AJAE appendix for “Is Exchange Rate Pass-Through in Pork Meat Export Prices Constrained by the Supply of Live Hogs?"
Comparative static

Let $D^a$ and $D^b$ represent the slope of the demand function in markets $a$ and $b$ respectively. Equations (10), (11) and (12) in Gervais and Khraief (2007) can be rewritten in matrix form as:

$$
\begin{bmatrix}
2e^a D^a & 0 & -e^a D^a \\
0 & 2e^b D^b & -e^b D^b \\
e^a D^a & e^b D^b & 0 \\
\end{bmatrix}
\begin{bmatrix}
dp^a \\
dp^b \\
d\lambda \\
\end{bmatrix}
= 
\begin{bmatrix}
\lambda D^a - 2p^a - t^a & D^a & d^a \\
\lambda D^b - 2p^b - t^b & D^b & d^b \\
dQ^a - p^a D^a d^a - p^b D^b d^b \\
\end{bmatrix}
$$

Using Cramer’s rule, the marginal impact on the export price in country $a$ of a change in the exchange rate between the domestic and market $a$’s currencies is:

$$
\frac{dp^a}{de^a} = \frac{-2p^a e^a D^a + e^b D^b + e^b D^b \lambda + t^a}{2e^a e^a D^a + e^b D^b < 0}
$$

In contrast, the exchange rate pass-through effect defined in equation (9) of Gervais and Khraief (2007) in the case in which capacity constraints are not binding can be written as (under the assumption of a linear demand function, $D^{\sigma^a} = 0$):

$$
\frac{\partial p^a}{\partial e^a} = \frac{-2p^a - t^a - r^a}{2e^a} = -\frac{p^a}{e^a} + \frac{t^a + r^a}{2e^a} < 0
$$

In the simplest case in which the slope of the two demand functions are equal $D^a = D^b = D'$, (2) can be rewritten as:

$$
\frac{dp^a}{de^a} = -\frac{p^a}{e^a} + \frac{e^b \lambda + t^a}{2e^a + e^b} < 0
$$

The marginal pass-through effects in (3) and (4) are similar but the second term on the right hand-side of the equations illustrates the main differences. When hog production
has no impact on pricing decisions, the change in the export price following a change in
the exchange rate is function of the mark-up over marginal cost (measured by \( r^n \)) as
profit maximizing behaviour implies stabilization of the price in the importing country’s
currency. When there are capacity constraints, the price response is function of the degree
to which predetermined hog supplies are binding and of the relative value of the
currencies in both markets. It is thus difficult to generalize the comparison between the
exchange rate pass-through effects even in the simplest case in which the demand slopes
in each market are identical.

**Unit root testing**

The standard Augmented Dickey-Fuller (ADF) test is performed to assess the degree of
integration of the variables. The variables used in Gervais and Khraief (2007) are export
unit values (denoted by \( p_{j,m} \); \( j = QB, MB, ON \) and \( m = US, JP \)), the exchange rate
weighted by the food price index for each destination \( e^m; m = US, JP \), the hog price in
each province \( r_j; j = QC, MB, ON \) and total hogs slaughtered in each province
\( Q_j; j = QC, MB, ON \). The ADF test involves estimating the equation (Hamilton, 1994):

\[
\Delta y_t = \alpha + \beta t + \rho y_{t-1} + \sum_{j=1}^{k} \gamma_j \Delta y_{t-j} + \varepsilon_t; \quad t = 1, \ldots, T;
\]

where \( t \) is a time trend, \( T \) is the sample length and \( k \) measures the length of the lag in the
dependent variable. The selection of this parameter is carried out using Ng and Perron
(2001) modified Akaike Information Criterion (MAIC). The objective is to minimize:

\[
MAIC \quad k = \ln \hat{\sigma}_k^2 + \frac{2 k + \tau}{T - k_{max}}; \quad \text{where } \hat{\sigma}_k^2 \text{ is the variance estimator and } k_{max} \text{ is defined}
\]
as the maximum degree of augmentation in (5) and is set to 
\[ k_{\text{max}} = \text{int} \left( \frac{12 \ T}{100} \right)^{0.25} = 14 \] (Cook and Manning, 2004). Visual inspection of the series determines whether a time trend is included in (5) or if it is estimated with the restriction \( \beta = 0 \). The critical values of the ADF unit root tests are provided in McKinnon (1991).

Table 1 presents the ADF test results. Two variables out of the 14 variables used in the empirical analysis have a statistic that exceeds the critical value of the test at the 5% significance level. It is however notorious that unit root tests suffer from low power and tend to under-reject the null hypothesis of a unit root (Maddala and Kim, 1998). Hence, table 1 also reports the stationarity test of Kwiatkowski et al. (KPSS, 1992). The KPSS testing procedure differs from standard unit root tests since the null hypothesis is that of stationarity in the level of a series. The KPSS test involves estimating the equation:

\[ y_t = \delta t + \zeta_t + \epsilon_t; \quad \zeta_t = \zeta_{t-1} + u_t; \quad u_t \sim iid \ 0, \sigma_u^2 \]

(6) 

The null hypothesis of trend stationarity is about the validity of a zero restriction on \( \sigma_u^2 \). Testing the null of level stationarity instead of trend stationarity involves regressing the series on a constant instead of a trend variable. The KPSS test is computed using the Bartlett kernel to account for the potential correlation of the residuals with a bandwidth selected using the procedure suggested by KPSS; \( i.e. \ l = \text{trunc} \ 4 \ 0.01T^{0.25} \). The KPSS test rejects the null hypothesis of stationarity for 10 out of the 14 possible cases. There are conflicting results between the two tests in some instances; a conclusion that is not unusual for this type of Confirmatory Data Analysis (CDA). Ambiguity about the degree of integration in each variable exists for 6 of the 14 variables. Carrion-i-
Sylvestre, Sanso-i-Rossello and Ortuno (2001) tabulated different sets of critical values to account for the jointness in the distribution of the two test statistics under the CDA approach. Their procedure yields a more powerful unit root investigation than standard unit root testing. Their set of critical values resolves ambiguity for two variables. Hence the joint hypothesis of a unit root cannot be rejected for 10 of the 14 variables.

**Residual-Based Cointegration Tests**

It is important to test for pre-cointegration among the variables of each equation to avoid the well-known spurious regression problem (Maddala and Kim, 1998). The Phillips-Ouliaris $Z_r$ and $Z_α$ statistics (Hamilton, 1994) are computed to test the null hypothesis of no-cointegration using the residuals generated by the OLS estimation of equation (14) in Gervais and Khraief (2007). Table 2 presents the $Z_r$ and $Z_α$ test statistics for each equation of both systems. The critical values are reported below the table. Both tests strongly rejects the null hypothesis that there is a unit root in the residuals; thus rejecting the null hypothesis of no-cointegration.

**Bootstrap**

Because statistical inference in cointegrated systems can exhibit significant bias in small samples (Li and Maddala, 1997), we also investigated potential improvements in the statistical inference through bootstrap methods. The bootstrap procedure must account for the potential endogeneity of the regressors in the current context and the potential autocorrelation in the residuals. We followed the suggestion of Li and Maddala (1997) and implemented the stationary bootstrap of Politis and Romano (1994). Their idea is to sample blocks of residuals whose length is randomly selected using a geometric
distribution. Consider the system of ERPT equations for market $m$ and the associated random walks:

\[
p_{t}^{QC,m} = \alpha^{QC} + \beta^{QC,US} e_{t}^{US} + \beta^{QC,JP} e_{t}^{JP} + \lambda^{QC} Q_{t}^{QC} + \phi^{QC} r_{t}^{QC} + z_{t}^{QC}
\]

\[
p_{t}^{MB,m} = \alpha^{MB} + \beta^{MB,US} e_{t}^{US} + \beta^{MB,JP} e_{t}^{JP} + \lambda^{MB} Q_{t}^{MB} + \phi^{MB} r_{t}^{MB} + z_{t}^{MB}
\]

\[
p_{t}^{ON,m} = \alpha^{ON} + \beta^{ON,US} e_{t}^{US} + \beta^{ON,JP} e_{t}^{JP} + \lambda^{ON} Q_{t}^{ON} + \phi^{ON} r_{t}^{ON} + z_{t}^{ON}
\]

(7) \hspace{1cm} \Delta e_{t}^{US} = u_{t}^{US}, \ \Delta e_{t}^{JP} = u_{t}^{JP}, \ \Delta r_{t}^{k} = v_{t}^{k}, \ \Delta Q_{t}^{k} = w_{t}^{k}; \ \ k = QC, MB, ON

The strategy is to use the residuals of the MDE estimates of (7) to obtain $\hat{z}_{t}^{k}$. Using the definitions in (8), we can block-bootstrap from the set $\hat{V}_{t}^{m} = \{z_{t}^{QC}, z_{t}^{MB}, z_{t}^{ON}, u_{t}^{US}, u_{t}^{JP}, v_{t}^{k}, w_{t}^{k}\}$, $t = 1, \ldots, T$. This bootstrapping preserves the contemporaneous correlation between the different residuals due to the potential endogeneity of the regressors while also accounting for the autocorrelation in the residuals. Let $\tilde{V}_{t}^{m}$ be the first residual vector sampled from the set $\hat{V}_{t}^{m}$ such that $\tilde{V}_{1}^{m} = \hat{V}_{1}^{m}$. The second observation in the bootstrap sample will be the vector $\tilde{V}_{2}^{m} = \hat{V}_{t+1}^{m}$ with probability $1 - p$ or a vector drawn from the whole distribution of $\hat{V}_{t}^{m}$ with probability $p$; i.e. $\tilde{V}_{2}^{m} = \hat{V}_{t}^{m}$. Hence, the average block length is $1/p$, where the parameter $p$ is set at 0.1. Using the residuals of the bootstrap sample and the actual values of the right hand-side variables in (7), export price time series are constructed under the null hypothesis of interest (e.g., $\lambda^{QC} = 0$). The MDE estimates are computed and the test statistic of interest is stored in a vector. This procedure was repeated 2,000 times to obtain the empirical distribution of the test statistic. Table 3 reports the bootstrap $p$-values of the test statistics associated with the capacity constraint in the ERPT equations. The results are consistent with the inference based on asymptotic theory reported in tables 2.
and 3 in Gervais and Khraief (2007), except perhaps in the case of the coefficient $\lambda^{MB}$ in the Japanese export system. The $p$-value is larger than the asymptotic $p$-value which is lower than 0.05. Thus, the bootstrap inference yields greater evidence that hog capacity has no significant impact on export price decisions of Manitoba pork exporters. The bootstrap $p$-values of the joint tests do not modify the qualitative nature of the conclusions reached in Gervais and Khraief (2007).

References


Table 1. Unit Root and Stationarity Tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>Deterministic specification</th>
<th>ADF</th>
<th>KPSS</th>
<th>Joint confirmation of a unit root at the 5% significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e_{US}$</td>
<td>T</td>
<td>1</td>
<td>-1.84</td>
<td>0.14</td>
</tr>
<tr>
<td>$e_{JP}$</td>
<td>T</td>
<td>2</td>
<td>-4.22</td>
<td>0.31</td>
</tr>
<tr>
<td>$Q^{QC}$</td>
<td>T</td>
<td>14</td>
<td>-3.41</td>
<td>0.60</td>
</tr>
<tr>
<td>$Q^{MB}$</td>
<td>T</td>
<td>11</td>
<td>-1.51</td>
<td>0.73</td>
</tr>
<tr>
<td>$Q^{ON}$</td>
<td>T</td>
<td>12</td>
<td>-1.77</td>
<td>0.37</td>
</tr>
<tr>
<td>$p_{QC,US}$</td>
<td>NT</td>
<td>2</td>
<td>-1.80</td>
<td>2.10</td>
</tr>
<tr>
<td>$p_{MB,US}$</td>
<td>NT</td>
<td>3</td>
<td>-3.86</td>
<td>1.77</td>
</tr>
<tr>
<td>$p^{ON,US}$</td>
<td>NT</td>
<td>7</td>
<td>-2.12</td>
<td>2.20</td>
</tr>
<tr>
<td>$p_{QC,JP}$</td>
<td>NT</td>
<td>7</td>
<td>-0.65</td>
<td>2.45</td>
</tr>
<tr>
<td>$p_{MB,JP}$</td>
<td>NT</td>
<td>6</td>
<td>-1.84</td>
<td>0.56</td>
</tr>
<tr>
<td>$p^{ON,JP}$</td>
<td>NT</td>
<td>10</td>
<td>-0.63</td>
<td>1.54</td>
</tr>
<tr>
<td>$r^{QC}$</td>
<td>NT</td>
<td>9</td>
<td>-2.12</td>
<td>0.23</td>
</tr>
<tr>
<td>$r^{MB}$</td>
<td>NT</td>
<td>9</td>
<td>-2.45</td>
<td>0.16</td>
</tr>
<tr>
<td>$r^{ON}$</td>
<td>NT</td>
<td>9</td>
<td>-2.24</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Note: Critical values for the ADF test without a trend are: -3.481, -2.884 and -2.574 at the 1%, 5% and 10% significance levels respectively. Critical values for the ADF test with a trend are: -4.011, -3.439 and -3.139 at the 1%, 5% and 10% significance levels respectively. Critical values for the KPSS stationarity test without a trend are: 0.739, 0.463 and 0.347 at the 1%, 5% and 10% significance levels respectively. Critical values for the KPSS stationarity test with a trend are: 0.216, 0.146 and 0.119 at the 1%, 5% and 10% significance levels respectively. Finally, the joint critical values of the ADF and KPSS tests to perform the confirmatory analysis at the 5% significance level are respectively -3.126 and 0.073 when there is no trend and -3.74 and 0.073 when there is a trend. Finally, T and NT stand respectively for trend and no trend in the unit root test specified in (5).
Table 2. Cointegration Tests

<table>
<thead>
<tr>
<th>Equation</th>
<th>( Z_t )</th>
<th>( Z_u )</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quebec</td>
<td>-6.06</td>
<td>-53.91</td>
</tr>
<tr>
<td>Ontario</td>
<td>-8.04</td>
<td>-89.13</td>
</tr>
<tr>
<td>Manitoba</td>
<td>-10.49</td>
<td>-121.25</td>
</tr>
<tr>
<td>Japan system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quebec</td>
<td>-6.54</td>
<td>-67.80</td>
</tr>
<tr>
<td>Ontario</td>
<td>-9.05</td>
<td>-113.54</td>
</tr>
<tr>
<td>Manitoba</td>
<td>-8.93</td>
<td>-106.12</td>
</tr>
</tbody>
</table>

Note: Critical values for the \( Z_t \) test statistic are: -4.45, -4.16 and -3.96 at the 5%, 10% and 15% significance levels respectively (MacKinnon, 1991). Critical values for the \( Z_u \) test statistic are: -37.15, -32.75 and -29.88 at the 5%, 10% and 15% significance levels respectively (MacKinnon, 1991).
Table 3. Bootstrap Inference

<table>
<thead>
<tr>
<th>Null hypothesis for the U.S. system</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda^{QC} = 0$</td>
<td>0.007</td>
</tr>
<tr>
<td>$\lambda^{MB} = 0$</td>
<td>0.794</td>
</tr>
<tr>
<td>$\lambda^{ON} = 0$</td>
<td>0.018</td>
</tr>
<tr>
<td>$\beta^{QC,JP} = \lambda^{QC} = 0$</td>
<td>0.001</td>
</tr>
<tr>
<td>$\beta^{MB,JP} = \lambda^{MB} = 0$</td>
<td>0.358</td>
</tr>
<tr>
<td>$\beta^{ON,JP} = \lambda^{ON} = 0$</td>
<td>0.007</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Null hypothesis for the Japan system</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda^{QC} = 0$</td>
<td>0.000</td>
</tr>
<tr>
<td>$\lambda^{MB} = 0$</td>
<td>0.139</td>
</tr>
<tr>
<td>$\lambda^{ON} = 0$</td>
<td>0.002</td>
</tr>
<tr>
<td>$\beta^{QC,US} = \lambda^{QC} = 0$</td>
<td>0.000</td>
</tr>
<tr>
<td>$\beta^{MB,US} = \lambda^{MB} = 0$</td>
<td>0.000</td>
</tr>
<tr>
<td>$\beta^{ON,US} = \lambda^{ON} = 0$</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Endnotes

1 Obviously, the independence between the blocks does not fully mimic the dependence structure in the initial sample (Andrews, 2004). Lahiri (1999) argues that bootstrap methods with a fixed block length are relatively more efficient than the stationary block bootstrap. This was challenged by Politis and White (2004) who argue that the results in Lahiri (1999) are driven by the assumption that the optimal length of the blocks is known. Moreover, one of the advantages of the stationary bootstrap is that the series generated are stationary unlike those from a moving block bootstrap which consists of sampling blocks of residuals (overlapping or non-overlapping) of fixed length.

2 Politis and White (2004) recently proposed an algorithm to optimally select the length of the block bootstrap based on the autoregressive coefficient and sample length. In our case, modifying the value of $p$ did not produce significantly different results.