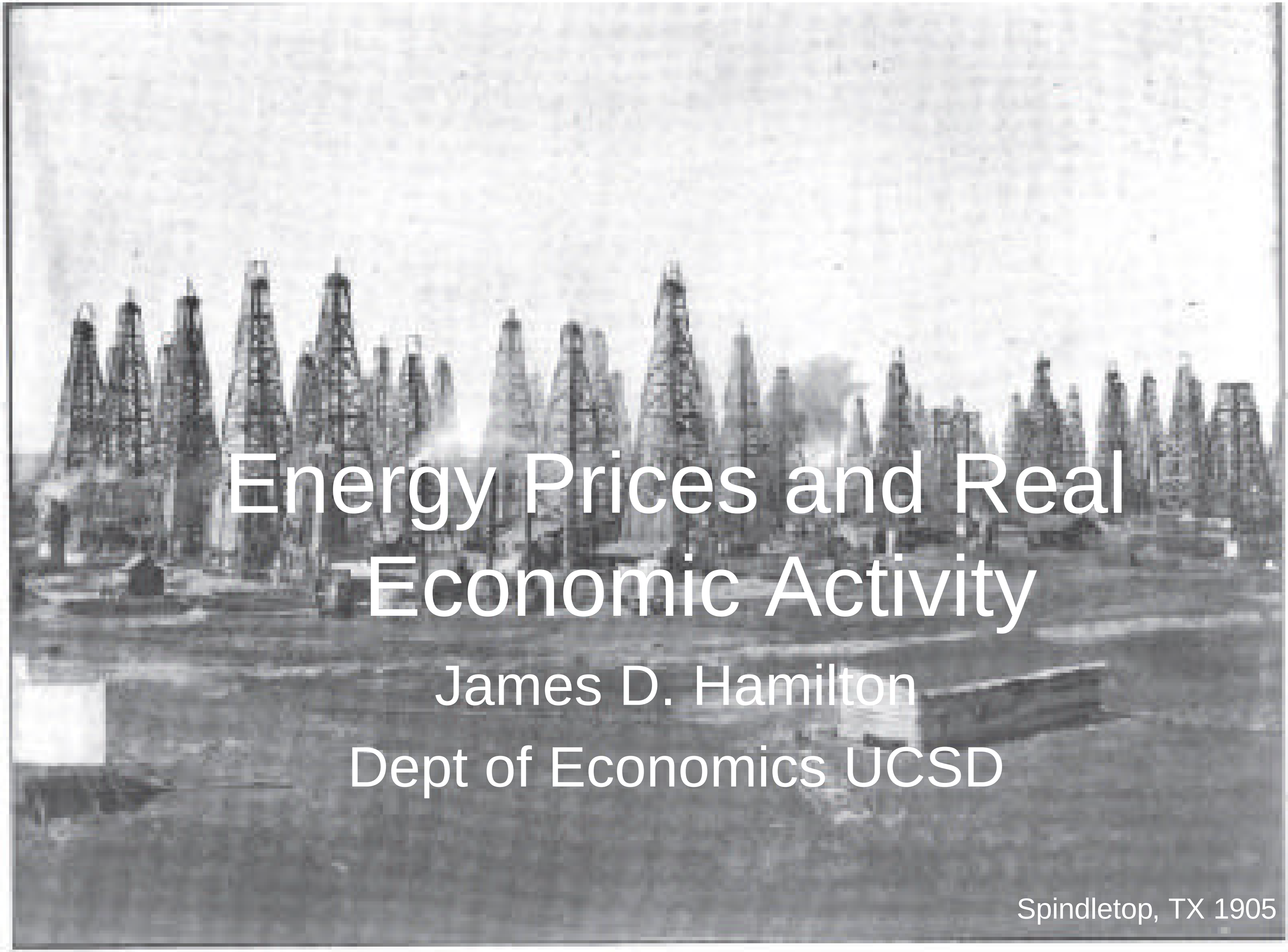

Energy Prices and Real Economic Activity

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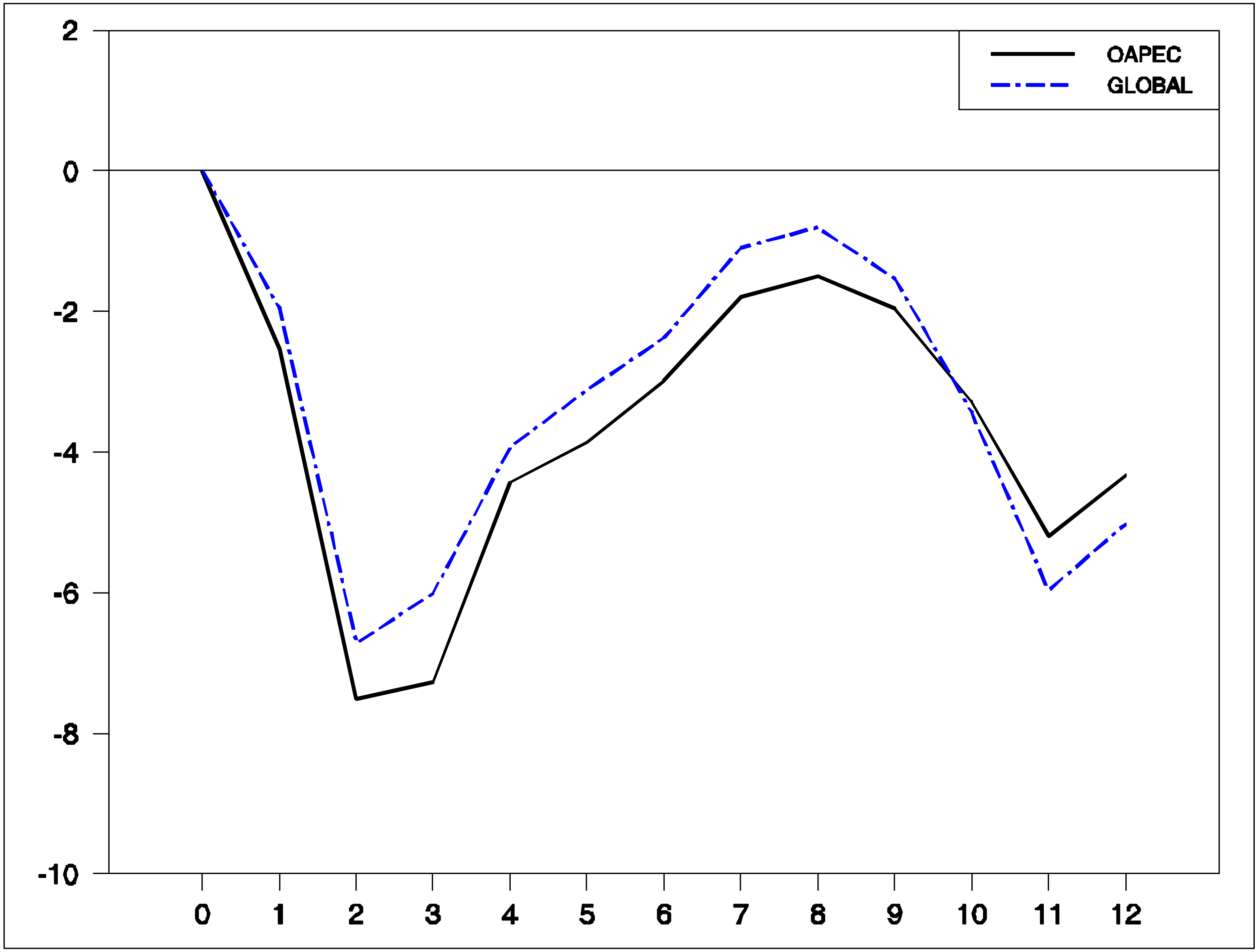
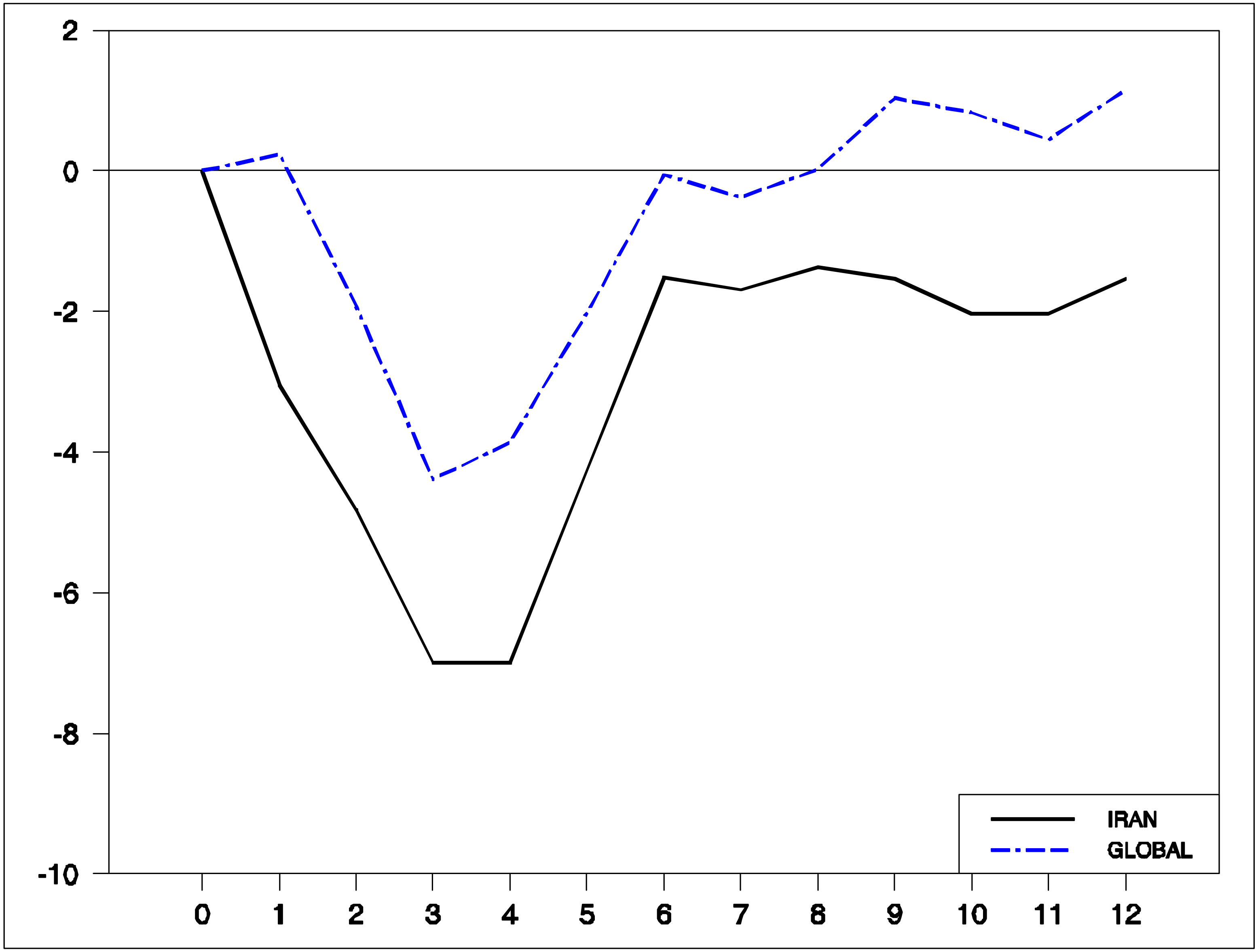
Spindletop, TX 1905

- Goal: survey literature and evidence on the effects of energy prices on real economic activity
- Initial question: what would happen if the world suddenly had to try to make do with 5% less oil production?

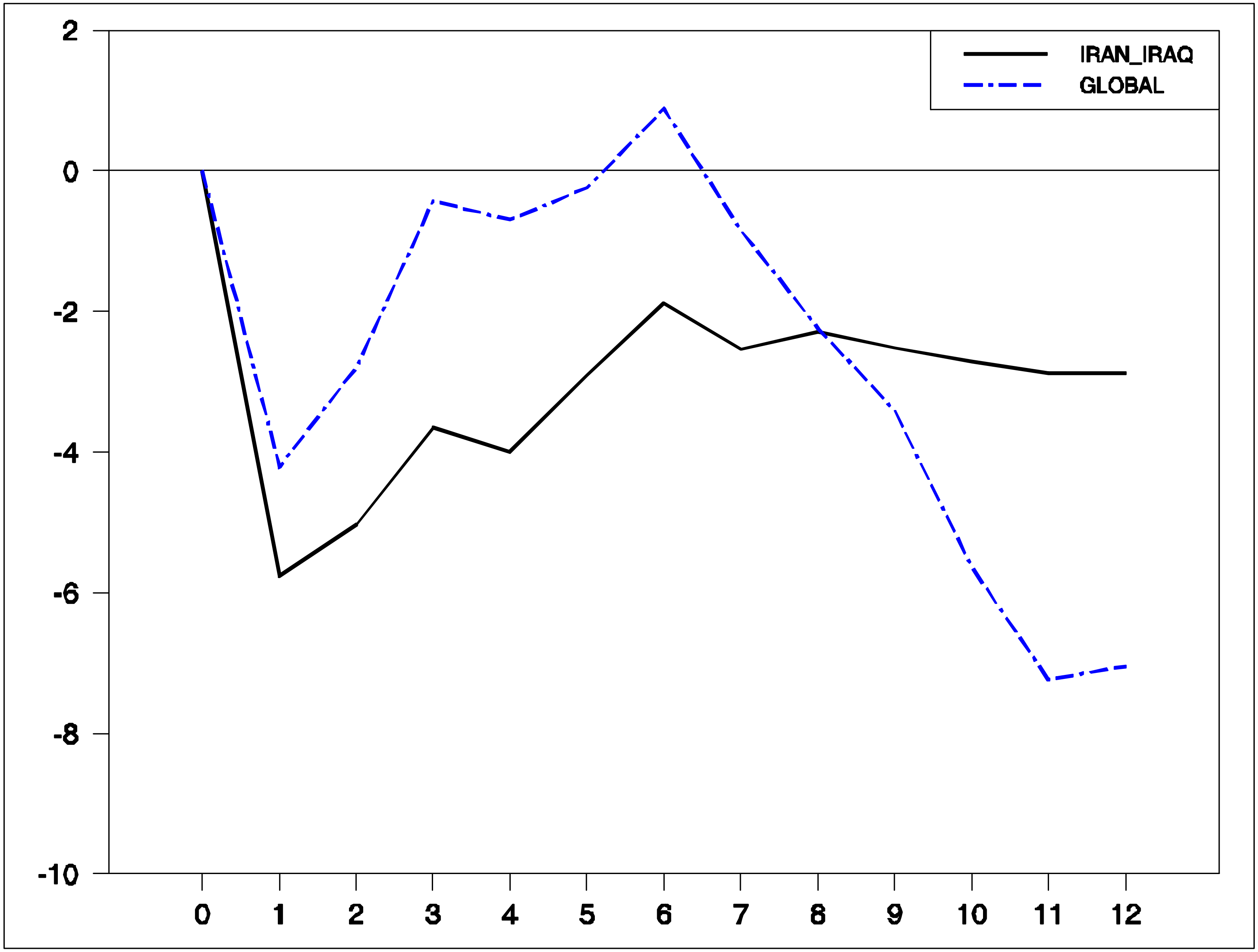
I. Review of postwar oil supply disruptions



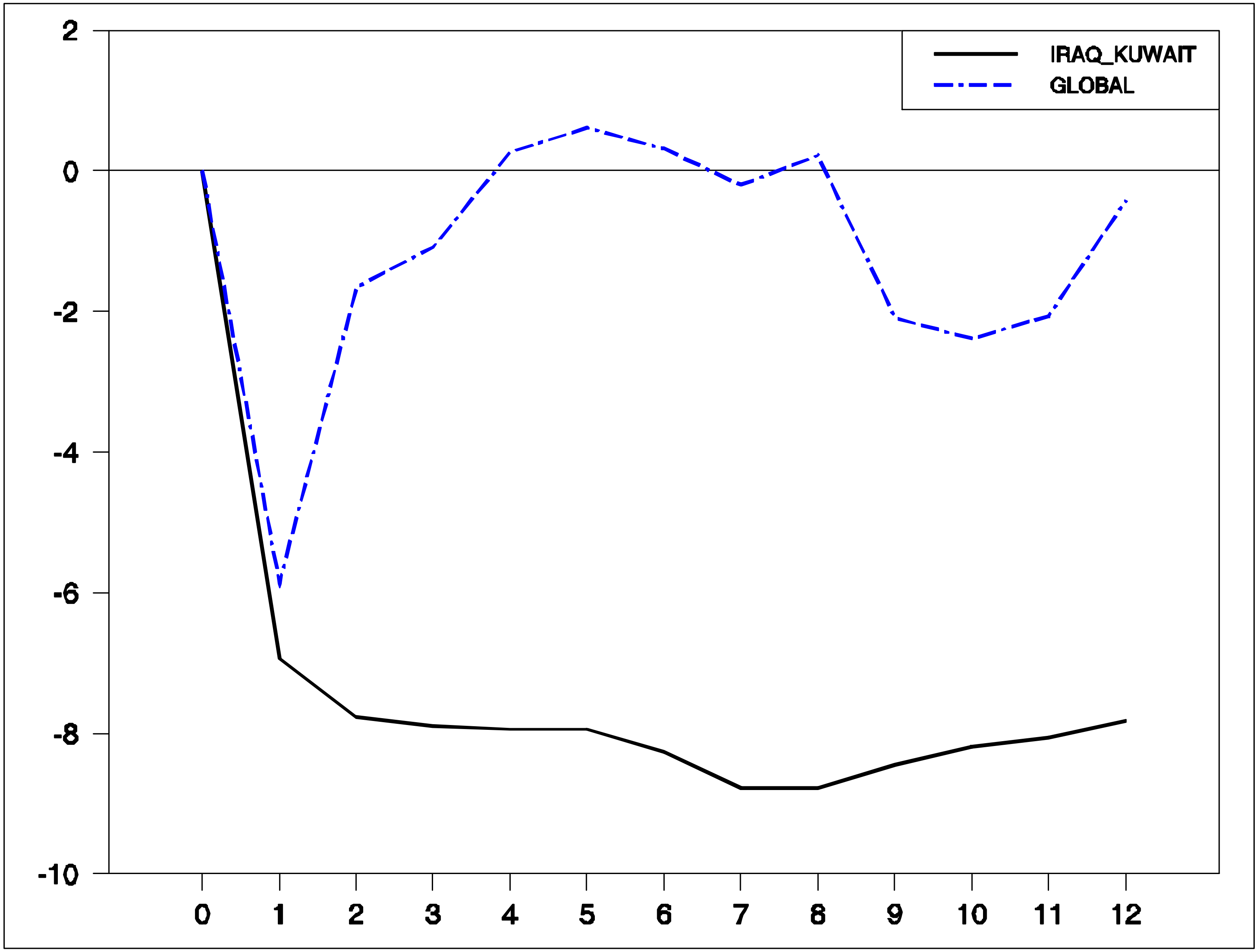
OPEC embargo: Oil production after Sept 1973 Arab-Israeli War.



Iranian revolution: production after Oct 1978



Iran-Iraq War: production after Sept 1980.

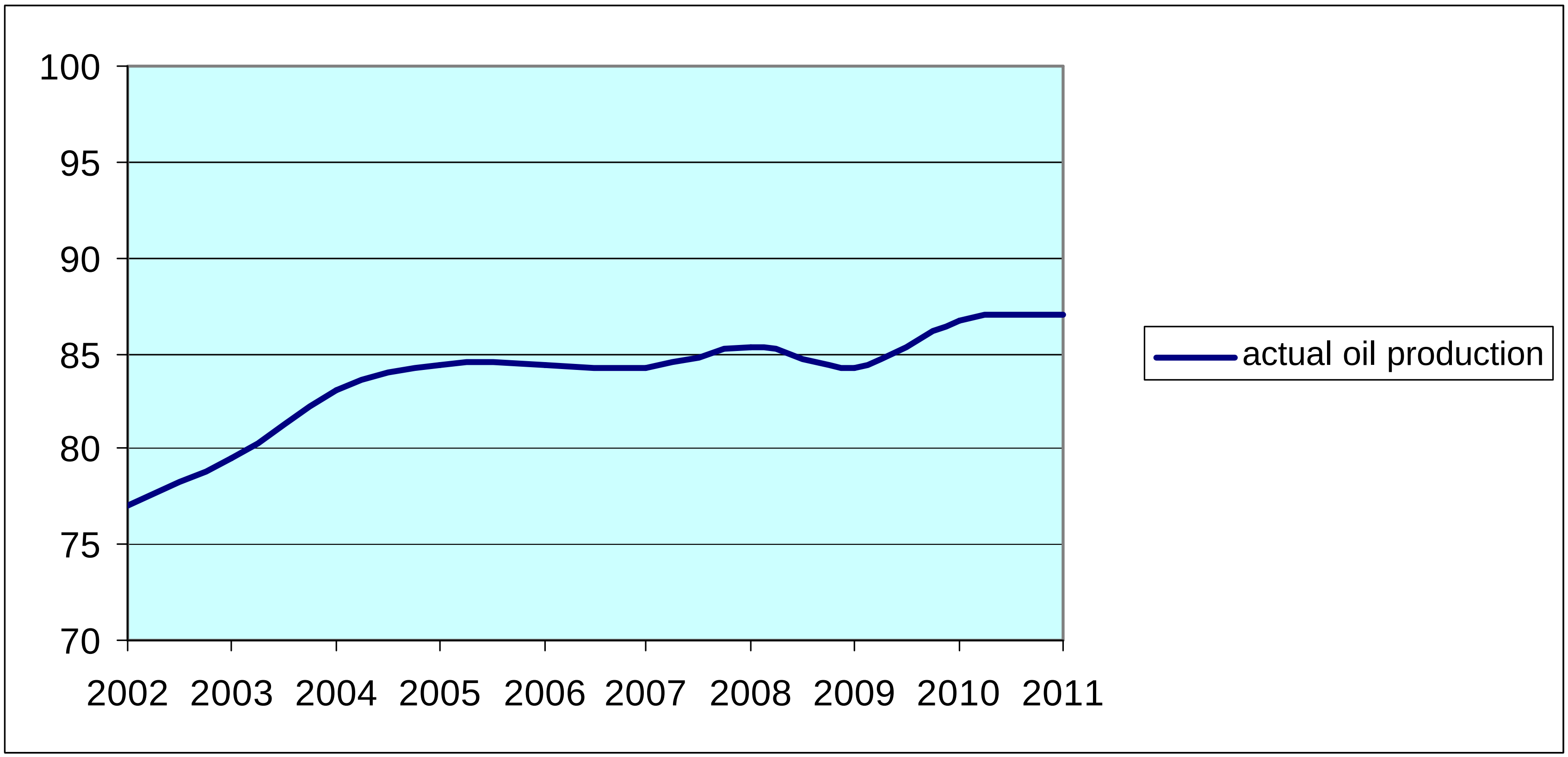


First Persian Gulf War: production after Aug 1990.

Major historical oil supply disruptions were followed by recessions

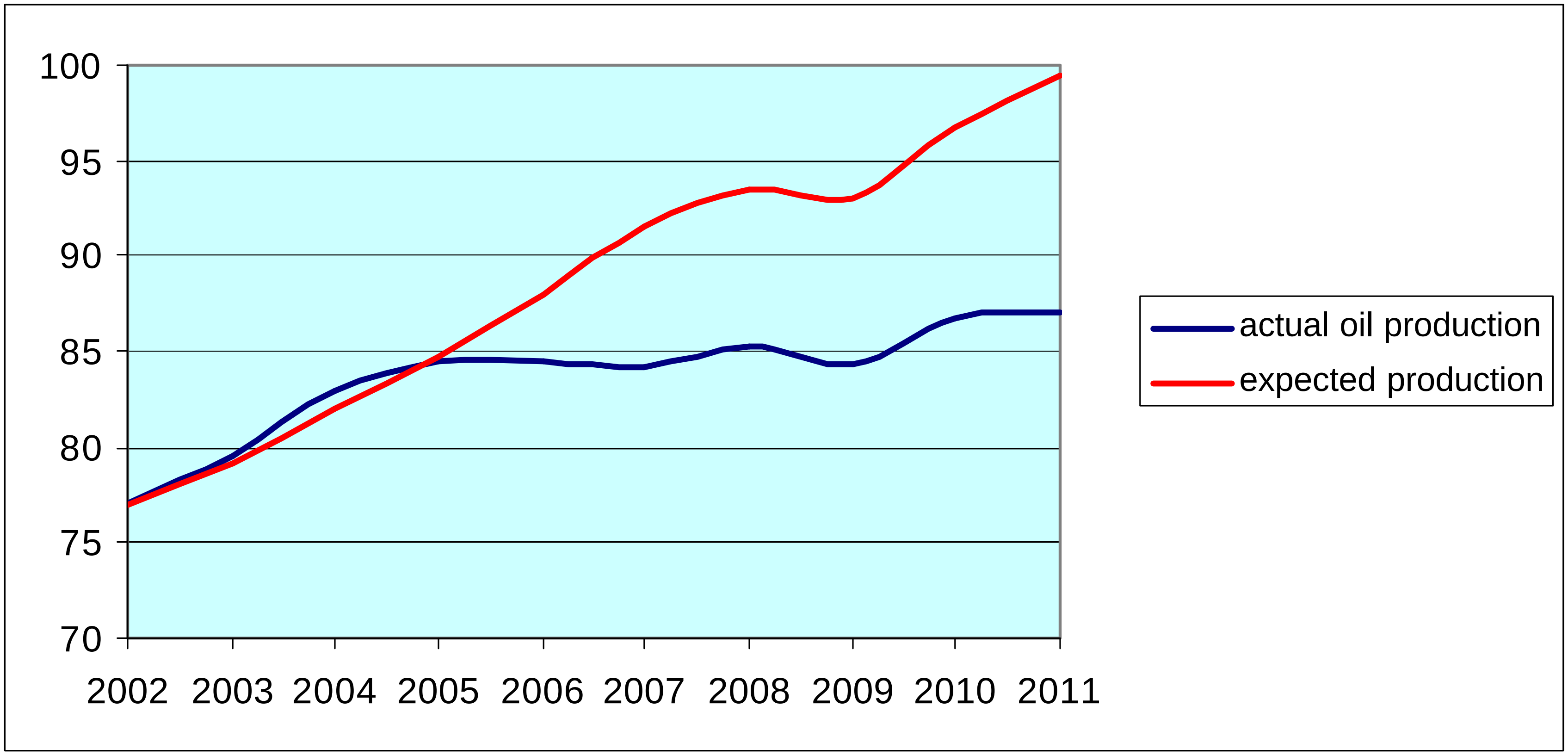
Date	Event	Supply cut (local)	Supply cut (global)	Price Change	Recession Start
Nov 73	OPEC embargo	7%	7%	51%	Dec 73
Nov 78	Iran revolution	7%	4%	57%	Feb 80
Oct 80	Iran-Iraq War	6%	4%	45%	Aug 81
Aug 90	Gulf War I	9%	6%	93%	Aug 90

Total global oil production, 2002-2011 (millions of barrels per day)



World real GDP increased 17.5% (logarithmically) from 2004 to 2008

Projected demand growth assuming constant price and income elasticity = 0.75

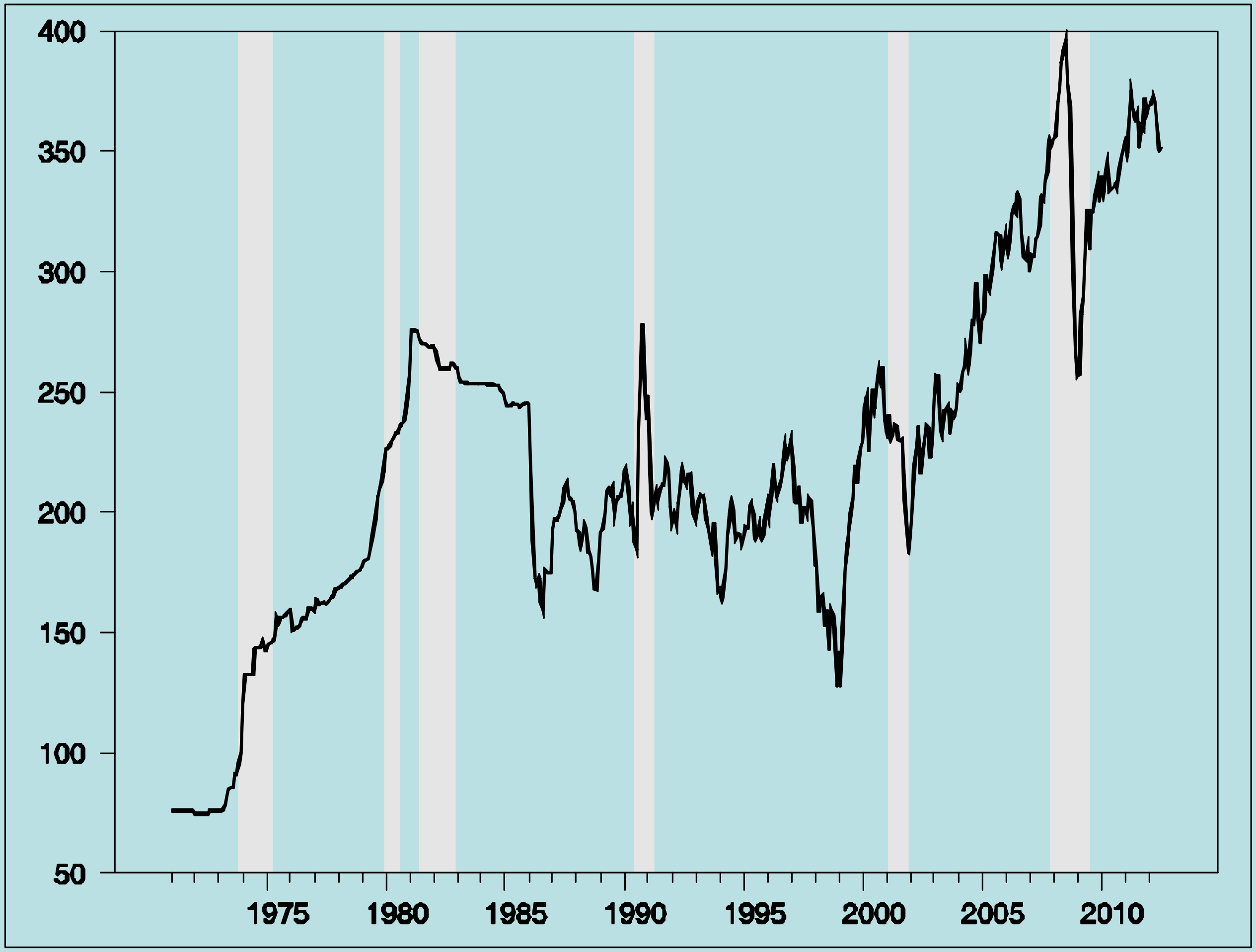


2011 shortfall = 12.5 mb/d (13.4% of world production)

Sample calculations

- Price of oil at end of 2004 was $50/barrel (in 2011 dollars)
- If we assume price elasticity of 0.1, price today should be (50)exp(0.1344/0.1) = $192/barrel (value reached in June 2008 was $147)
- If we assume price elasticity of 0.2, price today should be (50)exp(0.1344/0.2) = $98/barrel
- Oil price spike of 2007-2008 was also followed by a recession

Crude oil producer price index and U.S. recessions



100 times natural log relative to 1947:M1

Gasoline shortages	Price increase	Price controls	Key factors	Business cycle peak
Nov 47- Dec 47	Nov 47-Jan 48 (37%)	no (threatened)	strong demand, supply constraints	Nov 48
May 52	Jun 53 (10%)	yes	strike, controls lifted	Jul 53
Nov 56-Dec 56 (Europe)	Jan 57-Feb 57 (9%)	yes (Europe)	Suez Crisis	Aug 57
none	none	no	---	Apr 60
none	Feb 69 (7%) Nov 70 (8%)	no	strike, strong demand, supply constraints	Dec 69
Jun 73 Dec 73- Mar 74	Apr 73-Sep 73 (16%) Nov 73-Feb 74 (51%)	yes	strong demand, supply constraints, OAPEC embargo	Nov 73
May 79-Jul 79	May 79-Jan 80 (57%)	yes	Iranian revolution	Jan 80
none	Nov 80-Feb 81 (45%)	yes	Iran-Iraq War, controls lifted	Jul 81
none	Aug 90-Oct 90 (93%)	no	Gulf War I	Jul 90
none	Dec 99-Nov 00 (38%)	no	strong demand	Mar 01
none	Nov 02-Mar 03 (28%)	no	Venezuela unrest, Gulf War II	none
none	Feb 07-Jun 08 (145%)	no	strong demand, stagnant supply	Dec 07

Correlation could be

(1) coincidence

(2) oil shocks and recessions both caused by some third factor

(3) causal

Testing for coincidence: is there a statistically significant forecasting relation?

y_t = quarterly change in U.S. real GDP

o_t = quarterly change in nominal crude oil price

$x_t = (1, y_{t-1}, y_{t-2}, y_{t-3}, y_{t-4}, o_{t-1}, o_{t-2}, o_{t-3}, o_{t-4})'$

$y_t = b'x_t + e_t$

$$y_t = \underset{(0.18)}{1.14} + \underset{(0.09)}{0.20}\, y_{t-1} + \underset{(0.09)}{0.05}\, y_{t-2} - \underset{(0.09)}{0.10}\, y_{t-3} - \underset{(0.09)}{0.19}\, y_{t-4}$$

$$- \underset{(0.026)}{0.004}\, o_{t-1} - \underset{(0.026)}{0.027}\, o_{t-2} - \underset{(0.026)}{0.034}\, o_{t-3} - \underset{(0.027)}{0.065}\, o_{t-4}.$$

OLS estimates, 1949:Q2 to 1980:Q3. Source: Hamilton (1983)

Hamilton (1983):

Hypothesis that lagged oil prices don’t help predict real GDP growth strongly rejected, even using data only prior to 1972 and even using data only for 1973-1980

Correlation could be

(1) coincidence

(2) due to some other third factor

(3) causal

$$o_t = b'x_t + e_t$$

- Little indication prior to 1973 that any variables such as real GDP, unemployment, inflation, other commodity prices, interest rates could predict oil price changes
- Principal factors behind major oil price increases seem exogenous to U.S. economy

Gasoline shortages	Price increase	Price controls	Key factors	Business cycle peak
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1973-1974:

- Arab oil embargo announced following Arab-Israeli War in October 1973
- Arab oil production down 4.4 mb/d (= 7.5% of world production) between September and November

Barsky and Kilian (2001)

- Arab nations had discussed embargo before the war
- Embargo was lifted without achieving its purported objectives
- Embargo followed an acceleration of U.S. inflation, peak of U.S. oil production

II. Theoretical channels

A. Effects operating through supply-side effects

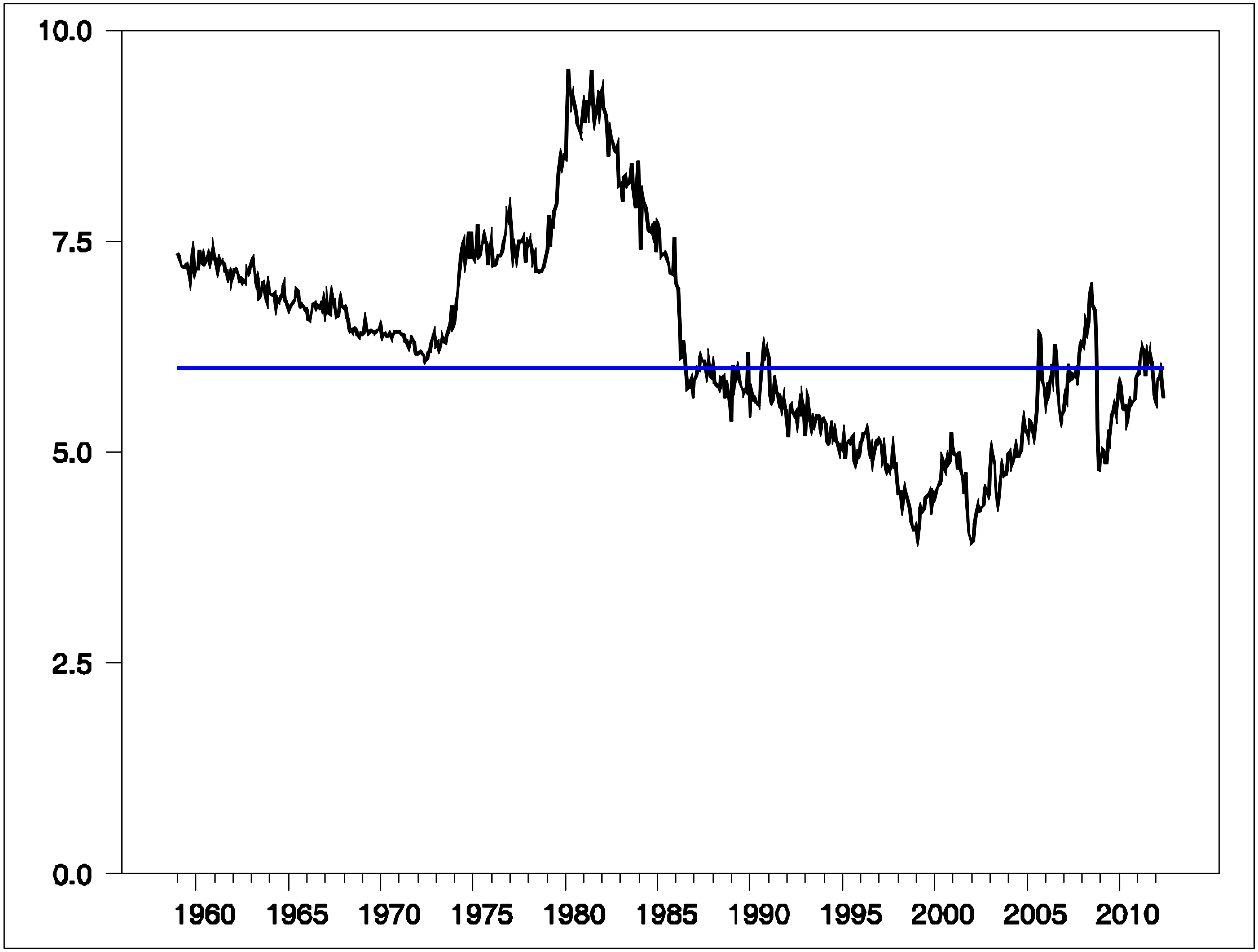
$$Y = F(K, N, E)$$

$$\frac{\partial Y}{\partial E} = P_E/P$$

$$\Rightarrow \frac{\partial \ln Y}{\partial \ln E} = \frac{P_E E}{PY}$$

$$\frac{\partial \ln Y}{\partial \ln(P_E/P)} = \frac{\partial \ln Y}{\partial \ln E} \frac{\partial \ln E}{\partial \ln(P_E/P)}$$

$$= \text{(expenditure share)} \times \text{(elasticity)}$$



Consumer expenditures on energy goods and services as a percentage of total consumption spending, 1959:M1-2012:M6

Problem: the expenditure share is small and short-run price elasticity is small-- could not generate big effects from this mechanism

E.g., relations discussed below imply that a 10% increase in energy prices leads one to predict 1.6% slower real GDP annual growth rate 4 quarters later

Expenditure share of 5% and unit price-elasticity of demand would predict only 0.5% slower growth

Kim and Loungani (1992)

- Embedded F(K,N,E) production function in calibrated dynamic stochastic general equilibrium model driven by exogenous energy price and technology shock to F(.)
- With expenditure share of 16% and Cobb-Douglas F(.), energy prices could account for 35% of output variability
- With CES F(.), would account for 16% of variability

Rotemberg and Woodford (1996):

Imperfect competition in output market would magnify effects

Increased energy price leads monopolist to raise markup, lower labor demand

Could get larger effects if N and K respond to P_E

$$Y = F(K, N, E)$$

$$\frac{\partial Y}{\partial E} = P_E / P$$

$$\Rightarrow \frac{\partial \ln Y}{\partial \ln E} = \frac{P_E E}{PY}$$

$$\frac{\partial \ln Y}{\partial \ln(P_E/P)} = \frac{\partial \ln Y}{\partial \ln E} \frac{\partial \ln E}{\partial \ln(P_E/P)}$$

$= \text{(expenditure share)} \times \text{(elasticity)}$

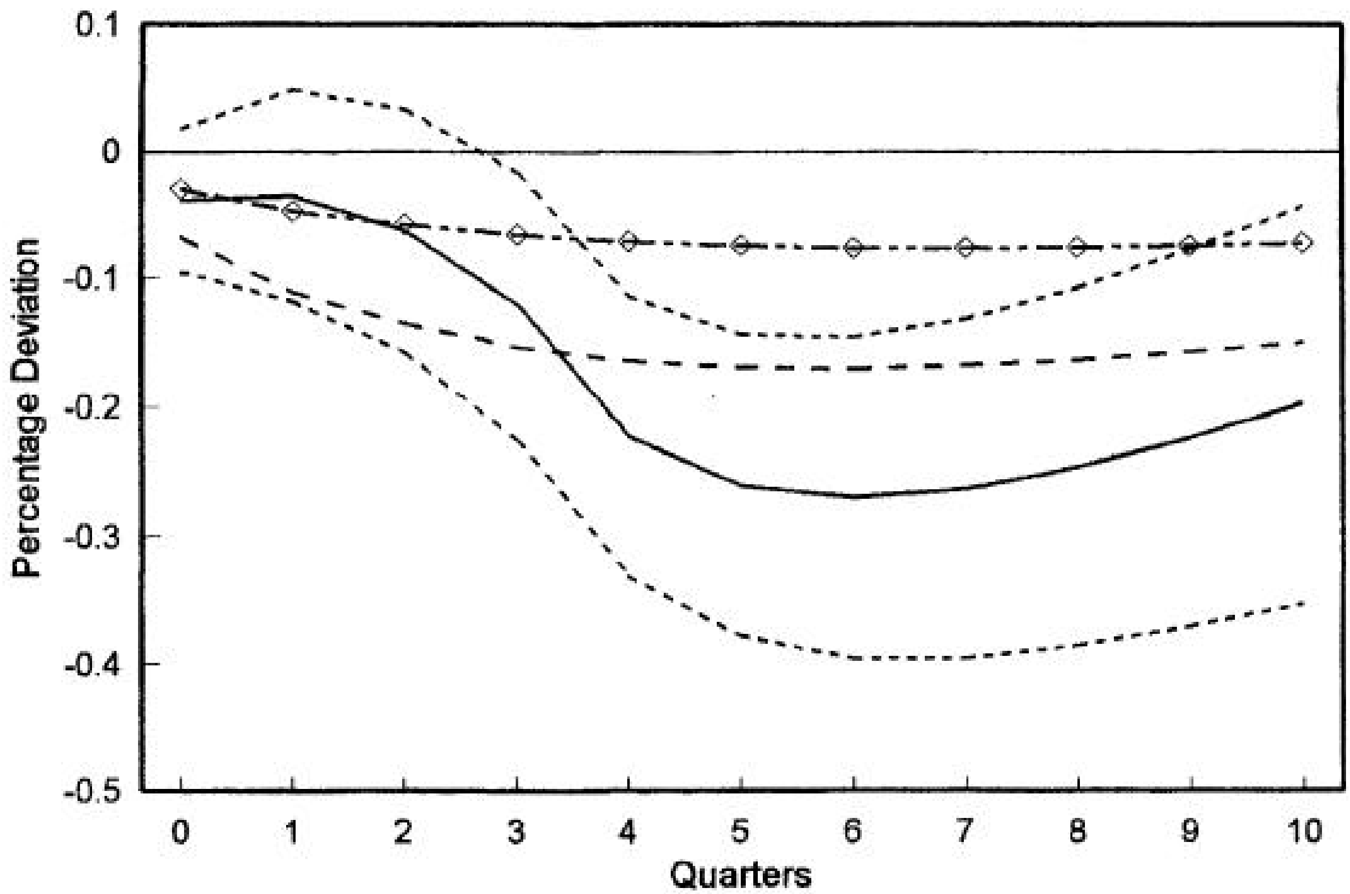
Response of capital utilization

Finn (2000):

For given capital utilization rate, capital and energy used in fixed proportions

Higher utilization increases energy costs and capital depreciation

Response of real value-added to 1% increase in energy price



Solid: response in data. Circles: response in Rotemberg and Woodford.
Dashed: response in Finn's model. Source: Finn (2000).

Response of employment

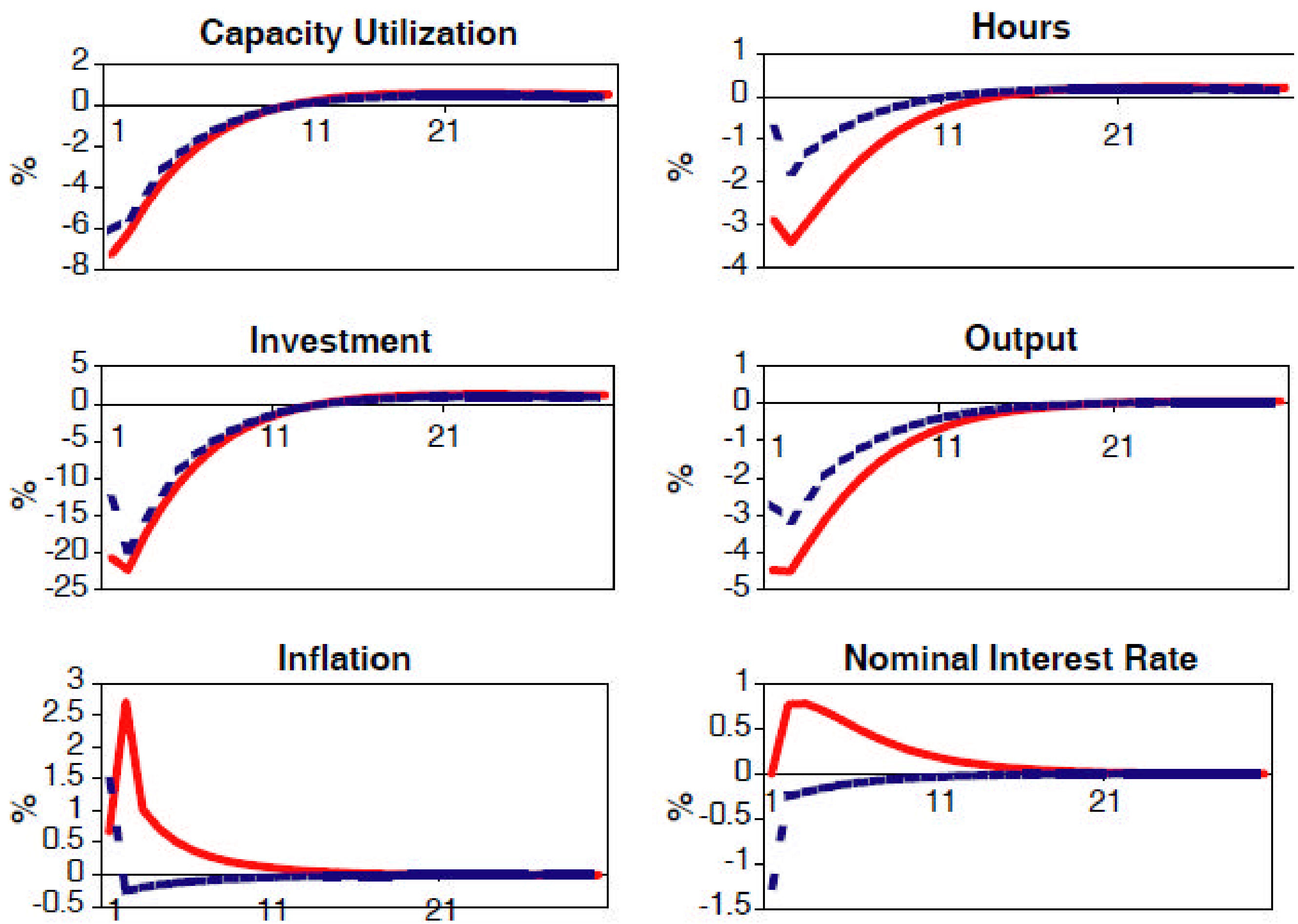
Wage and price rigidities can lead to unemployed labor--

if energy price increase lowers marginal product of labor, unemployment could result

Leduc and Sill (2004):

Combined Rotemberg-Woodford imperfect competition, Finn capital-utilization, and new Keynesian unemployment effects.

Response to a doubling in real oil price under two monetary policy rules



Source: Leduc and Sill (2004).

B. Effects operating through sectoral rigidities

- Effects on demand for labor in some sectors may be much greater than others
- Keynesian rigidities: this can produce unemployment if wages fail to fall to clear the market
- Sectoral rigidities (Davis, 1987): this can produce unemployment if it takes time for workers to retrain and relocate

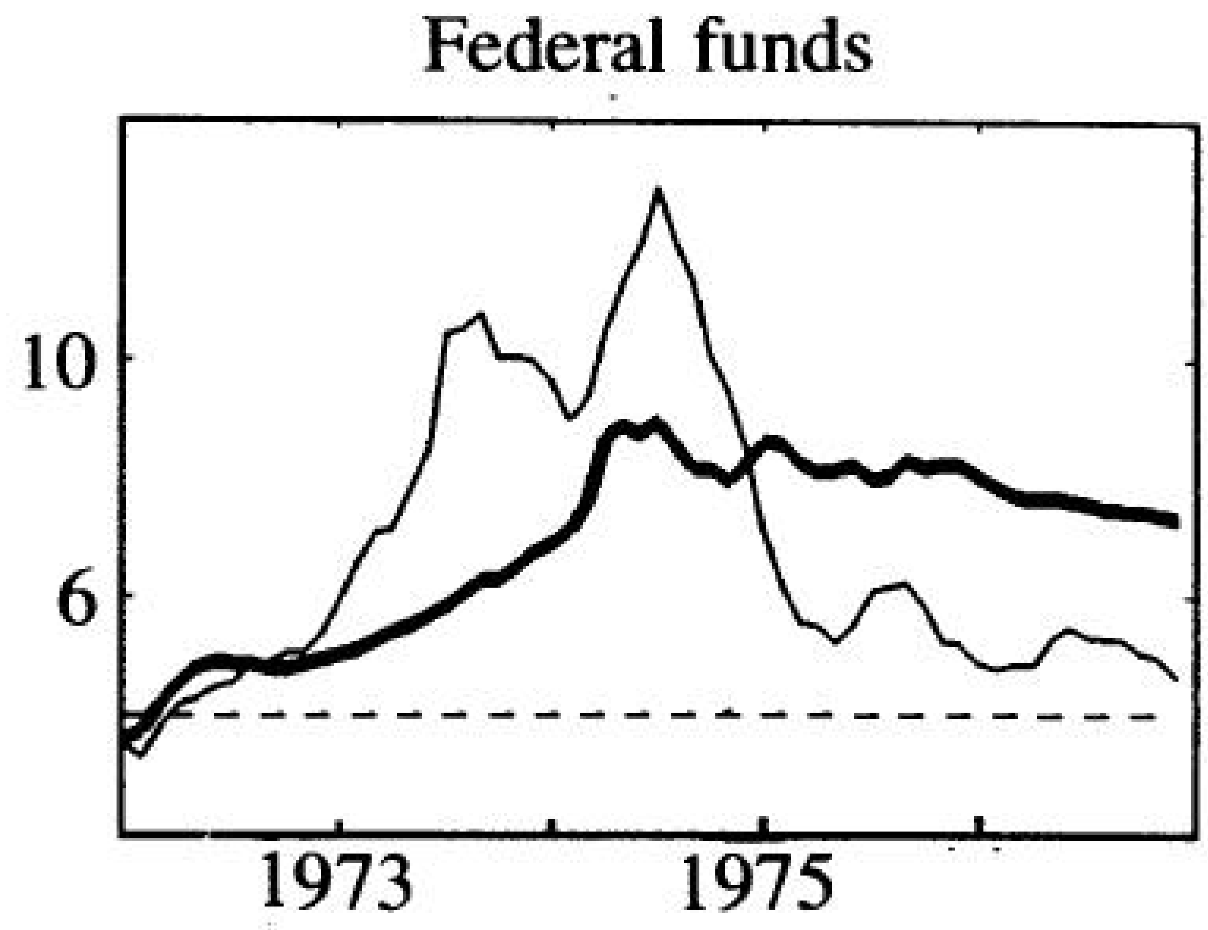
Hamilton (1988):

If there are real costs to retraining or relocating, workers may instead choose to remain unemployed as they wait for terms in their sector to improve

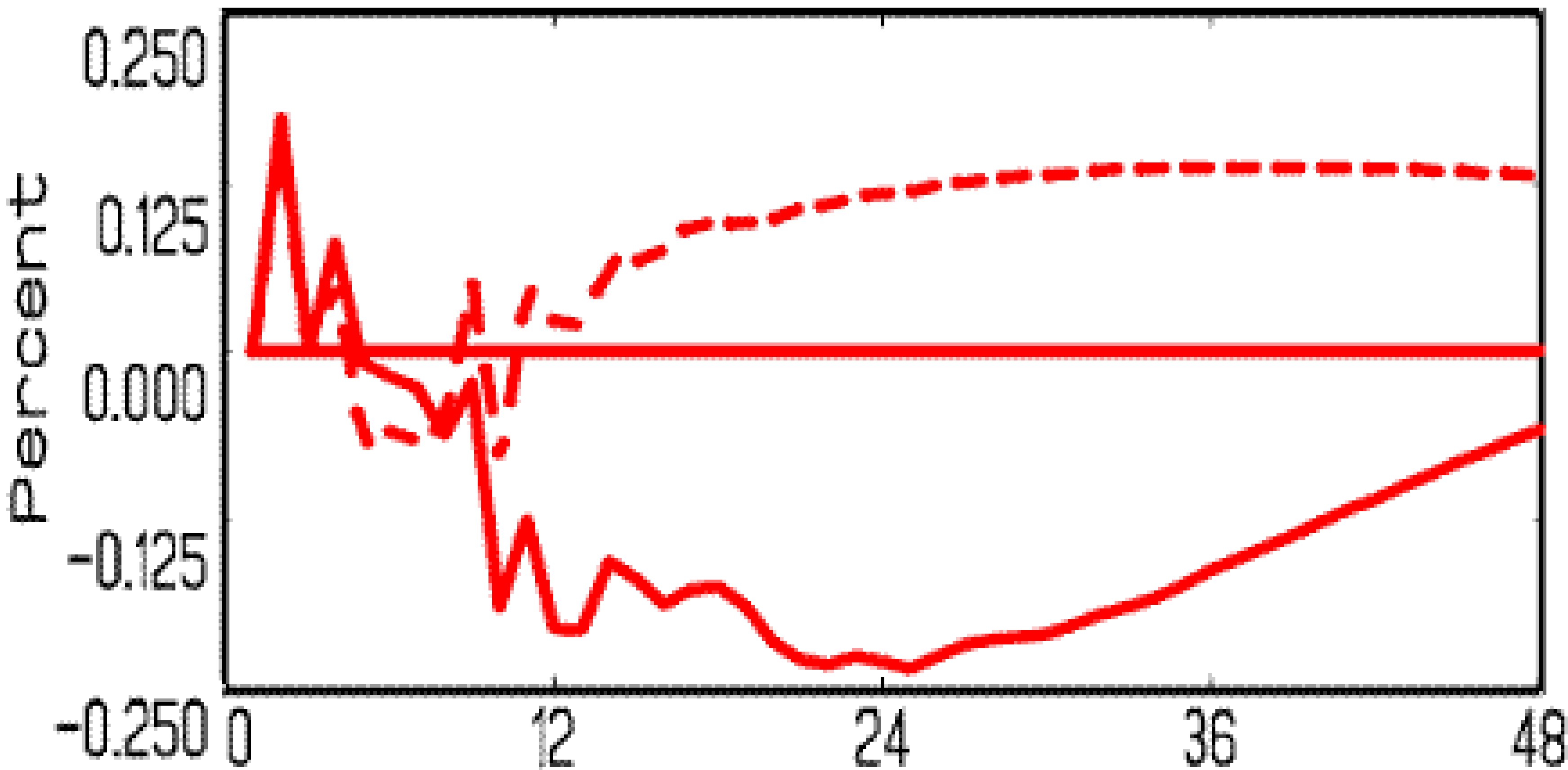
Multiplier comes from loss of output of unemployed workers rather than direct effects of less energy used

C. Effects operating through demand channels

- Could a monetary response (Fed raises interest rate when it sees higher oil prices) account for the correlation?
- Bernanke, Gertler, and Watson (1997): estimated a dynamic model of interaction between oil prices, interest rates, GDP, and other variables
- Simulated its behavior if interest rates don’t rise in response to oil shock



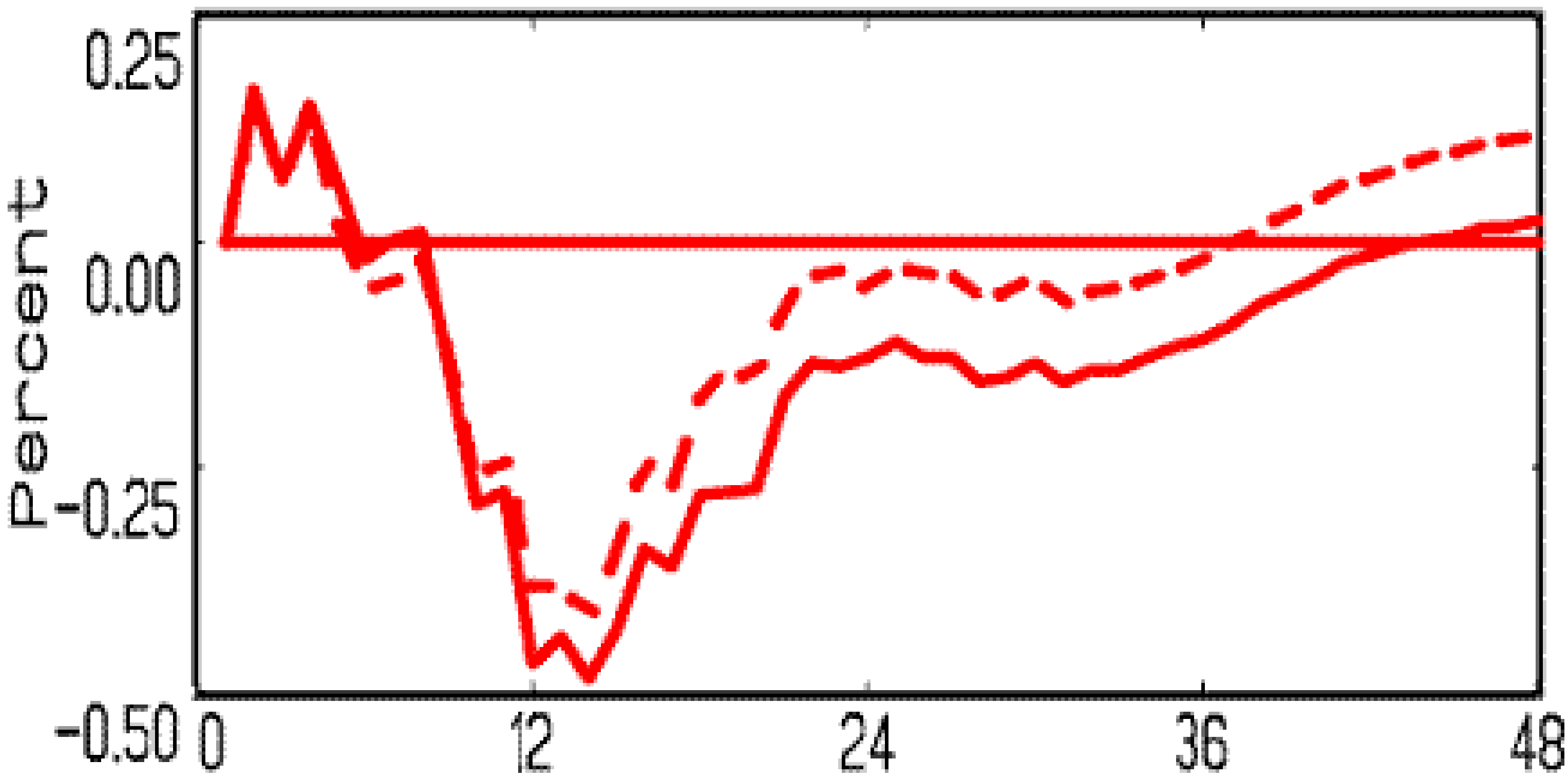
Solid line: actual behavior of U.S. fed funds rate, 1972-1976. Bold: simulated path of fed funds based on historical response to oil price and other variables. Dashed: path of fed funds under counterfactual simulation. Source: Bernanke, Gertler, and Watson (1997)



Solid line: Predicted response of real GDP to 10% increase in energy price at month 0 based on 7-lag system Horizontal axis: time in months from the increase. Dashed line: predicted response if Fed holds interest rate constant. Source: Hamilton and Herrera (2004) reproduction of Bernanke, Gertler and Watson (1997) figure.

Hamilton and Herrera (2004):

- Bernanke, Gertler and Watson (1997) based estimates on model with 7 monthly lags
- Biggest empirical effects in data come 3 and 4 quarters following oil price increase
- When BGW relations are re-estimated using 12 lags, the conclusions change radically



Solid line: Predicted response of real GDP to 10% increase in energy price at month 0 based on 12-lag system Horizontal axis: time in months from the increase. Dashed line: predicted response if Fed holds interest rate constant. Source: Hamilton and Herrera (2004).

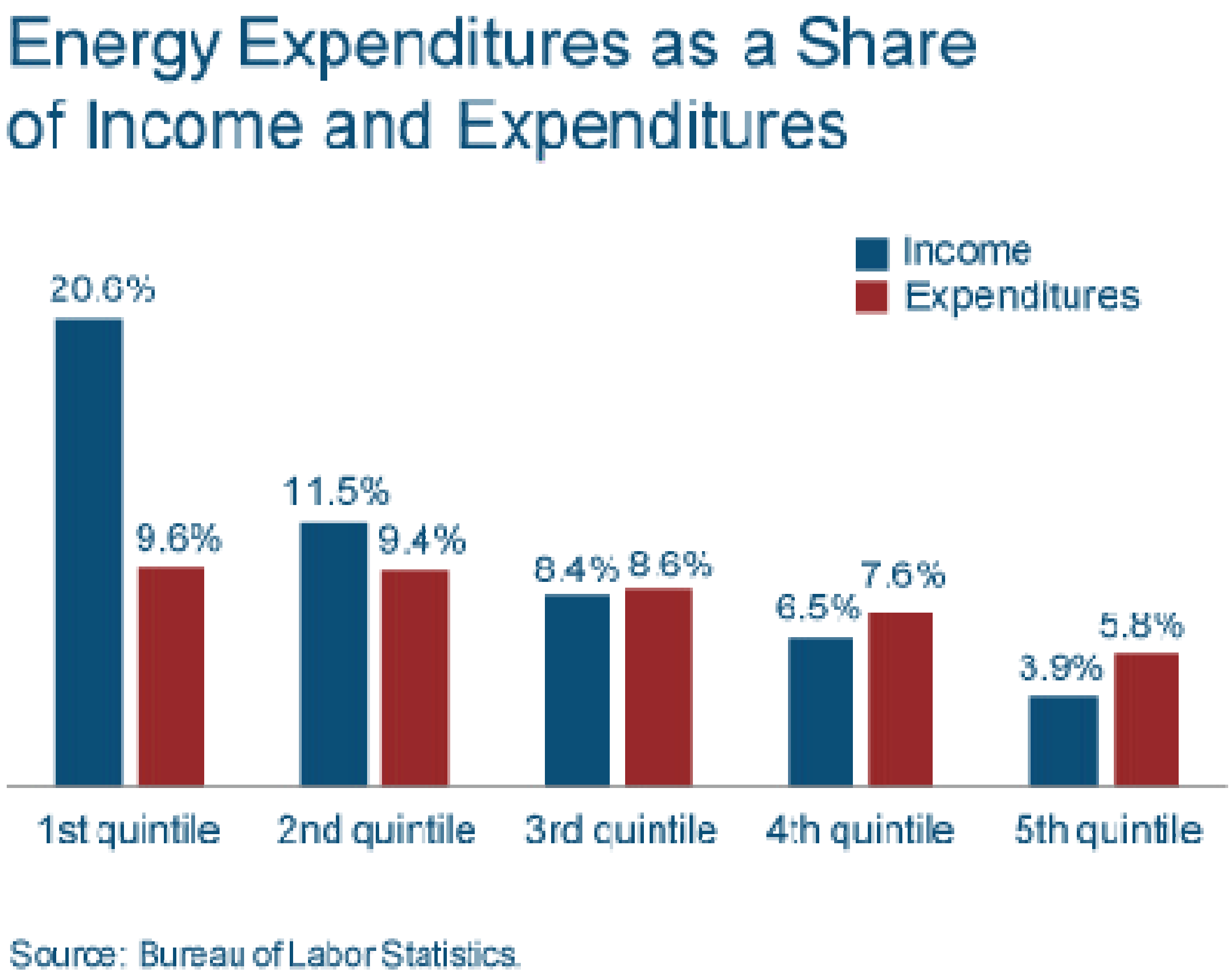
Effects on consumer spending

E.g., if

- 5% of consumer spending goes to energy (a_t = 0.05)
- energy price goes up 20%
- consumers purchase same quantity of energy

then

- saving or other spending must decline by 1%



Source: Daniel Carroll, FRB Cleveland, 2011
http://www.clevelandfed.org/research/trends/2011/0411/01houcon.cfm

Effects on investment and consumer durable demand

- An increase in uncertainty about energy prices could cause firms and consumers to postpone irreversible decisions
- Bernanke (1983)
- Lee, Kang and Ratti (2011)

III. Empirical evidence

A. Background: using vector autoregressions

Let $\mathbf{y}_t$ be a vector of variables of interest

y_{1t} = change in energy price

y_{2t} = rate of growth of real consumption

Consider linear forecast of $y_{2,t+1}$

$$\mathbf{x}_t = (1, \mathbf{y}'_t, \mathbf{y}'_{t-1}, \ldots, \mathbf{y}'_{t-p+1})'$$

$$y_{2,t+1} = \boldsymbol{\pi}'_2 \mathbf{x}_t + \varepsilon_{2,t+1}$$

Could estimate $\boldsymbol{\pi}_2$ by OLS

Could form similar equation to forecast energy prices

$$y_{1,t+1} = \boldsymbol{\pi}_1'\mathbf{x}_t + \varepsilon_{1,t+1}$$

Stack the two equations in a vector

$$\begin{bmatrix} y_{1,t+1} \\ y_{2,t+1} \end{bmatrix} = \begin{bmatrix} \boldsymbol{\pi}_1' \\ \boldsymbol{\pi}_2' \end{bmatrix} \mathbf{x}_t + \begin{bmatrix} \varepsilon_{1,t+1} \\ \varepsilon_{2,t+1} \end{bmatrix}$$

$$\mathbf{y}_{t+1} = \mathbf{c} + \boldsymbol{\Phi}_1 \mathbf{y}_t + \boldsymbol{\Phi}_2 \mathbf{y}_{t-1} + \cdots + \boldsymbol{\Phi}_p \mathbf{y}_{t-p+1} + \boldsymbol{\varepsilon}_{t+1}$$

$$E(\mathbf{y}_{t+1} | \mathbf{y}_t, \mathbf{y}_{t-1}, \ldots, \mathbf{y}_{t-p+1})$$

$$= \mathbf{c} + \boldsymbol{\Phi}_1 \mathbf{y}_t + \boldsymbol{\Phi}_2 \mathbf{y}_{t-1} + \cdots + \boldsymbol{\Phi}_p \mathbf{y}_{t-p+1}$$

Suppose prior to t we observe $\mathbf{y}_{t-1}, \mathbf{y}_{t-2}, \ldots, \mathbf{y}_{t-p+1}$ and we're told the value of energy price at t (y_{1t}). How would we change our forecast of $y_{2,t+1}$?

First note that y_{1t} tells us something about y_{2t}

Let $\sigma_{11} = E(\varepsilon_{1t}^2)$

$$\sigma_{12} = E(\varepsilon_{1t}\varepsilon_{2t})$$

$$\frac{\partial E_t(\varepsilon_{2t})}{\partial \varepsilon_{1t}} = \frac{\sigma_{12}}{\sigma_{11}}$$

$$E(\mathbf{y}_{t+1}|\mathbf{y}_t, \mathbf{y}_{t-1}, \ldots, \mathbf{y}_{t-p+1})$$

$$= \mathbf{c} + \mathbf{\Phi}_1\mathbf{y}_t + \mathbf{\Phi}_2\mathbf{y}_{t-1} + \cdots + \mathbf{\Phi}_p\mathbf{y}_{t-p+1}$$

$$\frac{\partial E(\mathbf{y}_{t+1}|y_{1t}, \mathbf{y}_{t-1}, \ldots, \mathbf{y}_{t-p+1})}{\partial y_{1t}} = \mathbf{\Phi}_1 \begin{bmatrix} 1 \\ \sigma_{11}^{-1}\sigma_{12} \end{bmatrix}$$

How would news about y_{1t} cause us to revise our forecast of $\mathbf{y}_{t+2}$?

$$\mathbf{y}_{t+1} = \mathbf{c} + \mathbf{\Phi}_1 \mathbf{y}_t + \mathbf{\Phi}_2 \mathbf{y}_{t-1} + \cdots + \mathbf{\Phi}_p \mathbf{y}_{t-p+1} + \boldsymbol{\varepsilon}_{t+1}$$

$$\mathbf{y}_{t+2} = \mathbf{c} + \mathbf{\Phi}_1 \mathbf{y}_{t+1} + \mathbf{\Phi}_2 \mathbf{y}_t + \cdots + \mathbf{\Phi}_p \mathbf{y}_{t-p+2} + \boldsymbol{\varepsilon}_{t+2}$$

$$\mathbf{y}_{t+2} = \mathbf{c} + \mathbf{\Phi}_1 (\mathbf{c} + \mathbf{\Phi}_1 \mathbf{y}_t + \mathbf{\Phi}_2 \mathbf{y}_{t-1} + \cdots + \mathbf{\Phi}_p \mathbf{y}_{t-p+1} + \boldsymbol{\varepsilon}_{t+1})$$

$$+ \mathbf{\Phi}_2 \mathbf{y}_t + \cdots + \mathbf{\Phi}_p \mathbf{y}_{t-p+2} + \boldsymbol{\varepsilon}_{t+2}$$

$$E_t(\mathbf{y}_{t+2}|\mathbf{y}_t, \mathbf{y}_{t-1}, \ldots, \mathbf{y}_{t-p+1})$$

$$= (\mathbf{c} + \mathbf{\Phi}_1\mathbf{c}) + (\mathbf{\Phi}_1^2 + \mathbf{\Phi}_2)\mathbf{y}_t + (\mathbf{\Phi}_1\mathbf{\Phi}_2 + \mathbf{\Phi}_3)\mathbf{y}_{t-1}$$

$$+ \quad \cdots + (\mathbf{\Phi}_1\mathbf{\Phi}_{p-1} + \mathbf{\Phi}_p)\mathbf{y}_{t-p+1} + \mathbf{\Phi}_1\mathbf{\Phi}_p\mathbf{y}_{t-p+1}$$

$$\frac{\partial E(\mathbf{y}_{t+2}|y_{1t}, \mathbf{y}_{t-1}, \ldots, \mathbf{y}_{t-p+1})}{\partial y_{1t}} = (\mathbf{\Phi}_1^2 + \mathbf{\Phi}_2)\begin{bmatrix} 1 \\ \sigma_{11}^{-1}\sigma_{12} \end{bmatrix}$$

$$= \mathbf{\Psi}_2\begin{bmatrix} 1 \\ \sigma_{11}^{-1}\sigma_{12} \end{bmatrix}$$

Similarly,

$$\frac{\partial E(\mathbf{y}_{t+s}|y_{1t},\mathbf{y}_{t-1},\ldots,\mathbf{y}_{t-p+1})}{\partial y_{1t}} = \boldsymbol{\Psi}_s \begin{bmatrix} 1 \\ \sigma_{11}^{-1}\sigma_{12} \end{bmatrix}$$

Plot of this vector as a function of s is called the orthogonalized impulse-response function with y_{1t} ordered first

B. Consumer responses

Recall theory--

- if 5% of consumer spending goes to energy (a_t = 0.05)
- energy price goes up 20%
- consumers purchase same quantity of energy

then

- saving or other spending must decline by 1%

Edelstein and Kilian (2009)

$\alpha_t =$ consumer expenditures on

energy goods and services as

fraction of total consumption spending

$P_t^E =$ index of cost of energy goods and services

$$y_{1t} = 100\alpha_t(\ln P_t^E - \ln P_{t-1}^E)$$

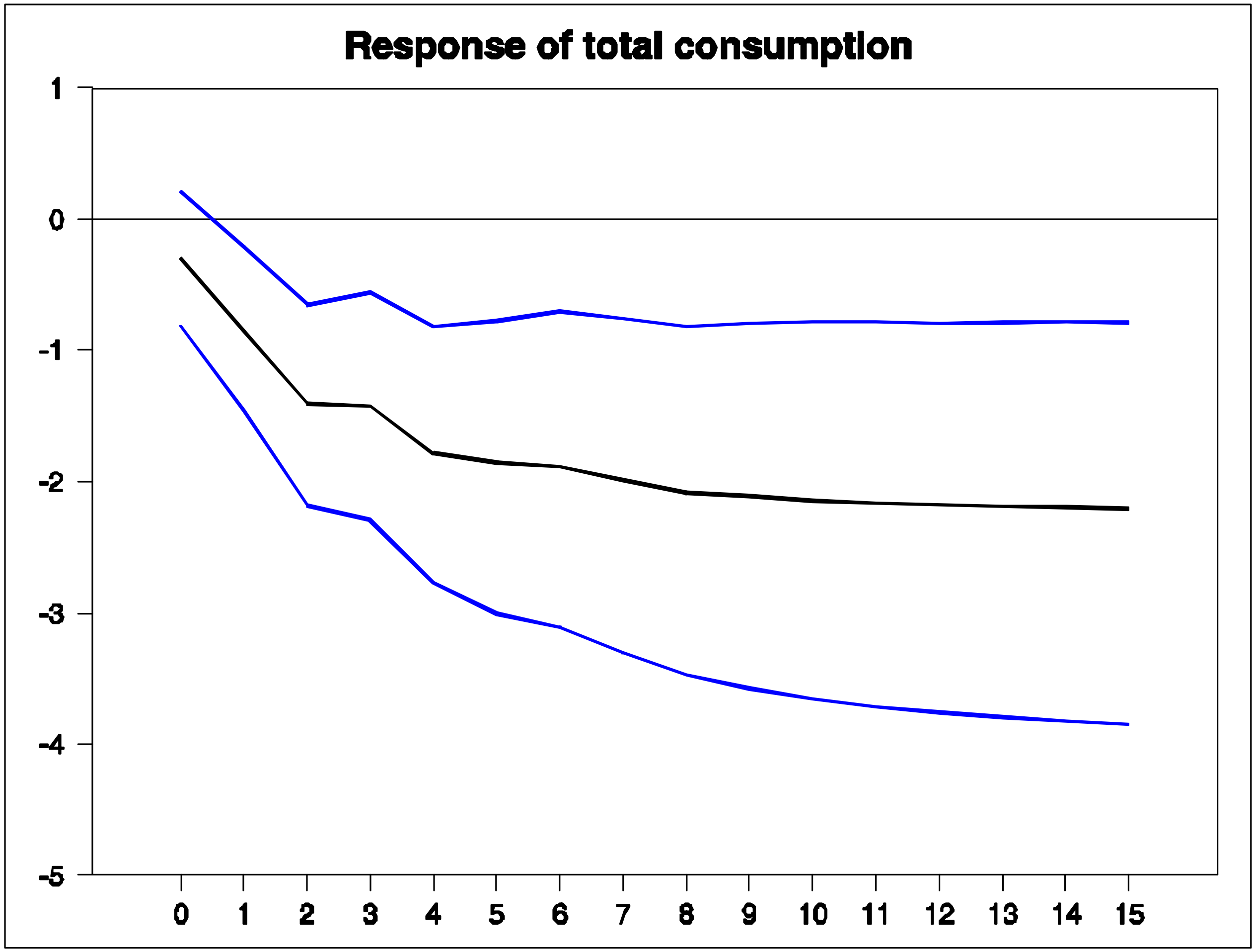
$y_{2t} =$ 100 times change in log of total

real consumption spending in month t

$$\mathbf{y}_{t+1} = \mathbf{c} + \mathbf{\Phi}_1\mathbf{y}_t + \mathbf{\Phi}_2\mathbf{y}_{t-1} + \cdots + \mathbf{\Phi}_p\mathbf{y}_{t-p+1} + \boldsymbol{\varepsilon}_{t+1}$$

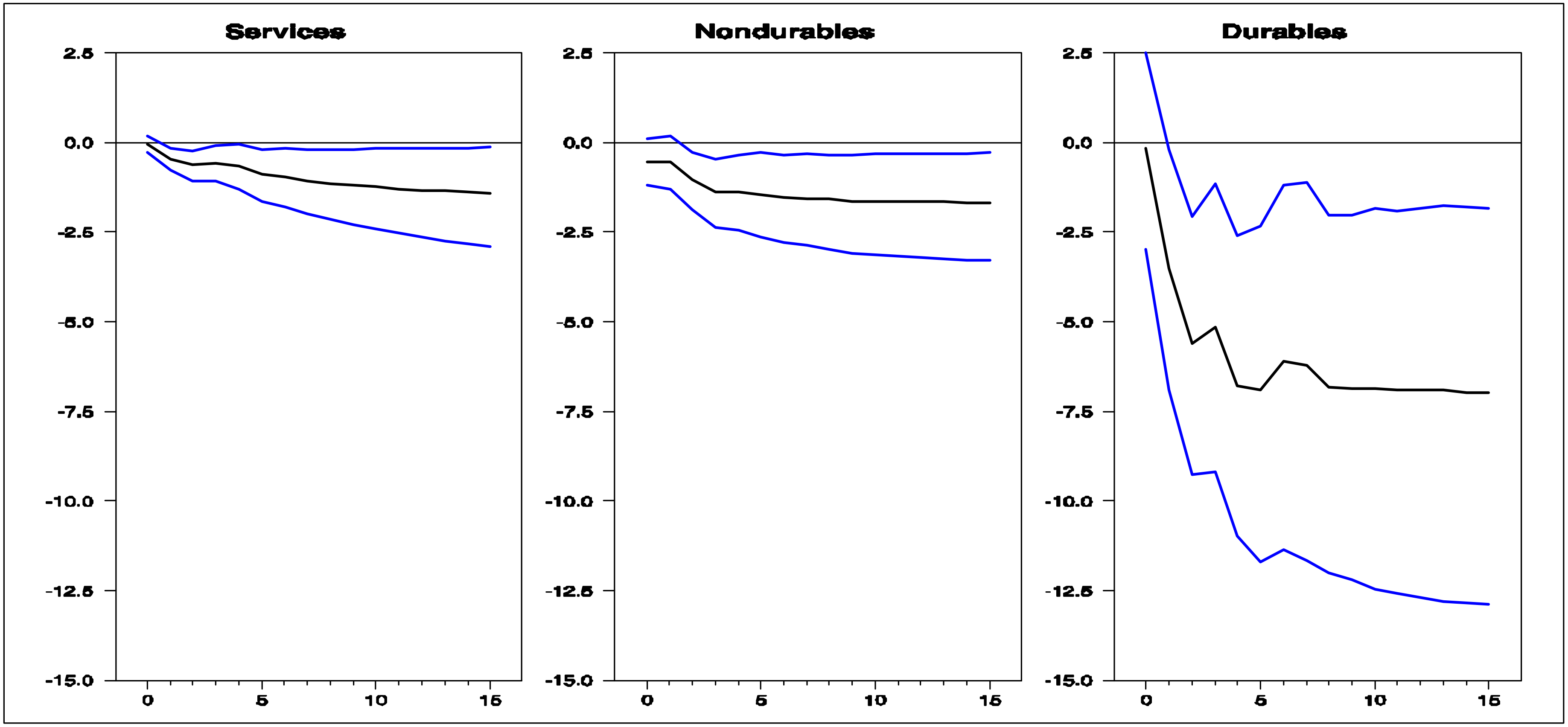
estimated 1970:M7 - 2006:M7

Pre-2007 estimated impulse-response function (and 95% confidence intervals) relating 100 times log of real consumption spending to energy price increase that corresponds to 1% of total spending



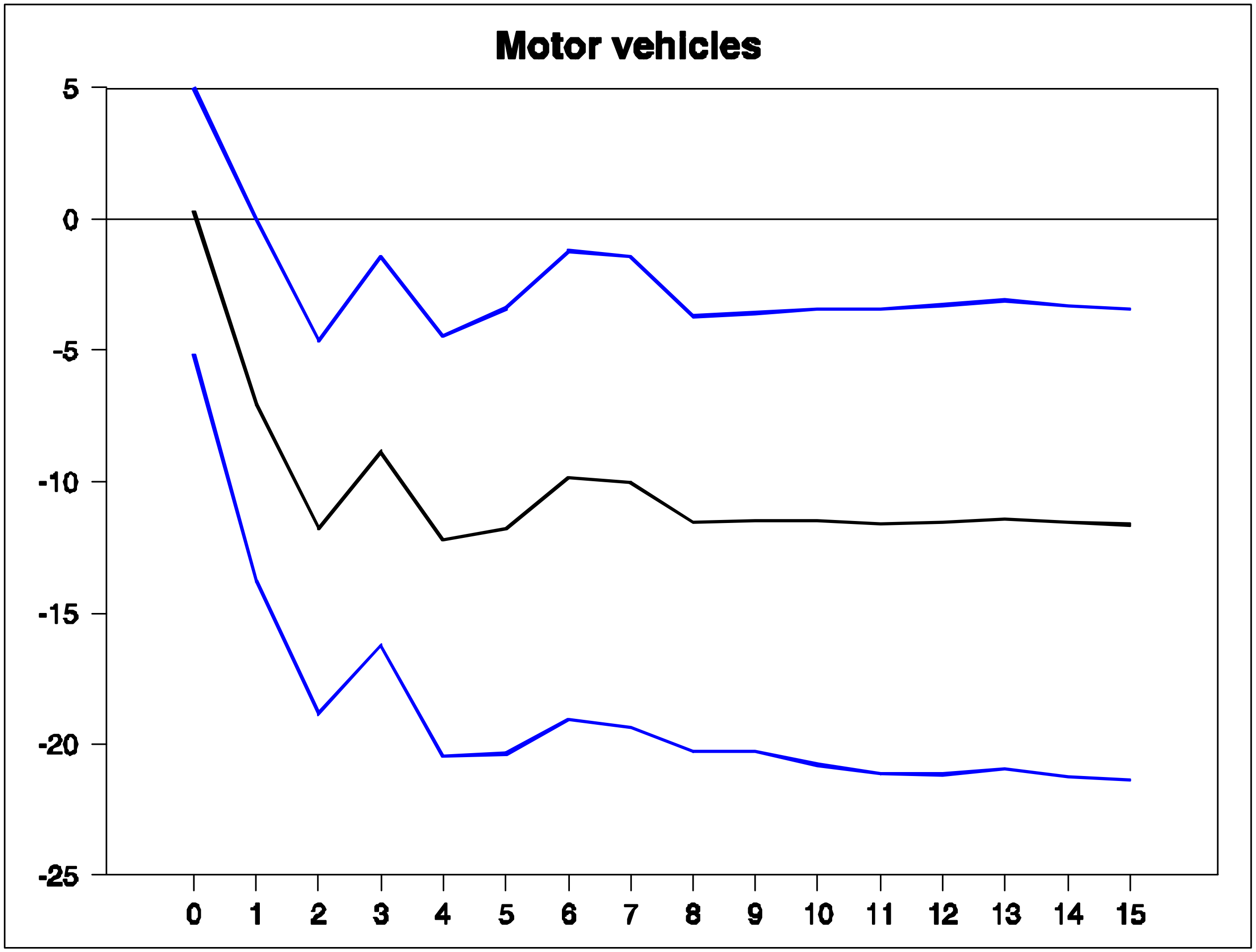
Reproduces Figure 8a in Edelstein and Kilian (2007)

Pre-2007 estimated impulse-response functions.



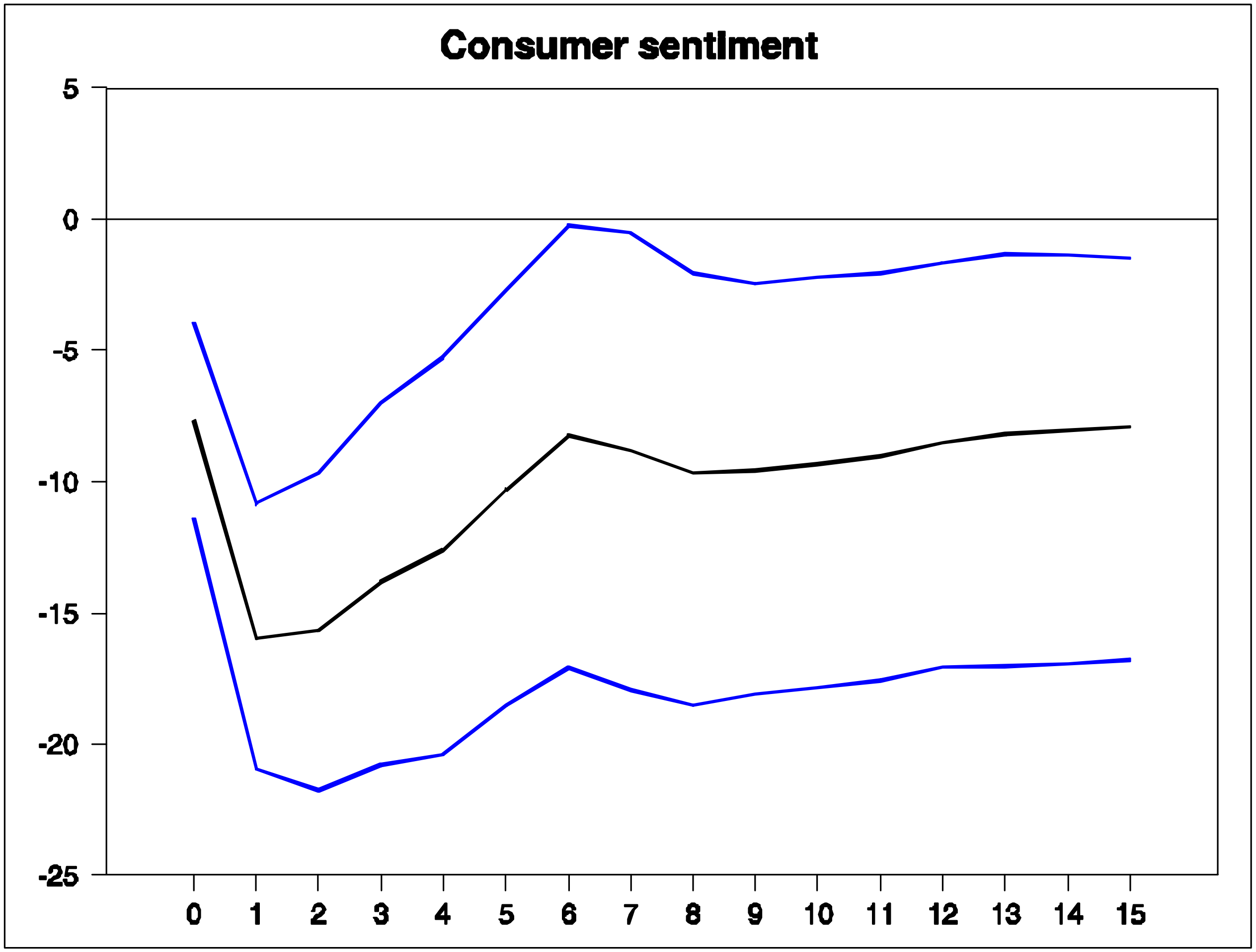
Reproduces Figure 8b-d in Edelstein and Kilian (2007)

Pre-2007 estimated impulse-response functions.



Reproduces Figure 8e in Edelstein and Kilian (2007)

Pre-2007 estimated impulse-response functions.



Reproduces Figure 11a in Edelstein and Kilian (2007)

C. Structural change and nonlinearity

Hamilton (1983)

$y_t = 100 \ln(GDP_t / GDP_{t-1})$ (quarterly rate)

$o_t = 100 \ln(P_t^o / P_{t-1}^o)$ (P_t^o = PPI crude petroleum)

Estimated 1949:Q2 to 1980:Q4

$$y_t = \underset{(0.18)}{1.14} + \underset{(0.09)}{0.20}\, y_{t-1} + \underset{(0.09)}{0.05}\, y_{t-2} - \underset{(0.09)}{0.10}\, y_{t-3} - \underset{(0.09)}{0.19}\, y_{t-4}$$

$$- \underset{(0.026)}{0.004}\, o_{t-1} - \underset{(0.026)}{0.027}\, o_{t-2} - \underset{(0.026)}{0.034}\, o_{t-3} - \underset{(0.027)}{0.065}\, o_{t-4}$$

$$\underset{(0.18)}{y_t = 1.14} + \underset{(0.09)}{0.20}\, y_{t-1} + \underset{(0.09)}{0.05}\, y_{t-2} - \underset{(0.09)}{0.10}\, y_{t-3} - \underset{(0.09)}{0.19}\, y_{t-4}$$

$$- \underset{(0.026)}{0.004}\, o_{t-1} - \underset{(0.026)}{0.027}\, o_{t-2} - \underset{(0.026)}{0.034}\, o_{t-3} - \underset{(0.027)}{0.065}\, o_{t-4}$$

Historically: o_t almost always positive

1985-1986: huge negative value for o_t

relation predicts economic boom that didn’t occur

Mork (1988)

$$o_t^+ = \begin{cases} o_t & \text{if } o_t \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

$$o_t^- = \begin{cases} o_t & \text{if } o_t < 0 \\ 0 & \text{otherwise} \end{cases}$$

Regress y_t on $(1, y_{t-1}, \ldots, y_{t-4}, o_{t-1}^+, \ldots, o_{t-4}^+,$
$o_{t-1}^-, \ldots, o_{t-4}^-)'$

Coefficients on o_{t-j}^- statistically insignificant

But Hooker (1996) found based on data through 1994 that Mork's asymmetric relation is also unstable

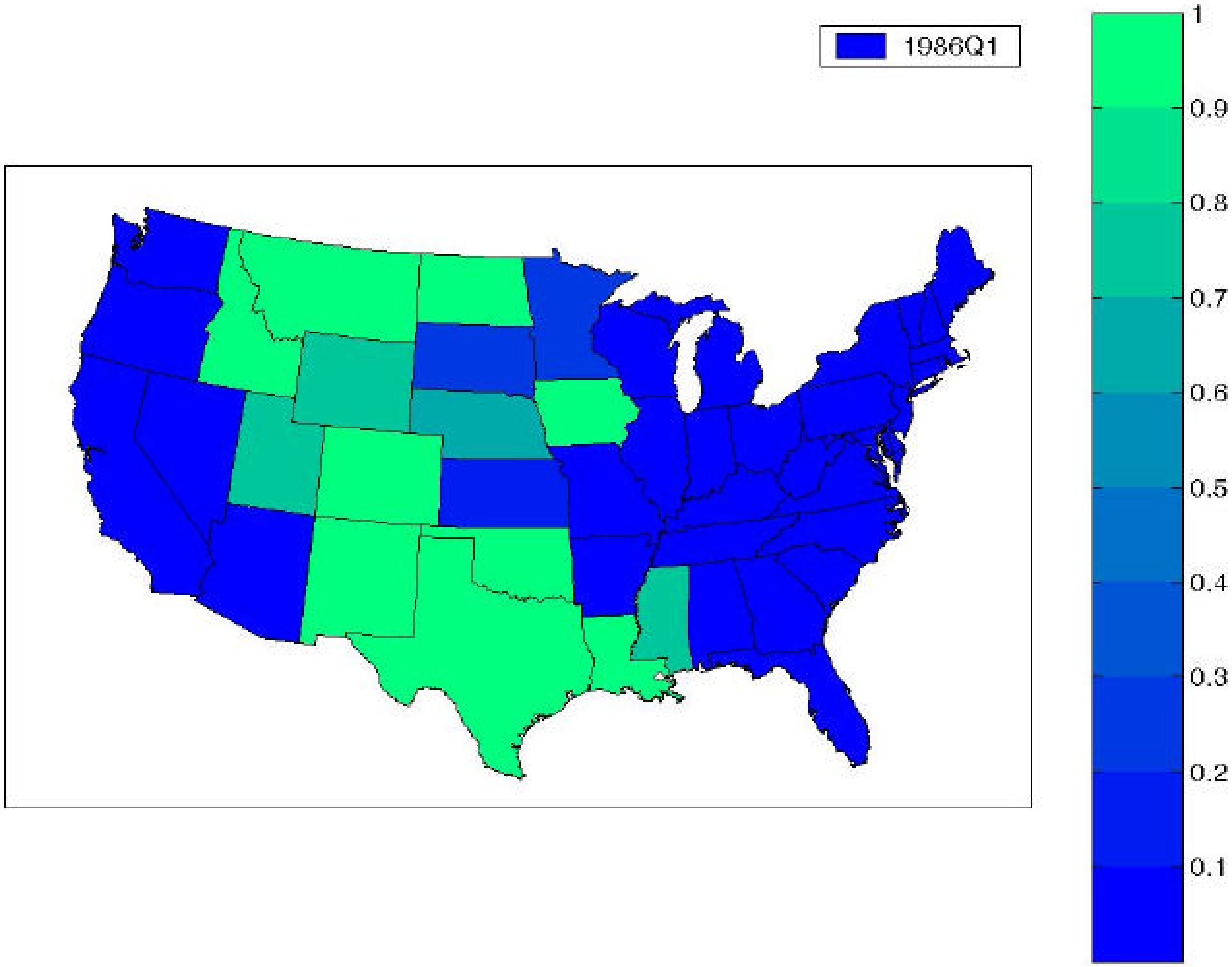
Why might effects of energy prices on economy be asymmetric?

(1) consumer durables-- effect operates through postponing purchases

(2) threshold effects-- less change in consumer plans and sentiment if these prices were seen recently

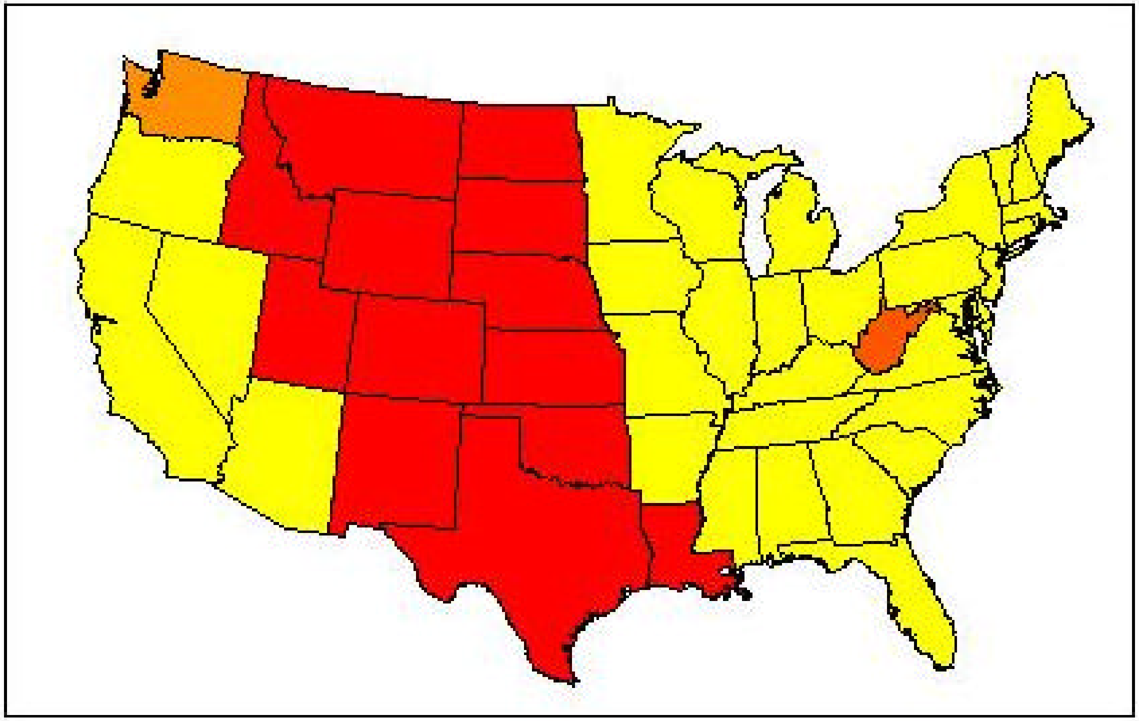
(3) sectoral effects: 1985-86 saw a recession in U.S. oil-producing states (Hamilton and Owyang, forthcoming)

Probability that state was in recession in 1986:Q1 (estimated independently)



Probability that state is included in group that experienced a mid 1980s recession (estimated jointly)

Cluster 2



Hamilton (2003)

- energy price decreases don’t produce economic boom
- an oil price increase that just reverses recent decline has little effect

O_t = log of oil price in quarter t

$o_t^m = O_t - \max\{O_{t-1}, O_{t-2}, \ldots, O_{t-12}\}$

= amount by which oil price is above or below its highest value of previous 3 years

$o_t^\# = \max(0, o_t^m)$

= net oil price increase

Regression of y_t on $(1, y_{t-1}, \ldots, y_{t-4}, o_{t-1}^\#, \ldots, o_{t-4}^\#)'$ appears to be stable

Other nonlinear specifications

Lee, Ni and Ratti (1995):

divide o_t^+ by oil price conditional standard deviation from GARCH model

Jo (2012):

uncertainty itself (conditional variance from stochastic volatility model or realized volatility model for oil prices) affects output

Kilian and Vigfusson (2011):

If oil price measure is a nonlinear function of original data, cannot use standard methods to calculate impulse-response function

$$o_{t+1}^{+} = \boldsymbol{\pi}_1' \mathbf{x}_t + \varepsilon_{1,t+1}$$

optimal forecast must be nonnegative

$$E(o_{t+1}^{+} | \mathbf{x}_t) \neq \boldsymbol{\pi}_1' \mathbf{x}_t$$

Instead must simulate draws for o_{t+s}^{+} rather than calculate analytically

However, if we reject hypothesis that

$\beta_j^+ = \beta_j^-$ in the regression

$$y_{t+1} = c + \alpha_1 y_{t-1} + \cdots + \alpha_p y_{t-p} + \beta_1^+ o_{t-1}^+ + \cdots$$
$$+\beta_p^+ o_{t-p}^+ + \beta_1^- o_{t-1}^- + \cdots + \beta_p^- o_{t-p}^- + \varepsilon_{t+1}$$

then correctly calculated impulse-response function *must* be nonlinear

Hamilton (2011):

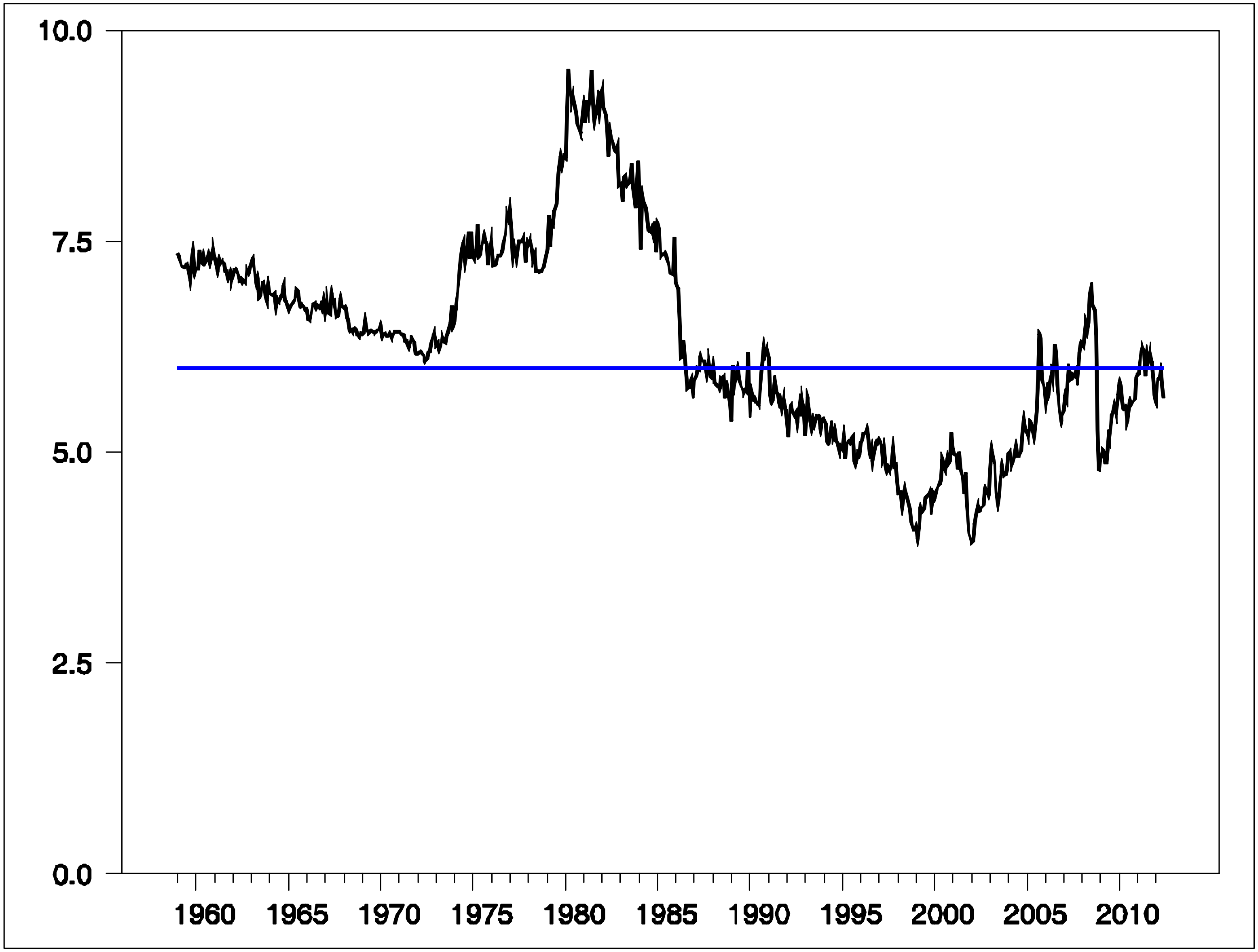
An easier alternative to simulation of nonlinear system is just to estimate s-period-ahead forecasts directly:

$$y_{t+s} = c + \alpha_1 y_{t-1} + \cdots + \alpha_p y_{t-p} + \beta_1 o^{\#}_{t-1} + \cdots + \beta_p o^{\#}_{t-p} + \varepsilon_{t+1}$$

D. Alternative interpretations of structural instabiility

Blanchard and Gali (2010): relation is linear, but economic importance of oil has decreased over time due to

- good luck (i.e. lack of concurrent adverse shocks)
- smaller share of oil in production
- more flexible labor markets
- improvements in monetary policy



Consumer expenditures on energy goods and services as a percentage of total consumption spending, 1959:M1-2012:M6

Hamilton (2009):

Improved fit (both historical and most recent data) if use net oil price times expenditure share: $\alpha_t o_t^{\#}$

- Baumeister and Peersman (2011) found in time-varying-coefficient VAR oil price increase of given size predicts smaller change in GDP over time
- They also estimate that the price-elasticity of demand has decreased over time, so that a disruption of supply of given size has bigger effect on price today
- Net implication is that a disruption of supply of given size has same predictive implications for future GDP

Ramey and Vine (2011):

- One reason that an observed oil price change of given magnitude seems to have had a bigger effect in the 1970s is consumer rationing
- shadow price > observed price

New York Times, Dec 1, 1956, reporting from London:

> There was no heat in some buildings; radiators were only tepid in others. Hotels closed off blocks of rooms to save fuel oil. . . . [T]he Netherlands, Switzerland, and Belgium have banned [Sunday driving]. Britain, Denmark, and France have imposed rationing.
>
> Nearly all British automobile manufacturers have reduced production and put their employees on a 4-day instead of a 5-day workweek. . . . Volvo, a leading Swedish car manufacturer, has cut production 30%.
>
> In both London and Paris, long lines have formed outside stations selling gasoline.

Source: Hamilton (forthcoming [a])

New York Times, May 4, 1979, reporting from L.A.

Throughout much of California today, and especially so in the Los Angeles area, there were scenes reminiscent of the nation’s 1974 gasoline crisis.

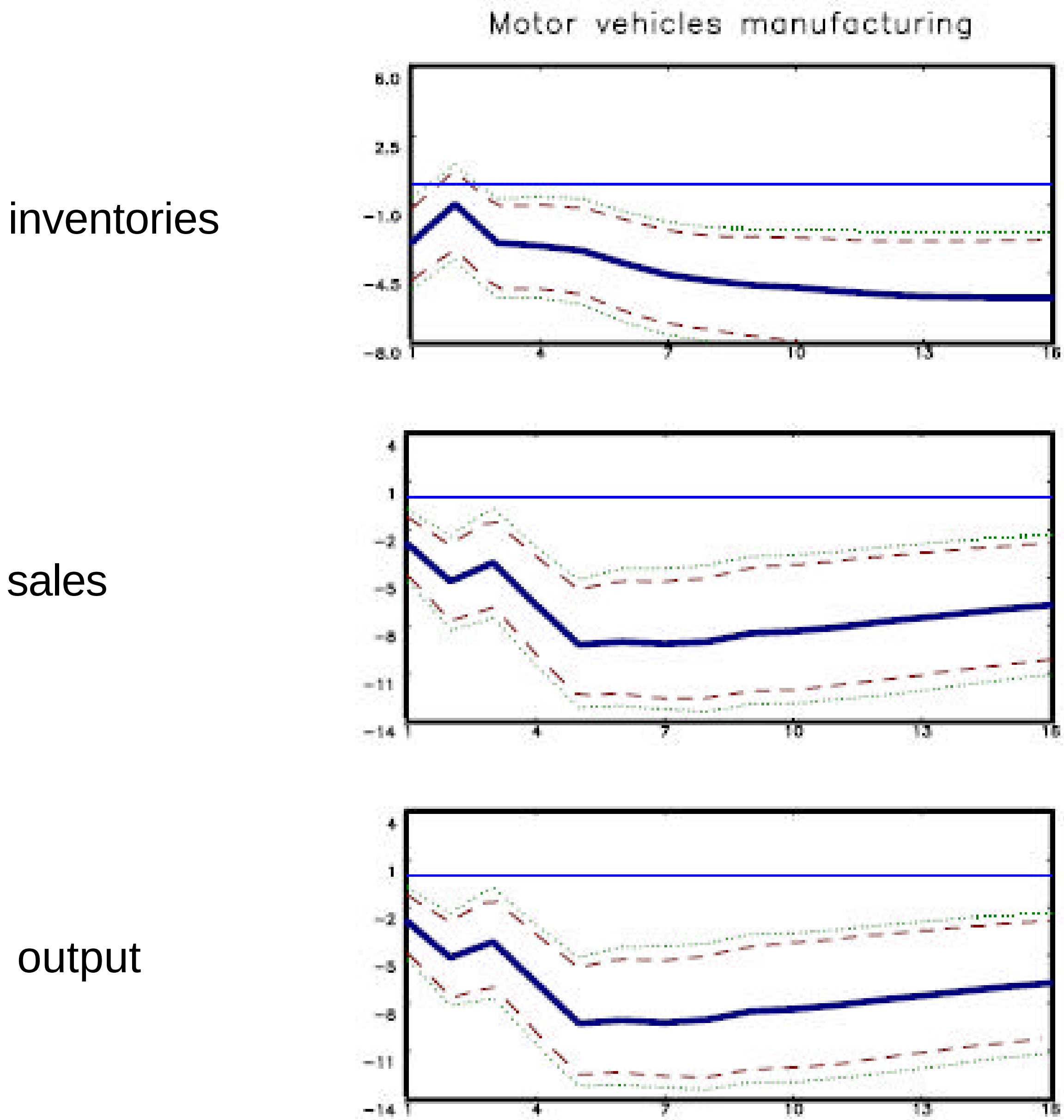
Lines of autos, vans, pickup trucks and motor homes, some of the lines were a half mile or longer, backed up from service stations in a rush for gasoline

Source: Hamilton (forthcoming [a])

D. Sectoral responses

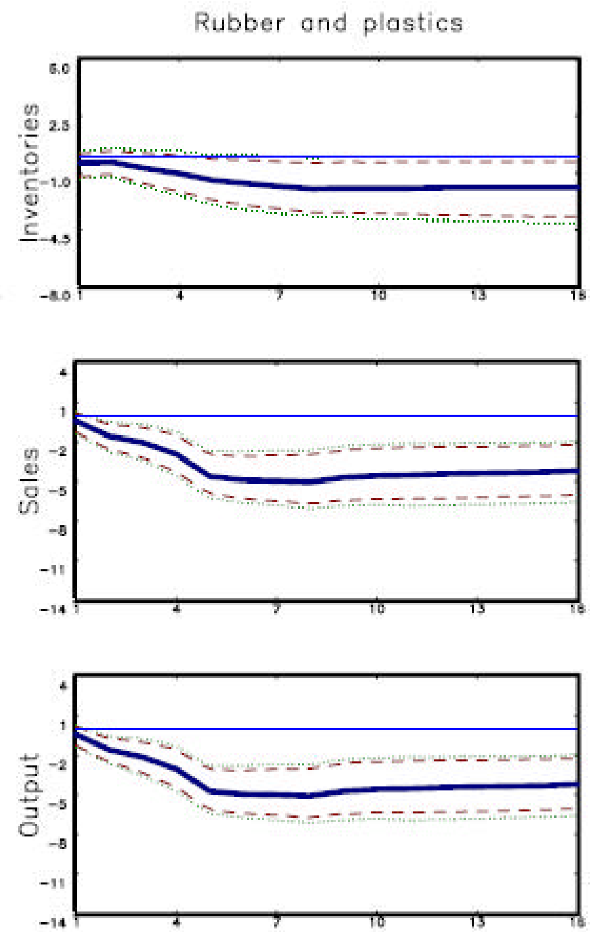
Herrera (2012):

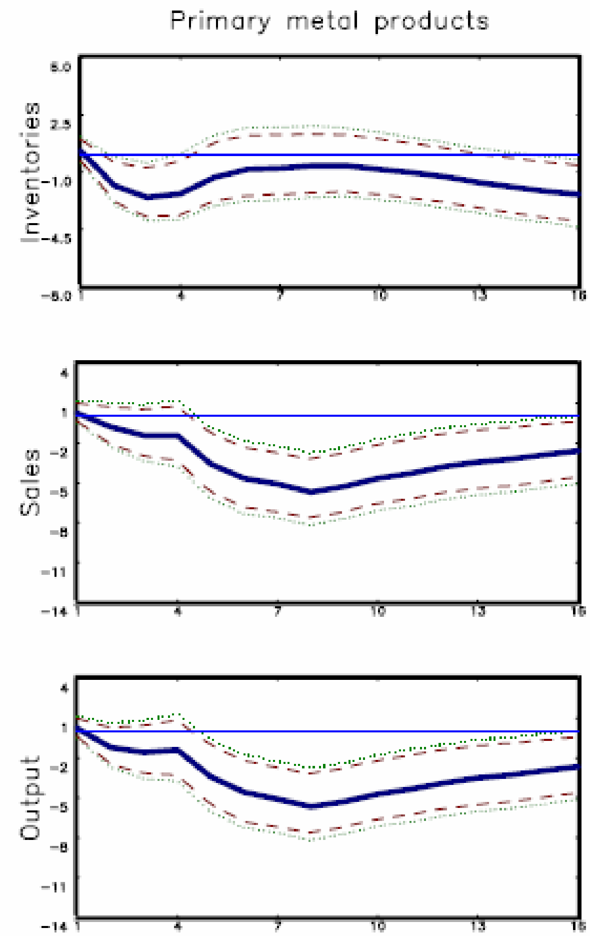
- Looked at behavior of sales, production, and inventories in different sectors following oil price shock
- Motor vehicles sales and production respond immediately
- Reducing inventories over time contributes to subsequent declines



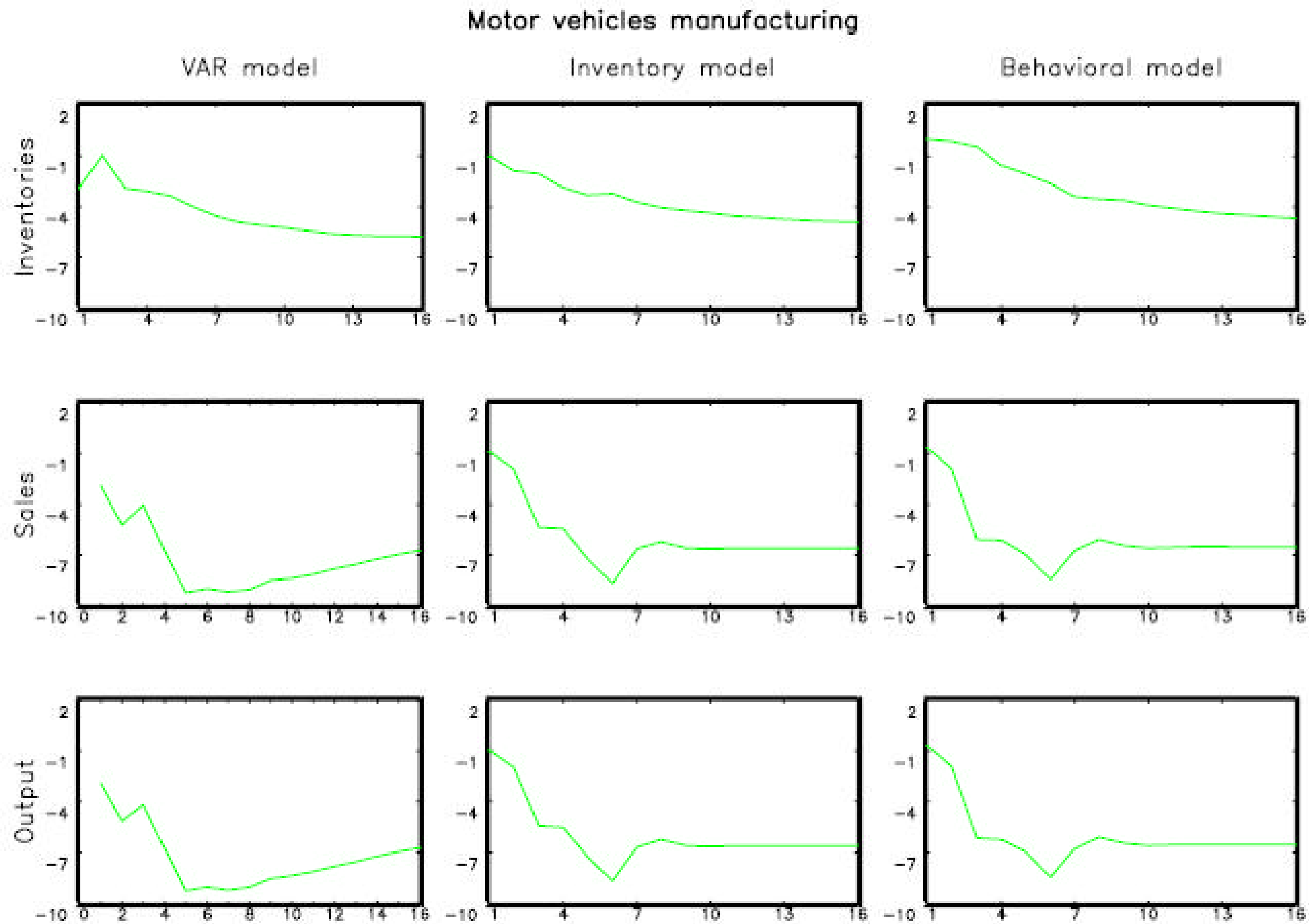
Cumulative impulse-response to 10% increase in net oil price in quarter 0.
Dashed 90% confidence intervals; dotted: 95%. Source: Herrera (2012)

Sectors that sell to the auto sector such as rubber and primary metals experience subsequent declines


Rubber and plastics
Inventories
Sales
Output
6.0
2.5
-1.0
-4.5
-8.0
4
1
-2
-5
-8
-11
-14
1
4
7
10
13
16


Primary metal products
Inventories
Sales
Output
6.0
2.5
-1.0
-4.5
-8.0
4
1
-2
-5
-8
-11
-14
1
4
7
10
13
16

Herrera studied these inventory dynamics using an optimizing model in which firms may not recognize full implications of energy prices (unintended inventory accumulation may contribute to dynamics)



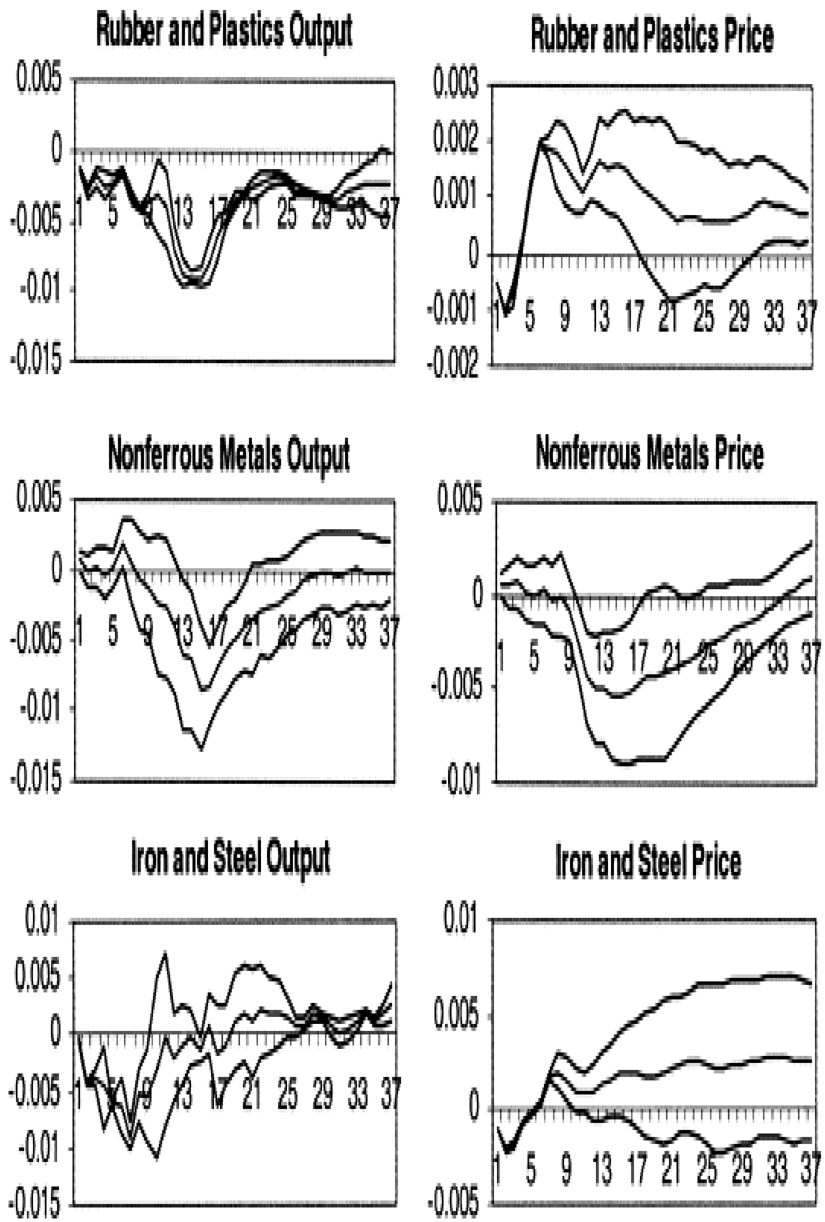
Motor vehicles manufacturing
VAR model
Inventory model
Behavioral model
Inventories
Sales
Output

Davis and Haltiwanger (2001)

- Studied employment response of individual firms
- Largest effect of energy price increase on firms with higher capital intensity, energy intensity, and producing durable goods

Lee and Ni (2002)

- Used industry-level quantity produced and price to try to isolate supply and demand channels



Monthly impulse-response functions. Source: Lee and Ni (2002)

Conclusions of Lee and Ni (2002)

Industries with supply effects dominant

- petroleum refining, industrial chemicals

Industries with demand effects dominant

- nonferrous metals, lumber, apparel, furniture, appliances, automobile

Industries with both effects

- paper, rubber and plastics, iron and steel, electronic machinery “in 1973 [t]he valve that limited [chemical] production growth was on the supply end of the flow chart, not the demand end. This was particularly true of organic chemicals where shortage of crude oil and natural gas, and the Arab oil embargo put a squeeze on petroleum feedstocks.” (*Chemical and Engineering News,* May 6, 1974, p. 10).

Source: Lee and Ni (2002).

E. International evidence

Mork, Olsen, and Mysen (1994) studied quarterly real GDP in 7 countries

- Oil price increases have negative and statistically significant predictive value for real GDP in U.S., Japan, West Germany, and U.K.
- Oil price increases have negative but not statistically significant ($p = 0.11$) predictive value for France and Canada
- Oil price increases have positive and statistically significant predictive value for Norway (oil exporter)

Cuñado and Pérez de Gracia (2003) studied quarterly industrial production growth in 14 European countries

- Found that net oil price increase has statistically significant predictive power in Germany, Belgium, Austria, France, Ireland, Luxembourg, UK, Netherlands, Denmark, Greece and Sweden
- Not statistically significant in Spain, Finland and Italy

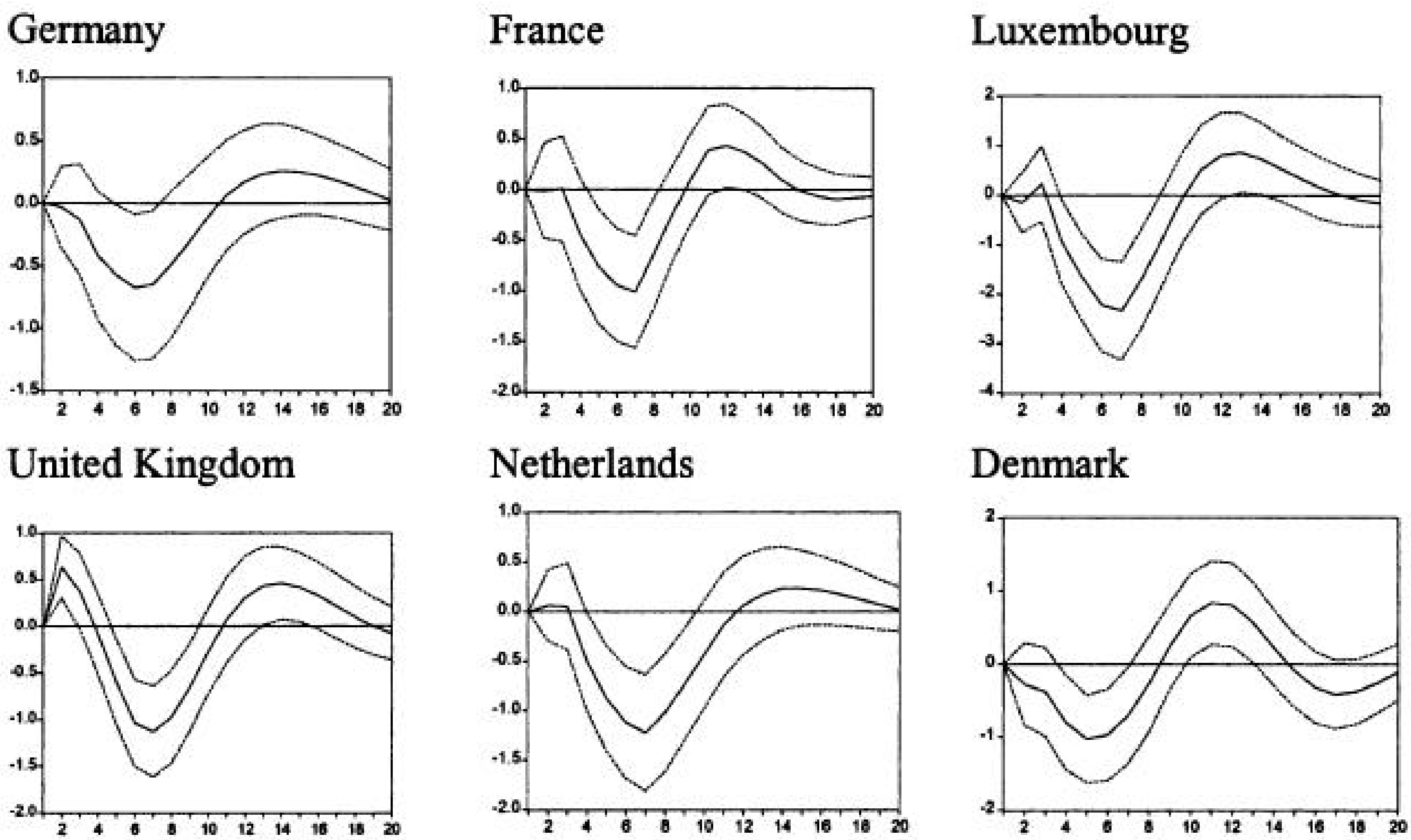


Fig. 2. Responses to NOPI (trivariate VAR) for some European countries.

Source: Cuñado and Pérez de Gracia (2003)

Rasmussen and Roitman (2011)

- 114 countries, limited evidence that oil shocks matter
- used annual data, which may miss cyclical effects

G. Sources of shocks

Oil prices might go up because:

- there is a disruption in production in the Middle East
- GDP is surging which puts upward pressure on demand

In the second case,

- There is good news about the economy which is also relevant for a forecast of future GDP
- Price change may be more gradual, giving consumers and firms more time to adapt

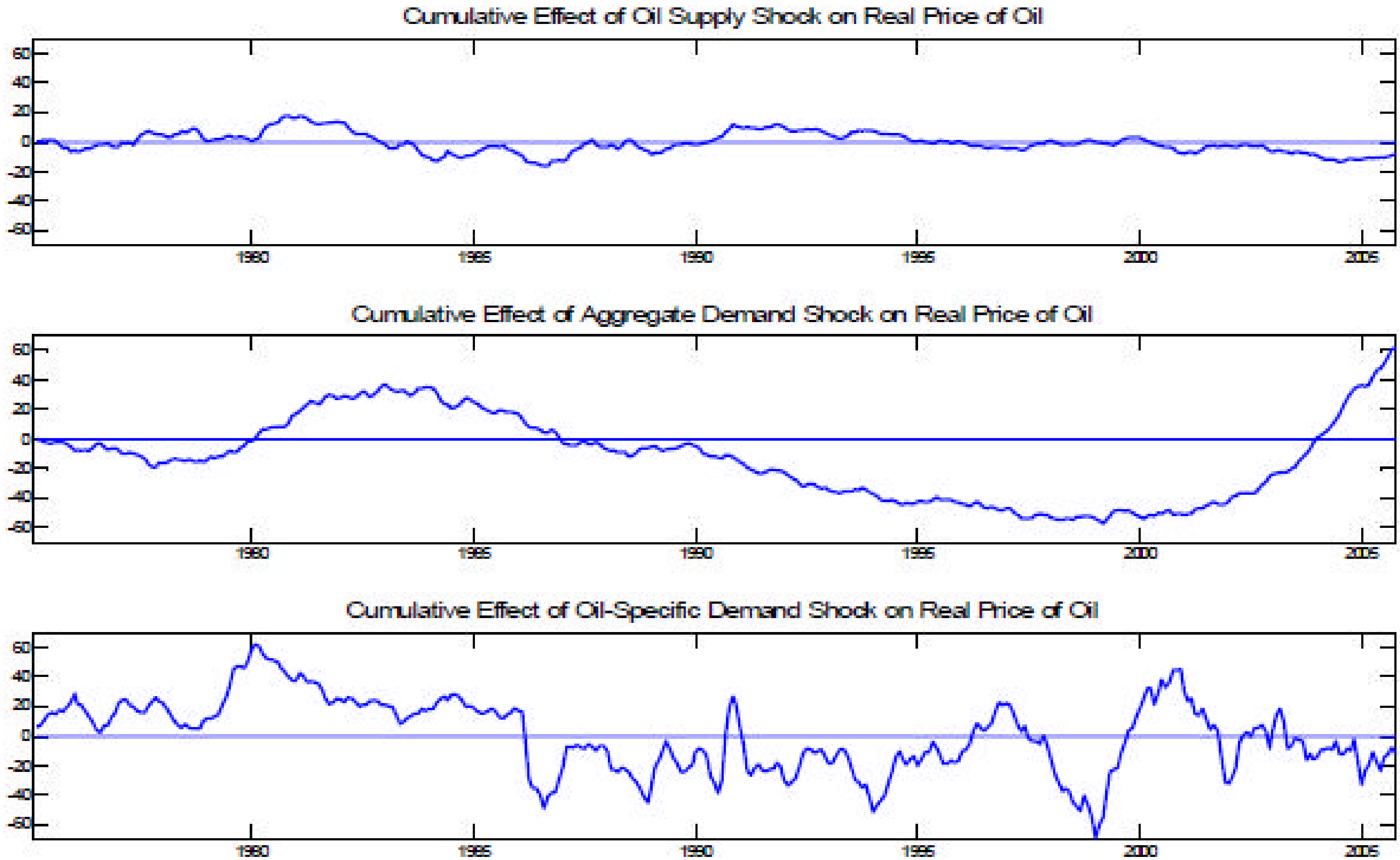
Kilian (2009)

(1) How does new information about world oil production lead to changed forecast of GDP (= “supply shock”)

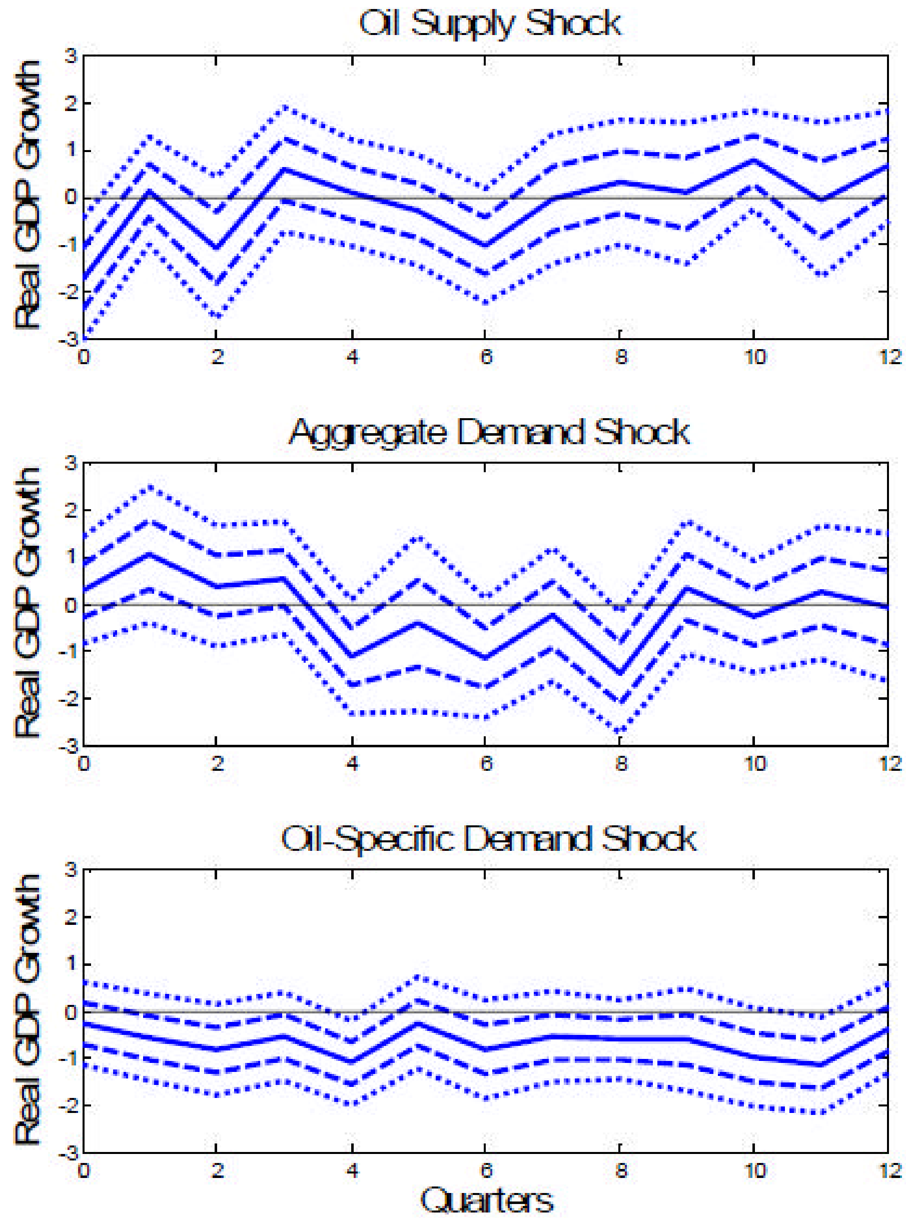
(2) How does new information about real economic activity (proxied by tanker shipping rates) lead to changed forecast if we already know world oil production (= “demand shock”)

(3) How does new information about real oil price (after we know (1) and (2)) lead to changed forecast (= “speculative demand shock”)

Figure 6: Historical Decomposition of Real Price of Oil
1975.2-2005.9



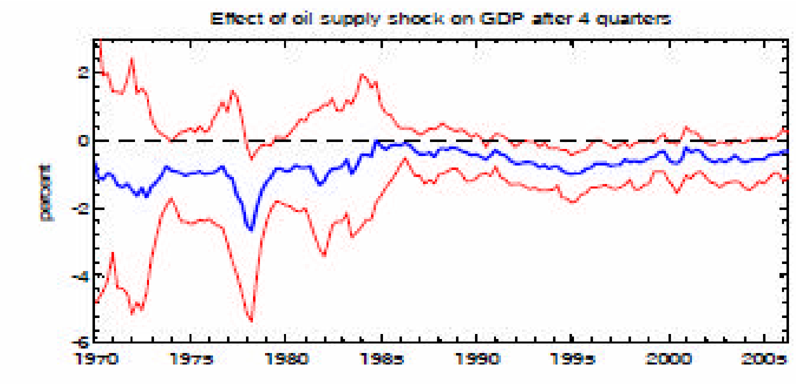
Source: Kilian (2009)

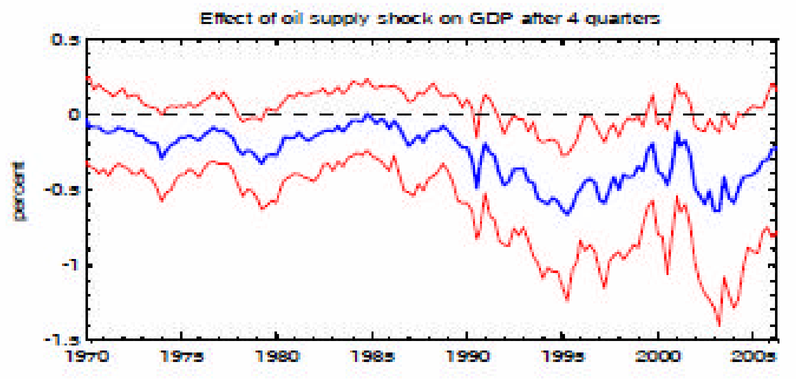


Impulse-response to a one-standard deviation shock that would increase real oil price with 67% and 95% confidence intervals. Source: Kilian (2007)

Baumeister and Peersman (2011): distinguished supply and demand based on sign restrictions

- supply shock raises oil price and lowers oil production
- demand shock raises oil price and raises oil production
- time-varying parameters

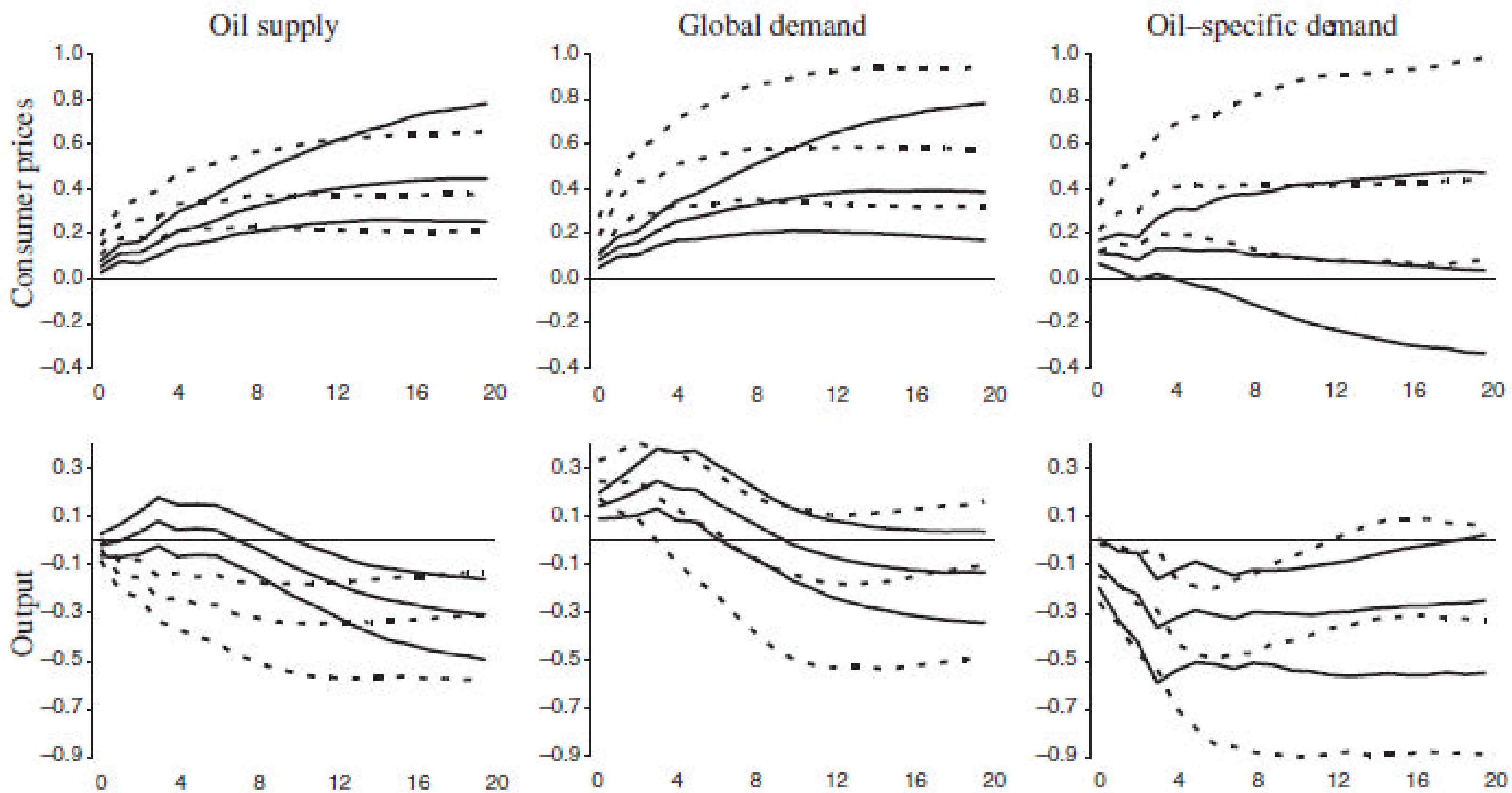




Median effect of an oil supply shock four quarters after the shock with 16th and 84th percentile confidence bands at each point in time.
Left panel: Responses after a 10% increase in the real price of oil.
Right panel: Responses after a 1% shortfall in world oil production.
Source: Baumeister and Peersman (2011).

Peersman and Van Robays (2009): distinguished oil supply, global economic activity, and oil-specific demand shocks based on sign restrictions

- European economies respond very differently to the different shocks
- European response is slower than U.S. and may involve secondary feedback from higher labor costs
- Significant differences across European countries

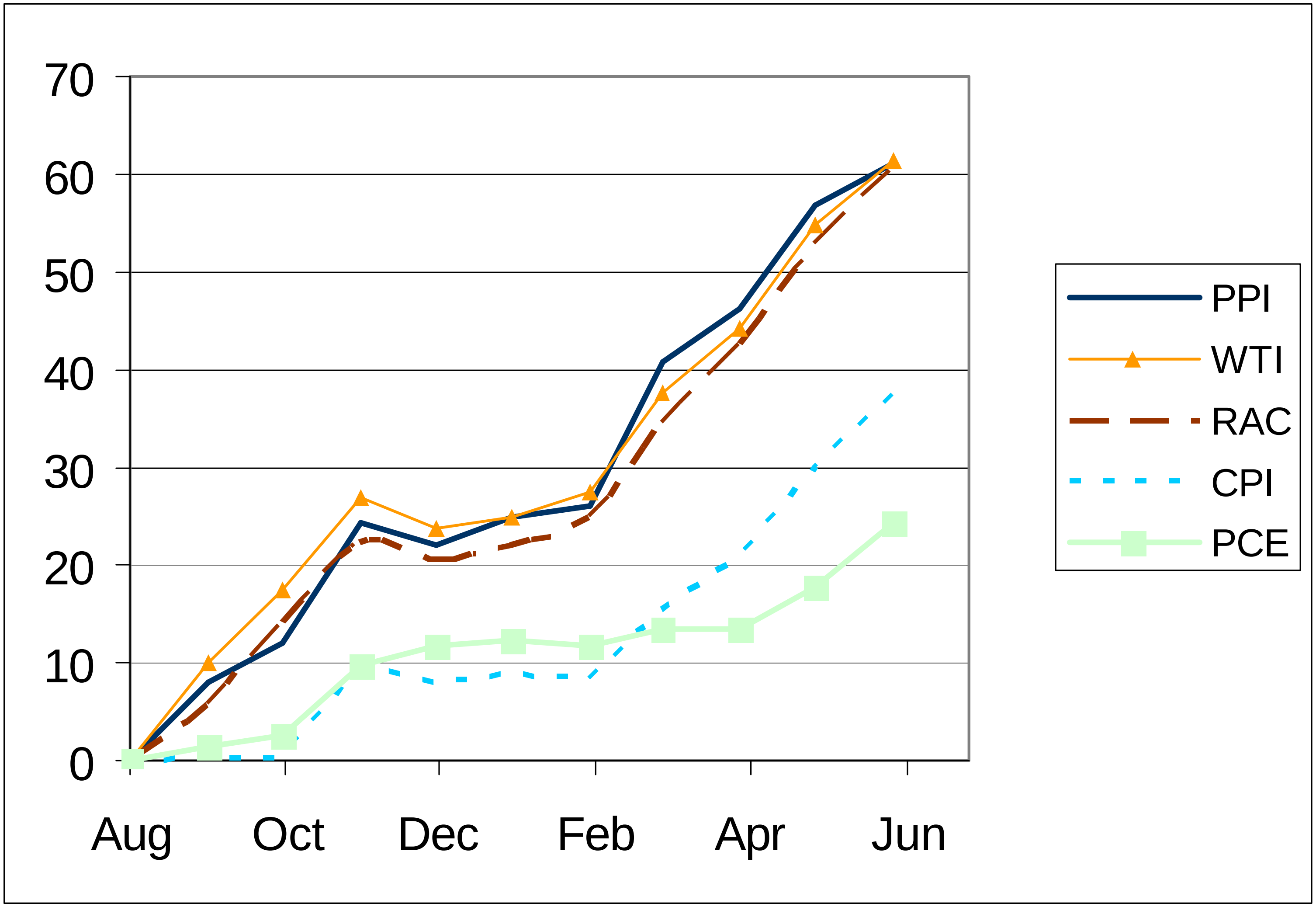


Response following a 10% increase in oil price resulting from one of 3 indicated shocks for U.S. (dashed) and Europe (solid) with 67% confidence intervals. Source: Peersman and Van Robays (2009).

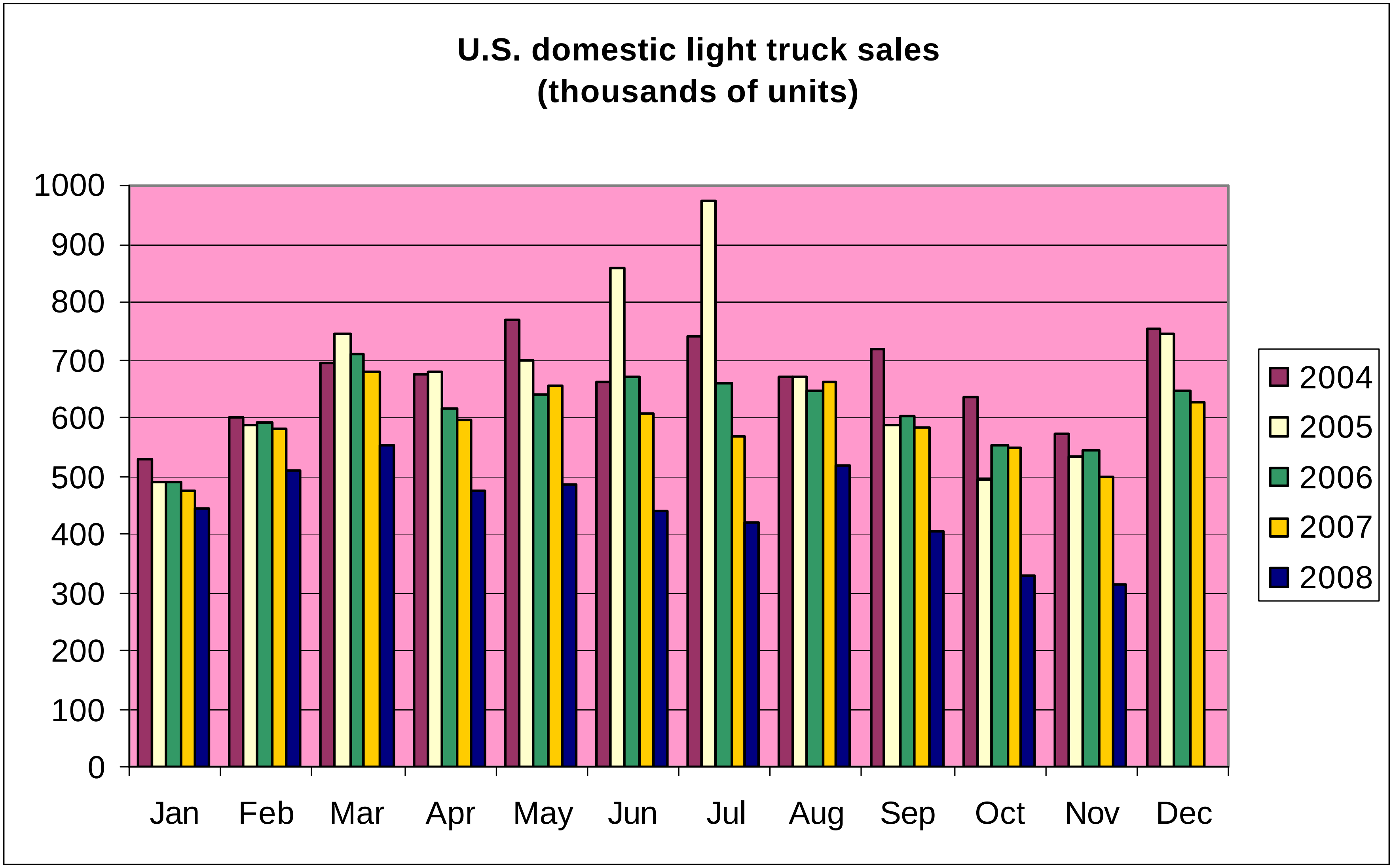
IV. Case studies

A. 2007-2008

Alternative measures of the change in energy prices, Aug 2007 - Jun 2008

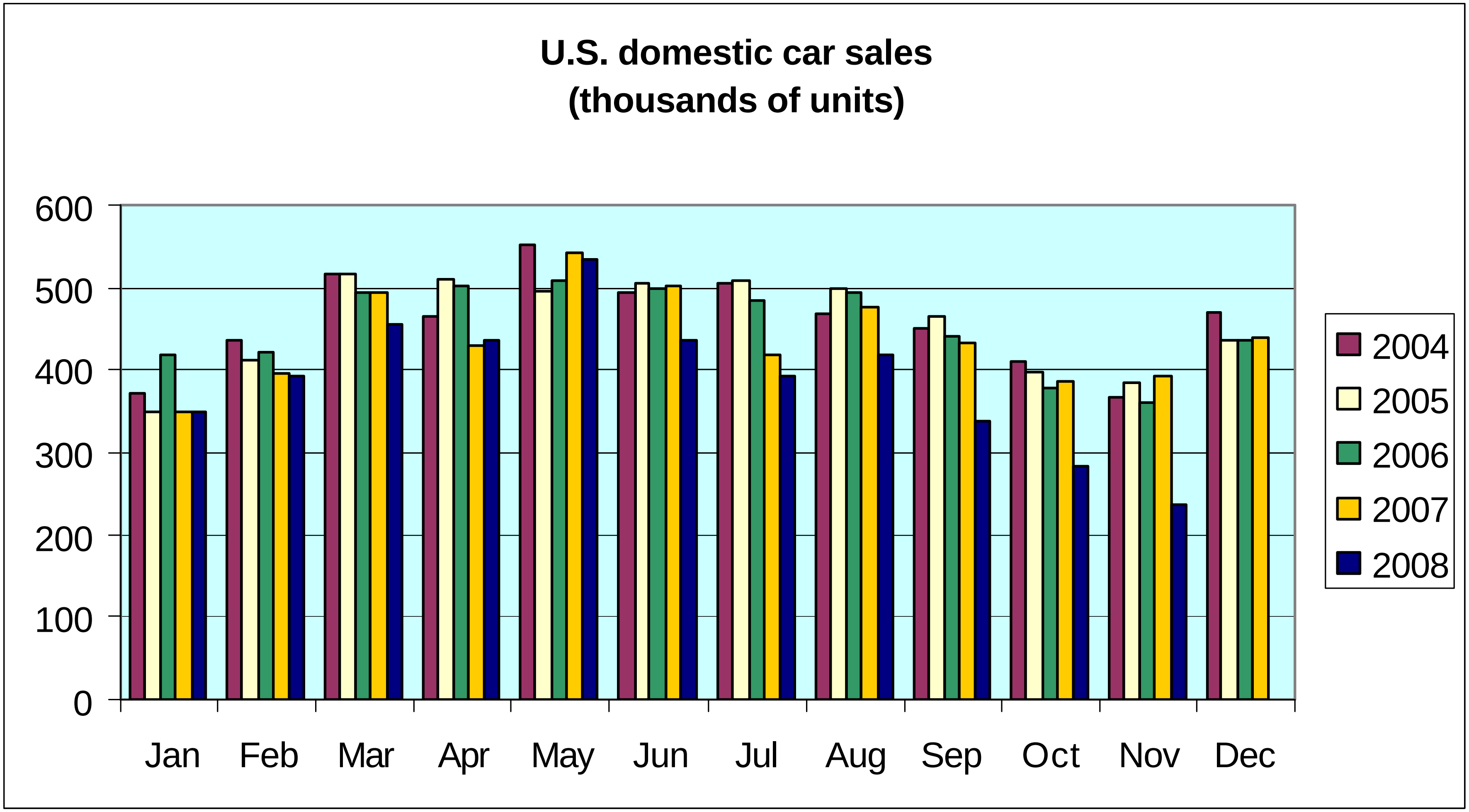


Source: Hamilton (2009)

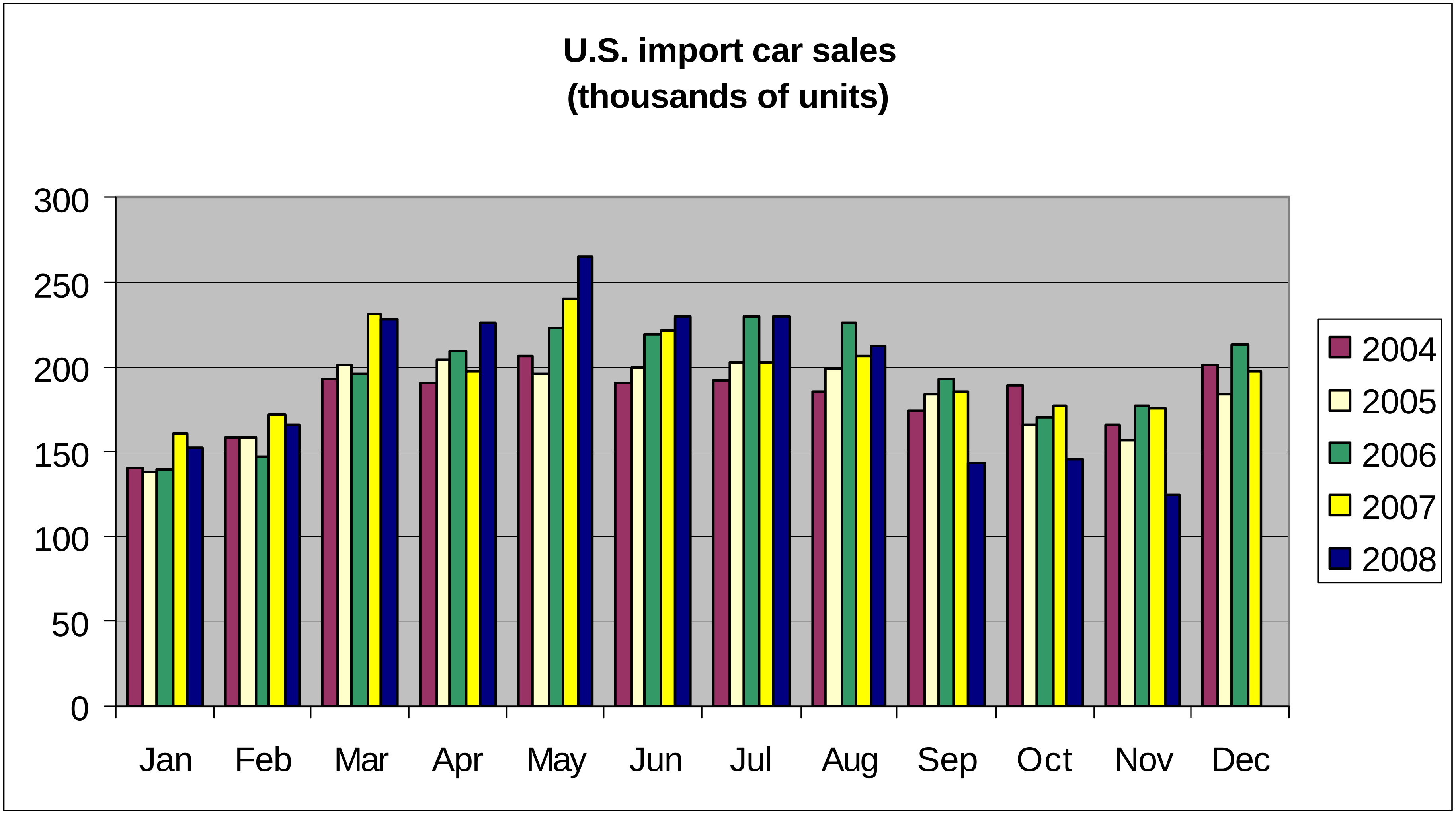


Down 26% July 07 to July 08

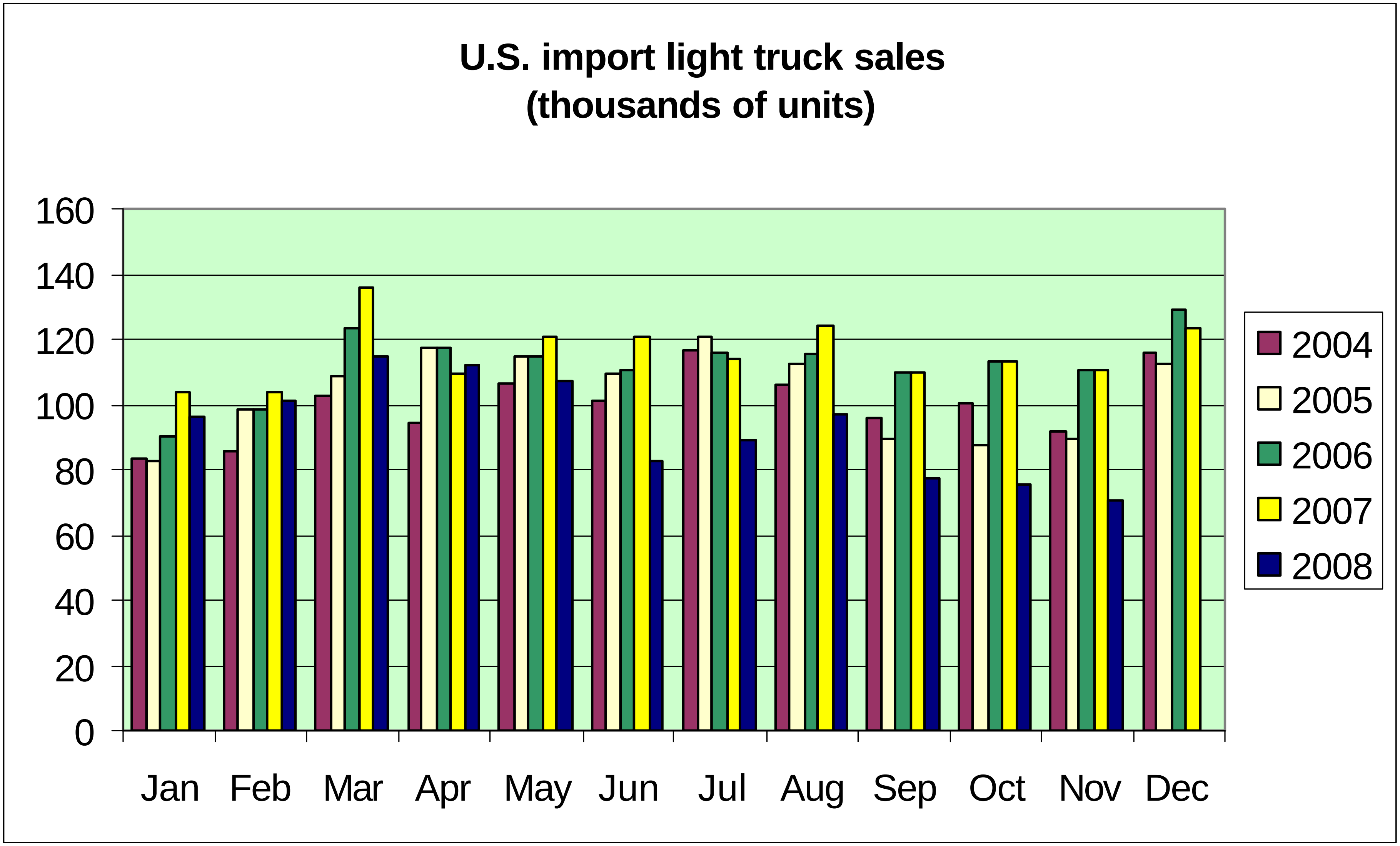
Down 6% July 07 to July 08

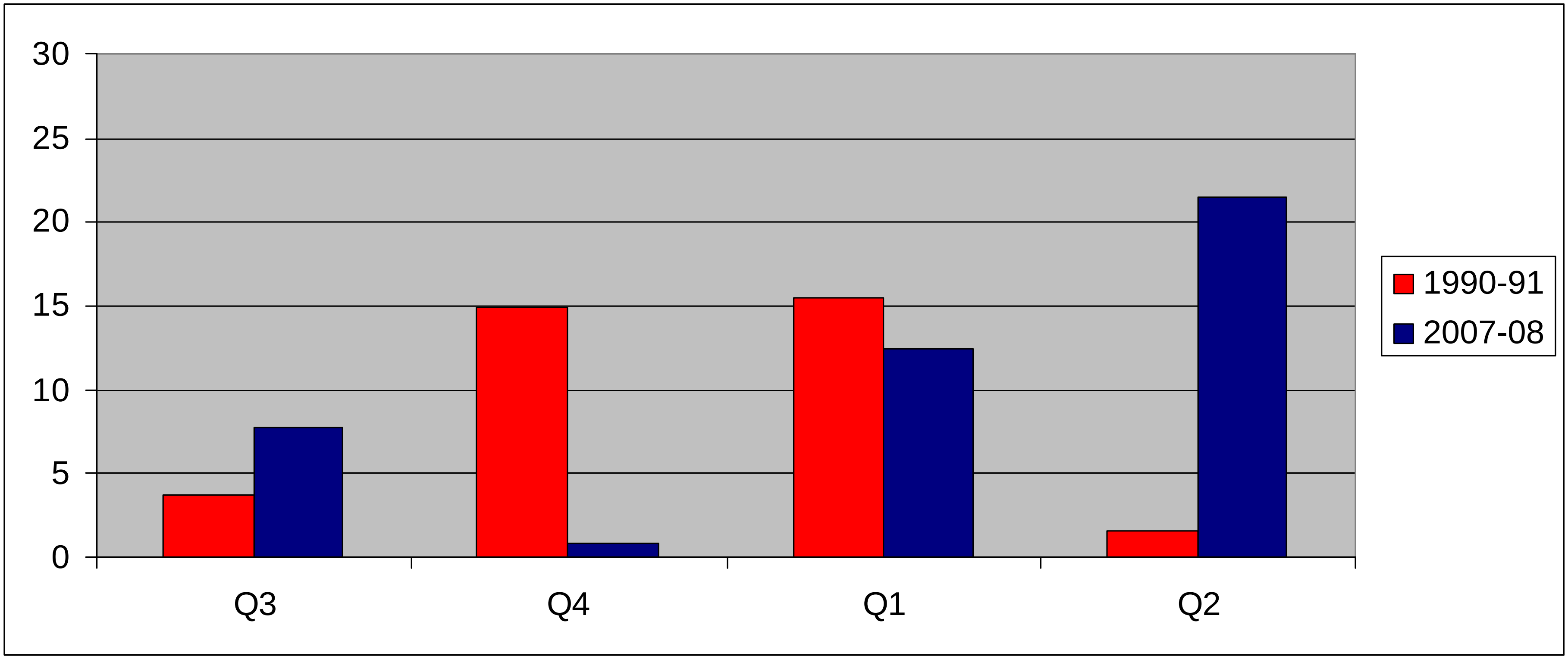


Up 14% July 07 to July 08

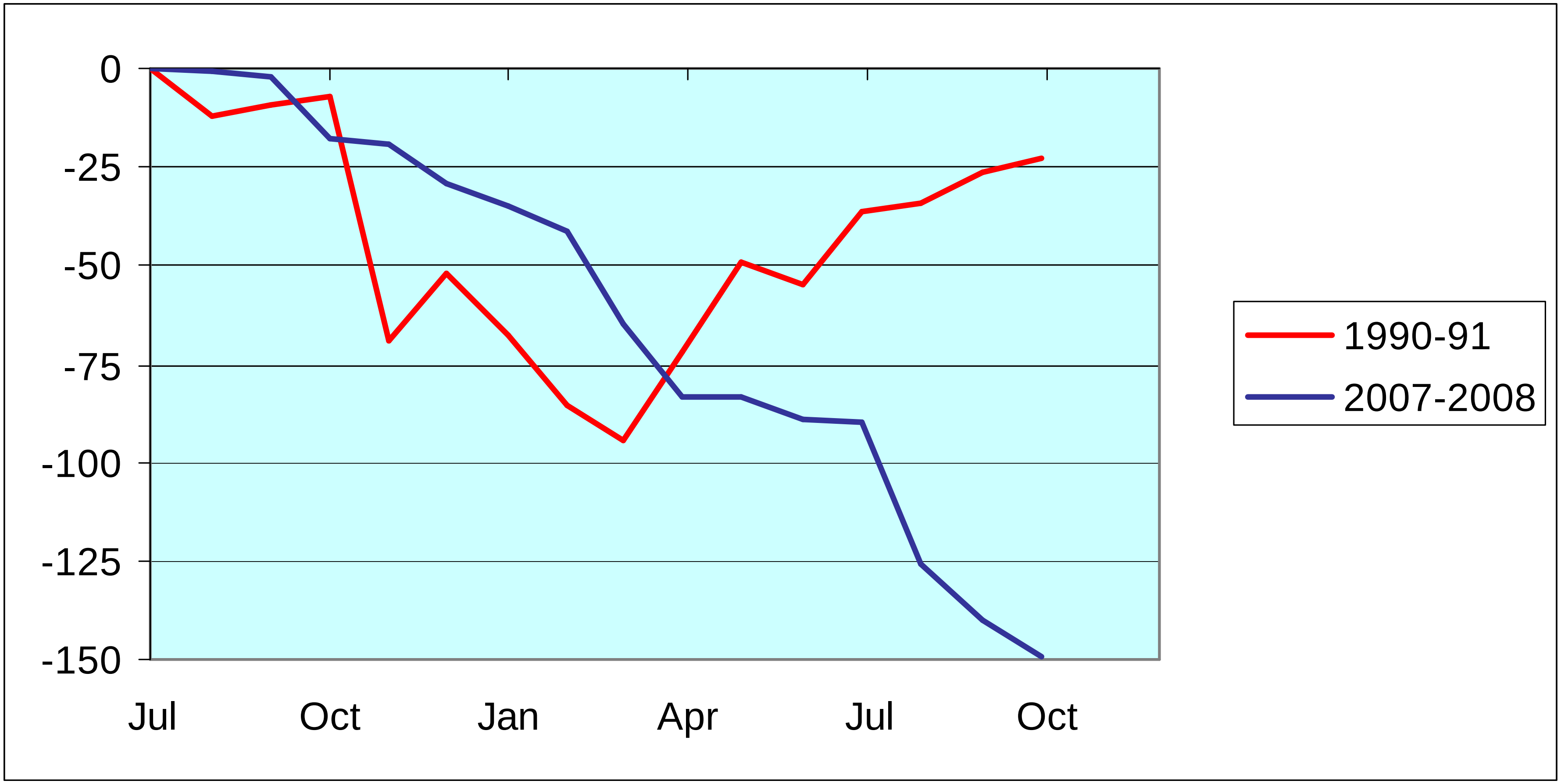


Down 22% July 07 to July 08





Amount by which motor vehicles and parts component of real GDP (measured in billions of year 2000 dollars at a seasonally adjusted annual rate) fell between indicated quarter and previous quarter during 1990-91 and 2007-08.

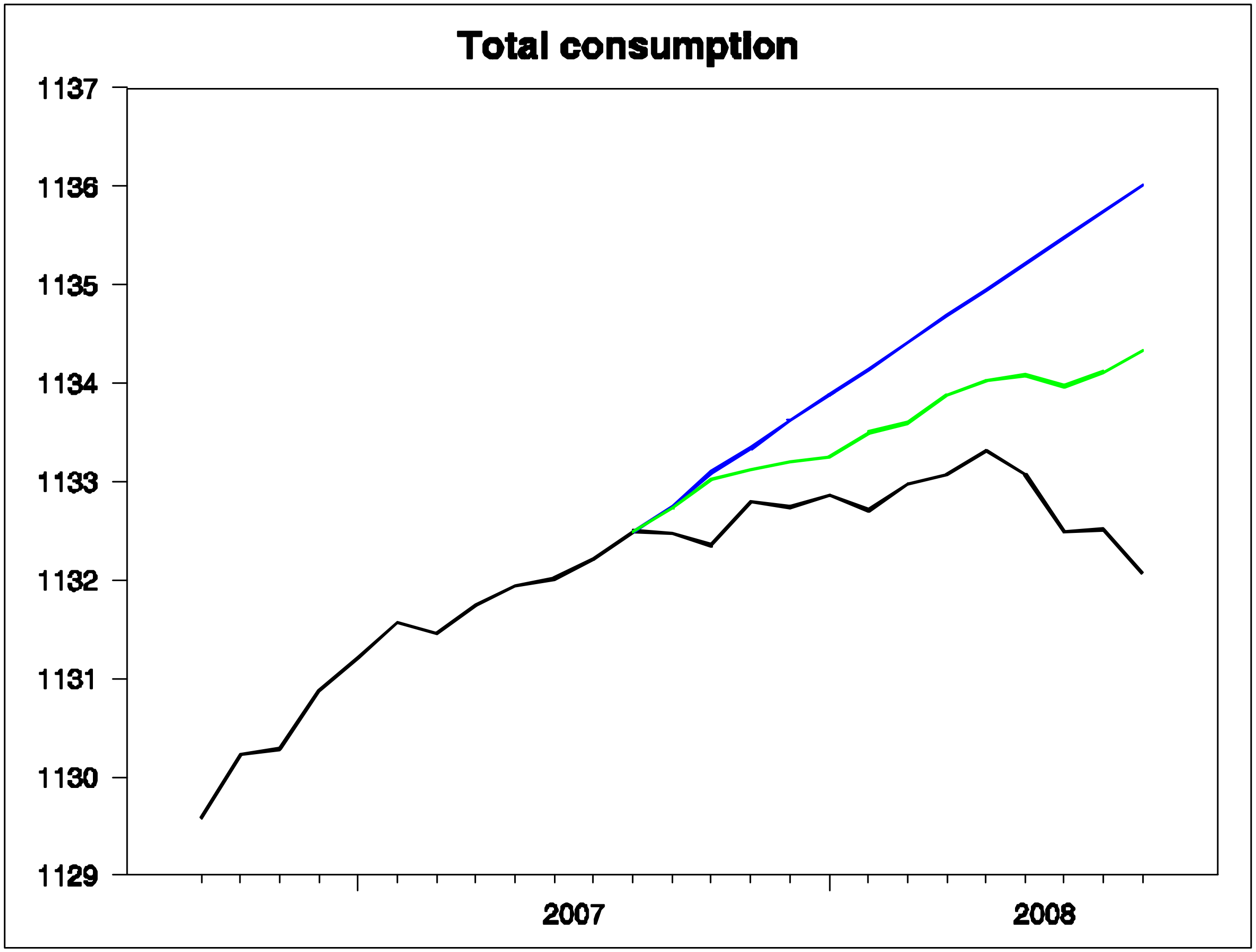


Cumulative change in seasonally adjusted number of workers in motor vehicles and parts manufacturing between July, 1990 or July 2007 and indicated month, in thousands of workers. (Total employment: 1990 = 109 million; 2007 = 138 million)

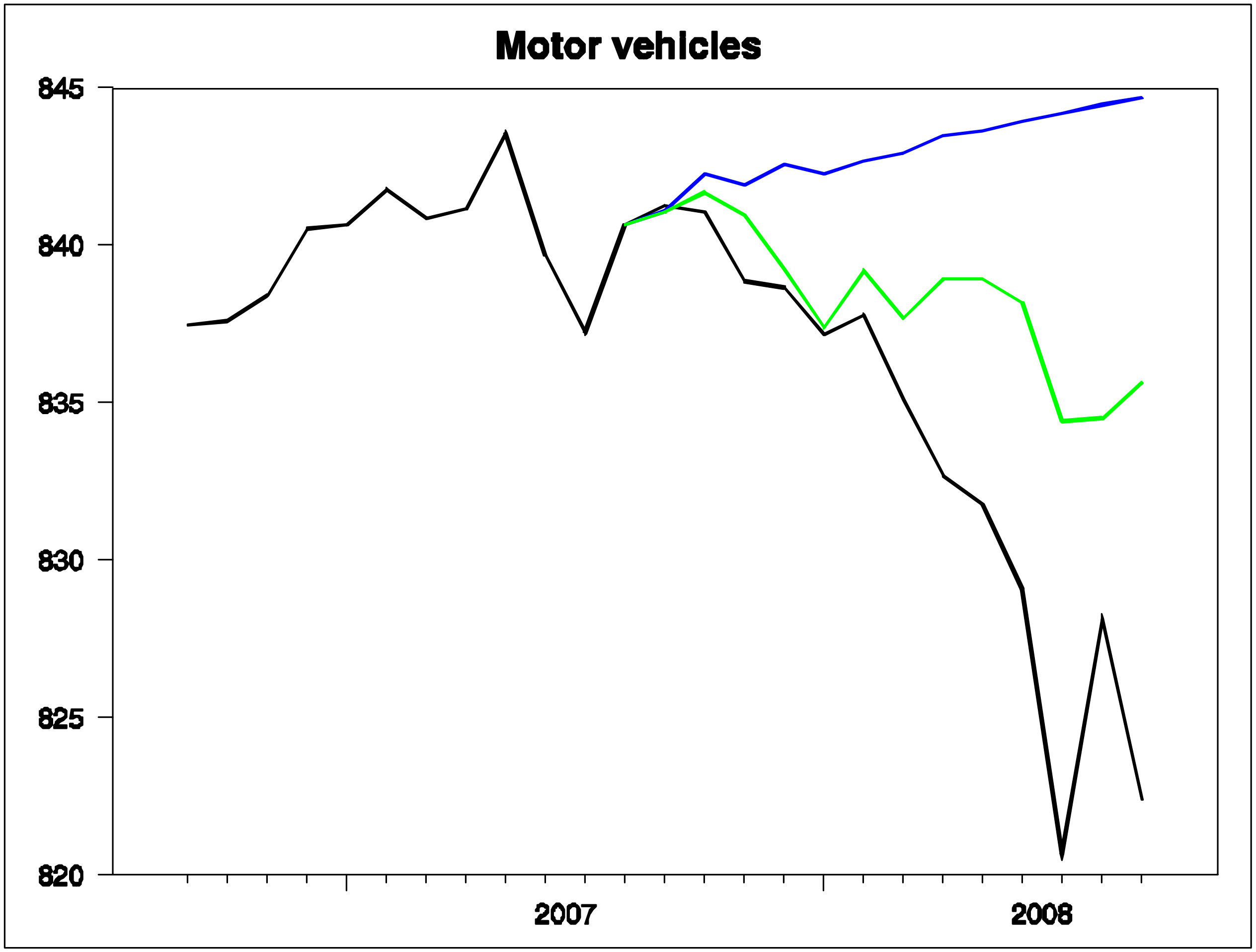
Black: 100 times log of actual real consumption

Blue: forecast formed 2007:M9

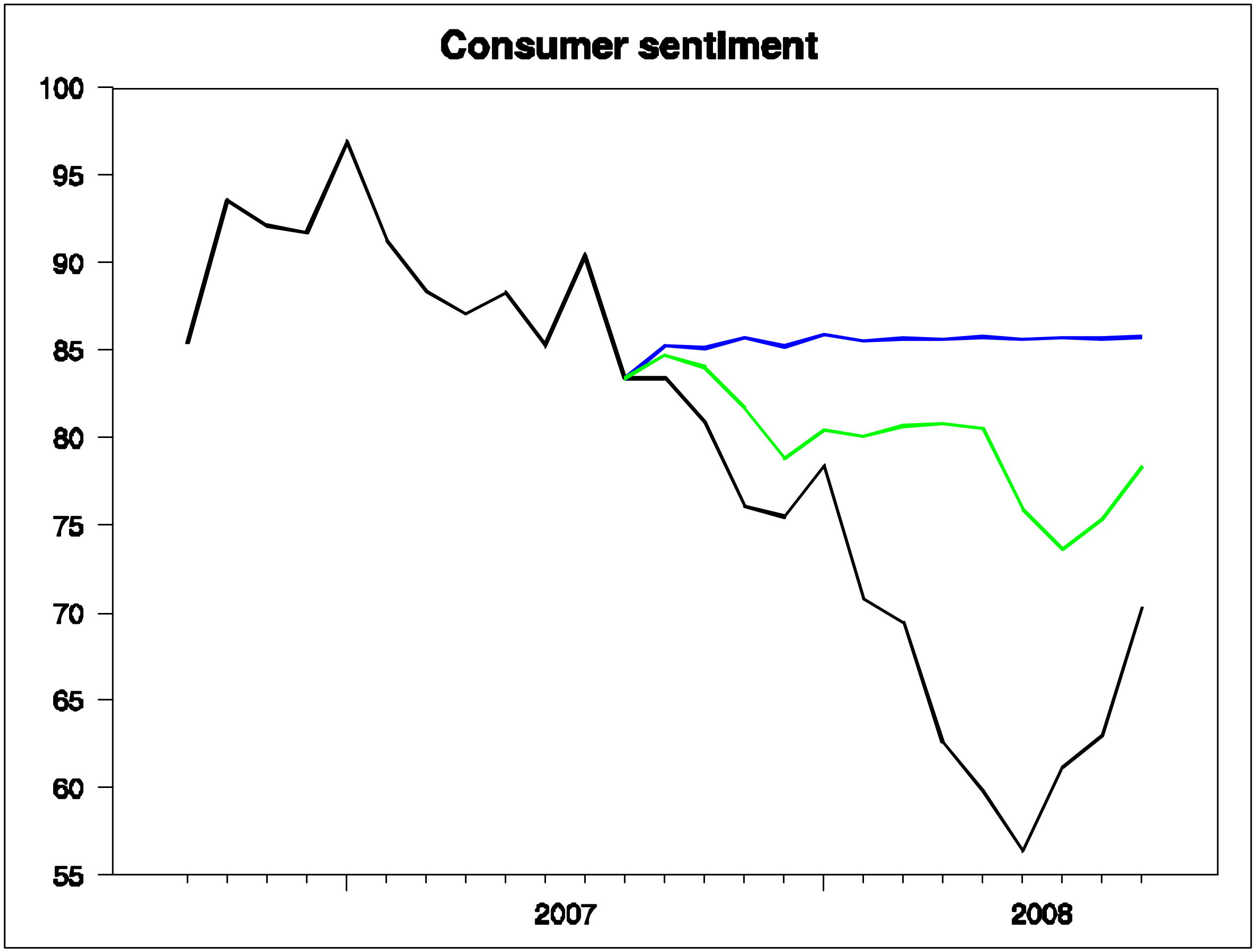
Green: Edelstein-Kilian forecast if we knew ex-post innovations *in* energy price

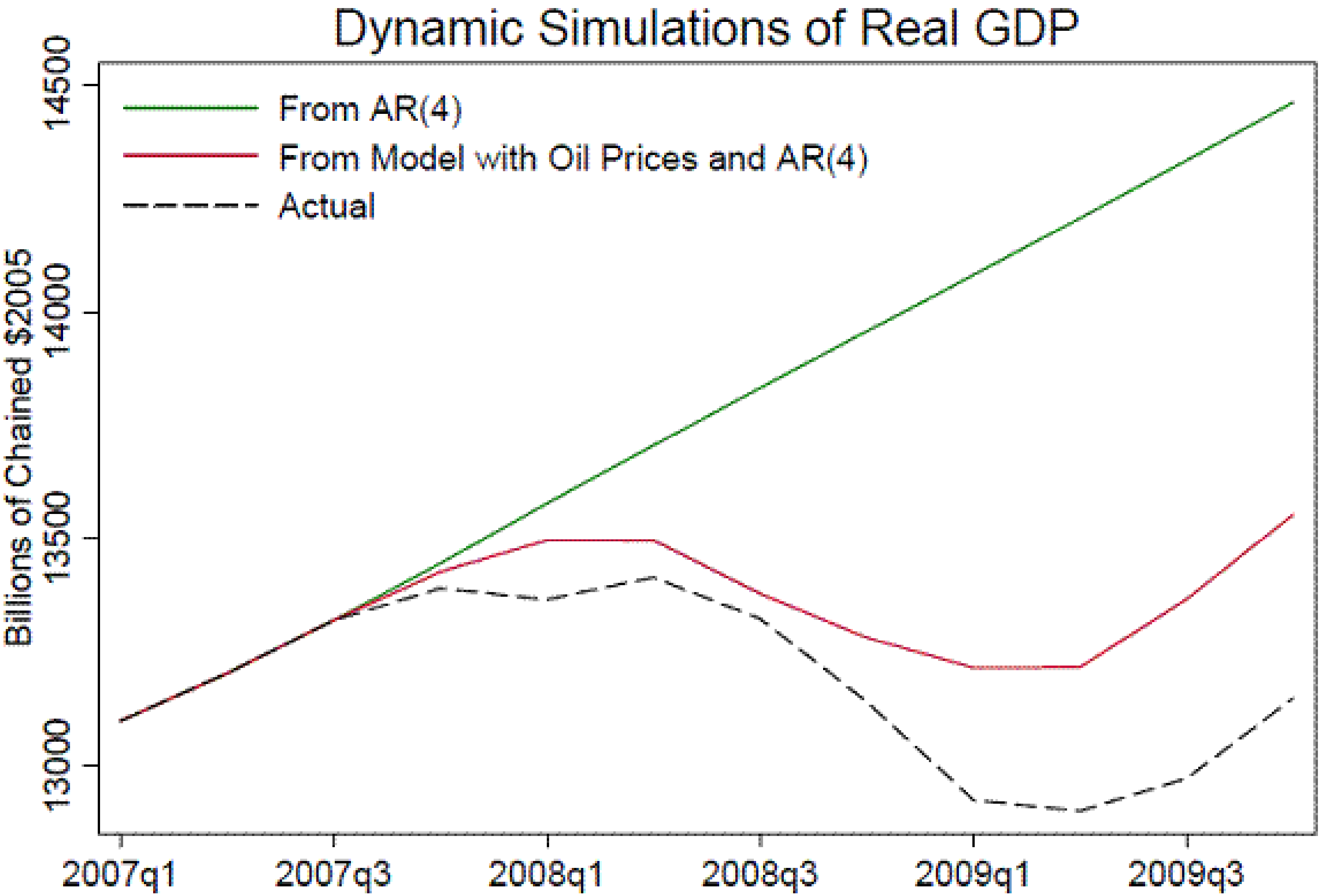


Black: 100 times log of actual real spending on motor vehicles & parts
Blue: forecast formed 2007:M9
Green: forecast if we knew ex-post innovations in energy price



Black: Actual value for Michigan index of consumer sentiment
Blue: forecast formed 2007:M9
Green: forecast if we knew ex-post innovations in energy price





Forecasts from equation (3.8) in Hamilton (2003) using GDP data through 2007:Q3 and crude oil price through 2008:Q3.

Financial crisis, housing, and the 2007-2009 recession

Unquestionably the housing downturn contributed to first year of recession (2007:Q4 - 2008:Q3) and aftermath of Lehman collapse in September 2008 to the severe downturn (2008:Q4 - 2009:Q2)

(a) Housing had been a drag on the economy without producing a recession by itself

Average contribution of residential fixed investment to GDP growth at an annual rate

2006:Q2 - 2007:Q3	-1.04%
2007:Q4 - 2008:Q3	-0.91%

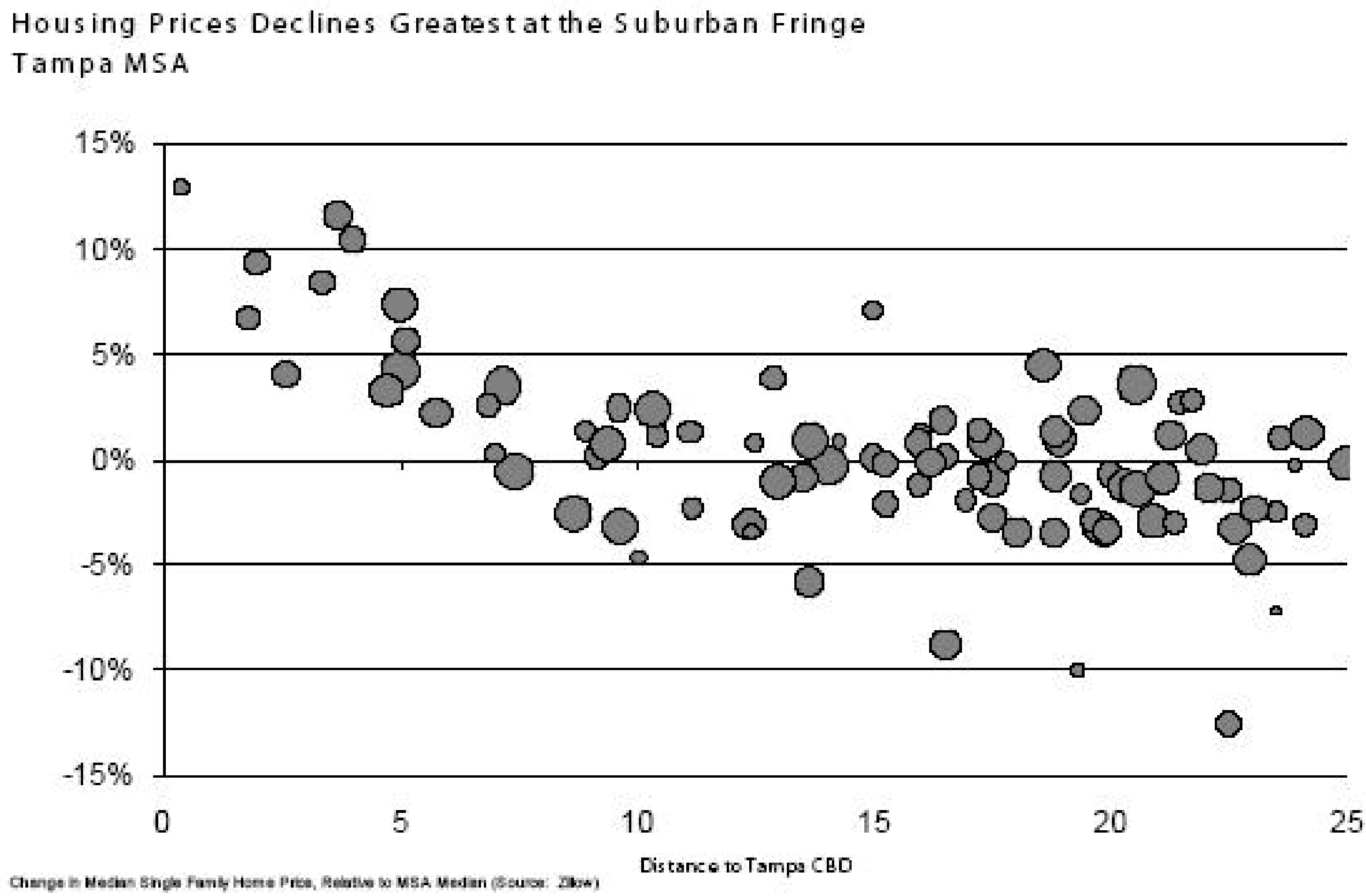
(b) If oil shock depressed GDP, that would directly impact housing

Hamilton (*J. Monetary Econ.*, 2008)--

1% decrease in real GDP

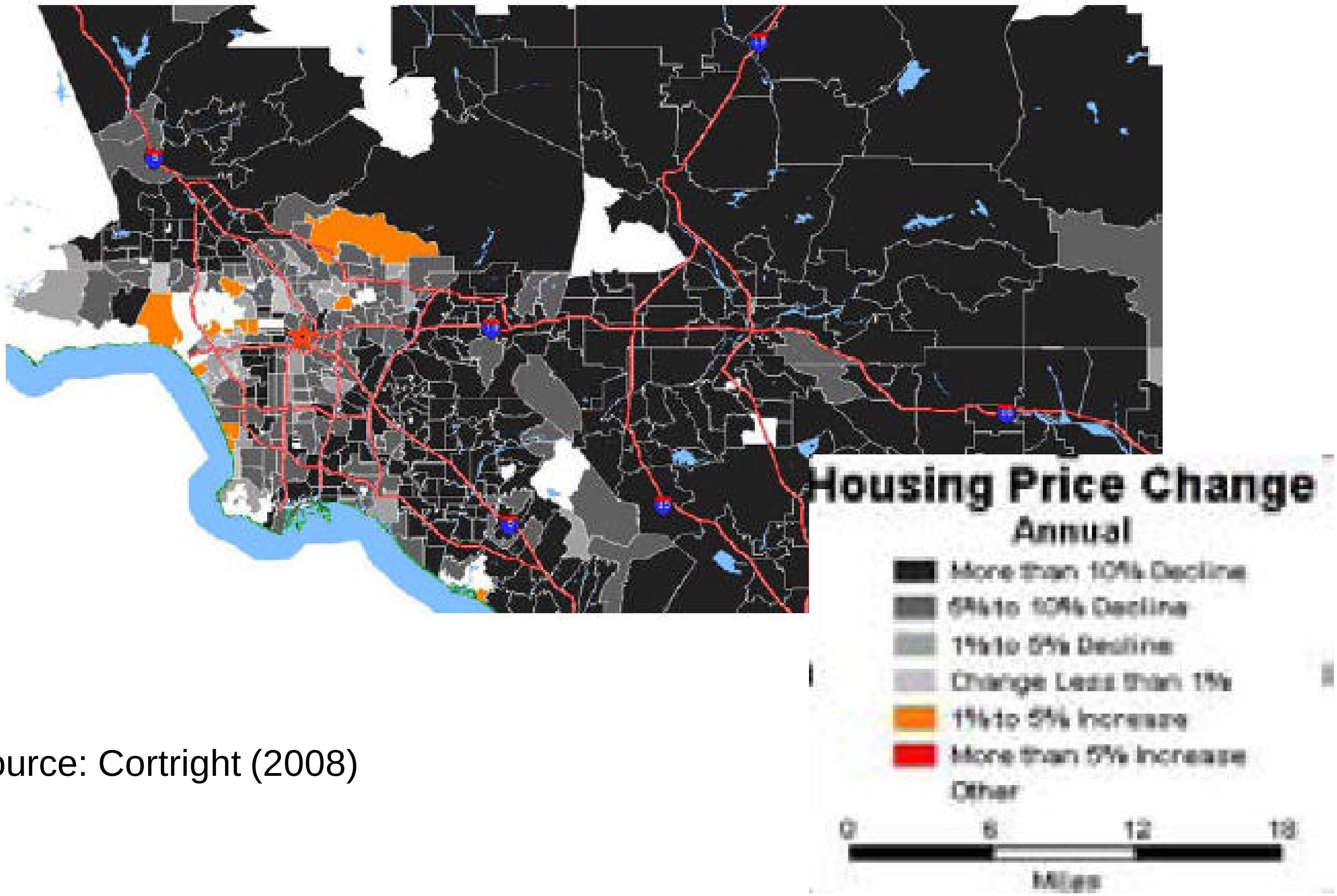
- ? 2.6% decrease in new home sales
- ? further real estate price declines
- ? further defaults

(c) interaction effect between oil shock and housing shock-- cost of commuting to exurbs



Source: Cortright (2008)

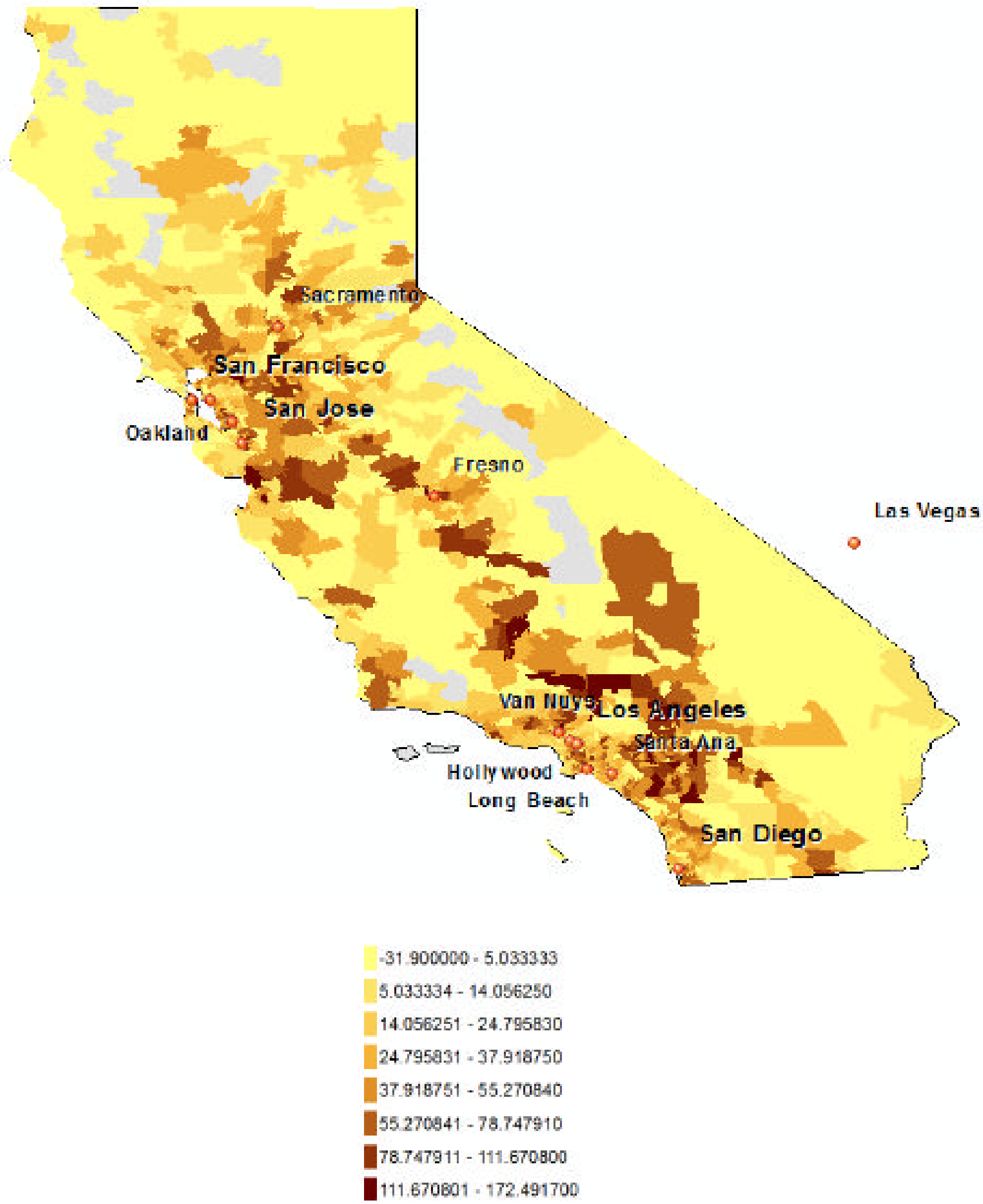
Los Angeles



Source: Cortright (2008)

Sexton, Wu, and David Zilberman (2012) model of housing demand:

- unanticipated increases in gas prices increased the cost of work commutes
- lowered the value of homes away from the city center and increased foreclosure rates



Change in foreclosure rates, 2007-2010. Source: Sexton, Wu, and Zilberman (2012)

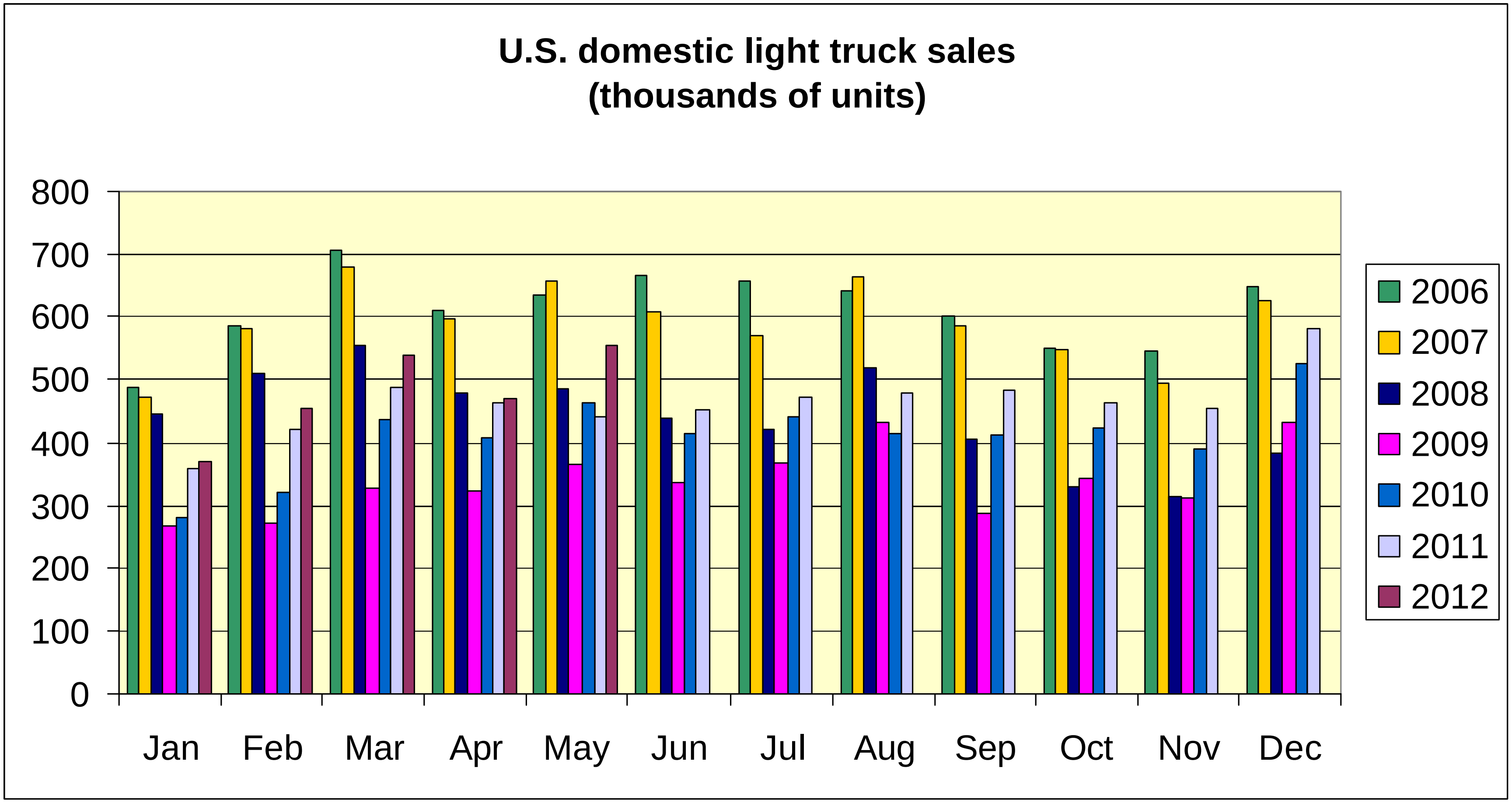
B. 2011-2012


60 Month Average Retail Price Chart
Regular Gas Price (US $/G)
Regular Gas Price (US $/G)
USA Average
4.12
3.87
3.62
3.37
3.11
2.86
2.61
2.36
2.11
1.86
1.61
6/12
8/14
10/16
12/18
2/19
4/22
6/24
8/26
10/28
12/30
3/3
5/5
7/7
9/8
11/10
1/12
3/16
5/18
7/20
9/21
11/23
1/25
3/29
5/31
8/2
10/4
12/6
2/7
4/10
6/12
2007
2008
2009
2010
2011
2012

Model in Hamilton (2003) would predict zero impact of oil price increases in 2011 and 2012

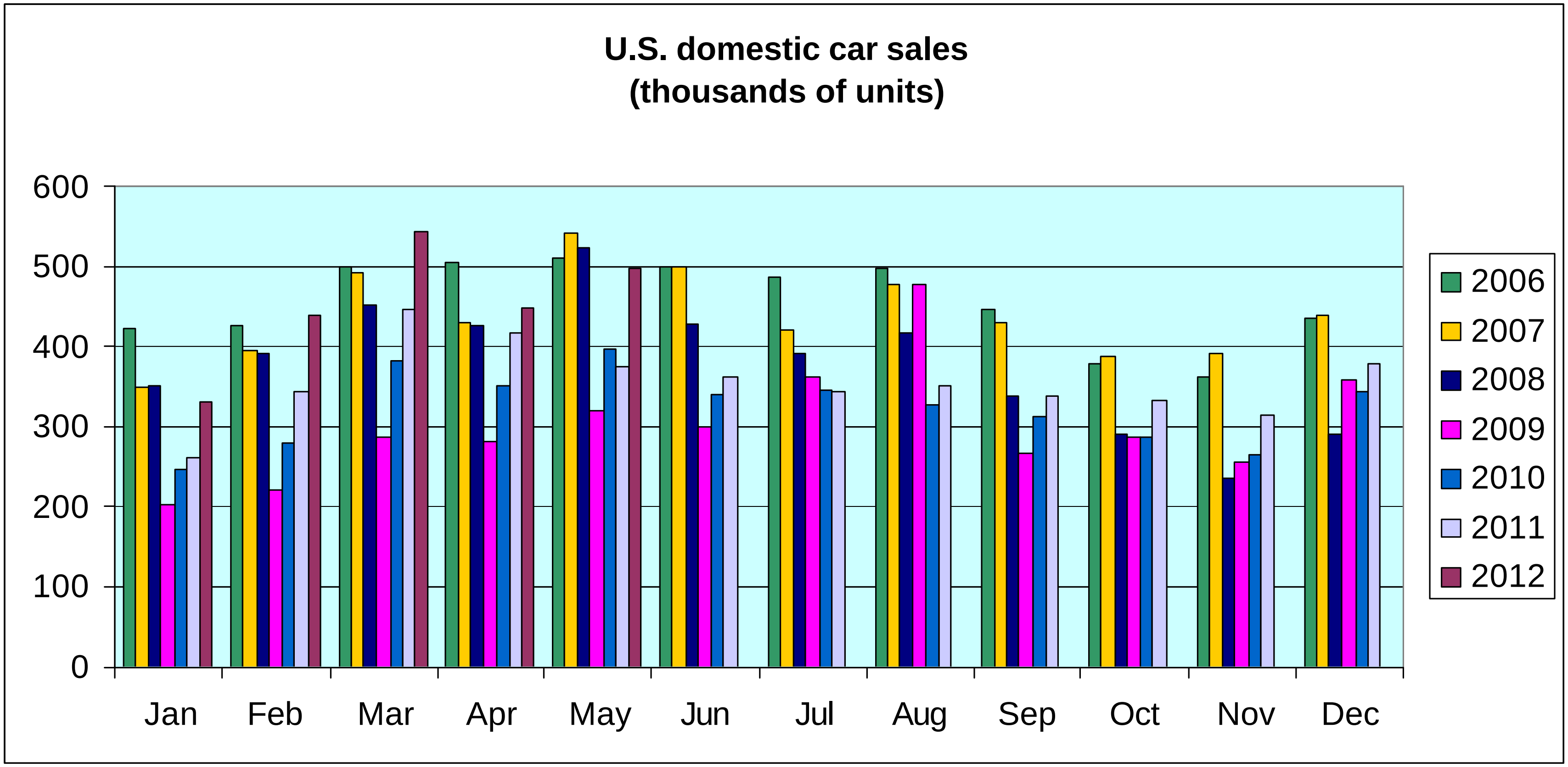
Price of oil and gasoline never exceeded 3-year high.

Truck sales still below start of 2008



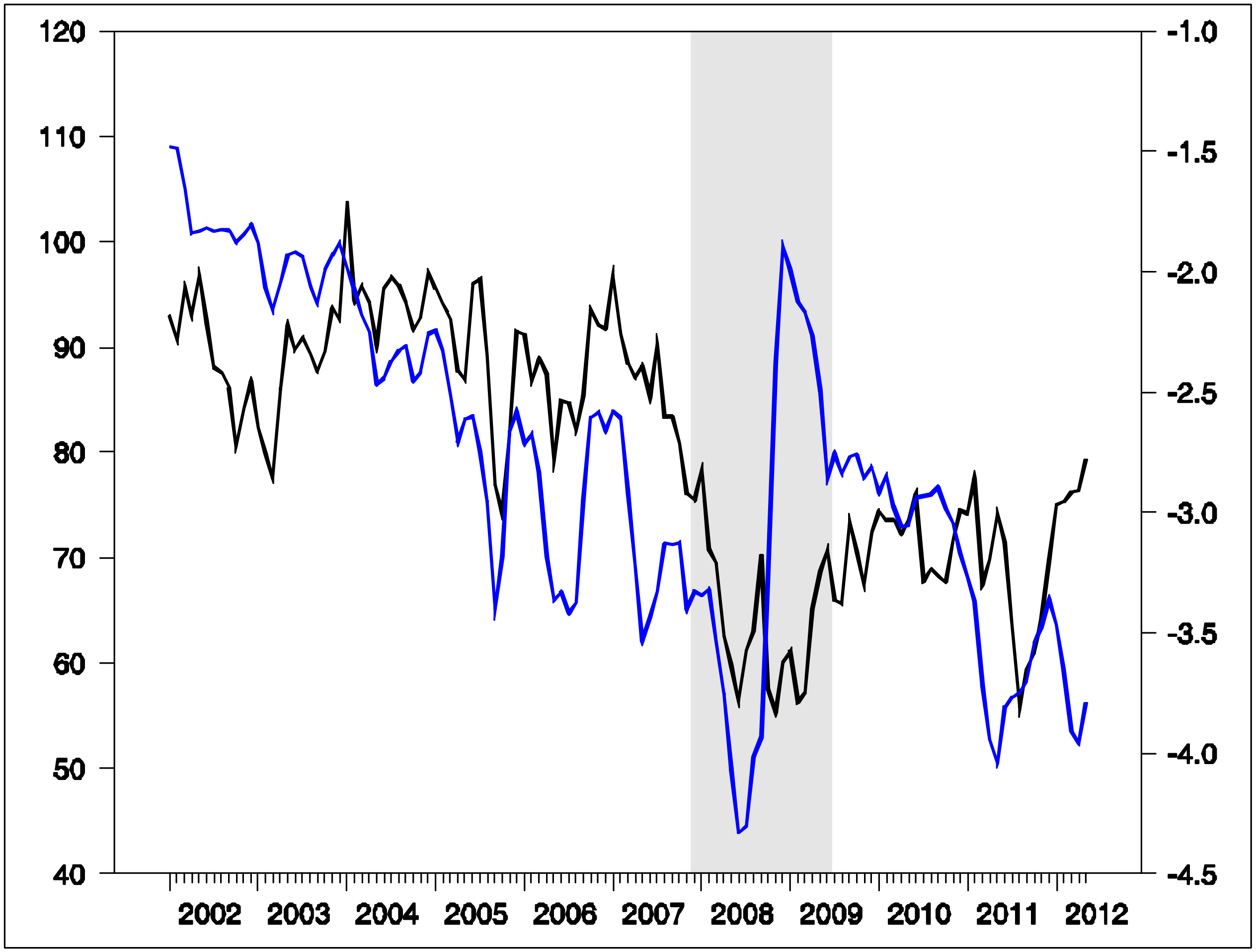
Domestic light trucks up 25% May 11 to May 12

Detroit successfully selling smaller cars



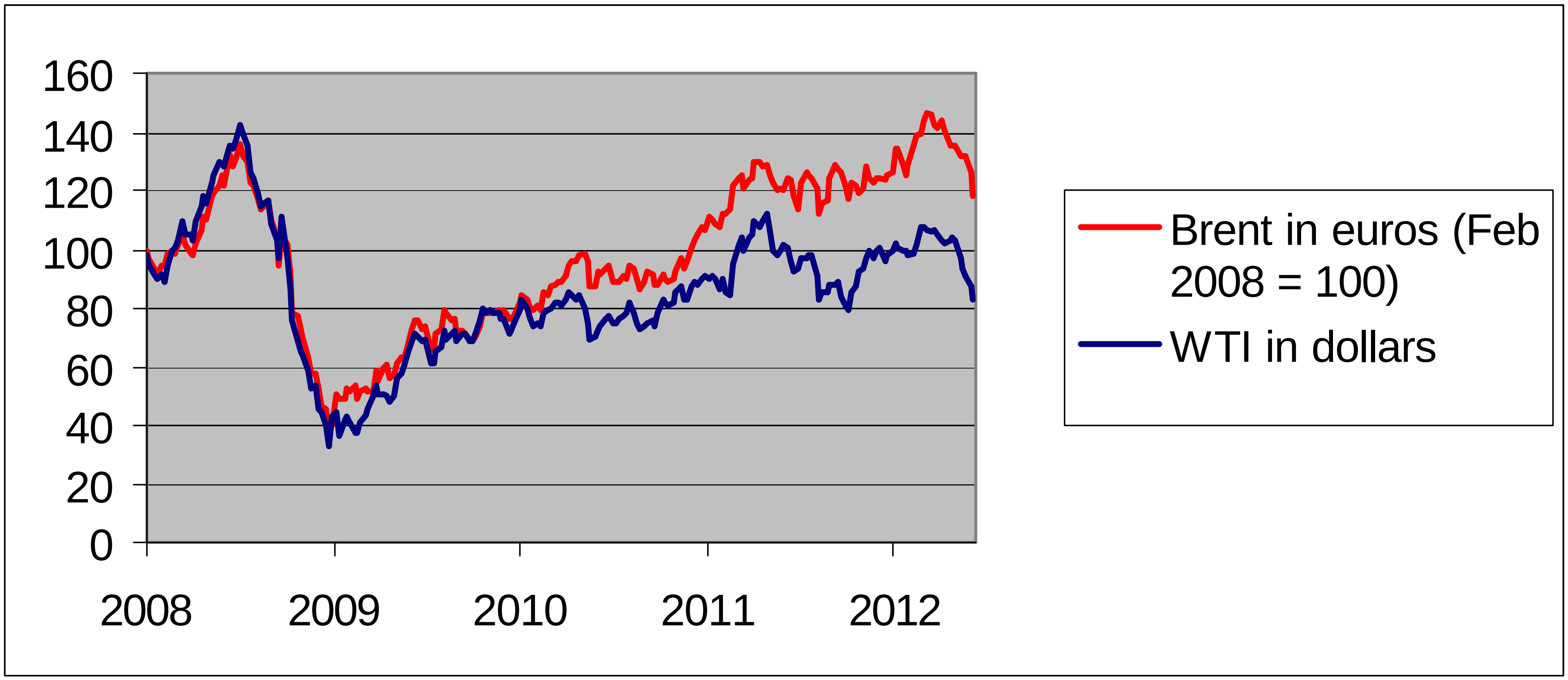
Domestic cars up 33% May 11 to May 12

Consumer sentiment became less responsive



Black: Michigan index of consumer sentiment.
Blue: negative of real retail gasoline price (2012 $/gallon)

Oil price has been a bigger problem for Europe



Added burden to sovereign debt crisis

Summary

- Oil price spikes historically have been a factor causing GDP temporarily to fall below potential
- Spike of 2012 contributed to Europe's problems but should be minimally disruptive for U.S. economy

A major conflict involving Iran could be 3 times as big as any historical episode

Date	Event	Supply cut (local)	Supply cut (global)	Price Change	Recession Start
Nov 73	OPEC embargo	7%	7%	51%	Dec 73
Nov 78	Iran revolution	7%	4%	57%	Feb 80
Oct 80	Iran-Iraq War	6%	4%	45%	Aug 81
Aug 90	Gulf War I	9%	6%	93%	Aug 90
Jul 12	Strait of Hormuz	20%	?	?	?