Modelling Asymmetries in the Market for Gasoline in Western Canada

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Objective

- To test for Symmetry / Asymmetry in the response of gasoline retail prices to changes in the price of crude oil.
- That is, investigate "Asymmetric Cost-to-Price Pass-Through" in this market.
- This will be done for 6 cities in Western Canada.

Summary of Findings

- Data for Vancouver and Victoria analyzed so far.
- Results provide clear evidence that the response is *asymmetric*.
- Gas prices respond more rapidly to oil price *increases* than to oil prices *decreases*.

Previous Literature

- Survey of ***70 papers*** – Frey & Mannera, *J. Economic Surveys*, 2007.
- Meta-Analysis – Perdiguero-García, W.P., 2010.
- Lots of positive evidence, beginning with Bacon, 1991 (UK).
- Recent papers by Honovar, 2009 (US); Polemis, 2012 (Greece); Lamotte *et al.*, 2012 (France).
- Overall, the evidence is "mixed" – especially among earlier studies.
- Results depend on time-period, country, type of gasoline, methodology.
- Canadian evidence:
    1. Quinn, 1997 (Calgary).
    2. Noel, 2009 (Toronto).

Why Asymmetric Pass-Through?

- *Edgeworth price cycle model* (Maskin and Tirole, 1988). "Competition may lead to relatively slow price undercutting down to cost and a rapid rise or resetting of the cycle initiated by a single firm and quickly followed by all its competitors".

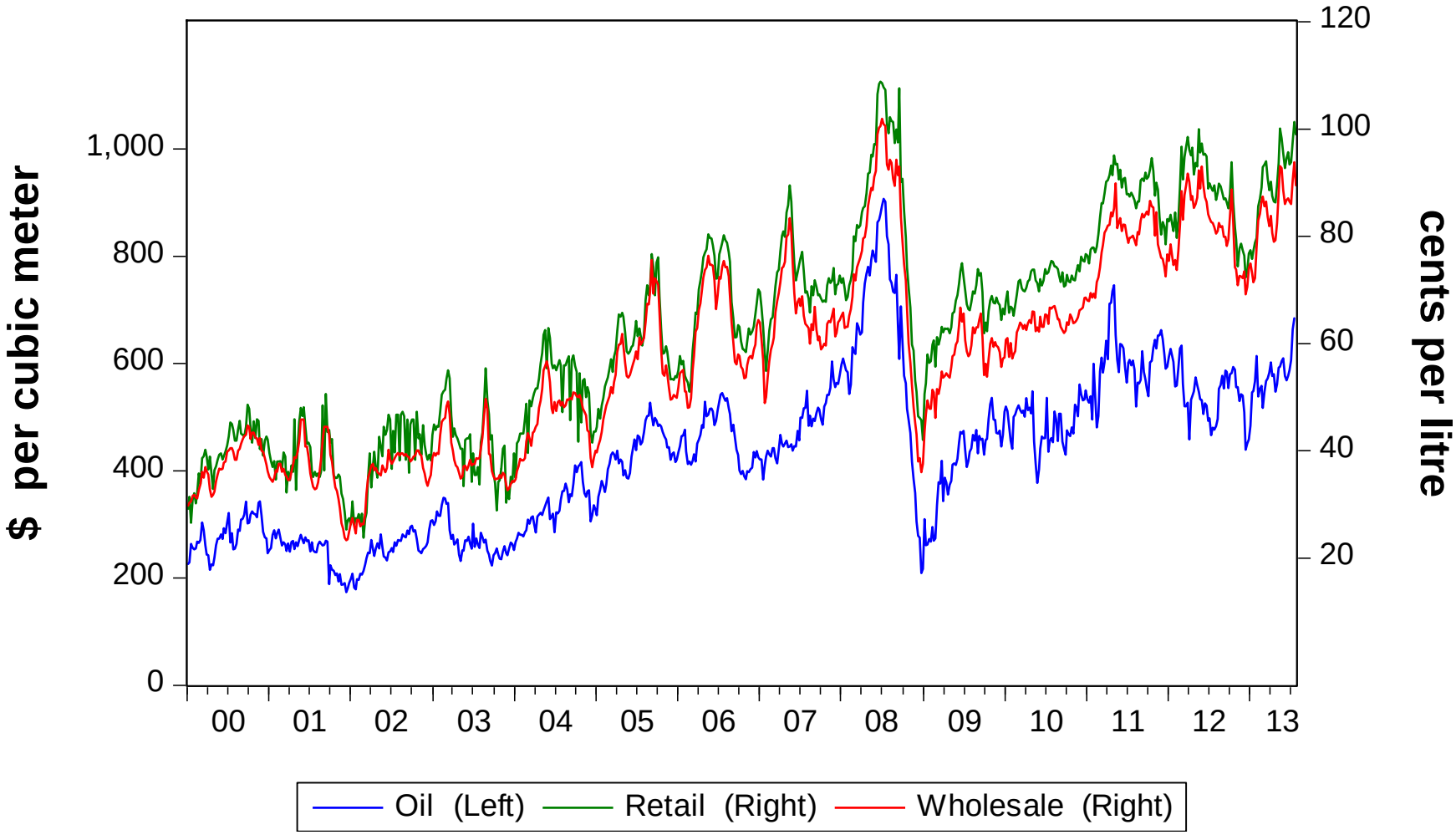
- *Consumer search costs*. “If consumers are more likely to search for a low price when prices are rising or expected to rise, then competition will be fierce when costs are rising and margins tight. However, if prices are falling, consumers may search less and this provides retailers with short-term market power and allows them to slowly lower prices and increase their margins”.

- *Explicit or implicit collusion*?

Data

- Data for crude oil price; wholesale gasoline price; retail gasoline price.
- Sample period is 1 January 2000 to 23 July 2013.
- **Oil**: Canadian Par @Edmonton; $CDN *per* m^3; ($1m^3 = 6.29bbl$); **daily**.
- **Wholesale ("Rack") Gasoline**: By centre; cents *per* litre; unleaded; **daily**.
- **Retail Gasoline**: By centre; cents *per* litre; unleaded; excludes taxes; **weekly**.
- Gasoline prices for 6 cities – Victoria, Vancouver, Edmonton, Calgary, Regina, Winnipeg
- Analysis here based on weekly data.

Crude Oil Price & Vancouver Wholesale & Retail Gasoline Prices



Group Unit Root Tests

Victoria

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.44850	0.3269	3	2116
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-1.60701	0.0540	3	2116
ADF - Fisher Chi-square	10.9782	0.0891	3	2116
PP - Fisher Chi-square	11.0679	0.0863	3	2119

Vancouver

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.00225	0.4991	3	2116
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-1.45226	0.0732	3	2116
ADF - Fisher Chi-square	10.1588	0.1181	3	2116
PP - Fisher Chi-square	10.8896	0.0918	3	2120

Granger Non-Causality Testing

- Use Toda-Yamamoto methodology to allow for non-stationarity of data.
- Maximum lag lengths in VAR models chosen using SIC.
- 3 –week lags selected for both Victoria and Vancouver.
- **One** additional lag of all series included in VAR's, **but not** in Wald tests.
- Specification tests:

    1. Inverse characteristic roots lie inside unit circle.
    2. No serial correlation in residuals.

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 09/05/13 Time: 11:35
Sample: 1/04/2000 7/23/2013
Included observations: 703

Vancouver

(Weekly Data)

Dependent variable: LC

Excluded	Chi-sq	df	Prob.
LR	3.551321	3	0.3142
LW	4.566005	3	0.2065
All	12.30008	6	0.0556

Dependent variable: LR

Excluded	Chi-sq	df	Prob.
LC	6.263909	3	0.0995
LW	230.1768	3	0.0000
All	293.3243	6	0.0000

W → R

Dependent variable: LW

Excluded	Chi-sq	df	Prob.
LC	30.35908	3	0.0000
LR	1.488854	3	0.6848
All	31.62501	6	0.0000

C → W

ARDL Models

- Pesaran & Shin (1999); Pesaran *et al*. (2001).
- Is there a long-run relationship? A mixture of I(0) and I(1) variables.
- ARDL procedure:
  1. Make sure than none of the variables are I(2).
  2. Estimate an "unrestricted" error-correction model (ECM) - a particular type of ARDL model.
  3. Perform a "Bounds Test" to see if there is evidence of a long-run relationship between the variables.
  4. If the outcome at step 3 is positive, estimate a long-run "levels model", as well as a separate "restricted" ECM.
  5. Use the results of the models estimated in step 4 to measure short-run dynamic effects, and the long-run equilibrating relationship between the variables.

ARDL Results for Vancouver

Dependent Variable: DLR
Method: Least Squares
Date: 08/07/13 Time: 11:05
Sample (adjusted): 1/25/2000 7/16/2013
Included observations: 704 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.194299	0.050895	-3.817644	0.0001
BREAK	-0.031417	0.013561	-2.316712	0.0208
LR(-1)	-0.133518	0.021229	-6.289467	0.0000
LC(-1)	0.123964	0.020625	6.010277	0.0000
DLR(-1)	-0.332123	0.035109	-9.459684	0.0000
DLC	0.174805	0.040518	4.314207	0.0000
DLC(-1)	0.156744	0.043376	3.613606	0.0003
DLC(-2)	0.077838	0.041642	1.869240	0.0620

R-squared	0.236557	Mean dependent var	0.001899
Adjusted R-squared	0.228879	S.D. dependent var	0.071057
S.E. of regression	0.062398	Akaike info criterion	-2.699278
Sum squared resid	2.709857	Schwarz criterion	-2.647497
Log likelihood	958.1460	Hannan-Quinn criter.	-2.679267
F-statistic	30.80846	Durbin-Watson stat	1.968068
Prob(F-statistic)	0.000000		

$H_0: \beta_3 = \beta_4 = 0$

F = 21.522

	5%		*1%*	
Bounds:	4.94	5.73	6.84	7.84

ECM Models

- Standard ECM:

$$\Delta y_t = \beta_0 + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum_{j=0}^{q} \gamma_j \Delta x_{t-j} + \delta z_{t-1} + \varepsilon_t$$

- Modified ECM to allow for possible *asymmetry*:

$$\Delta y_t = \beta_0 + \sum_{i=1}^{p} {\beta_i}^{+} \Delta^{+} y_{t-i} + \sum_{k=1}^{p'} \beta_k^{-} \Delta^{-} y_{t-k}$$

$$+ \sum_{j=0}^{q} {\gamma_j}^{+} \Delta^{+} x_{t-j} + \sum_{l=0}^{q'} {\gamma_l}^{-} \Delta^{-} x_{t-l} + \delta^{+} {z^{+}}_{t-1} + \delta^{-} {z^{-}}_{t-1} + \varepsilon_t$$

Interested in:

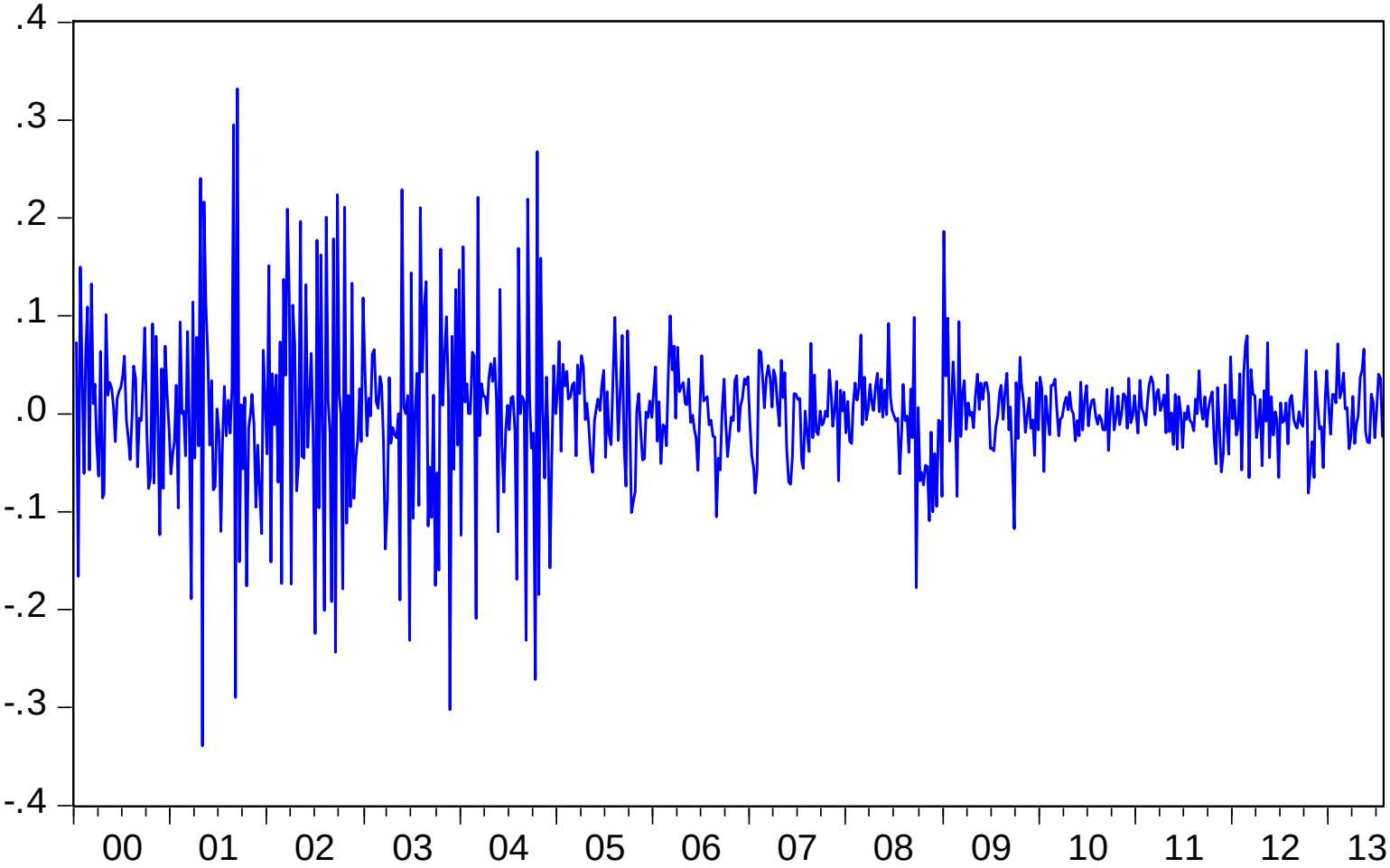
- $H_0: \sum_{j=0}^{q} \gamma_j^{+} = \sum_{j=0}^{q'} \gamma_j^{-}$ *vs.* $H_A: \sum_{j=0}^{q} \gamma_j^{+} \neq \sum_{j=0}^{q'} \gamma_j^{-}$ (Amount)
- $H_0: \gamma_j^{+} = \gamma_j^{-}$ *vs.* $H_A: \gamma_j^{+} \neq \gamma_j^{-}$; for some *j*
- $p \neq p'$
- $q \neq q'$
- $H_0: \delta^{+} = \delta^{-}$ *vs.* $H_A: |\delta^{+}| < |\delta^{-}|$

(Pattern)

- *One-sided* alternative in last case if our prior belief is that adjustment towards equilibrium is faster when $y_{t-1} > x_{t-1}$, than when $y_{t-1} < x_{t-1}$.

Results that follow relate only to relationships between *Crude Oil price* and *Gasoline Retail prices*.

D[log(Retail Price)]
Vancouver



ECM Results for Vancouver

$H_0: \beta_5 = \beta_7$

z = 1.99

p = 0.047

$H_0: \beta_6 = \beta_8$

z = 1.67

p = 0.096

$H_0: \beta_9 = \beta_{10}$

W = 8.01

p = 0.005

Dependent Variable: LOG(R_VAN)-LOG(R_VAN(-1))
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 09/04/13 Time: 13:14
Sample (adjusted): 1/18/2000 7/23/2013
Included observations: 706 after adjustments
Convergence achieved after 42 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(11) + C(12)*RESID(-1)^2 + C(13)*RESID(-2)^2

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.010583	0.003477	-3.043565	0.0023
BREAK	-0.034526	0.010004	-3.451137	0.0006
DLRP(-1)	-0.198569	0.050411	-3.938977	0.0001
DLRP(-2)	0.257153	0.021955	11.71271	0.0000
DLCP	0.237397	0.050673	4.684899	0.0000
DLCP(-1)	0.191634	0.054490	3.516890	0.0004
DLCN	0.079322	0.043610	1.818882	0.0689
DLCN(-1)	0.067521	0.037482	1.801415	0.0716
ZRCP(-1)	-0.033385	0.026698	-1.250450	0.2111
ZRCN(-1)	-0.164098	0.026495	-6.193554	0.0000

Variance Equation

C	0.001229	8.02E-05	15.33314	0.0000
RESID(-1)^2	0.309106	0.062798	4.922227	0.0000
RESID(-2)^2	0.717597	0.069734	10.29047	0.0000

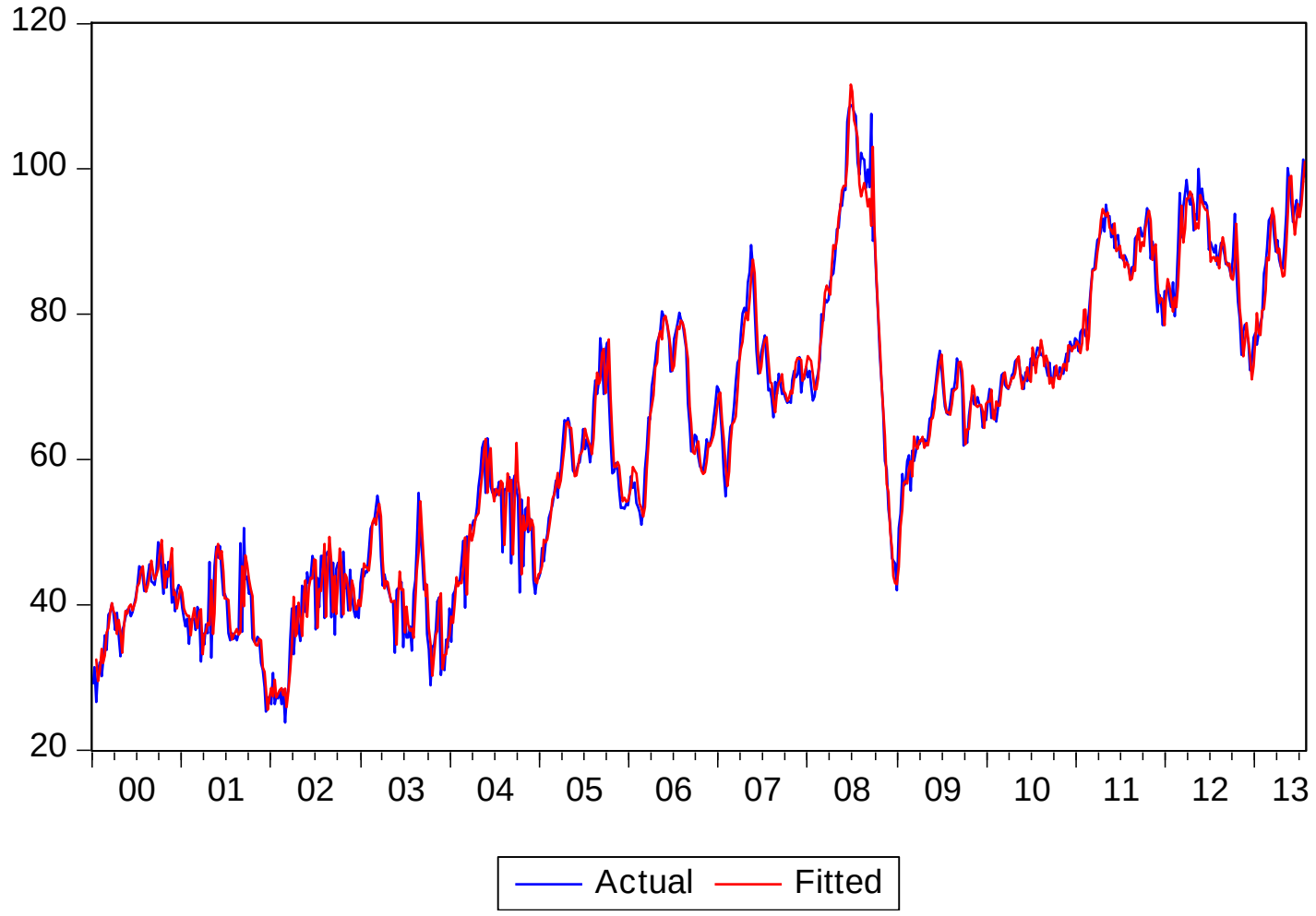
R-squared	0.164656	Mean dependent var	0.001627
Adjusted R-squared	0.153854	S.D. dependent var	0.071243
S.E. of regression	0.065533	Akaike info criterion	-2.881838
Sum squared resid	2.989062	Schwarz criterion	-2.797879
Log likelihood	1030.289	Hannan-Quinn criter.	-2.849395
Durbin-Watson stat	2.499608		

$H_0: (\beta_5 + \beta_6) = (\beta_7 + \beta_8)$

W = 7.65

p = 0.006

Actual & Fitted Retail Gasoline Prices (Vancouver)



Conclusions

- Results to date obtained relate only to Vancouver & Victoria.
- Results discussed here focus on linkage between crude oil price and gasoline *retail* price.
- **"Rockets and Feathers"** hypothesis is supported by our results.
- Clear evidence of "Amount Asymmetry" in both cities.
- Clear evidence of "Pattern Asymmetry" in both cities.
- Also have very similar results with gasoline *wholesale* (rack) price included, either with oil price, or with gasoline retail price.
- Work in progress deals with:
    1. Other four cities.
    2. Forecasting using MIDAS models.