The Impact of Foot and Mouth Disease on the Meat Prices in Malaysia

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Abstract. This paper examines the impact of foot and mouth disease (FMD) outbreaks on meat prices in Malaysia (i.e., at wholesale and retail of beef, imported mutton and mutton) from January 2000 to December 2015. The data were analyzed using time series methods (i.e. unit root test and error correction model). The results demonstrate that frequent FMD outbreaks have significant impacts on meat prices in Malaysia. Most of the drops in prices occurred within a short period of time. Due to FMD outbreaks, several meat price margins took a long time to recover, while some price margins improved quickly. This may occur due to the FMD reduces the amount of meat that an animal can produce, and animals affected by this disease require some time to recover. High demand with low supply will consequently cause an increase in the price of meat.

1. Introduction
Foot and mouth disease (FMD) are not a zoonotic disease and not related to the hand, foot and mouth disease (HFMD). The FMD only exist in cloven-hoofed animals (e.g. cattle, sheep, goats, deer, buffalos, and pigs) and caused by the Aphthovirus from Picornaviridae' family. The FMD virus takes typically 14 days to form and the symptoms detected through the fever and blister on mouth and hoof, lips, mammary glands, drooling and lameness. In general, the affected animals may not die but they suffer from depression, inappetence, weakness, and they may be unable to produce meat and milk consistently as they did before.

As discussed by McKenzie and Thomsen [1] and Paarlberg et al. [2] consumer fears are the main factors which affect the prices. Consumer fear may arise from meat recalls [3,1,4] and dissemination of news [5] in the market. On the other hand, consumer fears also depends on the types of animal disease and the level of awareness of consumer [5]. If the consumer understands the risk of animal disease to human health, it reduces the impact on the prices.

On the other hand, the impact of animal disease on meat prices varies according to the type and the magnitude of the illness [6,7]. The size of the impact is highest at the farm level compared to wholesale and retail levels. In one study, Lloyd et al. [8] found that the price of beef at the farm level dropped approximately twice as much as the retail price did—drops of 3% and 1.70% per kg,
respectively. In addition, Saghaian [9] reported two and threefold declines in the farm (21%) and wholesale (16%) prices of meat compared to the decrease in the retail price (6%). Nonetheless, these prices recovered and stabilized more quickly than the farm price did.

Furthermore, the impact of animal disease on the price of meat can last for an extended period of time. Park et al. [10] revealed that the market price took 16 months to fully recover after an FMD outbreak and 13 months after avian influenza or BSE outbreak. Moreover, Costa et al. [11] found that the price of meat at the farm level only recovered after the removal of an export ban by importing countries. In this research, we aimed to examine the impact of FMD on the retail and wholesale prices of different types of meat in Malaysia (i.e., beef, imported mutton and mutton).

2. Materials and Methods

2.1 Sources of Data

The data used consist of monthly meat prices (i.e. at wholesale and retail prices of beef, imported mutton and mutton) and number of FMD cases in Malaysia from January 2000 to December 2015. The meat prices data were obtained from the Federal Agricultural Marketing Authority (FAMA), while the FMD case data were collected from the Southeast Asia Foot and Mouth Disease (SEAFMD) database.

2.2 Data Analysis

This study adopted the econometric approach introduced by Abao et al. [12] and Park et al. [10] (for more details regarding the methods, please refer to the studies). Error correction model (ECM) method was applied, while, unit root tests were conducted for a stationary reason. As point out by Park et al. [10], ECM allows researcher to compare the actual price that is affected by animal disease and the forecasted price that uses only information before occurrence of the animal disease outbreak. The comparison will quantify the impacts on meat prices, as well as price margins. The ECM was conducted using the data from January 2000 to January 2004, while the sample forecasting was based on the data from February 2004 to December 2015 (i.e., 143 months after an FMD outbreak). To denotes the months with and without FMD outbreak a set of dummy variables (0 for months without FMD outbreaks and 1 for months with outbreaks) was used.

The forecast was needed to determine what the prices in the Malaysia would be without FMD outbreaks. Deflated January 2000 - January 2004 prices were then compared with forecasted February 2004 – December 2015 prices. The percentage changes of actual prices relative to forecast prices were calculated using Equation (1)

$$\Delta P_{ij} = \frac{A_{ij}}{F_{ij}} \times 100$$

(1)

where $\Delta P$ represents the price change, $A_{ij}$ denotes the actual price over $l$ and $j$, $F_{ij}$ refers to the forecast price over $l$ and $j$, $i$ is meat type, and $j$ indicates wholesale ($j = w$) and retail ($j = r$) prices. The changes in the profit margin from wholesale to retail were calculated using Equation (2)

$$PM_{iwr} = (A_{iw} - A_{ir}) - (F_{iw} - F_{ir})$$

(2)

where $PM_{iwr}$ refers to the wholesale-to-retail price margin change for each meat type, $A$ represents actual price, $F$ denotes forecasted price, and $i$ is meat type. The FMD outbreak widened the price margin at level $l$ relative to level if $PM_{i,lm} > 0$, had no effect on the price margin if $PM_{i,lm} = 0$, and narrowed the price margin if $PM_{i,lm} < 0$. The analysis was conducted using EViews 10.

3. Results and Discussion

Table 1 and 2 display the results for stationary of monthly series of meat prices. At the level, the results indicate that all price series were not stationary. Nonetheless, after conducting the first-order difference, all price series were stationary at the 1% significant level for both Augmented Dickey-
Fuller (ADF) and Philip Perron (PP) tests. Therefore, the data were said to be integrated and forecasting was possible using the first differential price series.

**Table 1.** Tests for the stationarity of monthly series of meat prices at the level

| Meat price series | ADF Intercept and trend | Intercept and trend | PP Intercept and trend |
|-------------------|-------------------------|---------------------|------------------------|
| Beef              |                         |                     |                        |
| In Wholesale      | 1.21                    | -1.57               | 1.43                   | -1.67 |
| In Retail         | 1.46                    | -1.94               | 1.78                   | -1.85 |
| Imported mutton   |                         |                     |                        |
| In Wholesale      | 0.17                    | -3.02               | 0.26                   | -3.01 |
| In Retail         | -0.33                   | -2.10               | -0.33                  | -2.26 |
| Mutton            |                         |                     |                        |
| In Wholesale      | -0.26                   | -2.82               | -0.31                  | -3.14 |
| In Retail         | 0.05                    | -2.69               | 0.09                   | -2.73 |

**Table 2.** Tests for stationary of monthly series of meat prices at the first difference

| Meat price series | ADF Intercept and trend | Intercept and trend | PP Intercept and trend |
|-------------------|-------------------------|---------------------|------------------------|
| Beef              |                         |                     |                        |
| In Wholesale      | -17.51***               | -17.66***           | -17.94***              | -18.84*** |
| In Retail         | -15.24***               | -15.52***           | -15.28***              | -15.53*** |
| Imported mutton   |                         |                     |                        |
| In Wholesale      | -11.22***               | -11.23***           | -13.14***              | -13.15*** |
| In Retail         | -12.70***               | -12.66***           | -12.70***              | -12.67*** |
| Mutton            |                         |                     |                        |
| In Wholesale      | -18.60***               | -18.55***           | -19.53***              | -19.49*** |
| In Retail         | -15.03***               | -15.00***           | -15.00***              | -14.97*** |

Note: *** indicate 1% significance level.

Note that, in the lag selection, the lowest the value is the better the model. Table 3 summarizes the optimal lag length and the co-integration rank jointly by using three different approaches: the Schwarz information criterion (SIC), the Akaike information criterion (AIC), and the Hannan–Quinn information criterion (HQC). The results indicate that the lag length was at the same value when determined jointly. In this study, all results from the SIC, AIC, and HQC metrics suggested a level vector auto regression (VAR) with one lag.

The trace and max-eigen results reveal that the rejected null hypothesis is same between the approach with and without linear trend. As shown in Table 4 and 5, for the trace and max-eigen test with and without linear trend, the null hypotheses of \( r = 0 \), \( r \leq 1 \) are rejected while \( r \leq 2 \) are not rejected. By implication, for the trace and max-eigen test without linear trend, \( r = 0 \) and \( r \leq 1 \) are rejected at 1% significance level. While, for the trace and max-eigen test with linear trend, the null hypotheses of \( r = 0 \) is rejected at 1% significance level while \( r \leq 1 \) is rejected at 5% significance level. Therefore, we can conclude that \( r = 2 \).
Table 3. Determining the optimal lag length and the co-integration rank jointly

| Lag | Schwarz information criterion (SIC) | Akaike information criterion (AIC) | Hannan–Quinn information criterion (HQC) |
|-----|-----------------------------------|-----------------------------------|----------------------------------------|
| 0   | -21.35135                         | -21.50861                         | -21.44487                              |
| 1   | -35.44017*                        | -37.01269*                        | -36.37533*                             |
| 2   | -33.72028                         | -36.70808                         | -35.49709                              |
| 3   | -32.17835                         | -36.58141                         | -34.79679                              |
| 4   | -30.69320                         | -36.11535                         | -34.15329                              |
| 5   | -28.96361                         | -36.19722                         | -33.26535                              |
| 6   | -27.40830                         | -36.05718                         | -32.55168                              |
| 7   | -25.68807                         | -35.75221                         | -31.67309                              |
| 8   | -24.12959                         | -35.60901                         | -30.95625                              |

* indicates lag selection order by the criterion

Table 4. Trace and max-eigen test for ECM without linear trend

| Rank | Trace statistics | Critical value (5%) | Max-eigen statistic | Critical value (5%) |
|------|------------------|---------------------|---------------------|---------------------|
| r = 0| 235.9132***      | 197.3709            | 60.62891***         | 58.43354            |
| r = 1| 175.2843***      | 159.5297            | 52.30564***         | 52.36261            |
| r = 2| 122.9787         | 125.6154            | 43.77826            | 46.23142            |
| r = 3| 79.20043         | 95.75366            | 29.88157            | 40.07757            |
| r = 4| 49.31886         | 69.81889            | 18.33942            | 33.87687            |
| r = 5| 30.97944         | 47.85613            | 15.98124            | 27.58434            |
| r = 6| 14.99820         | 29.79707            | 11.45204            | 21.13162            |
| r = 7| 3.546164         | 15.49471            | 3.489476            | 14.26460            |
| r = 8| 0.056687         | 3.841466            | 0.056687            | 3.841466            |

Note: *, **, and *** indicate the 10%, 5%, and 1% significance levels, respectively.

Table 5. Trace and max-eigen test for ECM with linear trend

| Rank | Trace statistics | Critical value (5%) | Max-eigen statistic | Critical value (5%) |
|------|------------------|---------------------|---------------------|---------------------|
| r = 0| 258.3323***      | 228.2979            | 64.63742***         | 62.75215            |
| r = 1| 193.6949**       | 187.4701            | 55.01856**          | 56.70519            |
| r = 2| 138.6763         | 150.5585            | 44.54502            | 50.59985            |
| r = 3| 94.13128         | 117.7082            | 29.88494            | 44.49720            |
| r = 4| 64.24634         | 88.80380            | 18.53524            | 38.33101            |
| r = 5| 45.71110         | 63.87610            | 17.07944            | 32.11832            |
| r = 6| 28.63166         | 42.91525            | 14.16943            | 25.82321            |
| r = 7| 14.46223         | 25.87211            | 11.33629            | 19.38704            |
| r = 8| 3.125941         | 12.51798            | 3.125941            | 12.51798            |

Note: *, **, and *** indicate the 10%, 5%, and 1% significance levels, respectively.

3.1 Impact of FMD on Prices and Margins

Figure 1, 2 and 3 illustrates the percentage changes of the actual price relative to forecast prices for beef, imported mutton and mutton in response to the frequent FMD outbreaks in Malaysia, respectively. As illustrated in Figure 1 (beef - wholesale) and Figure 3 (mutton – wholesale) prices dropped severely at the early stages of FMD outbreaks and then slowly recovered. Nevertheless, the percentages of the price drop and the month differed for each type of meat. For example, the wholesale prices for beef, imported mutton, and mutton dropped in April 2004, followed by a drop in retail prices in September 2004 (imported mutton) and June 2004 (mutton). However, the beef retail
price was not affected. The percentages of price drop reached up to 1.59% (wholesale beef), 5.52% (wholesale imported mutton), 8.17% (retail imported mutton), 2.74% (wholesale mutton) and 0.19% (retail mutton).

Similar to the percentages of price drop, the recovery process also varied according to the price for each type of meat. For beef, the wholesale price recovered 26 months (in March 2006) after the FMD outbreak. Meanwhile, both the retail and wholesale mutton prices recovered at the same time (in September 2004, after eight months). In contrast to the beef and mutton imported mutton prices continued to fall after the FMD outbreak but with several interspersed recovery episodes. Occurrence of prices drop during the early stage of FMD may occur due to the over supply of meat as infected animal are slaughtered and their meat without bone are allowed to sell and eat in the same township [13].

Afterward, as a result of the shortage in domestic production of beef apart of the majority Malaysian population are Muslim and beef is main red meat used, consumer does not have a choice to consume red meat despite FMD occur. In fact, in 2004 the consumption per capita of large ruminant (beef and buffalo) are 5.81kg which increased 12.16% compare to 2003 [14]. As consequences, prices of meat increased.

**Figure 1.** Percentage change of the actual relative to the forecasted beef prices

**Figure 2.** Percentage change of the actual relative to the forecasted imported mutton prices
Figure 3. Percentage change of the actual relative to the forecasted mutton prices

Figure 4, 5 and 6 illustrates the changes in the profit margins of wholesale and retail prices for beef, imported mutton and mutton following the FMD outbreaks. The figure demonstrates that the profit margins for all types of meat took a while to respond to the initial FMD outbreak. Unfortunately, it took 24 and 76 months for the profit margins of beef and imported mutton, respectively, to recover. Meanwhile, it was observed that the profit margin of mutton rebounded after 120 months. This finding is supported by the work of Abao et al. [12], who reported that several meat price margins responded quickly, some took a long time, and some were not able to recover until the end of the period of study (e.g., pork profit margins).

Figure 4. Changes in price margin of beef from wholesale to retail
3.2 Policy Implication

All in all, FMD was found to have a negative impact on meat prices. Government and research bodies should take some initiatives to control, or better yet, curb this FMD outbreak. If the FMD hit the nation it may prohibited the farmers from selling and exporting their products into the market. Therefore, the producers lose the export market for the farm products [2]. As consequences, domestic supply increases and the price of meat drops due to the dumping of domestic products [11].

By evaluating the alternative control strategies, Garner and Lack [15] and Roche et al. [16] demonstrated that stamping-out, ring vaccination, and the slaughter of dangerous contact herds are some of the effective ways to eliminate FMD outbreaks, as opposed to controlling movement [17]. Therefore, due to this issues, eliminating FMD outbreaks is essential in the attempt to avoid crises such as those in the Philippines [12], Korea [10], and Brazil [11].

4. Conclusion

The results demonstrated that frequent FMD outbreaks in Malaysia significantly affected meat prices and profit margins of meat. Drops in prices occurred in the early stages of FMD outbreaks. Prices drop during the early stage of FMD may occurs due the the over supply of meat as infected animal are
slaughtered and their meat without bone are allowed to sell and eat in the same township [13]. However, high demand with low supply will consequently cause an increase in the price of meat. This may occur due to the FMD reduces the amount of meat that an animal can produce, and animals affected by this disease require some time to recover [18,19].

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