An Economy Driven by Oil. Forecasting Key Provincial Economic Indicators Using a Time Series Approach

Scott Lynch
December 1, 2017

Funding Provided by the Vice President Academic's "Support for Scholarship in the Arts at Memorial Program" and " The Collaborative Applied Research in Economics (CARE) Initiative"

Forecasting Methods

* Large Scale Causal Econometric Models -NALEM (370 mathematical equations and 600 data series)
* Artificial Intelligence Methods -Neural networks
* Judgmental Forecasting Methods – Delphi Method
* Time Series Methods

Vector Auto Regressions (VAR)

Noble Prize Winner 2011 Christopher Simms famous article

"Macroeconomics and Reality" Econometrica , Vol 48, No. 1(January 1980), pp. 1-48

A Simple VAR Example

$$\begin{bmatrix} 1 & b12 \\ b21 & 1 \end{bmatrix} \cdot \begin{bmatrix} y1t \\ y2t \end{bmatrix} = \begin{bmatrix} b10 \\ b20 \end{bmatrix} + \begin{bmatrix} \gamma 11 & \gamma 12 \\ \gamma 21 & \gamma 22 \end{bmatrix} \cdot \begin{bmatrix} y1t-1 \\ y2t-1 \end{bmatrix} + \begin{bmatrix} \varepsilon y1t \\ \varepsilon y2t \end{bmatrix}$$

$$\begin{bmatrix} 1 & b12 \\ b21 & 1 \end{bmatrix}^{-1} \cdot \left(\begin{bmatrix} 1 & b12 \\ b21 & 1 \end{bmatrix} \cdot \begin{bmatrix} y1t \\ y2t \end{bmatrix} = \begin{bmatrix} b10 \\ b20 \end{bmatrix} + \begin{bmatrix} \gamma 11 & \gamma 12 \\ \gamma 21 & \gamma 22 \end{bmatrix} \cdot \begin{bmatrix} y1t-1 \\ y2t-1 \end{bmatrix} + \begin{bmatrix} \varepsilon y1t \\ \varepsilon y2t \end{bmatrix} \right)$$

$$y1t = \frac{b10 - b12 \cdot (b20 + y1t-1 \cdot \gamma 21 + y2t-1 \cdot \gamma 22 + \varepsilon y2t) + y1t-1 \cdot \gamma 11 + y2t-1 \cdot \gamma 12 + \varepsilon y1t}{1 - b12 \cdot b21}$$

$$y2t = \frac{b10 \cdot b21 - b20 + b21 \cdot (y1t-1 \cdot \gamma 11 + y2t-1 \cdot \gamma 12 + \varepsilon y1t) - y1t-1 \cdot \gamma 21 - y2t-1 \cdot \gamma 22 - \varepsilon y2t}{b12 \cdot b21 - 1}$$

$$\begin{bmatrix} y1t \\ y2t \end{bmatrix} = \begin{bmatrix} a10 \\ a20 \end{bmatrix} + \begin{bmatrix} a11 & a12 \\ a21 & a22 \end{bmatrix} \cdot \begin{bmatrix} y1t-1 \\ y2t-1 \end{bmatrix} + \begin{bmatrix} ey1t \\ ey2t \end{bmatrix}$$

There are 10 parameters in structural VAR(1) model but only 9 estimated parameters standard VAR(1) - The VAR is underidentified. Imposed a restiction b21=0 also know as a Choleski decomposition

$$a10 = b10 - b12 \cdot b20$$

$$a20 = b20$$

$$a11 = \gamma 11 - b12 \cdot \gamma 21$$

$$a12 = \gamma 12 - b12 \cdot \gamma 22$$

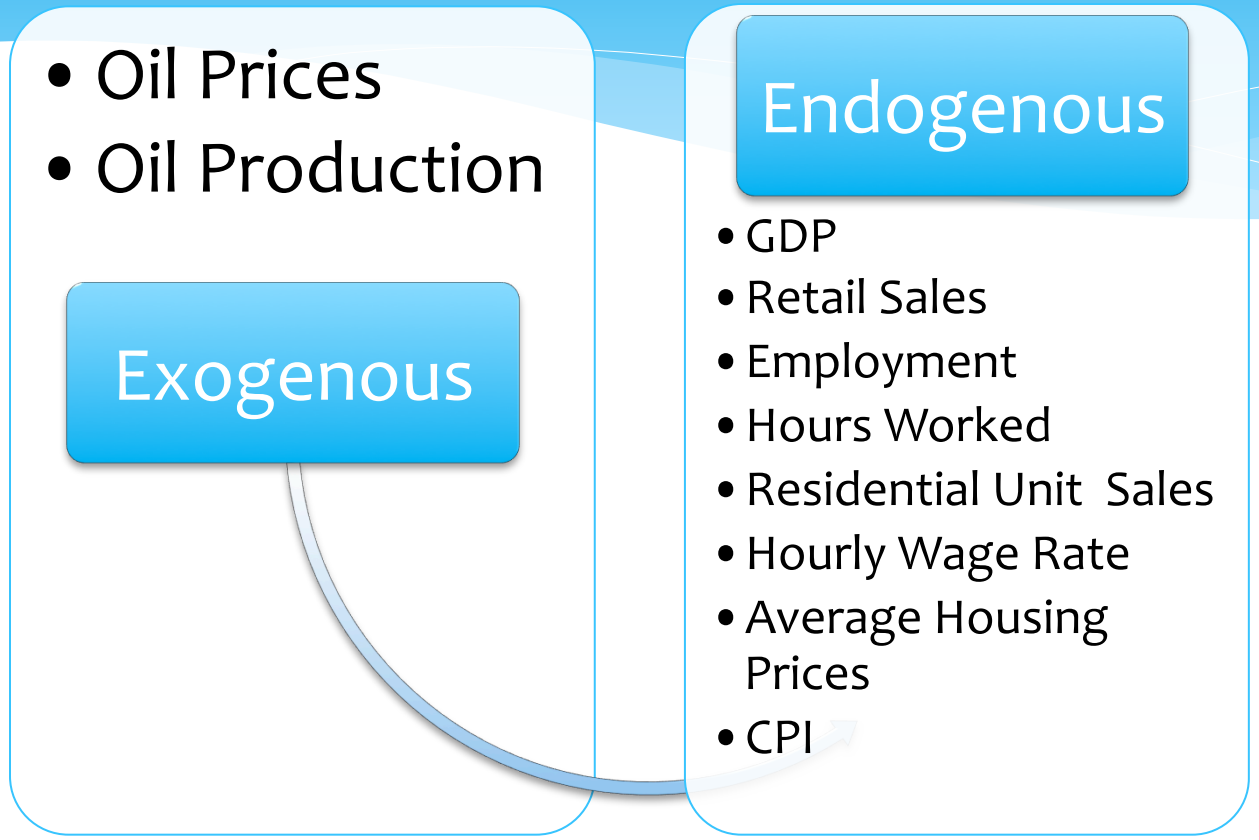
$$a21 = \gamma 21$$

$$a22 = \gamma 22$$

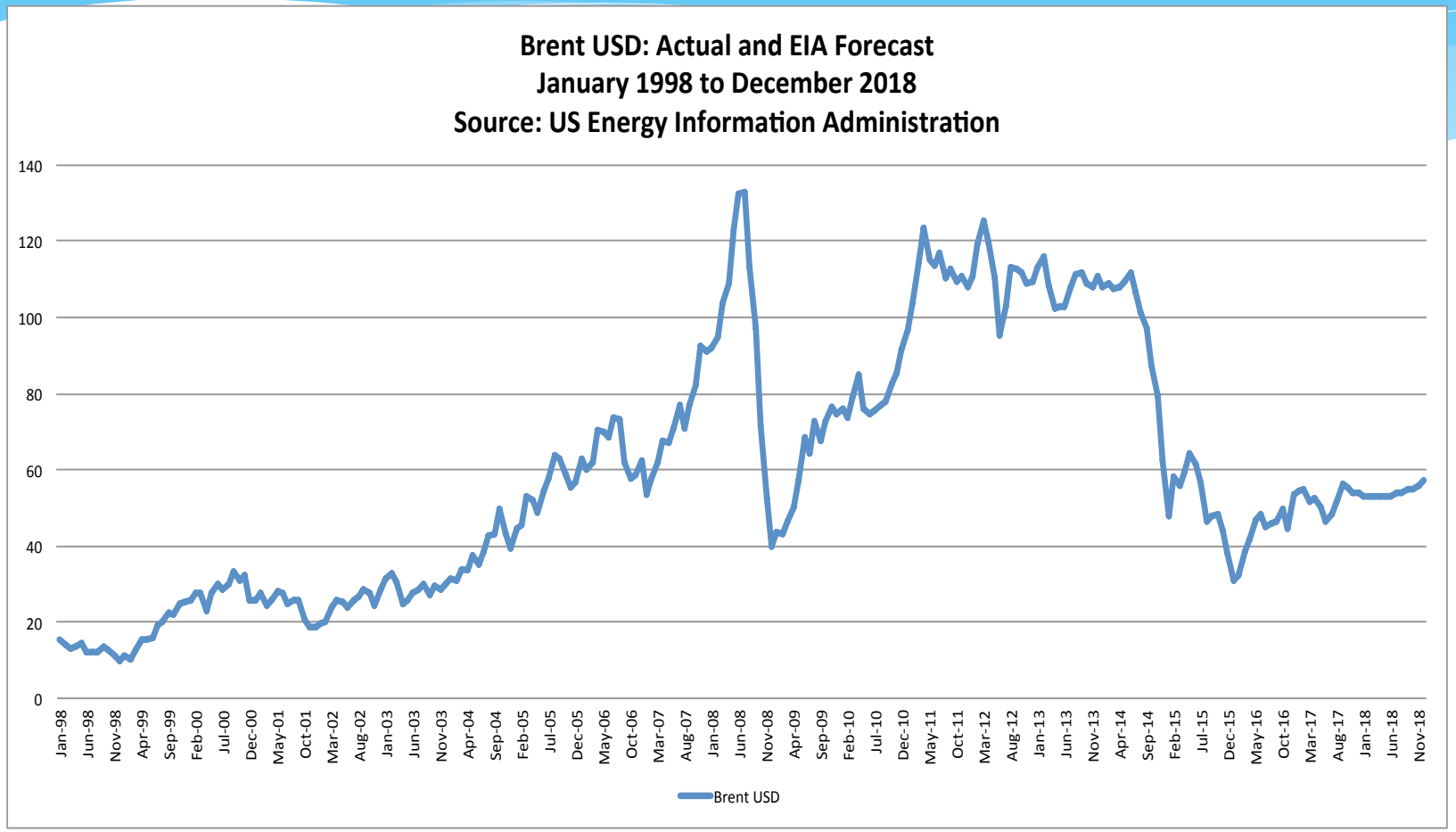
$$Var(ey1) = \sigma^2 y1 + b12 \cdot \sigma^2 y2$$

$$Var(ey2) = \sigma^2 y2$$

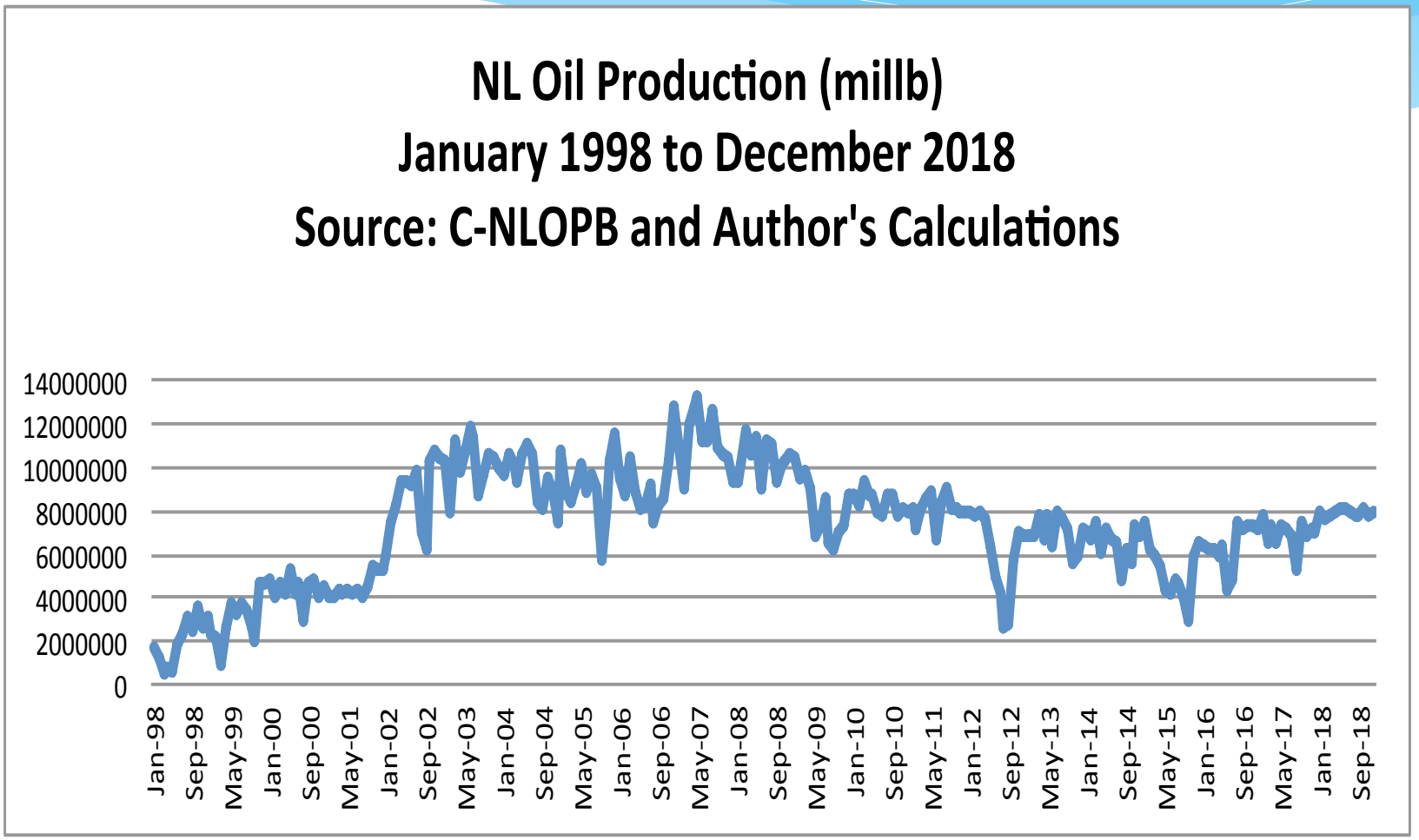
$$cov(ey1, ey2) = - b12 \cdot \sigma^2 y2$$


Oil Prices
Oil Production
Exogenous
Endogenous
GDP
Retail Sales
Employment
Hours Worked
Residential Unit Sales
Hourly Wage Rate
Average Housing Prices
CPI

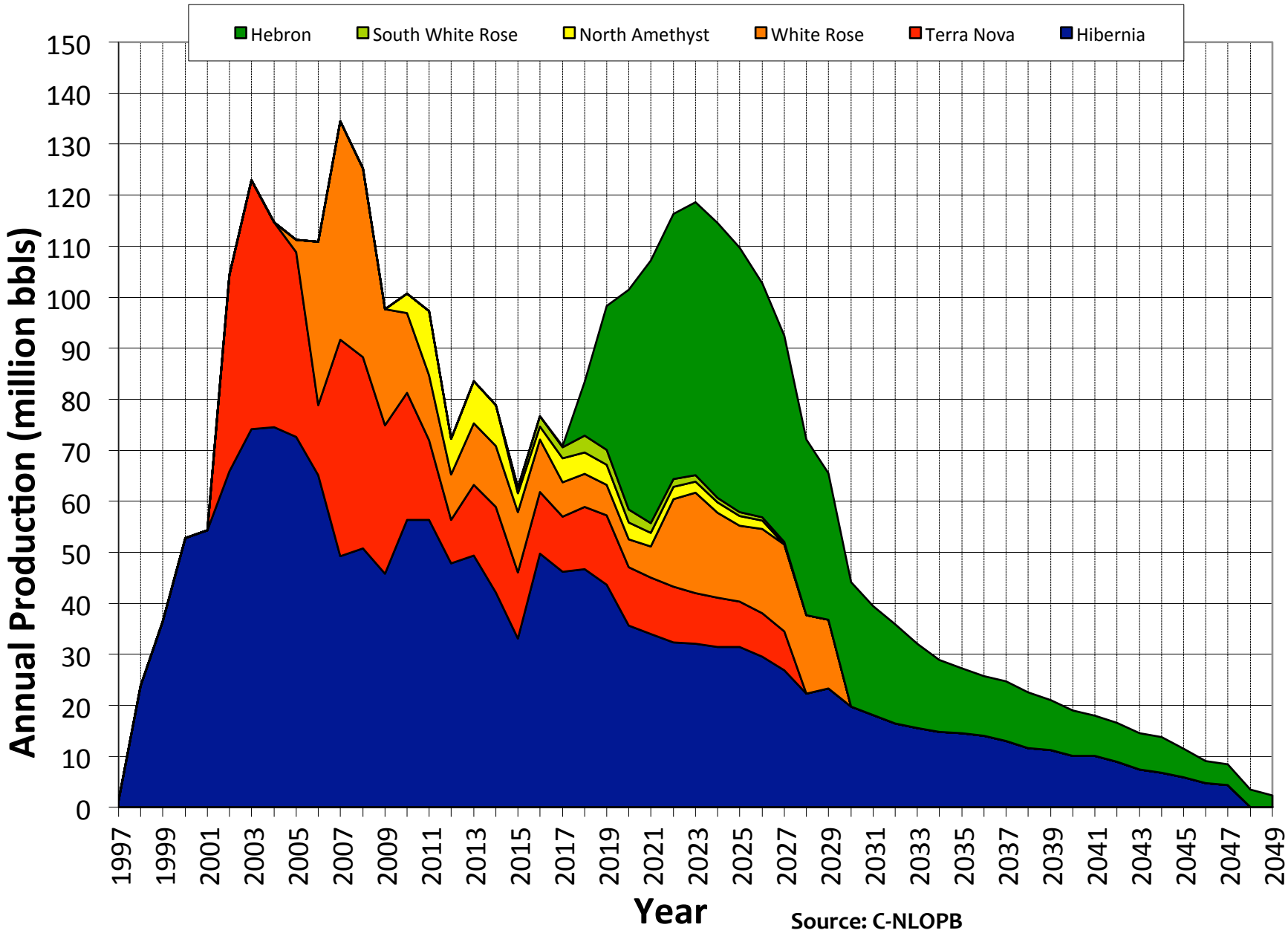
Oil Prices (Monthly Average)



Oil Production



Canada - Newfoundland and Labrador Offshore Area



The Modeling Process

* Step One: Update the data set and convert to year over growth rates
* Step Two (a): Apply the Denton Method if needed
* Step Two (b): Produce an estimate of GDP to complete the data set (choose optimal model based on lag structure criteria and check for stability)
* Step Three: Produce a x step ahead dynamic forecast of the complete model (in this case x=15, 3 months remaining in 2017 and 12 for 2018)
* Step Four: Choose optimal model based on lag structure criteria and check for stability
* Calculate annual growth rates for different periods

Lag Structure Decision Criteria

* Likelihood Ratio Test (LR)
* Final Prediction Error (FPE)
* Akaike's information criterion (AIC)
* Schwarz's Bayesian information criterion (SBIC)
* Hannan and Quinn information criterion (HQIC)

Sometimes there is mixed evidence that would produce alternative lagged structures or models.

The Denton Method

Interpolation of a low-frequency flow time series (annual series) by use of an associated high-frequency "indicator series“ (monthly series)

Adjustment of Monthly or Quarterly Series to Annual Totals: An Approach Based on Quadratic Minimization

Frank T. Denton

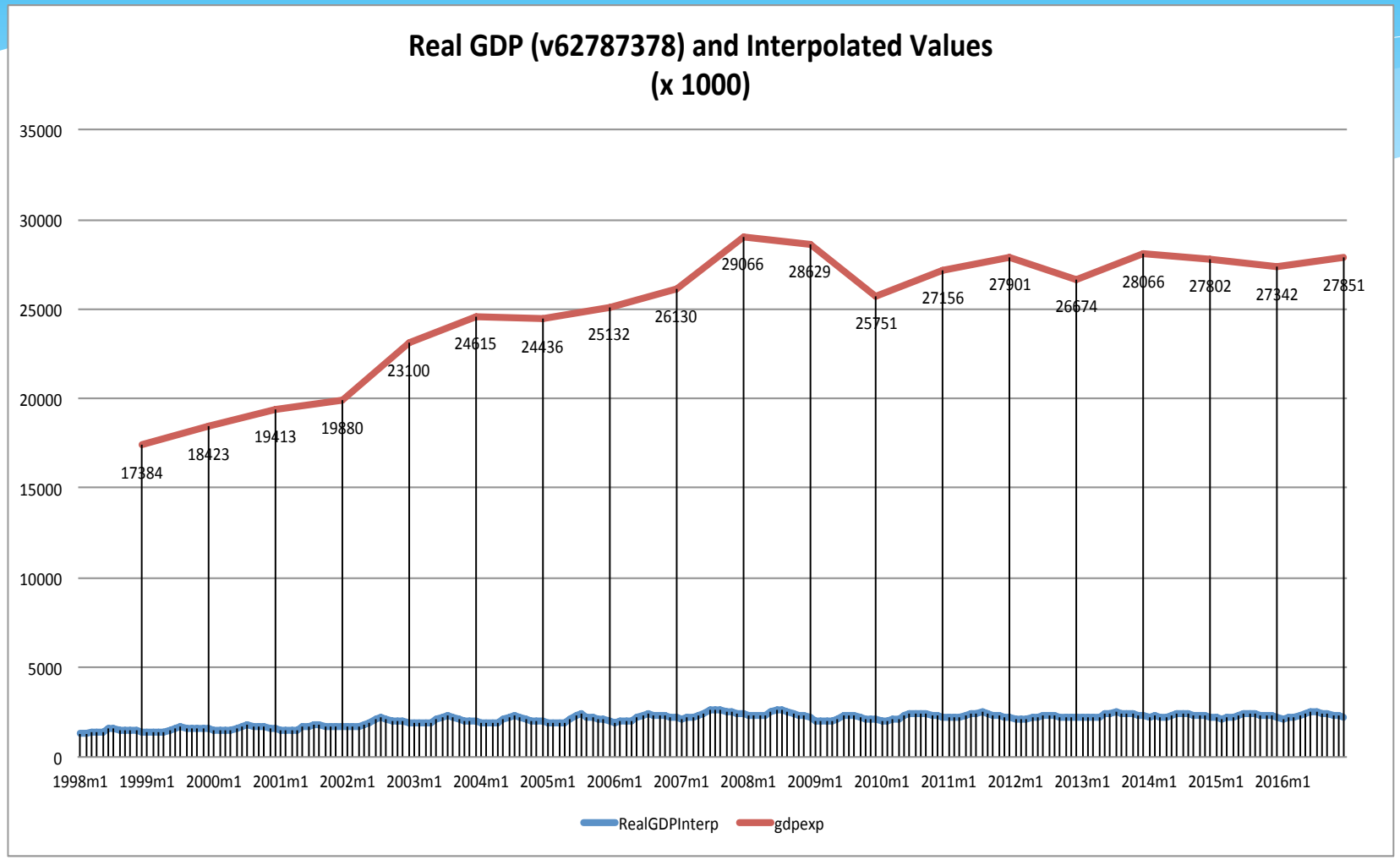
Journal of the American Statistical Association

Vol. 66, No. 333 (Mar., 1971), pp. 99-102

Frank Denton

Born	(1930-10-27) October 27, 1930 (age 87) Toronto, Ontario, Canada
Education	B.A., Economics, University of Toronto (1952) M.A., Economics, University of Toronto (1954)
Occupation	Economist
Employer	McMaster University

Denton Method



The Data

* **Hourly Wage** – CANSIM 282-0071 (v2135999 – Labour force survey estimates (LFS), wages of employees by type of work, North American Industry Classification System (NAICS), sex and age group, unadjusted for seasonality; Newfoundland and Labrador; Average hourly wage rate; Both full- and part-time employees; Total employees, all industries; Both sexes; 15 years and over)
* **Retail Sales** – CANSIM 080-0020 (**v52367393** – Retail trade, sales by the North American Industry Classification System (NAICS); Newfoundland and Labrador; Retail trade; Unadjusted)
* **Residential Unit Sales** – CREA (Canadian Real Estate Association http://creastats.crea.ca/stjo/index.htm

The Data

* **Real Gross Domestic Product** - CANSIM 384-0038 (v62787378 - Gross Domestic Product, expenditure-based, provincial and territorial; Newfoundland and Labrador; 2007 chained prices).
* **Employment** – CANSIM 282-0001 (v2091702 - Labour force survey estimates (LFS), by sex and detailed age group, unadjusted for seasonality; Newfoundland and Labrador; Employment (x 1,000); Both sexes; 15 years and over)
* **Hours Worked** – CANSIM 282-0027 (v3502861 - Labour force survey estimates (LFS), by total and average usual and actual hours worked, main or all jobs, type of work, sex and age group, unadjusted for seasonality; Newfoundland and Labrador; Total actual hours; All jobs; Both full- and part-time employment; Both sexes; 15 years and over (x 1,000)

The Data

* **Housing Prices** – CREA – Residential Average Price - http://creastats.crea.ca/stjo/index.htm
* **Housing Starts** – CANSIM 027-0001 (v729951 – Canada Mortgage and Housing Corporation, housing starts, under construction and completions in centres 10,000 and over, Canada, provinces, selected census metropolitan areas; Newfoundland and Labrador; Housing starts; Total units) **Consumer Price Index** (CPI) – CANSIM 326-0020 (v41691244 – Consumer Price Index; Newfoundland and Labrador; All-items)

The Data

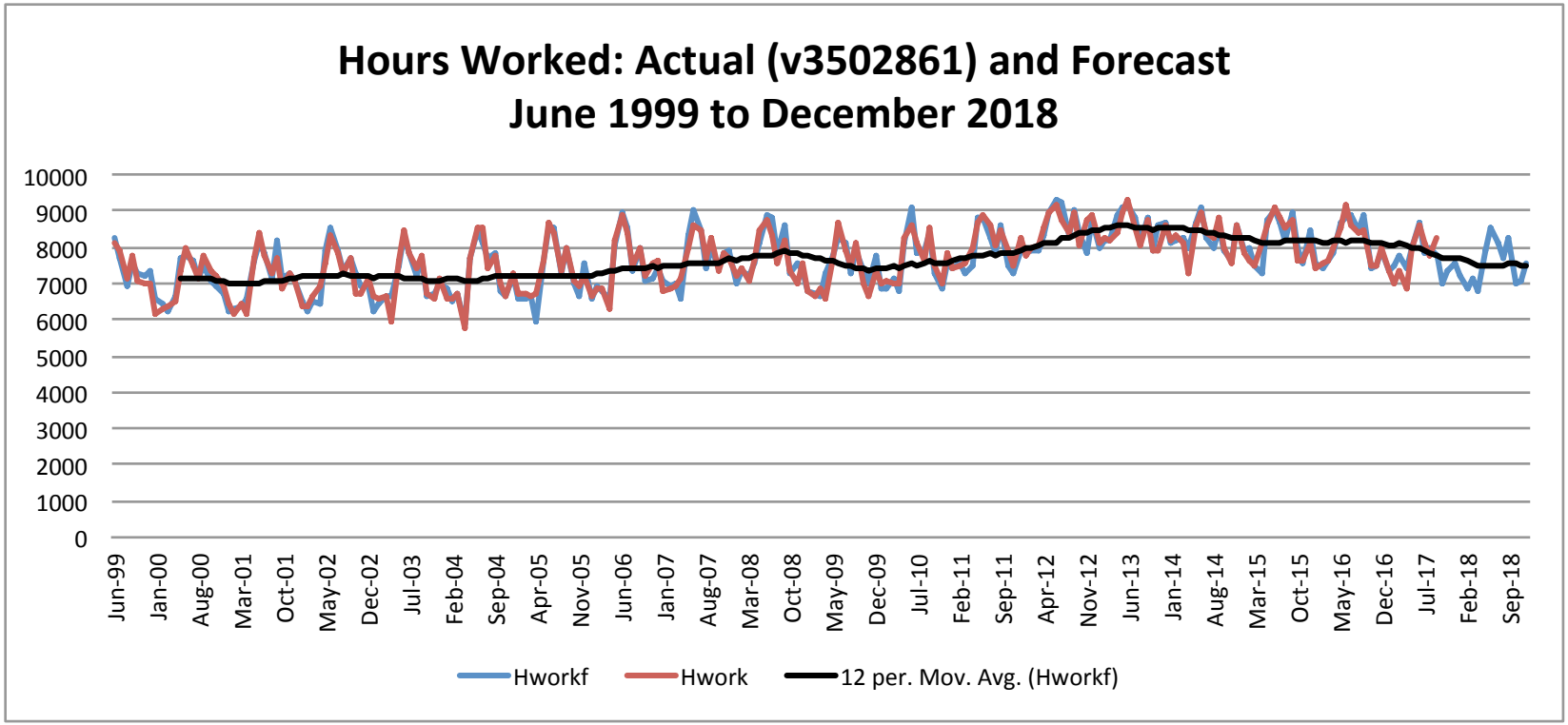
* **Brent USD** - EIA (US Energy Information Administration) US Prices, Petroleum, Crude Oil, Brent Spot

http://www.eia.gov/forecasts/steo/query/index.cfm

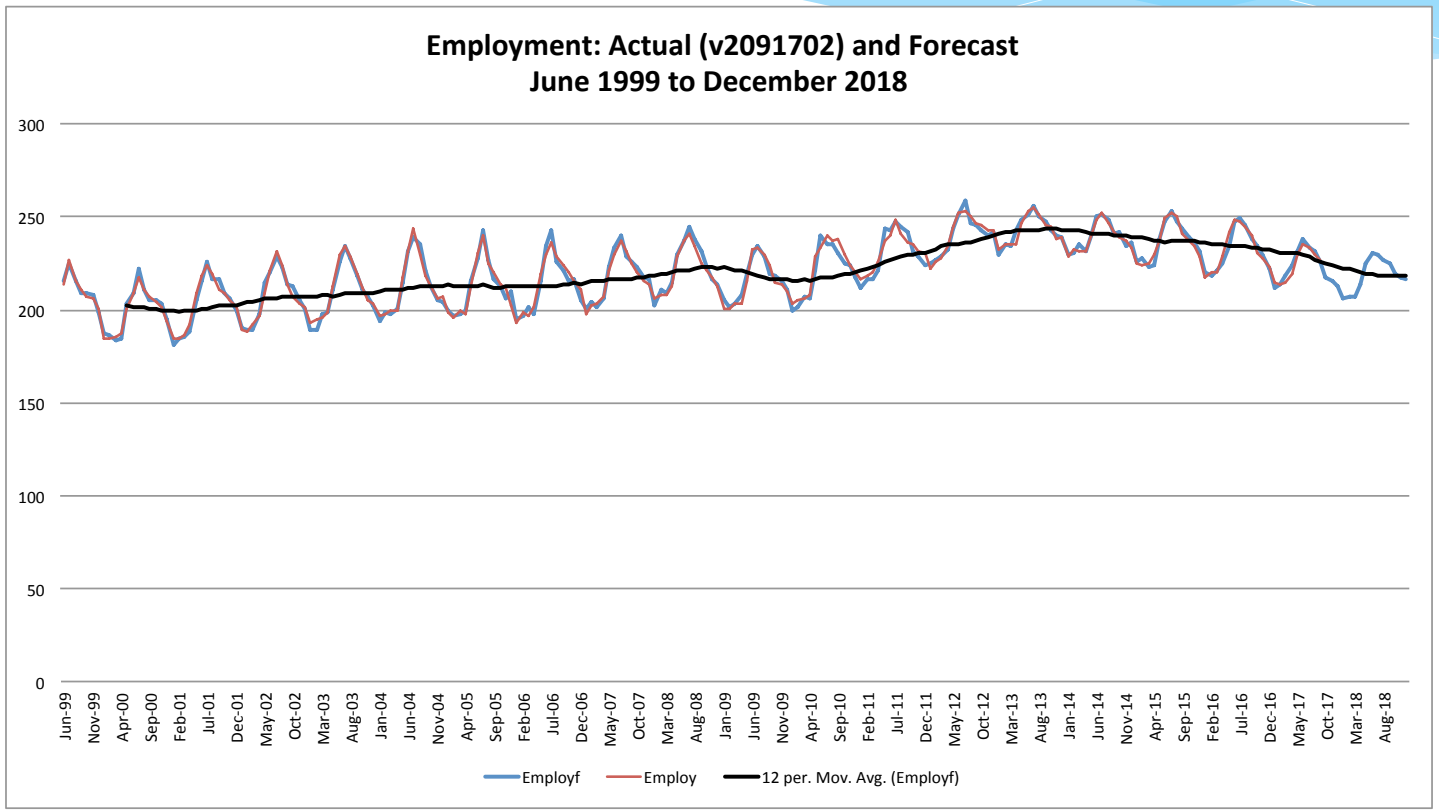
* **Oil Production** – C-NLOPB http://www.cnlopb.ca/information/statistics.php#rm

  Total Monthly production

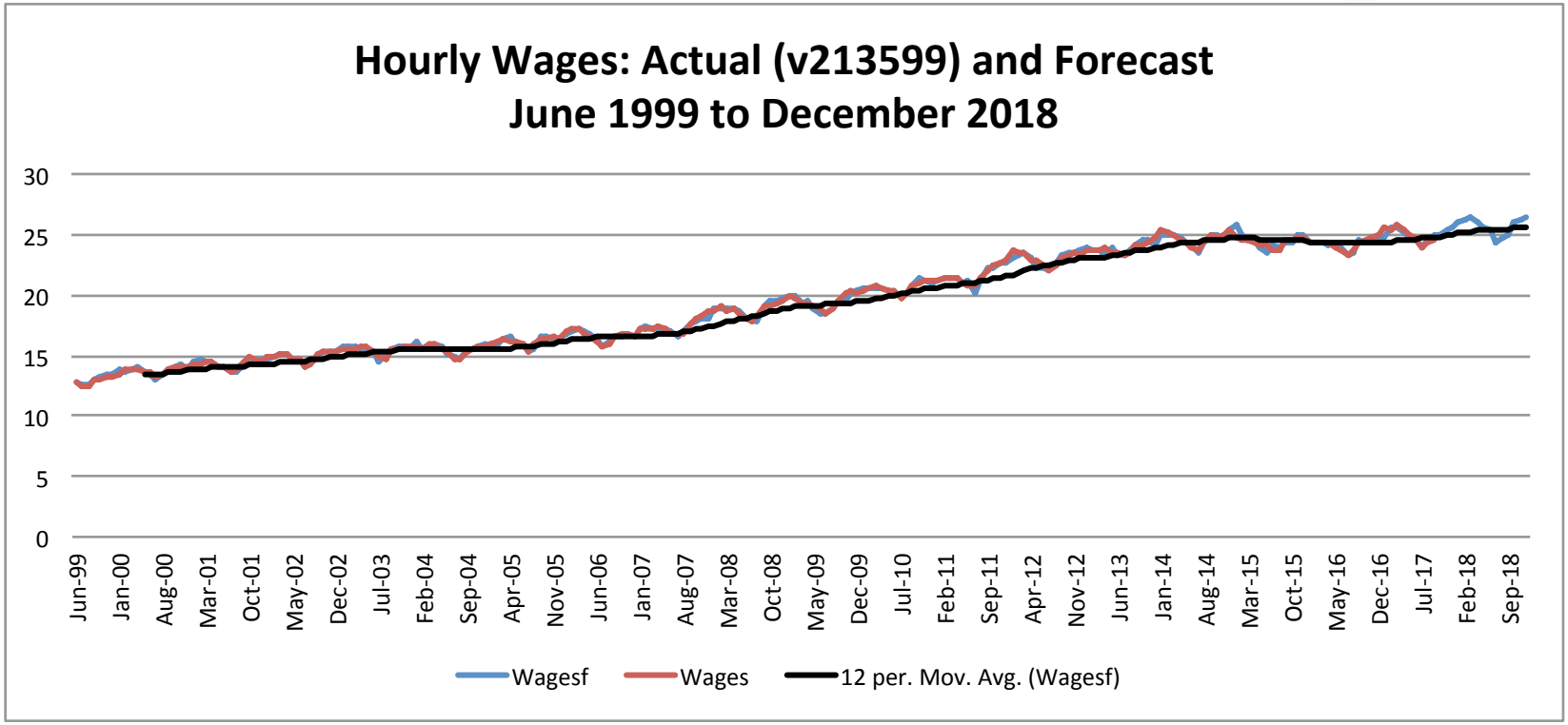
Hours Worked (x 1000)



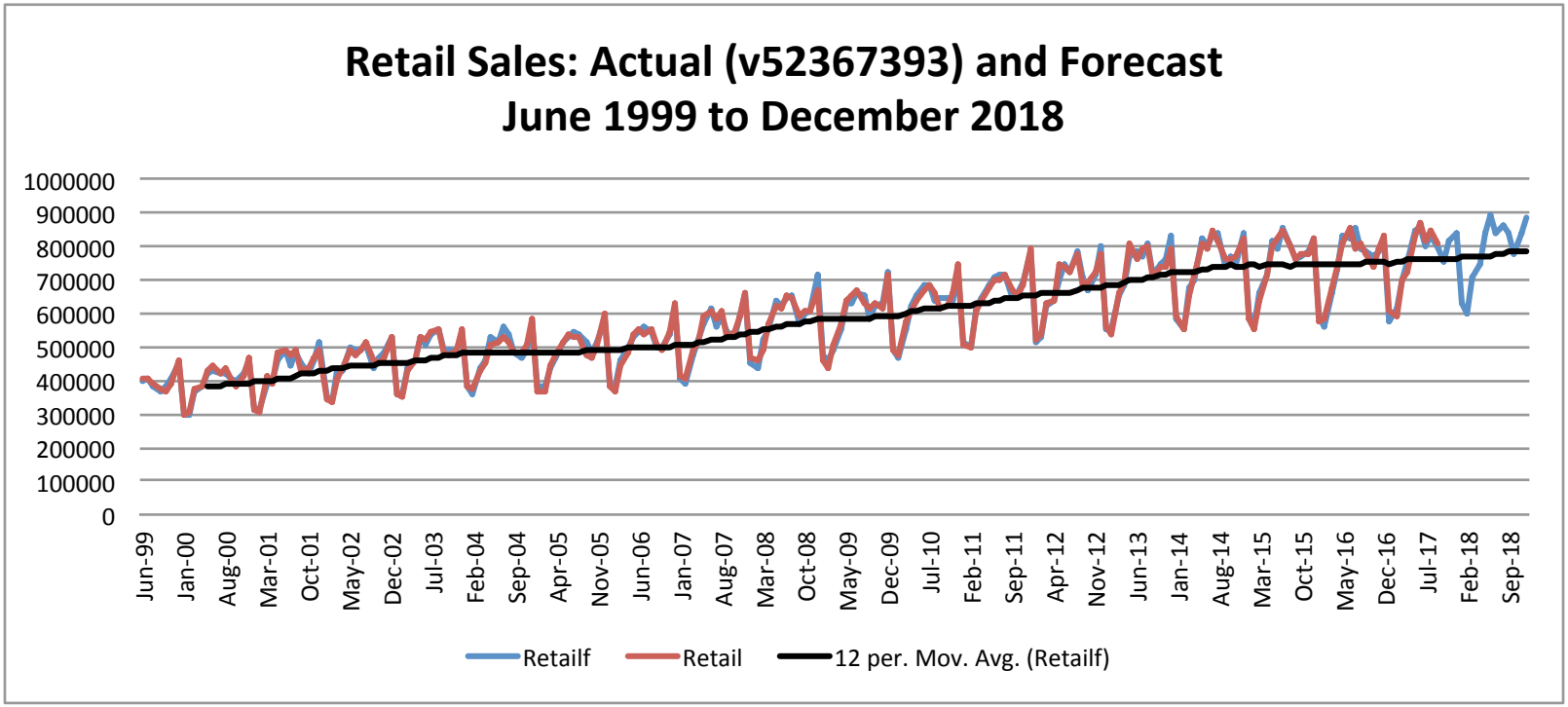
Employment (x 1000)



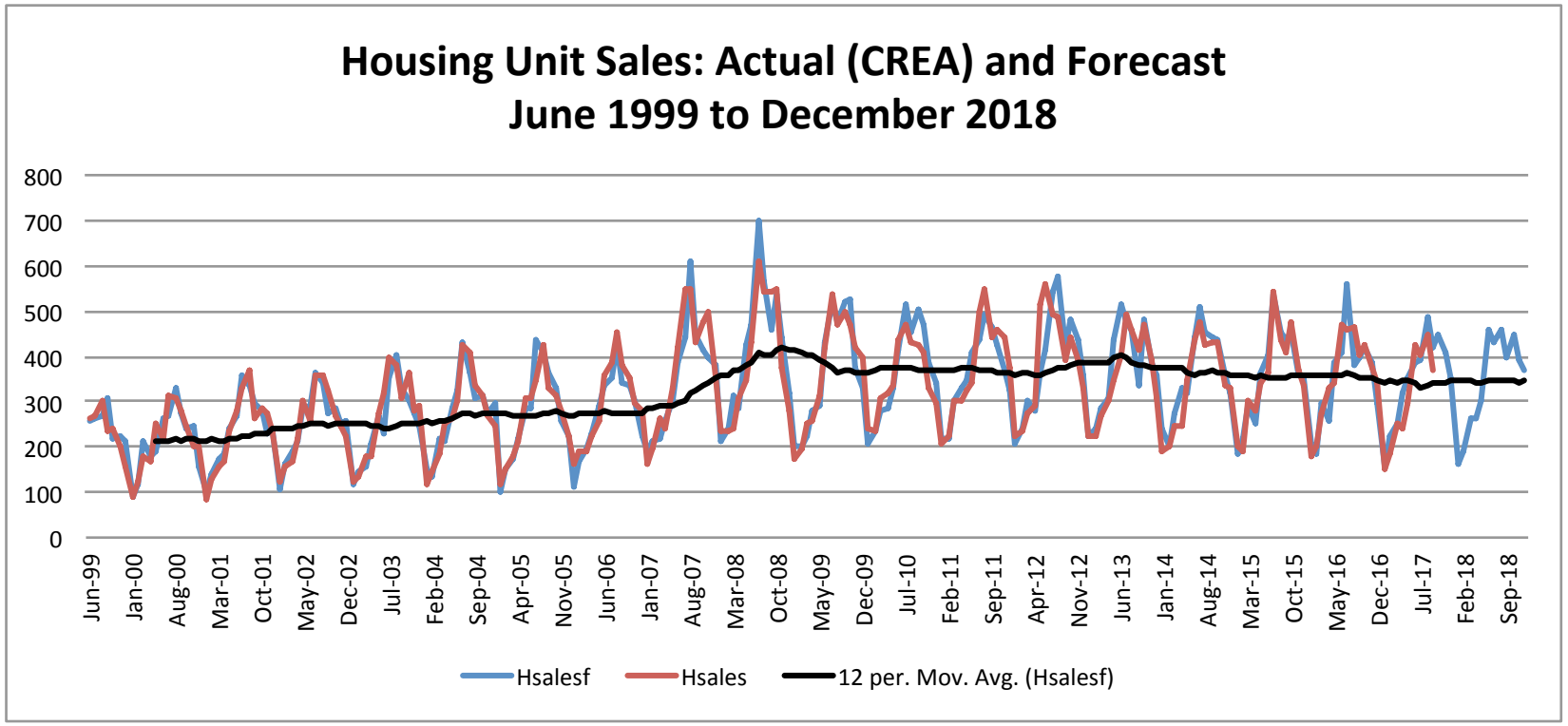
Hourly Wages



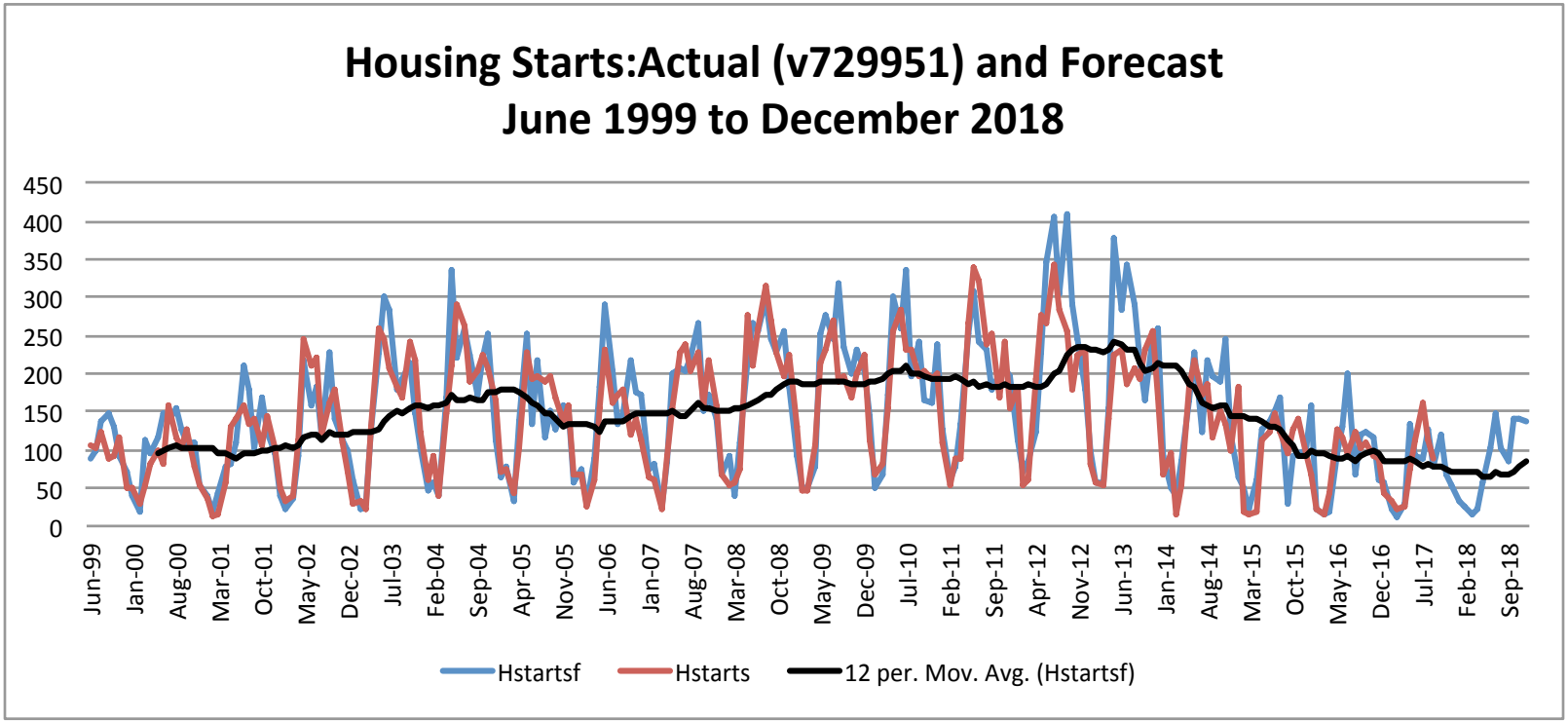
Retail Sales (x 1000)



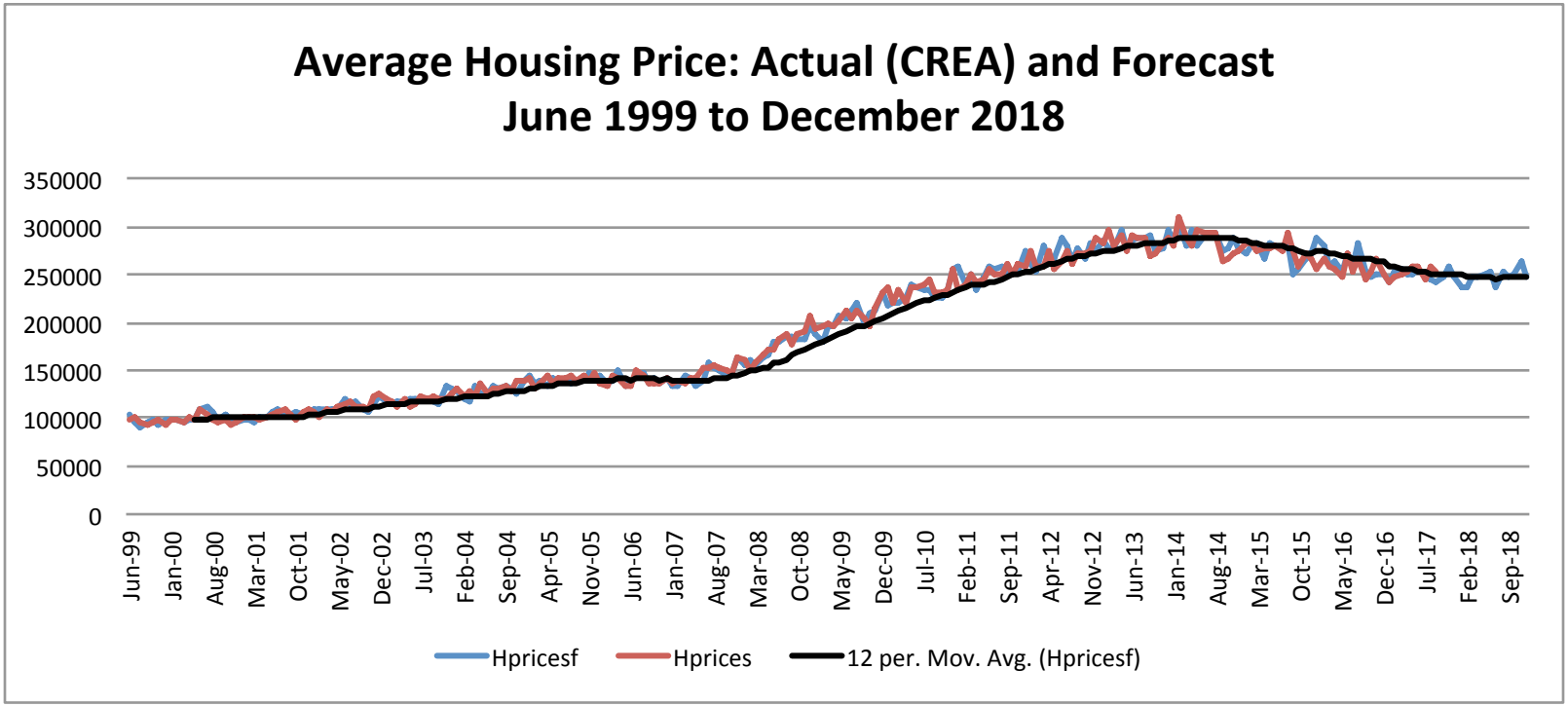
Residential Unit Sales
x 1000



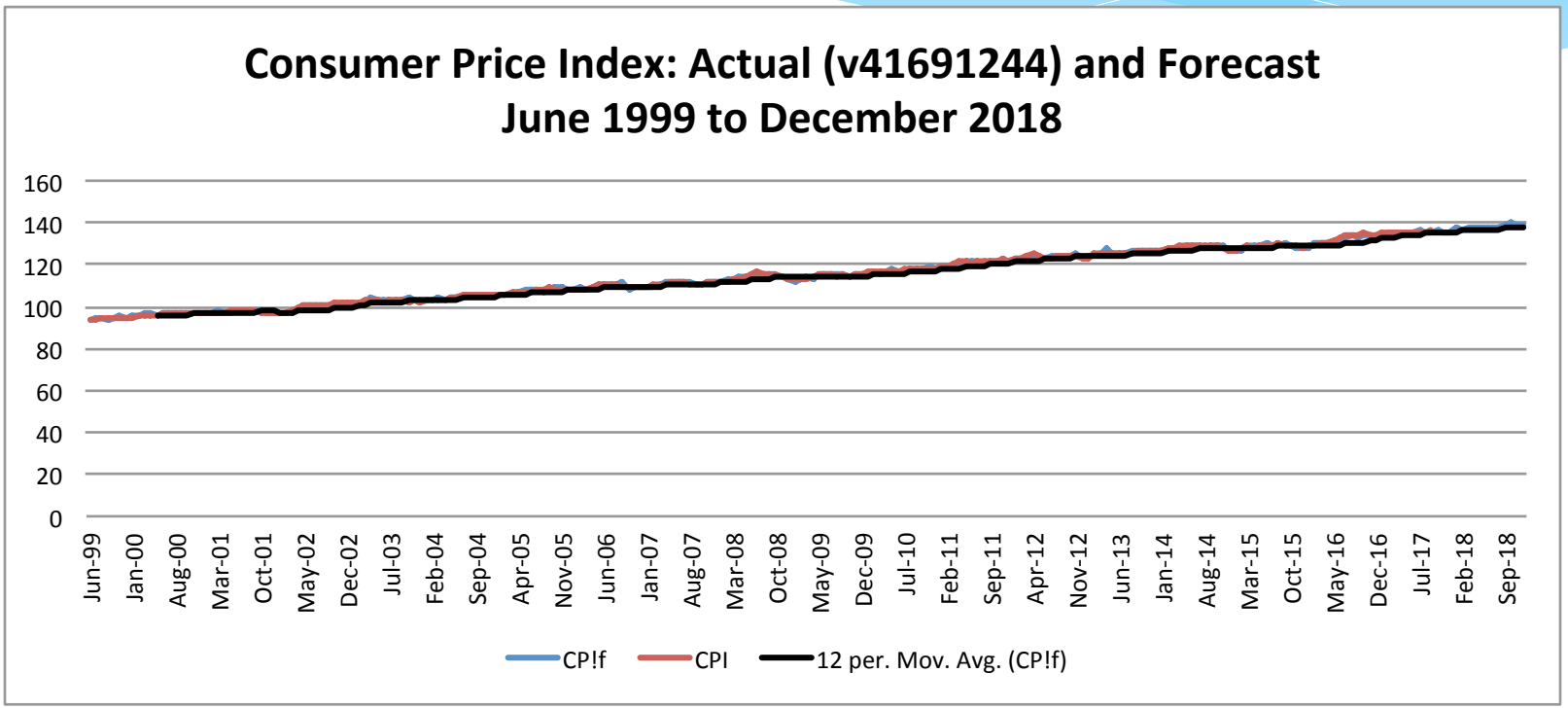
Housing Starts



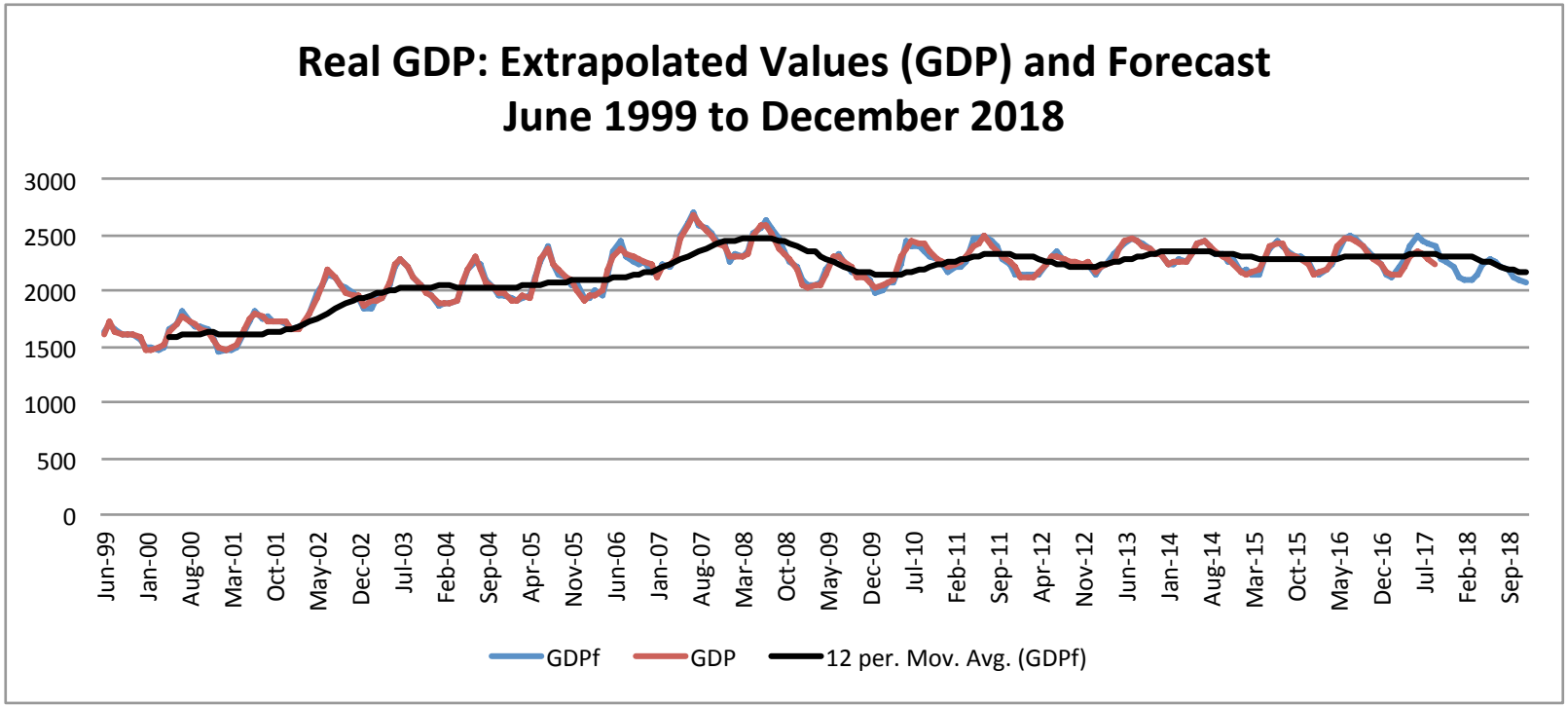
Residential Average Price



Consumer Price Index



Real GDP


Real GDP: Extrapolated Values (GDP) and Forecast
June 1999 to December 2018
3000
2500
2000
1500
1000
500
0
Jun-99
Jan-00
Aug-00
Mar-01
Oct-01
May-02
Dec-02
Jul-03
Feb-04
Sep-04
Apr-05
Nov-05
Jun-06
Jan-07
Aug-07
Mar-08
Oct-08
May-09
Dec-09
Jul-10
Feb-11
Sep-11
Apr-12
Nov-12
Jun-13
Jan-14
Aug-14
Mar-15
Oct-15
May-16
Dec-16
Jul-17
Feb-18
Sep-18
GDPf
GDP
12 per. Mov. Avg. (GDPf)

Economic Forecasts

2017 Real GDP Forecast

Real GDP Growth CARE	Date Completed Jan-17	Growth Rate -2.71%
CIBC World Markets	Feb-17	-3.00%
Scotiabank Group	Mar-17	-2.70%
TD Economics	Dec-16	-1.20%
BMO Nesbitt-Burns	Mar-17	-2.80%
Conference Board of Canada	Nov-16	-1.40%
RBC	Dec-16	-3.60%
Private Sector Average		-2.45%
NL Deptartment of Finance	Sep-16	-4.50%

Real GDP Growth CARE	Date Completed May-17	Growth Rate 0.51%
CIBC World Markets	Jul-17	-1.80%
Scotiabank Group	Jul-17	-1.80%
TD Economics	Jun-17	-1.90%
BMO Nesbitt Burns	Jul-17	-2.00%
Conference Board of Canada	Feb-17	-1.90%
RBC	Jun-17	-2.20%
Private Sector Avg		-1.93%
NL Department of Finance	Apr-17	-3.80%

2017 Employment Forecast

Employment Growth CARE	Date Completed Jan-17	Growth Rate -2.66%
CIBC World Markets	Feb-17	0.00%
Scotiabank Group	Mar-17	-2.00%
TD Economics	Dec-16	-1.40%
BMO Nesbitt Burns	Mar-17	-2.00%
Conference Board of Canada	Nov-16	-3.00%
RBC	Dec-16	-2.50%
Private Sector Avg		-1.82%
NL Department of Finance	Sep-16	-4.20%

Employment Growth CARE	Date Completed May-17	Growth Rate -3.89%
CIBC World Markets	Jul-17	0.60%
Scotiabank Group	Jul-17	-2.60%
TD Economics	Jun-17	-2.40%
BMO Nesbitt Burns	Jul-17	-3.00%
Conference Board of Canada	Feb-17	-4.10%
RBC	Jun-17	-3.10%
Private Sector Avg		-2.43%
NL Department of Finance	Apr-17	-1.90%

Latest Economic Forecasts

Real GDP Forecasts	Date Completed	
CARE	**Nov29-17**	**-0.96**
CIBC World Market	Jul-17	-1.80%
Scotibank Group	Oct-17	-1.60%
TD Economics	Sep-17	-1.60%
BMO Nesbitt Burns	Oct-17	-2.00%
Coference Board of Canada	Jul-17	-3.00%
RBC	Sep-17	-1.00%
Private Sector Avg		-1.70%
NL Department of Finance	Nov-17	-3.20%

Employment Growth	Date Completed	
CARE	**Nov29-17**	**-4.57%**
CIBC World Markets	Jul-17	-0.60%
Scotiabank Group	Oct-17	-3.70%
TD Economics	Sep-17	-3.10%
BMO Nesbitt Burns	Oct-17	-4.10%
Conference Board of Canada	Jul-17	-3.30%
RBC	Sep-17	-3.80%
Private Sector Avg		-3.10%
NL Depatement of Finance	Nov-17	-4.10%

Latest Economic Forecasts

Forecast Agency	Date Completed	Real GDP Growth (%)	
		2017	2018
CARE	Nov29	-0.96	-2.38
CIBC World Markets	14-Jul	-1.8	-0.9
Scotiabank Group	3-Nov	-1.5	-0.2
TD Economics	28-Sep	-1.6	1.6
BMO Nesbitt Burns	17-Nov	-2.0	0.0
Royal Bank of Canada	8-Sep	-1.0	-0.7
National Bank of Canada	28-Sep	-1.0	4.0
Conference Board of Canada	1-Nov	-3.5	2.3
Private Sector Average		**-1.8**	**0.9**
Department of Finance	**1-Nov**	**-3.2**	**0.2**

Forecast Agency	Date Completed	Employment Growth (%)	
		2017	2018
CARE	29-Nov	-4.57	-1.89
CIBC World Markets	14-Jul	-0.6	0.4
Scotiabank Group	3-Nov	-3.9	-0.9
TD Economics	28-Sep	-3.1	-0.1
BMO Nesbitt Burns	17-Nov	-4.1	-2.0
Royal Bank of Canada	8-Sep	-3.8	-3.1
National Bank of Canada	28-Sep	-3.4	-1.5
Conference Board of Canada	1-Nov	-4.0	-1.8
Private Sector Average		**-3.3**	**-1.3**
Department of Finance	**1-Nov**	**-4.1**	**-1.5**

Economic Forecasts
CARE
2017:2018

	2017	2018
Realgdp	-0.96%	-2.38%
Employment	-4.57%	-1.89%
Hours Worked	-5.67%	-0.98%
Hourly Wage	3.41%	1.95%
Retail Sales	2.36%	2.77%
Residential Unit Sales	-7.27%	5.33%
Housing Starts	-2.85%	-11.62%
Average Housing Prices	-2.14%	-2.38%
Inflation	2.40%	1.67%

Conclusions
Things to Think About When Forecasting

* Its about Assumptions and Decisions
* The world can change
* The data can be revised – this happens all the time
* You could be wrong
* **"If you have to forecast, forecast often. "**
* **"He who lives by the crystal ball soon learns to eat ground glass."**

Edgar R. Fiedler in *The Three Rs of Economic Forecasting-Irrational, Irrelevant and Irreverent* , June 1977.