A Framework for Decomposing Shocks and Measuring Volatilities Derived from Multi-Dimensional Panel Data of Survey Forecasts

Econometrics in Public Policy

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DUQUESNE UNIVERSITY Antony Davies, Ph.D.
www.business.duq.edu/faculty/davies

Dimensionality of Forecast Data Sets

1. Uni-dimensional: Cross-Sectional or Longitudinal

   → Multiple forecasters aim at a single target (cross-sectional)

   → A single forecaster aims at multiple targets (longitudinal)

2. Two-dimensional (panel data): Combined cross-sectional and longitudinal

   → Multiple forecasters aim at multiple targets

3. Three-dimensional: Combined cross-sectional, longitudinal, and horizonal

   → Multiple forecasters aim at multiple targets from multiple horizons

Increases in Data Dimensionality Pre-Date Requisite Analytic Techniques

Three-dimensional data sets have a reasonably long history:

- Livingston Survey (from 1946)
- ASA-NBER Survey of Professional Forecasters (from 1968)
- Blue Chip Survey of Professional Forecasters (from 1976)

Not until early 1990's that the first two-dimensional analytic techniques were employed:

- Swindler and Ketcher (JMCB, 1990)
- Keane and Runkle (AER, 1990)
- Batchelor and Dua (JMCB, 1991)
- De Bont and Bange (JFQA, 1992)

Increases in Data Dimensionality Pre-Date Requisite Analytic Techniques

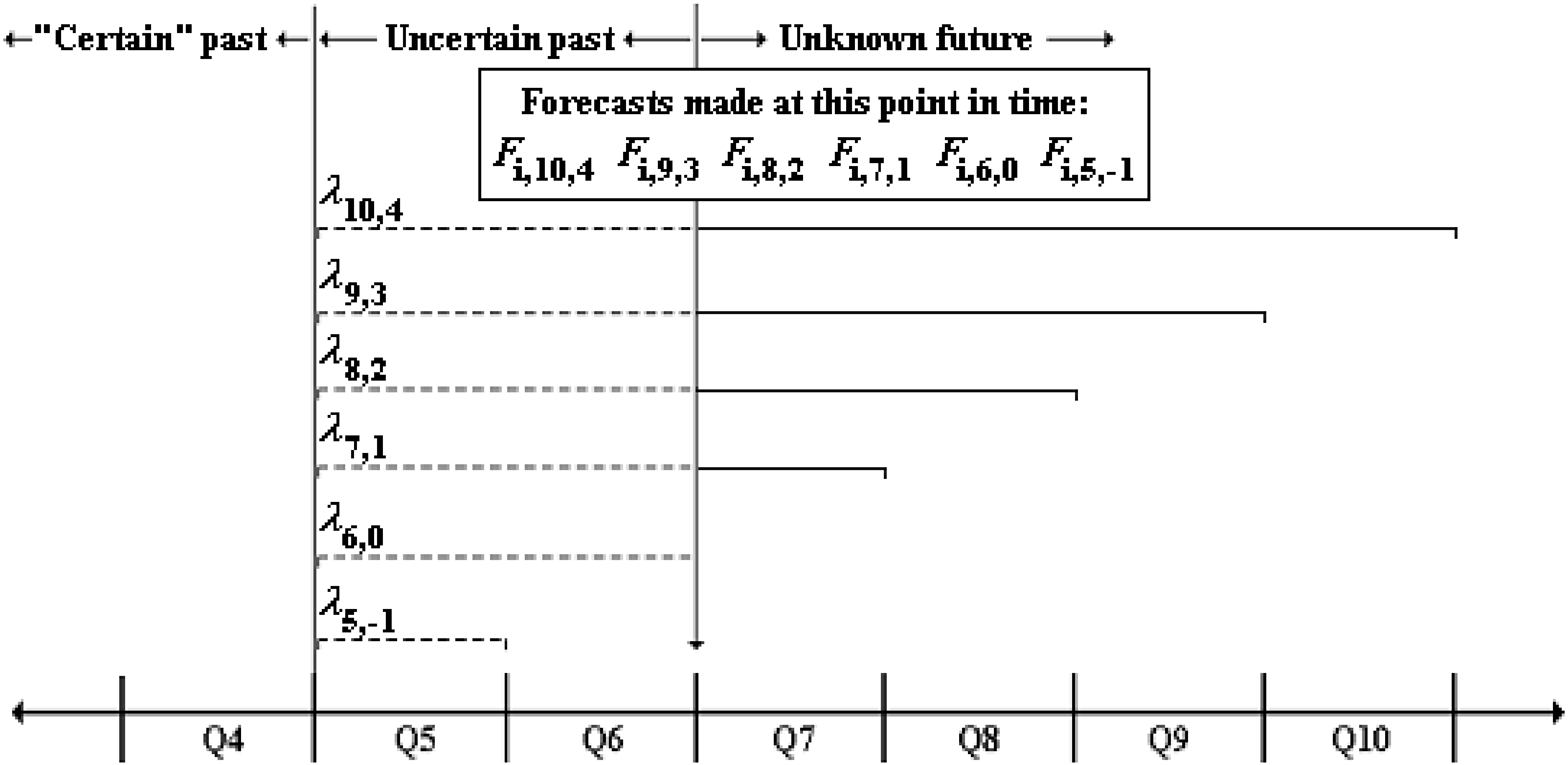
Not until late 1990’s that first three-dimensional techniques were developed

Davies and Lahiri (JE, 1995; Analysis of Panels…, 1999)

Developed for the purpose of testing forecast rationality, the Davies-Lahiri framework also implied the existence of new measures of economic shocks and volatility.

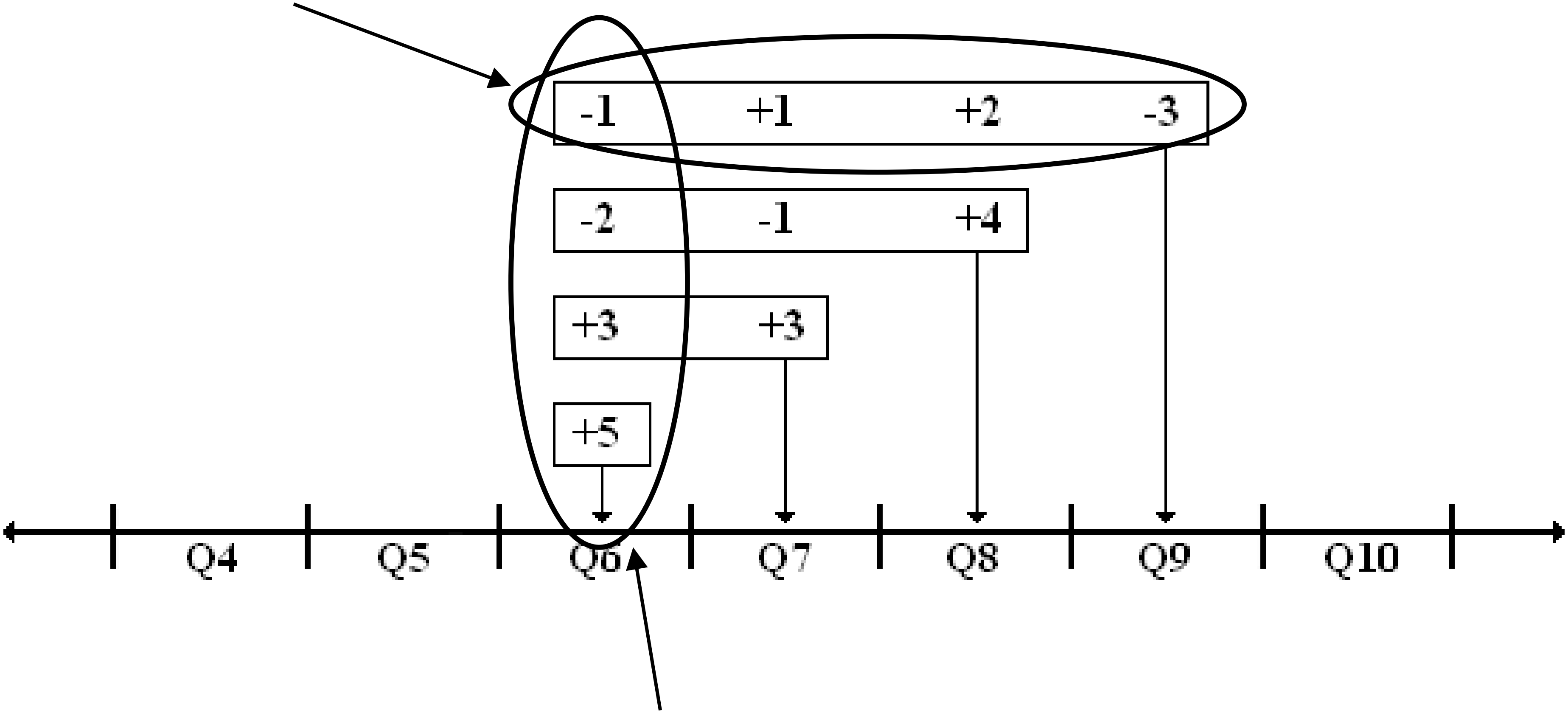
The purpose of this research is to extract the shocks and volatilities implied in the Davies-Lahiri framework.

Three-Dimensional Structure of the ASA-NBER Data Set



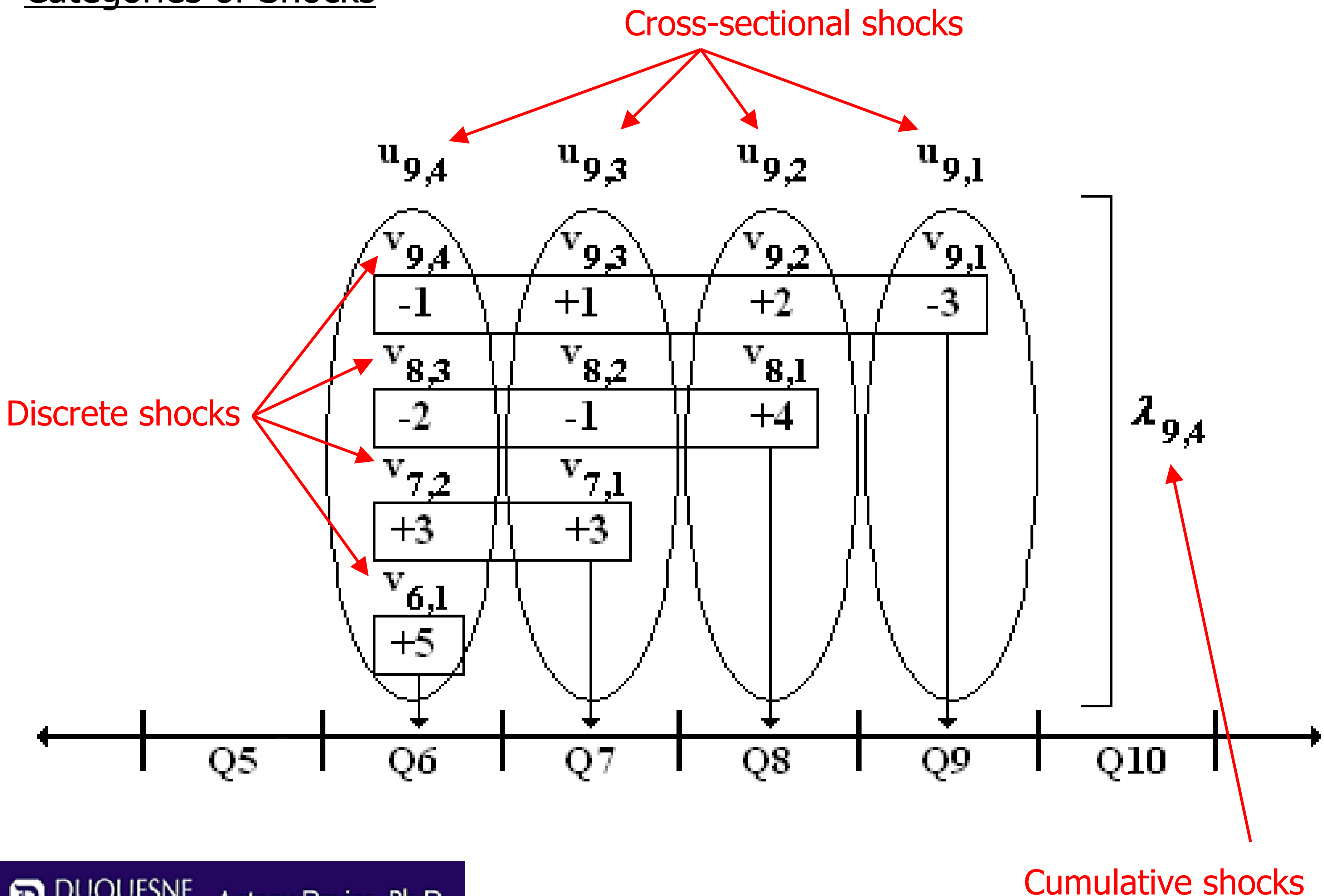
Timing of Shock Occurrence vs. Shock Impact

These shocks all impact inflation in quarter 9 but occur in different quarters.



These shocks all occur in quarter 6 but impact inflation in different quarters.

Categories of Shocks



Shock Measures

Shock Measure	Shocks Occur From	Shocks Impact Inflation From
Cumulative shocks λ_{th}	**Beginning of quarter *t* – *h* to the end of quarter *t*.**	**Beginning of quarter *t* – *h* to the end of quarter *t*.**
Cross-sectional shocks u_{th}	**Beginning of quarter *t* – *h* to the end of quarter *t* – *h*.**	**Beginning of quarter *t* – *h* to the end of quarter *t*.**
Discrete shocks v_{th}	**Beginning of quarter *t* – *h* to the end of quarter *t* – *h*.**	**Beginning of quarter *t* to the end of quarter *t*.**

Davies-Lahiri Framework

Inflation for quarter *t*

Cumulative shocks to inflation impacting from *h* quarters prior to the end of quarter *t* to the end of quarter *t*

$$A_t = A^*_{th} + \gamma_{th} + \lambda_{th}$$

(Possibly unobserved) inflation at *h* quarters prior to the end of quarter *t*

Unbiased and efficient forecasted change in inflation anticipated to occur from *h* quarters prior to the end of quarter *t* to the end of quarter *t*

Davies-Lahiri Framework

Individual *i* forecast for quarter *t* made *h* quarters prior to the end of quarter *t*

Individual *i* forecast bias specific to horizon *h* forecasts

$$F_{ith} = A^*_{th} + \gamma_{th} + \phi_{ih} + \varepsilon_{ith}$$

(Possibly unobserved) inflation at *h* quarters prior to the end of quarter *t*

Idiosyncratic error (assumed white noise over all three dimensions)

Unbiased and efficient forecasted change in inflation anticipated to occur from *h* quarters prior to the end of quarter *t* to the end of quarter *t*

Implied Shock Measures

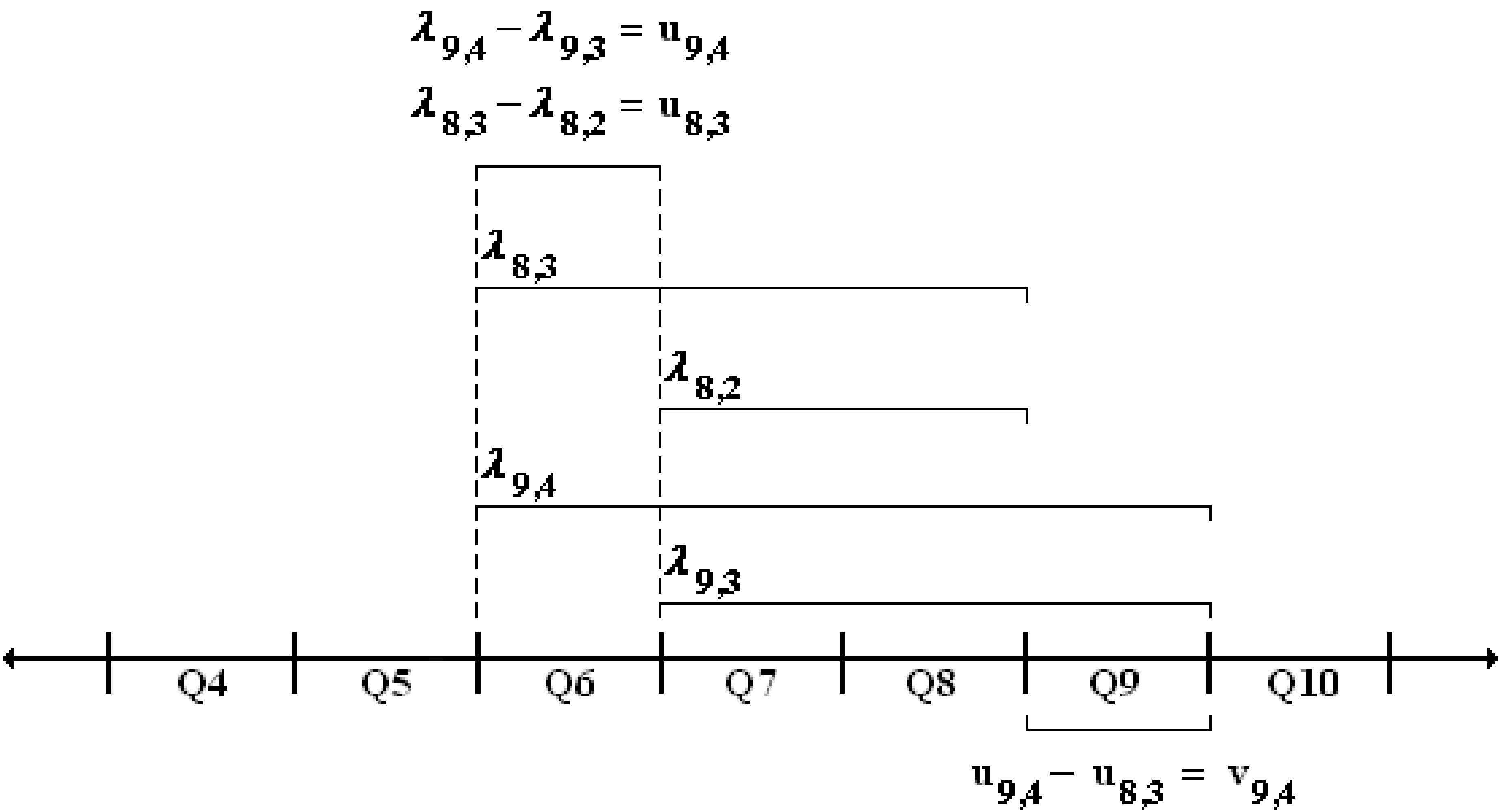
$$\hat{\lambda}_{th} = \frac{1}{N}\sum_{i=1}^{N}\left(A_t - F_{ith} - \frac{1}{T}\sum_{t=1}^{T}\left(A_t - F_{ith} \right)\right)$$

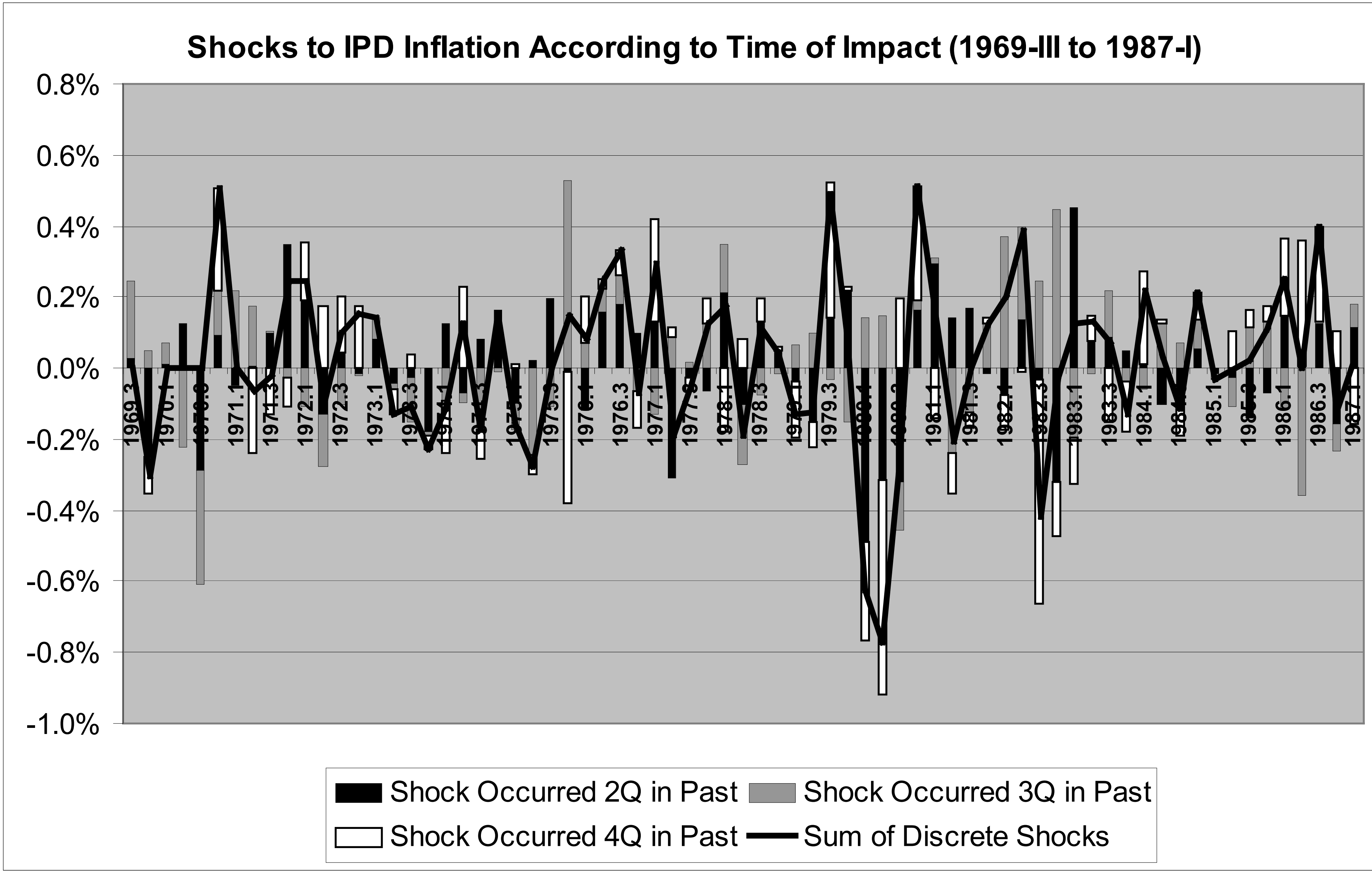
$$\hat{u}_{th} = \hat{\lambda}_{th} - \hat{\lambda}_{t,h-1} = \frac{1}{N}\sum_{i=1}^{N}\left(-F_{ith} + F_{i,t,h-1} - \frac{1}{T}\sum_{t=1}^{T}\left(-F_{ith} + F_{i,t,h-1} \right)\right)$$

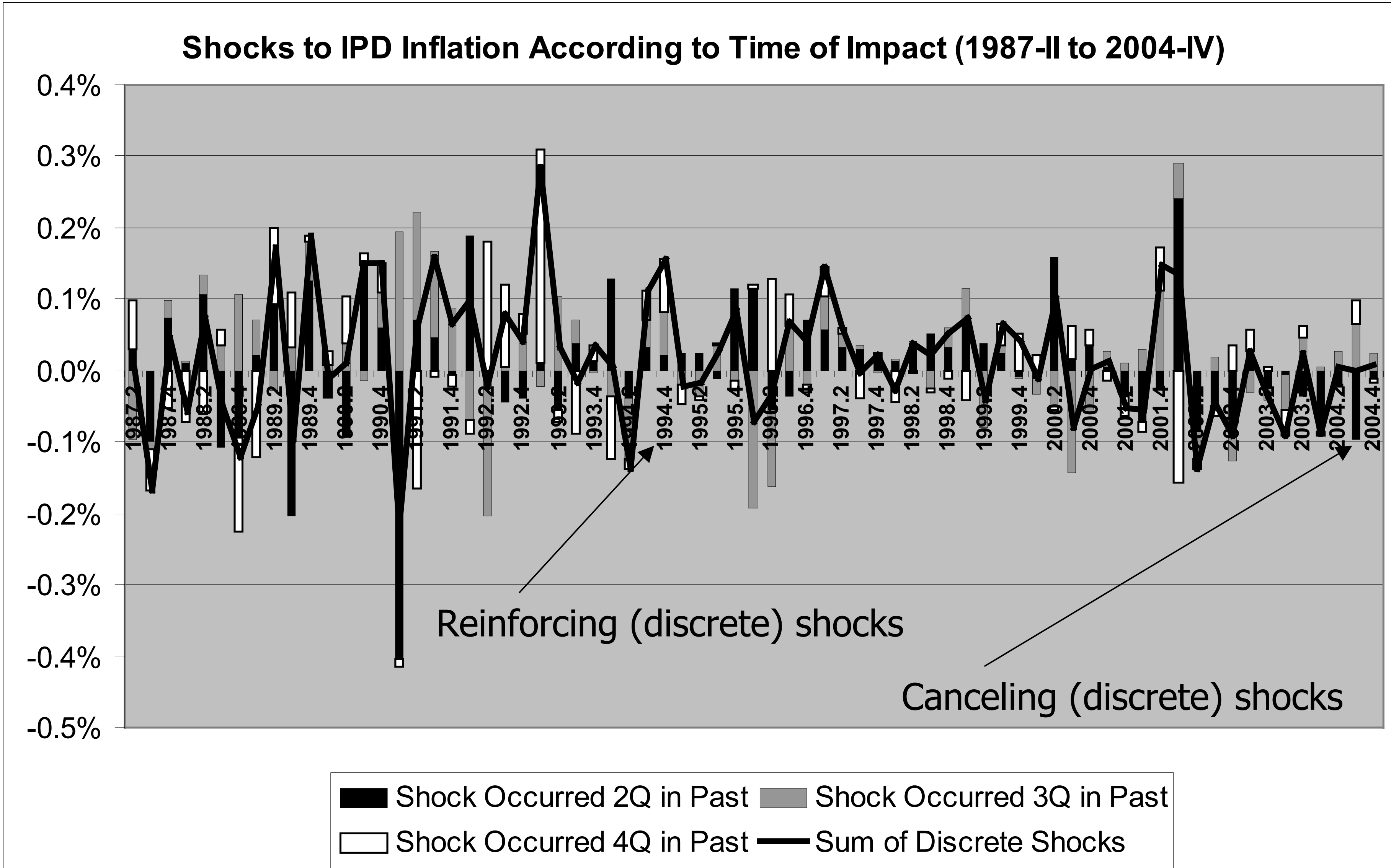
$$\hat{v}_{th} = \hat{u}_{th} - \hat{u}_{t-1,h-1} = \hat{\lambda}_{th} - \hat{\lambda}_{t,h-1} - \left(\hat{\lambda}_{t-1,h-1} - \hat{\lambda}_{t-1,h-2} \right)$$

$$= \frac{1}{N}\sum_{i=1}^{N}\left(-F_{ith} + F_{i,t,h-1} + F_{i,t-1,h-1} - F_{i,t-1,h-2} - \frac{1}{T}\sum_{t=1}^{T}\left(-F_{ith} + F_{i,t,h-1} + F_{i,t-1,h-1} - F_{i,t-1,h-2} \right)\right)$$

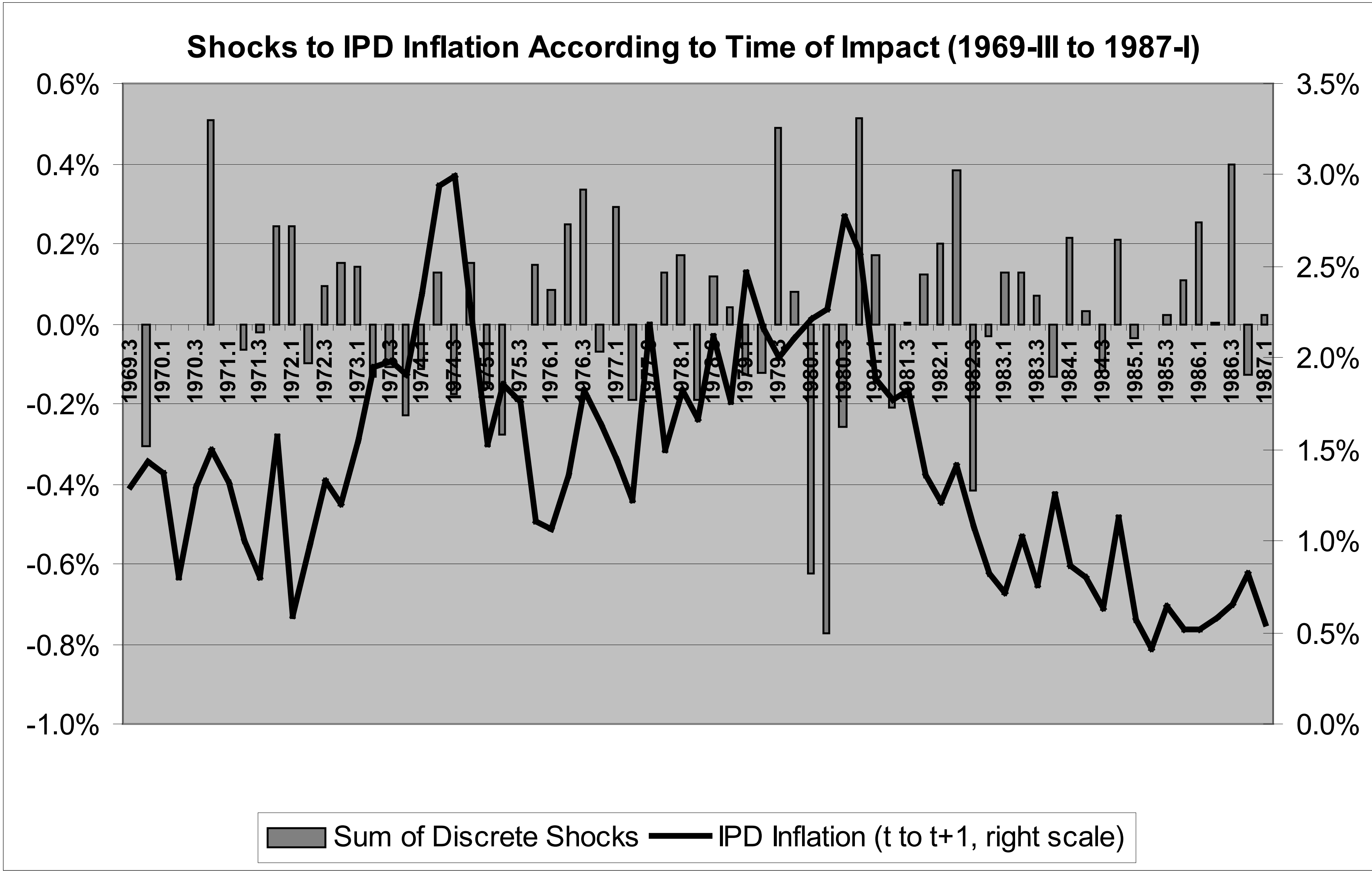
Implied Shock Measures

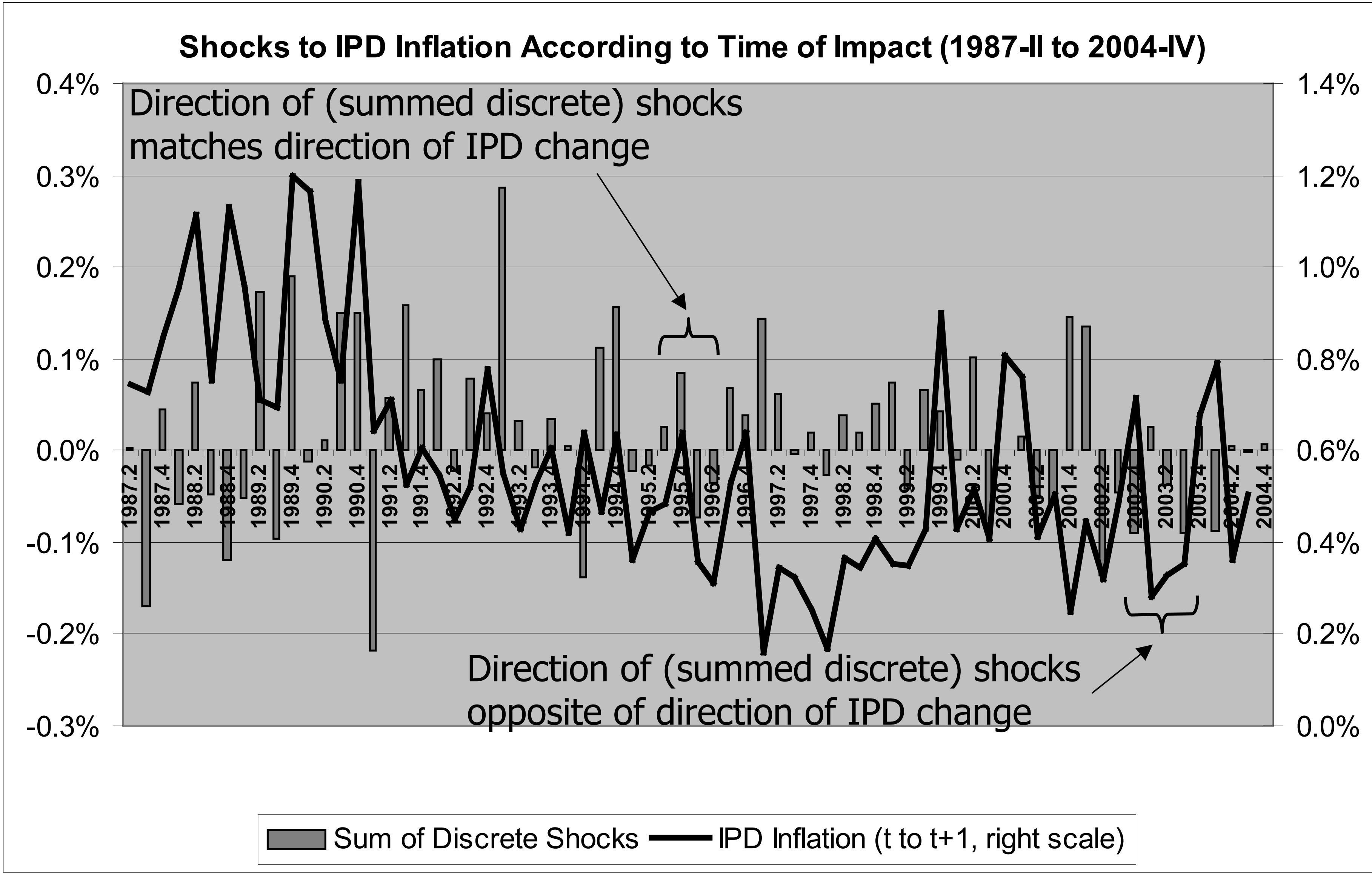



Shocks to IPD Inflation According to Time of Impact (1969-III to 1987-I)
0.8%
0.6%
0.4%
0.2%
0.0%
-0.2%
-0.4%
-0.6%
-0.8%
-1.0%
1969.3
1970.1
1971.1
1972.1
1972.3
1973.1
1976.3
1977.1
1978.3
1979.3
1983.1
1984.1
1985.1
1986.1
1986.3
Shock Occurred 2Q in Past
Shock Occurred 3Q in Past
Shock Occurred 4Q in Past
Sum of Discrete Shocks



Shocks to IPD Inflation According to Time of Impact (1987-II to 2004-IV)
0.4%
0.3%
0.2%
0.1%
0.0%
-0.1%
-0.2%
-0.3%
-0.4%
-0.5%
1987.2
1987.4
1988.2
1989.2
1989.4
1990.4
1991.4
1992.2
1992.4
1993.4
1994.4
1995.2
1995.4
1996.4
1997.2
1997.4
1998.2
1998.4
1999.4
2000.2
2000.4
2001.4
2003.2
2004.2
2004.4
Reinforcing (discrete) shocks
Canceling (discrete) shocks
Shock Occurred 2Q in Past
Shock Occurred 3Q in Past
Shock Occurred 4Q in Past
Sum of Discrete Shocks


Shocks to IPD Inflation According to Time of Impact (1969-III to 1987-I)
0.6%
0.4%
0.2%
0.0%
-0.2%
-0.4%
-0.6%
-0.8%
-1.0%
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
1969.3
1970.1
1970.3
1971.1
1971.3
1972.1
1972.3
1973.1
1974.3
1975.3
1976.1
1976.3
1977.1
1978.1
1981.3
1982.1
1983.1
1983.3
1984.1
1985.1
1985.3
1986.1
1986.3
1987.1
Sum of Discrete Shocks
IPD Inflation (t to t+1, right scale)

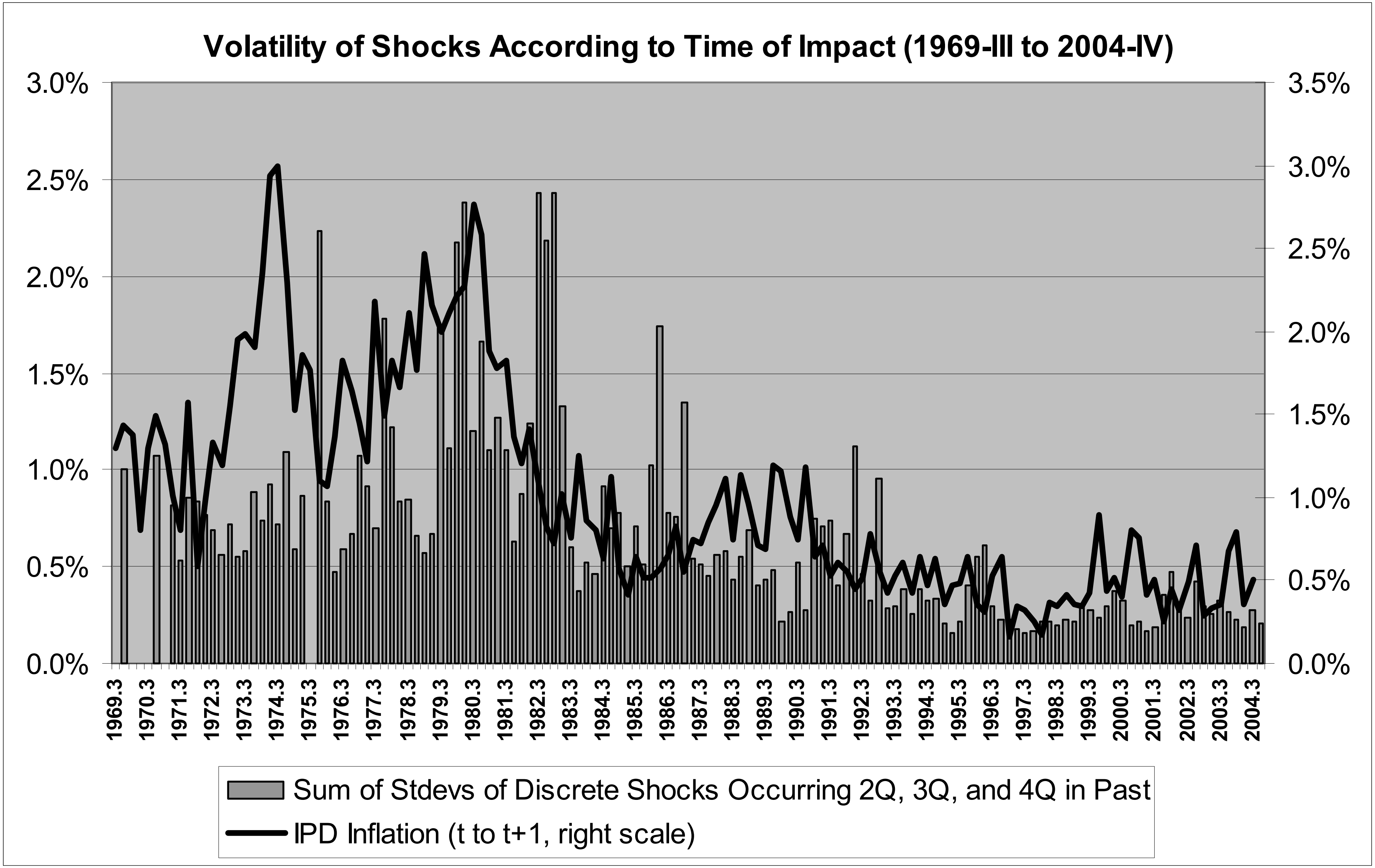

Shocks to IPD Inflation According to Time of Impact (1987-II to 2004-IV)
Direction of (summed discrete) shocks matches direction of IPD change
Direction of (summed discrete) shocks opposite of direction of IPD change
0.4%
0.3%
0.2%
0.1%
0.0%
-0.1%
-0.2%
-0.3%
1.4%
1.2%
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
Sum of Discrete Shocks
IPD Inflation (t to t+1, right scale)

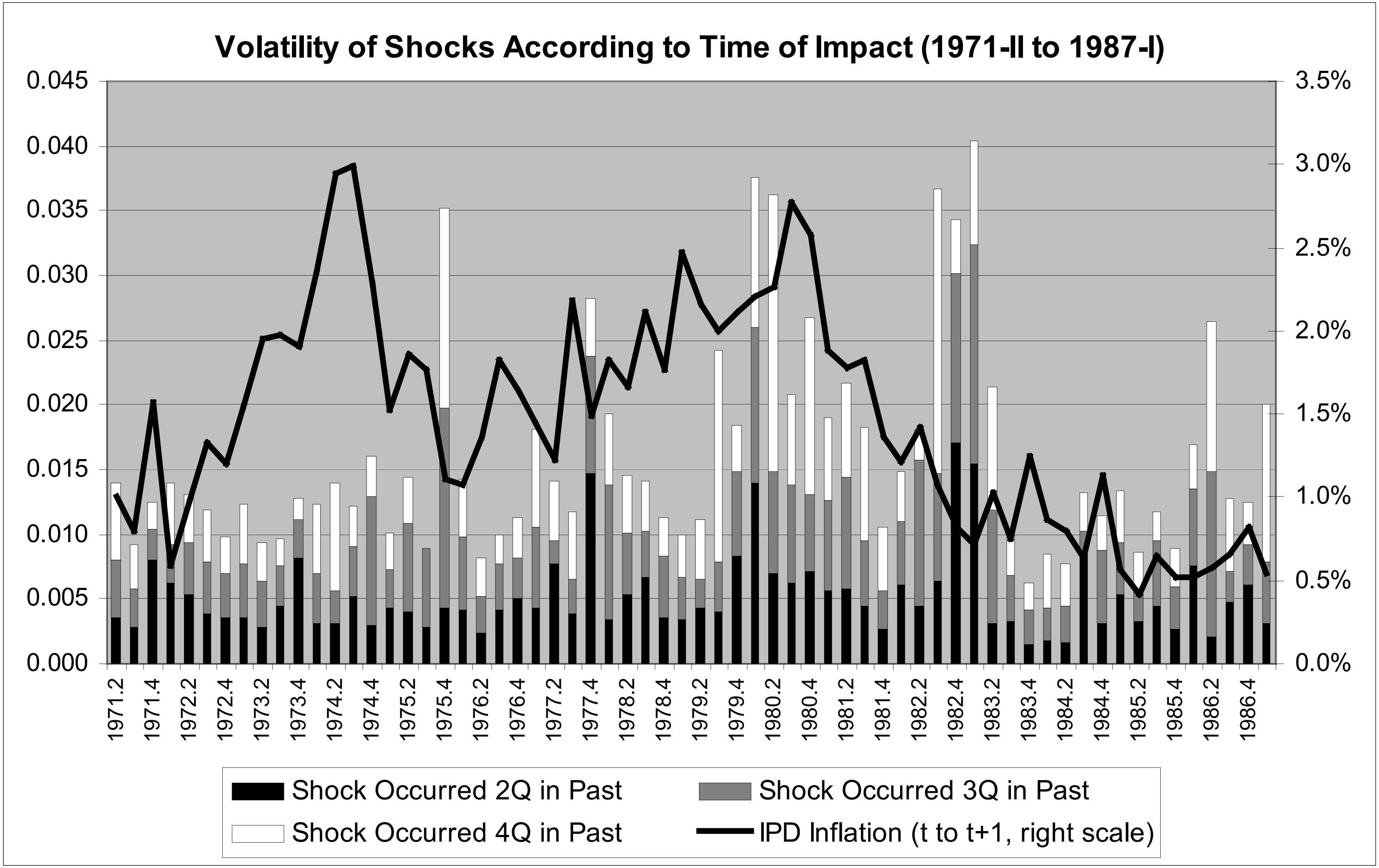
Volatility

The three categories of shock measure imply three corresponding categories of volatility measure.

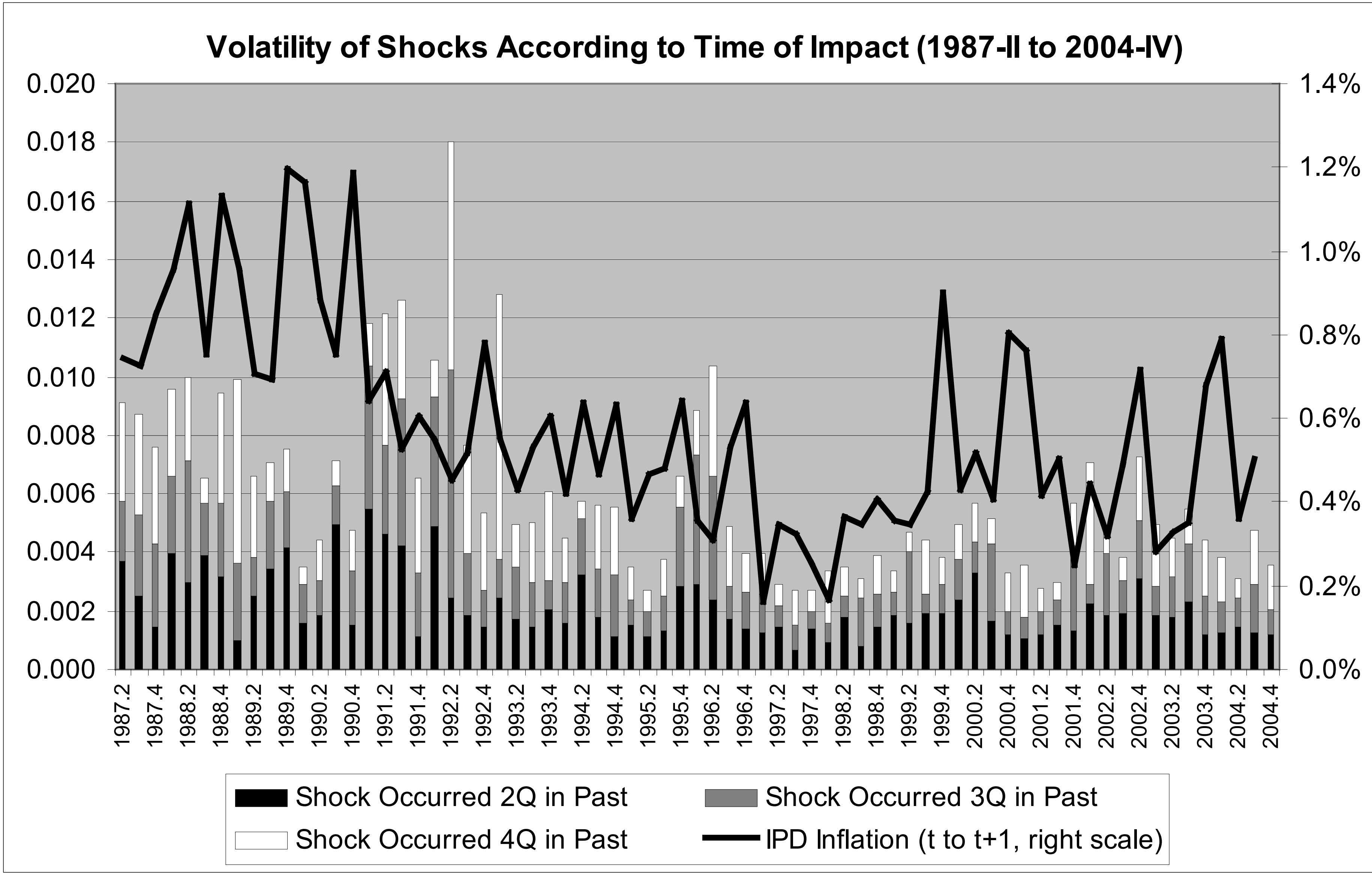
Discrete shock volatility:

$$\hat{\sigma}^2_{v_{th}} = \frac{1}{N}\sum_{i=1}^{N}\left(-F_{ith} + F_{i,t,h-1} + F_{i,t-1,h-1} - F_{i,t-1,h-2} + \hat{\phi}_{ih} - 2\hat{\phi}_{i,h-1} + \hat{\phi}_{i,h-2} - \hat{v}_{th}\right)^2$$


Volatility of Shocks According to Time of Impact (1969-III to 2004-IV)
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
1969.3
1970.3
1971.3
1972.3
1973.3
1974.3
1975.3
1976.3
1977.3
1978.3
1979.3
1980.3
1981.3
1982.3
1983.3
1984.3
1985.3
1986.3
1987.3
1988.3
1989.3
1990.3
1991.3
1992.3
1993.3
1994.3
1995.3
1996.3
1997.3
1998.3
1999.3
2000.3
2001.3
2002.3
2003.3
2004.3
Sum of Stdevs of Discrete Shocks Occurring 2Q, 3Q, and 4Q in Past
IPD Inflation (t to t+1, right scale)



Volatility of Shocks According to Time of Impact (1971-II to 1987-I)
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
1971.2
1971.4
1972.2
1972.4
1973.2
1973.4
1974.2
1974.4
1975.2
1975.4
1976.2
1976.4
1977.2
1977.4
1978.2
1978.4
1979.2
1979.4
1980.2
1980.4
1981.2
1981.4
1982.2
1982.4
1983.2
1983.4
1984.2
1984.4
1985.2
1985.4
1986.2
1986.4
Shock Occurred 2Q in Past
Shock Occurred 3Q in Past
Shock Occurred 4Q in Past
IPD Inflation (t to t+1, right scale)



Volatility of Shocks According to Time of Impact (1987-II to 2004-IV)
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
1.4%
1.2%
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
1987.2 1987.4 1988.2 1988.4 1989.2 1989.4 1990.2 1990.4 1991.2 1991.4 1992.2 1992.4 1993.2 1993.4 1994.2 1994.4 1995.2 1995.4 1996.2 1996.4 1997.2 1997.4 1998.2 1998.4 1999.2 1999.4 2000.2 2000.4 2001.2 2001.4 2002.2 2002.4 2003.2 2003.4 2004.2 2004.4
Shock Occurred 2Q in Past
Shock Occurred 3Q in Past
Shock Occurred 4Q in Past
IPD Inflation (t to t+1, right scale)

Davies-Lahiri Framework

$$\boldsymbol{\Sigma} = \begin{bmatrix} \mathbf{A}_1 & \mathbf{B} & \mathbf{B} & \ldots & \mathbf{B} & \mathbf{B} \\ \mathbf{B} & \mathbf{A}_2 & \mathbf{B} & \ldots & \mathbf{B} & \mathbf{B} \\ \vdots & & & & & \\ \mathbf{B} & \mathbf{B} & \mathbf{B} & \ldots & \mathbf{B} & \mathbf{A}_N \end{bmatrix}_{NTH \text{ x } NTH} \qquad \text{where } \mathbf{A}_i = \sigma^2_{\varepsilon_i}\mathbf{I} + \mathbf{B}$$

$$\mathbf{B} = \begin{bmatrix}
\mathbf{b}_{1,1} & \mathbf{c}_{1,2} & \mathbf{d}_{1,3} & \mathbf{e}_{1,4} & \mathbf{f}_{1,5} & \mathbf{g}_{1,6} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \ldots & \mathbf{0} \\
\mathbf{c}'_{2,1} & \mathbf{b}_{2,2} & \mathbf{c}_{2,3} & \mathbf{d}_{2,4} & \mathbf{e}_{2,5} & \mathbf{f}_{2,6} & \mathbf{g}_{2,7} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \ldots & \mathbf{0} \\
\mathbf{d}'_{3,1} & \mathbf{c}'_{3,2} & \mathbf{b}_{3,3} & \mathbf{c}_{3,4} & \mathbf{d}_{3,5} & \mathbf{e}_{3,6} & \mathbf{f}_{3,7} & \mathbf{g}_{3,8} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \ldots & \mathbf{0} \\
\mathbf{e}'_{4,1} & \mathbf{d}'_{4,2} & \mathbf{c}'_{4,3} & \mathbf{b}_{4,4} & \mathbf{c}_{4,5} & \mathbf{d}_{4,6} & \mathbf{e}_{4,7} & \mathbf{f}_{4,8} & \mathbf{g}_{5,9} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \ldots & \mathbf{0} \\
\mathbf{f}'_{5,1} & \mathbf{e}'_{5,2} & \mathbf{d}'_{5,3} & \mathbf{c}'_{5,4} & \mathbf{b}_{5,5} & \mathbf{c}_{5,6} & \mathbf{d}_{5,7} & \mathbf{e}_{5,8} & \mathbf{f}_{6,9} & \mathbf{g}_{6,10} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \ldots & \mathbf{0} \\
\mathbf{g}'_{6,1} & \mathbf{f}'_{6,2} & \mathbf{e}'_{6,3} & \mathbf{d}'_{6,4} & \mathbf{c}'_{6,5} & \mathbf{b}_{6,6} & \mathbf{c}_{6,7} & \mathbf{d}_{6,8} & \mathbf{e}_{7,9} & \mathbf{f}_{7,10} & \mathbf{g}_{7,11} & \mathbf{0} & \mathbf{0} & \ldots & \mathbf{0} \\
\mathbf{0} & \mathbf{g}'_{7,2} & \mathbf{f}'_{7,3} & \mathbf{e}'_{7,4} & \mathbf{d}'_{7,5} & \mathbf{c}'_{7,6} & \mathbf{b}_{7,7} & \mathbf{c}_{7,8} & \mathbf{d}_{8,9} & \mathbf{e}_{8,10} & \mathbf{f}_{8,11} & \mathbf{g}_{8,12} & \mathbf{0} & \ldots & \mathbf{0} \\
\vdots & & & & & & & & & & & & & & \\
\mathbf{0} & \ldots & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{g}'_{T,T-5} & \mathbf{f}'_{T,T-4} & \mathbf{e}'_{T,T-3} & \mathbf{d}'_{T,T-2} & \mathbf{c}'_{T,T-1} & \mathbf{b}_{T,T}
\end{bmatrix}_{TH \text{ x } TH}$$

Davies-Lahiri Framework

$$\mathbf{b}_{t_1,t_2} = \begin{bmatrix} \sum_{h=-1}^{4} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{3} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{2} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{1} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{0} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{-1} \sigma^2_{u_{s,h}} \\ \sum_{h=-1}^{3} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{3} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{2} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{1} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{0} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{-1} \sigma^2_{u_{s,h}} \\ \sum_{h=-1}^{2} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{2} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{2} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{1} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{0} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{-1} \sigma^2_{u_{s,h}} \\ \sum_{h=-1}^{1} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{1} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{1} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{1} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{0} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{-1} \sigma^2_{u_{s,h}} \\ \sum_{h=-1}^{0} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{0} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{0} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{0} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{0} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{-1} \sigma^2_{u_{s,h}} \\ \sum_{h=-1}^{-1} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{-1} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{-1} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{-1} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{-1} \sigma^2_{u_{s,h}} & \sum_{h=-1}^{-1} \sigma^2_{u_{s,h}} \end{bmatrix}, \; s = \min(t_1, t_2) - 1$$

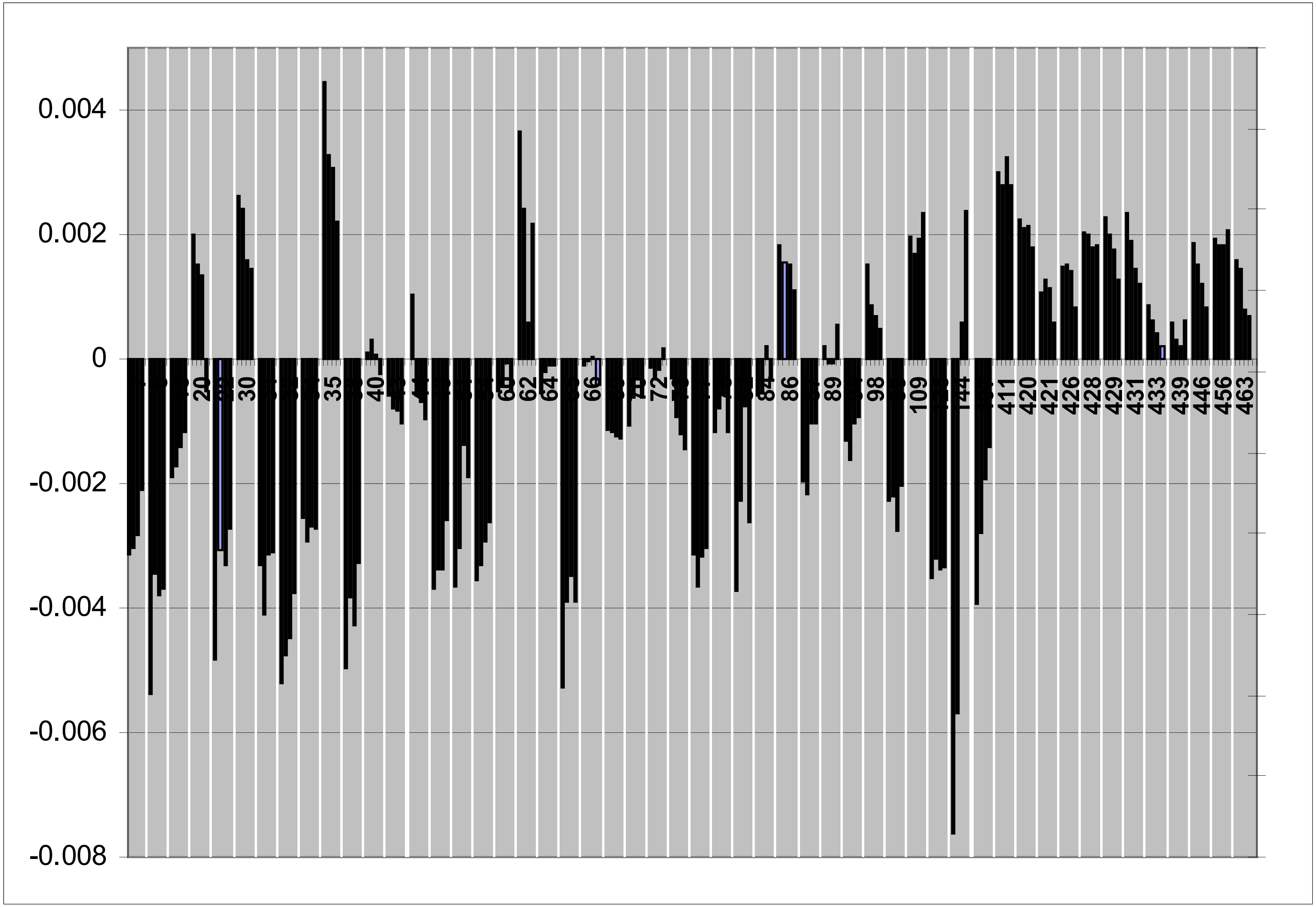
Davies-Lahiri Framework

Feasible GMM

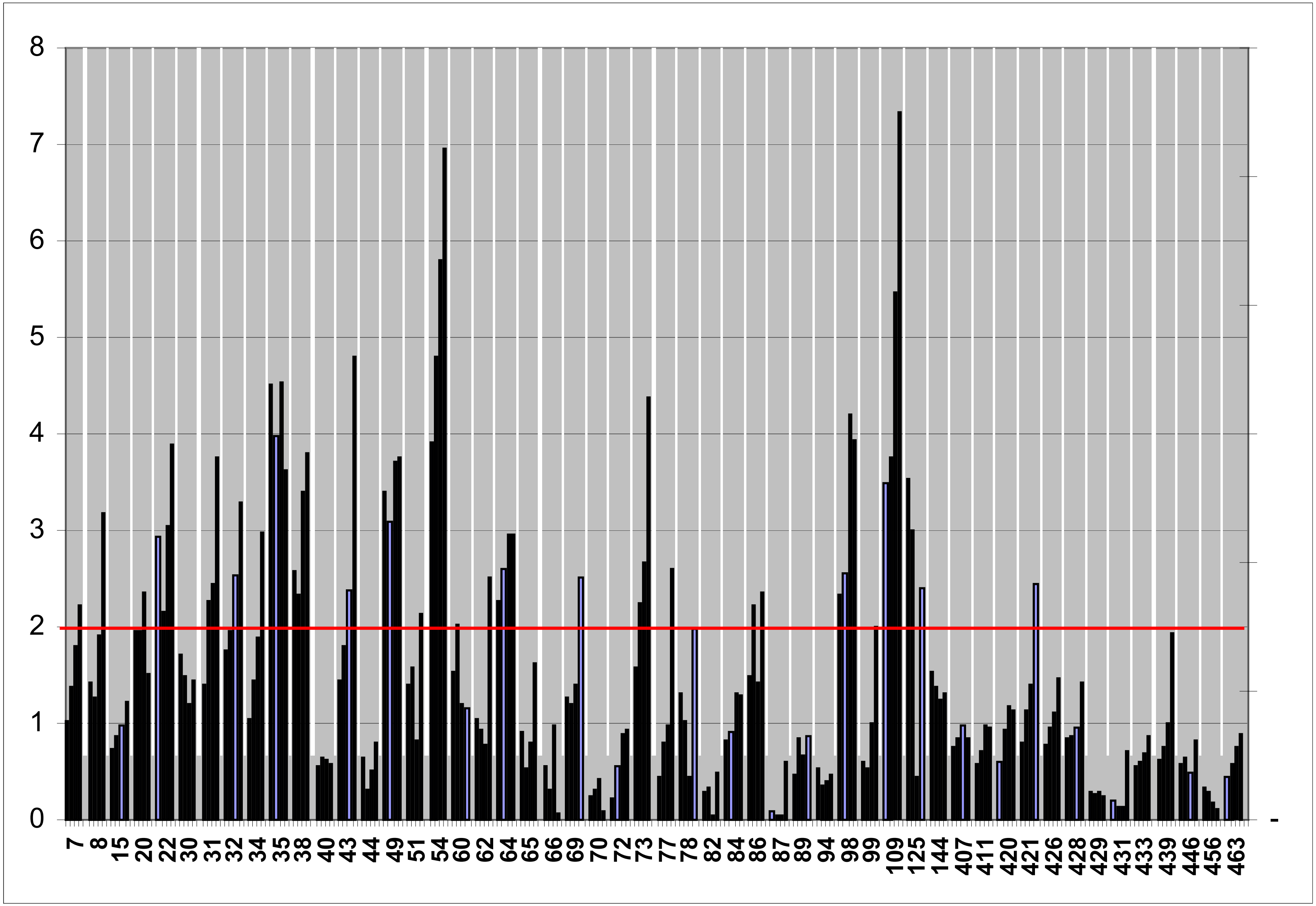
58 million elements in the error covariance matrix based on 146 parameter estimates.

208 regressors corresponding to 4 bias terms for each of 52 forecasters.

Forecaster Biases (four horizons per forecaster)



Significance of Forecaster Biases (four horizons per forecaster)



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