the export market to the farm level is slightly higher than for the reverse direction. About 62-69 per cent of the price changes in one market result in changes at the other end. However, the rate of change in the export price induces almost the full rate of change in the farm price but this is not so for the reverse case.
Figure 4: Quantile regression estimates with 95% confident bounds for backward rice price transmission when export price falls and rises (export market to farm)

\[ \ln(P_{F_t} / P_{F_{t-1}}) = f(\ln(P_{E_t} / P_{E_{t-1}})) \]

Figure 5: Quantile regression estimates with 95% confident bounds for forward rice price transmission when the farm price falls and rises (farm to export market)

\[ \ln(P_{E_t} / P_{E_{t-1}}) = f(\ln(P_{F_t} / P_{F_{t-1}})) \]

3.2 Domestic market integration

To explore price relationships in the domestic market, we select the most common quality of rice (5% white) for the study. We investigate the farm-to-terminal market linkage of white rice and parboiled rice using the farm and wholesale prices of white rice and the wholesale price of parboiled rice. Parboiled rice is basically processed rice for export while about 60% of white rice is domestically consumed.

Table 3 summarizes the results of the quantile regression analysis at q.15, q.25, q.75, q.95 and at the median for each pair of prices to reveal backward and forward relationships.
The findings show that regression models of most quantiles are well fitted and the long-term relationships hold for the respective pairs.

**Table 3: Summary of elasticities of price transmission of rice domestic market (Monthly data)**

<table>
<thead>
<tr>
<th>Model/statistics</th>
<th>Section A: $\beta$ of $\ln \left( P_t \right)$</th>
<th>Section B: $\beta$ of $\frac{\ln (P_t)}{P_{t-1}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Backward (a)</td>
<td>Forward (b)</td>
</tr>
<tr>
<td>1. Farm-wholesale white</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- $\beta$ slope coefficient</td>
<td>0.94-0.98(0.96)(e)</td>
<td>0.89-1.01(0.99)(e)</td>
</tr>
<tr>
<td>- long-term relationship</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>- quantile slope equality</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>2. Farm-wholesale parboil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- $\beta$ slope coefficient</td>
<td>0.77-0.83(0.82)</td>
<td>1.14-1.25(1.12)</td>
</tr>
<tr>
<td>- long-term relationship</td>
<td>✓</td>
<td>✓ except q.95</td>
</tr>
<tr>
<td>- quantile slope equality</td>
<td>✓ except q.75</td>
<td>Reject</td>
</tr>
<tr>
<td>3. Wholesale white-parboil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- $\beta$ slope coefficient</td>
<td>0.78-0.86(0.74)</td>
<td>1.02-1.25(1.16)</td>
</tr>
<tr>
<td>- long-term relationship</td>
<td>✓ except q.95</td>
<td>✓</td>
</tr>
<tr>
<td>- quantile slope equality</td>
<td>✓</td>
<td>Reject</td>
</tr>
</tbody>
</table>

**Note:**
(a) Backward transmission, e.g., in Model 1, refers to farm price being the dependent variable.
(b) Forward transmission, e.g., in Model 1, refers to wholesale white rice being the dependent variable.
(c) Range of slope coefficients; all slope coefficients are significant at least at the 5% level except when indicated as 0.00.
(d) Regression models of those $\beta$s=0 are statistically insignificant (quasi-LR test)
(e) Figures in parenthesis are slope coefficients at the median, q.50.

As for the farm and the wholesale white rice (Model 1), Section A reports the coefficients of the natural logarithm of price transmission in backward and forward directions. In Section B, the coefficients of the natural logarithm of the price ratio are reported for both directions of the linkage. The coefficients in Section A indicate that, at all quantiles, the elasticities of backward price transmission are close to 1.00 (i.e., the range is 0.94 to 0.98) as well as for the forward transmission from the farm price to the wholesale price. A long-term relationship of these two price series exists.

Section B presents the effects of price decreases versus price increases. For the backward transmission (from the white rice wholesale market to the farm level), the coefficients range from 0.41 (when price falls) to 0.85 (when price rises). Despite this wide range, the Wald test shows that the null hypothesis of slope equality cannot be rejected. Therefore, we suggest that the coefficient at q.50 (the median) is 0.53 to represent the degree of backward transmission. The results of the quantile regressions are different for the forward relationship. When the farm price falls, the decline is not transferred to the wholesale market but the transfer is as high as 114 per cent of the farm price increase. This is confirmed by the test for a long-term relationship which holds true only for the price increases (q.75, q.95). This particular finding suggests that considering the price changes without the direction of the
change could result in a wrong conclusion. This result implies that during price falls in the production area, middle agents are able to maintain the prevailing price. In the reverse situation, when the price increases, even more than 100 per cent of the rise is for the farm price.

We note that elasticities of backward transmission (Section A of Model 2) from the wholesale parboiled market to the local farm market are less than those from the wholesale white rice market to the local market but the results are the opposite for forward transmission. The relationship between the wholesale markets of white and parboiled rice (Model 3) characterizes the same pattern as in Model 2. When negative and positive shocks are considered separately, both Models 2 and 3 suggest backward price transmissions of reductions in the price in the parboiled market do not affect the wholesale price. On the contrary, the wholesalers react positively to an increase in the price in the parboiled market.

It is clear that the wholesale market of white rice has significant power in the domestic market such that wholesalers can take advantage of the price fluctuations occurring in both the parboiled rice market (Model 3 B(1)) and the local farm market (Model 1 B(2)).

4. Conclusions

The quantile regression technique is applied in this study to evaluate the differences in the degree of price transmission at different levels (and ratios) of the price of rice as a dependent variable. The results suggest no advantage in estimating different quantile regressions when analyzing annual data of export and farm prices for rice in Thailand. However, when monthly data are used in the analysis of domestic market associations, this technique strongly indicates that there are cases where the null hypothesis of equality of slope coefficients is rejected. Evidently, asymmetry exists between backward and forward transmissions and between rises and falls in prices. The estimates of price transmission from earlier methods (e.g., cointegration and error correction methods) could be illusive.

The empirical findings convey the message that middle agents in the wholesale market hold strong market power. High prices could be passed on to consumers when farm prices increase, whereas the wholesale price of white rice could be maintained when prices in other markets (from upstream (farm) or downstream (parboiled rice wholesale)) decrease. When wholesalers can maintain and raise prices, it implies that consumers demand the product at these higher prices. Therefore, policy measures could be implemented to improve transmission of prices from wholesalers back to producers at the farm level. An active and effective market information network is recommended to provide all stakeholders with timely
and accurate information. Up to this time, the present government’s policy of a farm price guarantee has been appropriate because the market itself does not operate in an efficient fashion to equitably distribute benefits to farmers. Our findings suggest that the Thai government could take further action to monitor wholesalers’ marketing conduct and to prevent over charging of the wholesale price.

While it is generally believed that middle agents do not upset consumers by using a stabilizing price strategy to change the price charged to consumers, these maintained prices stay relatively high. Margins accrued could have been passed on to restore incentives to farmers. Without knowing marketing costs, the degree of price transmission could clearly signal the need for enhancing the market or competitive environment. The government should continue to encourage millers, wholesalers and exporters, as well as farmers’ cooperatives, to actively participate in futures trading such that they could take advantage of market and price information.

For future study, the analysis of market price associations could be extended to explore the forms of price change. Furthermore, the association between export and farm markets using monthly data needs to be re-examined. Furthermore, export, wholesale, and retail markets (and spot and futures markets) could be explored for further information on rice price associations in Thailand.

References


EViews 6 *Econometric Software Package*, Quantitative Micro Software, LLC.


### Appendix 1: Descriptive statistics of data

<table>
<thead>
<tr>
<th>Paddy/ product price</th>
<th>Mean</th>
<th>S.D.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm price of paddy (5% white rice)$^a$</td>
<td>6330.4</td>
<td>1957.2</td>
<td>4384.04</td>
<td>13259.15</td>
</tr>
<tr>
<td>Wholesale price (5% white rice)$^a$</td>
<td>1209.6</td>
<td>391.1</td>
<td>855.00</td>
<td>2794.61</td>
</tr>
<tr>
<td>Wholesale price of parboiled rice$^a$</td>
<td>1043.8</td>
<td>413.0</td>
<td>662.36</td>
<td>2707.50</td>
</tr>
<tr>
<td>Export price$^b$ (annual)</td>
<td>275.4</td>
<td>56.0</td>
<td>188.00</td>
<td>407.00</td>
</tr>
<tr>
<td>Farm price$^c$ (annual)</td>
<td>138.5</td>
<td>28.5</td>
<td>89.38</td>
<td>204.34</td>
</tr>
</tbody>
</table>

**Source:**
- a Office of Agricultural Economics, Bangkok.
- b Food and Agriculture Organization of the United Nations.
- c ASEAN Food Security Information System.

**Notes:**
Appendix 2: Logarithm of ratio of price changes

(A) Annual farm price

(B) Annual export price