Beef Market Integration and Price Transmission in the Trans-Pacific Partnership (TPP) Countries

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Background

- **The world largest integrated regional market**
  - GDP : $28 trillion (36% of the world).
  - Population : 800 million people (11% of the world).

- **The biggest trade stage of global agricultural products**
  - Agricultural imports account for 51 % of the world.
  - Agricultural exports account for 43% of the world.

- **One of the key agricultural commodities : "Beef"**
  - In 2014, 42% of the world beef export is made by the TPP countries; Australia, United States, New Zealand, Canada and Mexico.
  - Also 30% of the global beef imported is destined to the Japan, Canada and United States.

Objective

- **Information on trade relationship is very important**
  - Characteristic of the beef market in terms of market efficiency.
  - A role in trading beef in each bilateral trade relationship.
- **The objective of this study**
  - Investigating beef market integration among the TPP countries.
  - Testing for asymmetric price transmission in beef trade.
- **Research Questions**
  - Q1**:** Whether the pairs of beef price are co-integrated in the TPP countries.
  - Q2: whether price transmission of co-integrated pairs of prices is symmetry

Theoretical concepts

- **Co-integration & long-run equilibrium relationship**
  - If two prices are co-integrated each other, it implies that there is the presence of a long-run relationship (Rapsomanikis et.al., 2006).
- **Symmetric price transmission**
  - If the market system were well integrated, then price increases should be transmitted to the same extent as price decreases (Goletti and Babu, 1994).
- **The Law of One Price (LOP)**
  - A stable tendency can be achieved by arbitrage process, which implicitly assumes symmetric price transmission (Ghoshray, 2002).

Factors affecting price transmission

- **Barrier factors for co-integration & symmetric price transmission**
  - Quality differences, transaction costs, imperfect competition, policy intervention and exchange rates (Ghoshray, 2002; Abdulai, 2000; Rapsomanikis et al., 2006).
- **Quality differences, imperfect competition and policy intervention are most relevant**
  - Quality differences : breed & feeding method, fresh/chilled vs frozen beef
  - Imperfect competition : high dependence on exports & imports, market power
  - Government intervention : tariff & tariff rate quotas lead to failure on price arbitrage

Data

- **All series are the monthly average price and the nominal USD**
  - Australian beef export price (AUS) : Jan 1995~Dec 2015, fresh/frozen

    - Source : Meat & livestock Australia
  - American beef export price (US) : Mar 2004~Dec 2015, fresh/frozen

    - Source : USDA/FAS
  - American utility cow price (USUC) : Jan 1997~Dec 2015, carcass

    - Source : USDA/AMS, slaughter cow in Sioux falls
  - New Zealand beef export price (NZ) : Jan 1995~Dec 2015, fresh/frozen

    - Source : Statistics New Zealand
  - Canadian beef export price (CAN) : Sept 2003~Dec 2015, fresh/frozen

    - Source : Canadian International Merchandise Trade Database
  - Japanese wholesale price (JAN) : Jan 1995~Dec 2015, carcass

    - Source : Agriculture & Livestock Industries Corporation

Methods

- **Unit root test : Three approaches**
  - Augmented Dickey-Fuller (ADF), Phillips-Parron (PP) _(H_0: nonstationarity)
  - Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) _(H_0: stationarity)
- **Co-integration test : Three approaches**
  - Engle & Granger two steps procedure

    - 1) estimating co-integrating equations, 2) testing for stationarity of residuals from co-integrating equations
  - Johansen's co-integration test

    - Multiple and pairwise tests
  - Threshold co-integration test proposed by Enders and Granger (1998)

Methods

- **Threshold co-integration test**

TAR model : $\Delta\hat{\varepsilon}_t = I_t\gamma_1\hat{\varepsilon}_{t-1} + (1 - I_t)\gamma_2\hat{\varepsilon}_{t-1} + \omega_t,\quad I_t = \begin{cases} 1 & if \quad \hat{\varepsilon}_{t-1} \geq \tau \\ 0 & if \quad \hat{\varepsilon}_{t-1} < \tau \end{cases}$

M-TAR model : $\Delta\hat{\varepsilon}_t = I_t\gamma_1\hat{\varepsilon}_{t-1} + (1 - I_t)\gamma_2\hat{\varepsilon}_{t-1} + \omega_t,\quad I_t = \begin{cases} 1 & if \quad \Delta\hat{\varepsilon}_{t-1} \geq \tau \\ 0 & if \quad \Delta\hat{\varepsilon}_{t-1} < \tau \end{cases}$

- First, test for $H_0 : \gamma_1 = \gamma_2 = 0$, if the null is rejected, the series are co-integrated.
- Second, test for $H_0 : \gamma_1 = \gamma_2$, if the null is rejected, the series are asymmetric adjustment.
- Interpretation of γ_1 and γ_2

- $-1 < \gamma_1 < \gamma_2 < 0$, the negative deviations of the $\{\hat{\varepsilon}_t\}$ series will tend to be more persistent in TAR model.

- $|\gamma_1| < |\gamma_2|$, there is little adjustment for positive deviations of $\Delta\hat{\varepsilon}_{t-1}$ in M-TAR model.

Methods

- **Error Correction Models**

  Symmetric ECM : $\Delta P_t^{US} = a_0 + a_1 \hat{\varepsilon}_{t-1} + \sum_{i=1}^{p} \delta_i \, \Delta P_{t-i}^{US} + \sum_{j=1}^{n} \theta_j \, \Delta P_{t-j}^{AUS} + \mu_t$

  Asymmetric ECM : $\Delta P_t^{US} = a_0 + a_2 \hat{\varepsilon}_{t-1}^{+} + a_3 \hat{\varepsilon}_{t-1}^{-} + \sum_{i=1}^{p} \delta_i \, \Delta P_{t-i}^{US} + \sum_{j=1}^{n} \theta_j \, \Delta P_{t-j}^{AUS} + \mu_t$

- **Calculation of adjustment time**

$$\mathrm{n} = \frac{\log(1-p)}{\log(1-a_i)}$$

  - p : given proportion of the disequilibrium to be corrected

  - a_{i} : short-run adjustment speed coefficient from ECMs, i=1,2,3

- **Miscellaneous**
  - Test for autocorrelation of the residuals by using Ljung-Box Q test
  - Determination of appropriate lag length and model selection are based on minimum Schwarz Bayesian Criterion (SBC)

Results of unit root

Table 1. Results of the unit root tests in logged level

		AUS	US	USUC	CAN	NZ	JAP
ADF	w/drift	-0.46	-1.38	-1.00	-0.93	-0.74	-2.51
	w/drift and trend	-2.94	-2.62	-2.43	-2.59	-4.76**	-3.45*
PP	w/drift	-1.37	-1.84	-1.34	-1.15	-0.70	-2.54
	w/drift and trend	-6.41**	-5.26**	-2.85	-3.10	-4.12**	-3.51**
KPSS	w/drift	3.91**	3.55**	3.28**	5.00**	7.98**	5.02**
	w/trend	0.28**	1.09**	0.40**	1.48**	0.40**	0.55**
Number of lags		5	4	4	1	2	1

Table 2. Results of the unit root tests in logged first difference

		AUS	US	USUC	CAN	NZ	JAP
ADF	w/drift	-12.95**	-10.42**	-8.55**	-7.77**	-10.20**	-11.75**
	w/drift and trend	-12.97**	-10.44**	-8.54**	-7.75**	-10.20**	-11.77**
PP	w/drift	-33.05**	-18.37**	-11.70**	-13.12**	-13.17**	-15.83**
	w/drift and trend	-33.05**	-18.45**	-11.69**	-13.13**	-13.16**	-15.82**
KPSS	w/drift	0.06	0.12	0.07	0.26	0.07	0.06
	w/trend	0.05	0.05	0.04	0.10	0.04	0.03
No. of lags		2	3	1	1	1	1

Notes: Asterisks denote levels of significance (* for 10%, ** for 5%).

- In logged level, all series have a unit root, which means that all series are non-stationary.
- In its first difference, all three tests confirm all series are stationary.

Results of Johansen test

Table 3. Co-integration rank test using trace for the TPP countries

$H_0: Rank = r$	$H_1: Rank > r$	**Trace**
0	0	216.76 (0.00)
1	1	93.55 (0.00)
2	2	56.39 (0.01)
3	3	27.11 (0.09)
4	4	13.71 (0.09)
5	5	1.16 (0.28)

Table 4. Johansen ML pairwise co-integration tests

	No. of lags	$H_0: Rank = r$	$H_1: Rank > r$	**Trace**
USUC – AUS	3	0	0	16.77 (0.03)
		1	1	0.89 (0.35)
CAN – AUS	2	0	0	35.65 (0.00)
		1	1	0.89 (0.35)
NZ – AUS	4	0	0	13.90 (0.09)
		1	1	0.31 (0.58)
JAP – AUS	3	0	0	16.39 (0.04)
		1	1	0.17 (0.68)
USUC – CAN	1	0	0	30.37 (0.00)
		1	1	1.10 (0.29)
USUC – NZ	2	0	0	19.12 (0.01)
		1	1	1.53 (0.22)
JAP – US	1	0	0	20.09 (0.01)
		1	1	3.86 (0.05)
CAN – US	1	0	0	16.08 (0.04)
		1	1	1.12 (0.29)
CAN – NZ	2	0	0	26.69 (0.00)
		1	1	1.23 (0.27)
JAP – CAN	2	0	0	20.04 (0.01)
		1	1	0.80 (0.37)
JAP – NZ	1	0	0	14.54 (0.07)
		1	1	0.26 (0.61)

Notes: The p-values are stated in parenthesis.

Results of Engle-Granger test

Table 5. Results of Engle-Granger co-integration test

	No. of lags	β_1	ADF		PP		KPSS	
			w/drift	w/drift and trend	w/drift	w/drift and trend	w/drift	w/trend
USUC – AUS	1	0.83 (26.04)**	-3.97**	-3.98**	-4.66**	-4.68**	1.57**	1.46**
CAN – AUS	3	0.92 (13.47)**	-2.66*	-3.20*	-5.13**	-5.51**	0.91**	0.73**
NZ – AUS	3	0.96 (58.21)**	-3.85**	-3.83**	-11.72**	-11.70**	0.53**	0.55**
JAP – AUS	4	0.29 (15.14)**	-4.76**	-4.68**	-4.43**	-4.40**	0.18	0.17**
USUC – CAN	3	1.18 (28.35)**	-5.57**	-5.91**	-5.44**	-5.44**	0.82**	0.23**
USUC – NZ	2	0.89 (35.04)**	-4.74**	-4.72**	-4.34**	-4.32**	0.74**	0.75**
JAP – US	1	0.01 (0.30)	-4.27**	-4.30**	-4.25**	-4.27**	0.34	0.24**
CAN – US	1	0.66 (18.62) **	-2.86**	-2.82**	-3.10**	-3.06**	1.34**	1.36**
CAN – NZ	1	0.81 (17.23) **	-3.50**	-3.55**	-4.33**	-4.34**	1.38**	1.38**
JAP – CAN	1	0.01 (0.31)	-4.44**	-4.48**	-4.65**	-4.68**	0.42*	0.23**
JAP – NZ	1	0.26 (12.58) **	-3.85**	-3.83**	-3.81**	-3.78**	0.44*	0.48**

Notes: Asterisks denote levels of significance (* for 10%, ** for 5%).

- ADF & PP test confirm residuals from each co-integrating EQ are stationary.

  - There is the presence of long-run equilibrium relationship in each pairs of series

- In short, there is sufficient evidence for co-integrating relationship between in all cases.

  - The beef market in the TPP countries might be well integrated market .

Results of threshold analysis

Table 6. Results of the TAR model

	lags	$\gamma_1{}^a$	$\gamma_2{}^b$	$H_0^1: \gamma_1 = \gamma_2 = 0^c$	$H_0^2: \gamma_1 = \gamma_2{}^d$	τ	$Q(6)$	F_{test}
USUC – AUS	0	-0.11 [-2.18]**	-0.30 [-5.08]**	15.26**	**5.90 (0.02)**	-0.042	9.36 (0.15)	15.26 (0.00)
CAN – AUS	1	-0.17 [-2.41]**	-0.26 [-3.42]**	8.57**	0.82 (0.37)	-0.032	3.19 (0.79)	17.77 (0.00)
NZ – AUS	3	-0.24 [-2.94]**	-0.36 [-3.46]**	7.88**	1.11 (0.29)	-0.043	7.90 (0.25)	45.23 (0.00)
JAP – AUS	3	-0.27 [-4.43]**	-0.13 [-3.48]**	14.65**	**3.66 (0.06)**	0.024	1.69 (0.95)	10.09 (0.00)
USUC – CAN	2	-0.30 [-3.39]**	-0.37 [-4.76]**	15.58**	0.45 (0.50)	0.024	4.09 (0.66)	8.25 (0.00)
USUC – NZ	2	-0.11 [-2.78]**	-0.21 [-4.34]**	12.58**	2.48 (0.12)	-0.017	3.49 (0.75)	7.52 (0.00)
JAP – US	0	-0.16 [-2.27]**	-0.34 [-3.75]**	9.63**	2.30 (0.13)	-0.017	4.55 (0.60)	9.63 (0.00)
CAN – US	1	-0.14 [-2.59]**	-0.08 [-1.49]	4.37*	0.59 (0.44)	0.008	4.16 (0.65)	9.43 (0.00)
CAN – NZ	0	-0.20 [-4.18]**	-0.10 [-1.87]*	10.48**	1.86 (0.18)	0.012	5.63 (0.47)	10.48 (0.00)
JAP – CAN	0	-0.18 [-2.49]**	-0.37 [-4.15]**	11.71**	2.81 (0.10)	-0.016	3.75 (0.71)	11.71 (0.00)
JAP – NZ	0	-0.16 [-3.27]**	-0.08 [-2.21]**	7.80**	1.92 (0.17)	0.0186	8.40 (0.21)	7.80 (0.01)

Table 7. Results of the M-TAR model

	lags	$\gamma_1{}^a$	$\gamma_2{}^b$	$H_0^1: \gamma_1 = \gamma_2 = 0^c$	$H_0^2: \gamma_1 = \gamma_2{}^d$	τ	$Q(6)$	F_{test}
USUC – AUS	1	-0.10 [-2.08]**	-0.25 [-4.00]**	9.80**	3.55 (0.06)	-0.012	7.08 (0.31)	11.08 (0.00)
CAN – AUS	2	-0.08 [-1.30]	-0.40 [-4.25]**	9.65**	8.41 (0.00)	-0.038	0.16 (0.98)	16.27 (0.00)
NZ – AUS	3	-0.24 [-3.19]**	-0.45 [-3.64]**	8.80**	2.85 (0.09)	-0.044	8.06 (0.23)	42.88 (0.00)
JAP – AUS	3	-0.09 [-1.90]*	-0.23 [-5.27]**	15.04**	4.38 (0.04)	0.002	2.47 (0.87)	10.26 (0.00)
USUC – CAN	2	-0.24 [-2.64]**	-0.40 [-5.29]**	16.44**	**1.86 (0.18)**	0.009	4.21 (0.65)	8.69 (0.00)
USUC – NZ	2	-0.09 [-2.55]**	-0.30 [-5.24]**	16.34**	9.30 (0.00)	-0.011	4.34 (0.63)	9.43 (0.00)
JAP – US	0	-0.13 [-1.79]*	-0.36 [-4.19]**	10.36**	3.95 (0.05)	-0.002	5.08 (0.53)	10.36 (0.00)
CAN – US	1	-0.14 [-3.36)]**	0.08 [0.76]	5.99**	3.66 (0.06)	-0.021	4.44 (0.62)	10.66 (0.00)
CAN – NZ	0	-0.24 [-3.35]**	-0.10 [-2.25]**	8.16**	**2.73 (0.10)**	0.010	6.53 (0.37)	8.16 (0.00)
JAP – CAN	0	-0.15 [-2.06]**	-0.36 [-4.23]**	11.06**	3.53 (0.06)	-0.001	4.78 (0.57)	11.06 (0.00)
JAP – NZ	0	-0.14 [-4.27]**	-0.004 [-0.08]	9.11**	4.75 (0.03)	-0.017	7.52 (0.28)	9.11 (0.00)

Notes: Asterisks stand for levels of significance (* for 10%, ** for 5%). p-values are stated in parenthesis

Results of threshold analysis

- **Summary of the results of TAR and M-TAR model**
  - First, adjustment rates of both the TAR model and the M-TAR model in almost all cases are significant, except for γ_2 of CAN-US in TAR, $\gamma_1$of CAN-AUS, γ_2 of both CAN-US and JAP-NZ in M-TAR.
  - Second, the rate of adjustment for the negative deviation from long-run equilibrium tends to be more quickly than that for the positive deviation in beef trade.
  - Third, In all pairings, the null of $H_0: \gamma_1 = \gamma_2 = 0$) is rejected.

  - There co-integrating relationship between all pairs of price series exists.

  - Fourth, In most of cases, **asymmetric price adjustment is confirmed** by rejecting the null of symmetric price adjustment ($H_0: \gamma_1 = \gamma_2$).

  - USUC-CAN pairing and CAN-NZ pairing appear to be symmetric adjustment.

Results of ECM

Table 8. Estimates of asymmetric ECM

Dependent variable	Independent variable	lags	ECT		$Q(6)$	F_{test}
			$\hat{\varepsilon}^{+}_{t-1}$	$\hat{\varepsilon}^{-}_{t-1}$		
USUC	**AUS**	1;1	0.03 [0.43]	-0.22 [-4.83]**	10.63 (0.10)	11.15 (0.00)
AUS	**USUC**	2;2	-0.09 [-1.27]	-0.05 [-0.78]	2.67 (0.85)	22.72 (0.00)
CAN	**AUS**	1;1	-0.07 [-1.42]	-0.09 [-1.47]	6.86 (0.33)	2.79 (0.03)
AUS	**CAN**	1;1	-0.42 [-3.10]**	-0.22 [-1.99]*	8.86 (0.18)	19.10 (0.00)
NZ	**AUS**	1;1	-0.17 [-3.05]**	0.01 [0.22]	3.12 (0.61)	4.69 (0.00)
AUS	**NZ**	3;3	-0.36 [-2.94]**	-0.06 [-0.52]	4.14 (0.66)	32.56 (0.00)
JAP	**AUS**	1;1	-0.23 [-3.28]**	-0.06 [-1.40]	6.09 (0.41)	4.99 (0.00)
AUS	**JAP**	2;2	-0.07 [-1.69]*	0.03 [0.71]	3.53 (0.74)	30.93 (0.00)
USUC	**NZ**	2;2	-0.03 [0.50]	-0.21 [-3.35]**	1.73 (0.94)	7.12 (0.00)
NZ	**USUC**	1;1	-0.05 [-1.11]	-0.06 [-1.51]	4.65 (0.59)	7.22 (0.00)
JAP	**US**	1;1	-0.16 [-1.63]	-0.41 [-3.24]**	5.93 (0.43)	5.95 (0.00)
US	**JAP**	1;1	0.02 [0.55]	-0.09 [2.16]**	8.24 (0.22)	6.76 (0.00)
CAN	**US**	1;1	-0.10 [-1.52]	-0.02 [-0.27]	10.06 (0.12)	1.53 (0.20)
US	**CAN**	1;1	-0.13 [-1.50]	-0.07 [-1.56]	8.12 (0.23)	8.95 (0.00)
JAP	**CAN**	1;1	-0.17 [-1.68]	-0.42 [-3.24]**	3.89 (0.69)	5.46 (0.00)
CAN	**JAP**	1;1	0.02 [0.61]	-0.08 [-1.55]	7.61 (0.27)	1.04 (0.39)
JAP	**NZ**	1;1	-0.20 [-3.12]**	-0.05 [-1.37]	10.10 (0.12)	4.58 (0.00)
NZ	**JAP**	1;1	-0.03 [-1.81]*	0.02 [0.86]	7.27 (0.30)	3.79 (0.01)

Table 9. Estimates of symmetric ECM

Dependent variable	Independent variable	lags	$\hat{\varepsilon}_{t-1}$	$Q(6)$	F_{test}
USUC	**CAN**	1;1	-0.17 [-3.50]**	4.18 (0.65)	7.43 (0.00)
CAN	**USUC**	2;2	-0.19 [-3.69]**	6.60 (0.36)	5.43 (0.00)
CAN	**NZ**	1;1	-0.11 [-3.65]**	7.46 (0.28)	6.77 (0.00)
NZ	**CAN**	1;1	-0.06 [-2.43]**	7.80 (0.31)	8.06 (0.00)

Notes: Asterisks stand for levels of significance (* for 10%, ** for 5%). p-values are stated in parenthesis

Results of ECM

- **Main findings of ECM models**
  - First, USUC only responds to negative shock created by increase in AUS or NZ.

    - The speed of adjustment is 9 month (22%) for AUS and 10 month (21%) for NZ.

    - In each pairings, Australia and New Zealand lead a price in each beef trade relationship.
  - Second, the JAP only responds to the positive shocks created by decrease in the AUS and the NZ. However, it only responds to the negative shocks created by increase in the US and the CAN.

    - These results may be due to quality difference and different end-use.

    - Only Canada can serve as a price leader in its relationship with Japan.
  - Third, in CAN-AUS, Canada can be considered as a price leader .

    - Decrease in the CAN results in a more swift response of the AUS.

Results of ECM

- **Summary, cont.**
  - Fourth, in AUS-NZ, neither country can be accepted as a price leader.

    - The speed of adjustment of AUS to positive shocks from the NZ tends to be faster.
  - Lastly, for symmetric cases,

    - In CAN-NZ, about 6-11% of adjustment to long-run equilibrium occurs bidirectionally.

      * Neither country can be regarded as a price leader.

    - In USUC-CAN, each price adjusts to long-run equilibrium after change in another price in approximately 11 months.

      * Neither country can be considered as a price leader in its relationship.

Final conclusions

- **The TPP countries are well integrated in their beef trade.**
  - There is a long-run equilibrium relationship between pairs of price series.
- **Asymmetric pricing behavior in beef trade exits.**
  - This may be due to quality difference, imperfect competition, and trade policy.
- **Such findings might have important policy implications**
  - There might be potential market inefficiencies in beef trade among the TPP countries.
  - There are welfare distribution implications for both consumers and producers that shoulc be taken into account by policy makers.

  - Relatively slow speed of price adjustment to the equilibrium might cause the potential losses to market participants.

Thanks !