

# **Structural Breaks in Inflation and Causality in International Transmission of Price Shocks**

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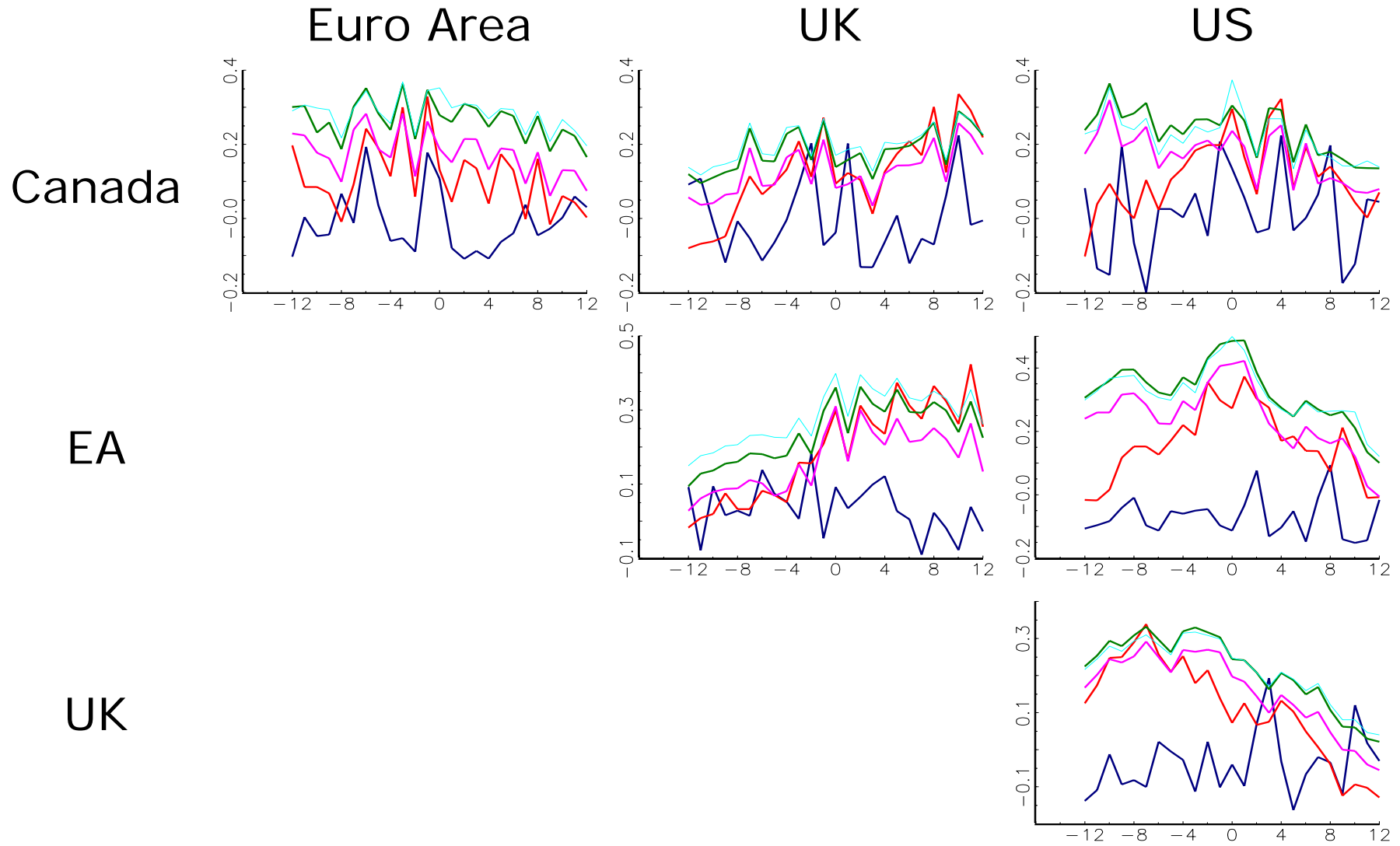
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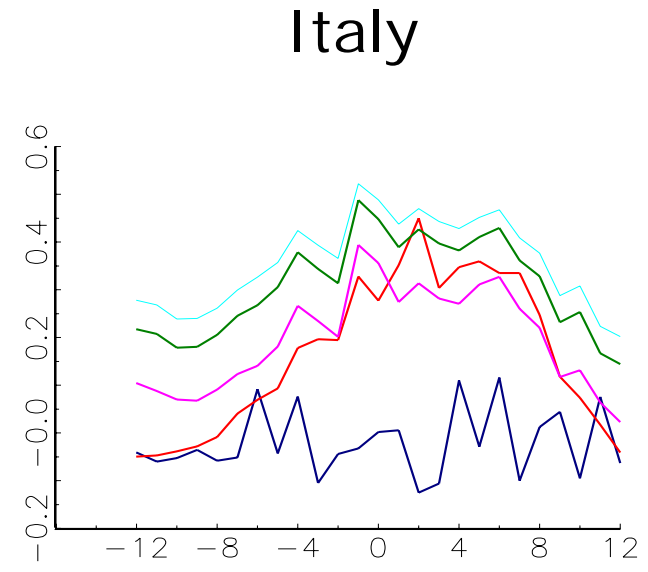
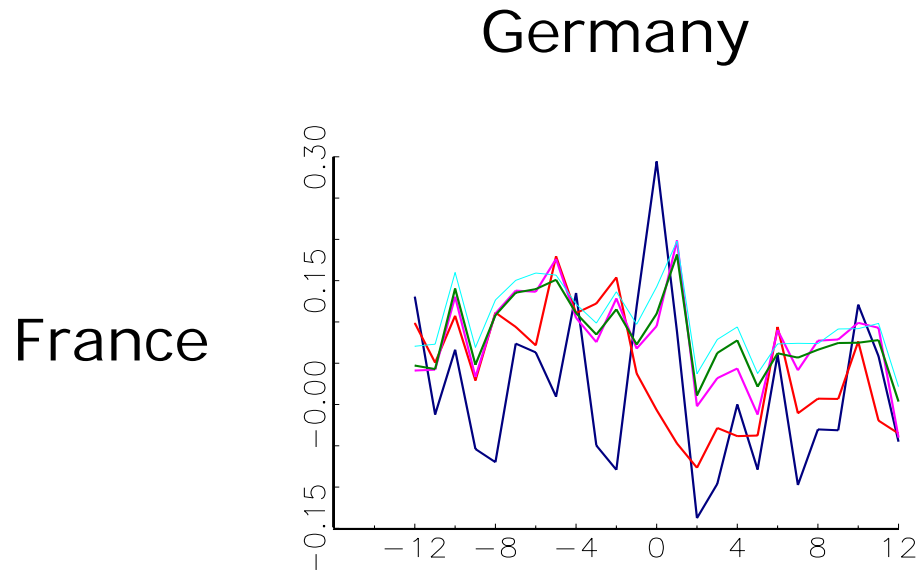
## Background

- Recent research finds strong international inflation interactions:
  - VAR models
    - Crowder (1996)
    - Eun and Jeong (1999)
    - Yang, Guo and Wang (2006)
  - Factor models
    - Ciccarelli and Mojon (2005)
    - Mumtaz and Surico (2006)
  
- Two broad conclusions:
  - Inflation patterns are global
  - Interactions not confined to fixed exchange rate period

# International Inflation Cross-Correlations by Decade



# Euro Area Inflation Cross-Correlations by Decade

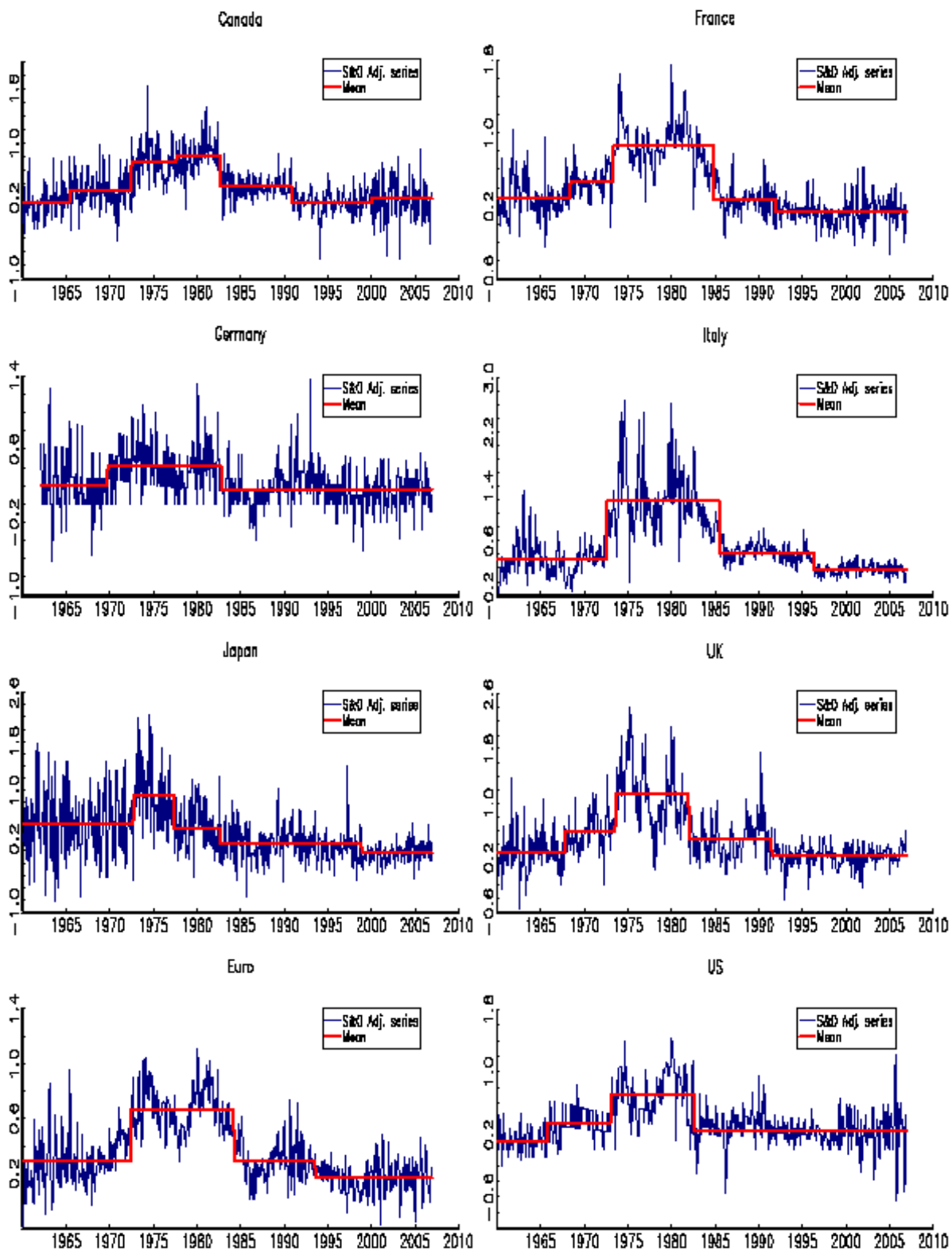


- Previous analyses typically ignore time-variation in inflation interactions and/or volatilities post-1973
  
- Present paper examines:
  - Breaks in interactions
  - (Granger) causality in interactions
  - Breaks in volatility of inflation shocks
  - (Granger) causality in inflation uncertainty

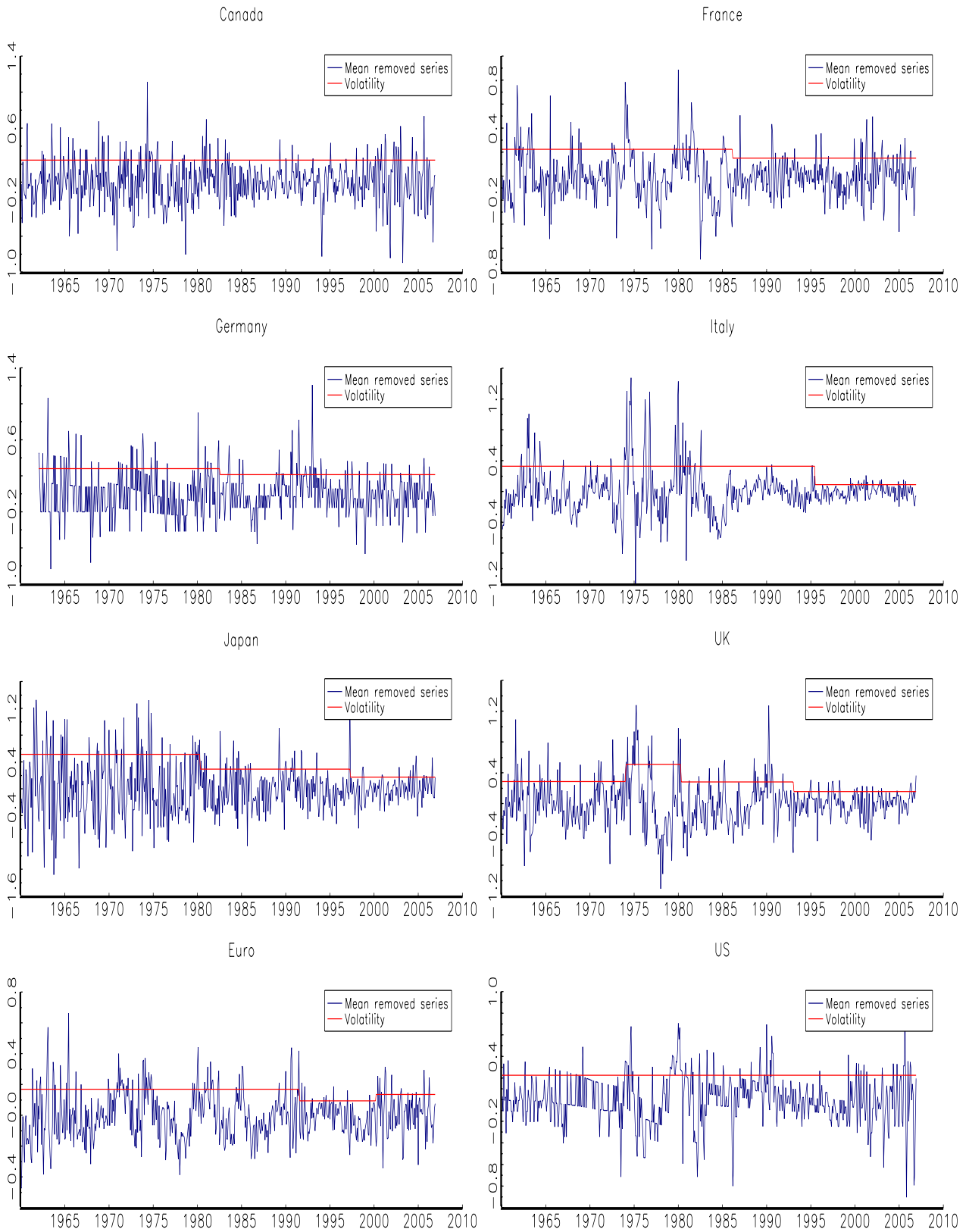
## Data & Initial Analysis

- CPI inflation for G-7 countries
  - Monthly, 1960:01-2006:12
  - Seasonally & outlier adjusted
  
- Test for max of 8 univariate mean breaks
  - Methodology of Qu & Perron (2007)
  - Autocorrelation & heteroskedastic consistent
  
- Subsequent analysis applied to demeaned series
  
- Also examine univariate volatility breaks
  - Allowing possible GARCH effects

# Inflation data and mean breaks



# Unconditional volatility breaks



Mean breaks (in line with previous studies):

- All countries have at least 2 mean changes
- All except Germany have 1972-73 break
- All have mean break 1981-85
- Break early/mid-1990s also common (except Germany/US)

Volatility breaks (less previous literature):

- Relatively few
  - None for Canada & US; 1 for France, Germany Italy
  - 2 for Japan & Euro Area; 3 for UK
- Mainly in 1980s (4) & 1990s (4)

## **Main Questions:**

- 1. Do breaks account for apparent correlations shifts?**
- 2. Or do international causal patterns also change over time?**
- 3. Is inflation uncertainty transmitted across countries?**

Use VAR system analysis to examine these

## System coefficients

Analyze two VAR systems:

- Canada, Euro Area, UK & US (International VAR)
- France, Germany, Italy (Euro Area VAR)

After (univariate) demeaning

- Apply Qu & Perron system break test (hetero consistent) to VAR coefficients
- Maximum 5 breaks
- VAR(1), as selected by SIC, no intercept

## Structural breaks in VAR coefficients

| International VAR | Euro Area VAR  |
|-------------------|----------------|
| <b>1973.05</b>    | <b>1972.04</b> |
| 1971.10           | 1971.10        |
| 1978.03           | 1979.01        |
| <b>1991.07</b>    | <b>1985.06</b> |
| 1990.06           | 1985.02        |
| 1993.02           | 1987.04        |
| <b>1999.03</b>    |                |
| 1989.03           |                |
| 2006.06           |                |

Estimated break dates & 90% confidence intervals

- No break around 1999 found in univariate persistence

- Apply causality tests (hetero consistent) to sub-samples defined by break dates

### Euro Area VAR

|   | 60.02-72.03 |      |                      | 72.04-85.05          |                      |                      | 85.06-06.12 |               |                      |
|---|-------------|------|----------------------|----------------------|----------------------|----------------------|-------------|---------------|----------------------|
|   | Fr          | Ger  | Italy                | Fr                   | Ger                  | Italy                | Fr          | Ger           | Italy                |
| <b>Joint test</b><br>( <i>p</i> -value) | 0.55        | 0.80 | 0.99                 | 0.17                 | <b>0.01</b>          | 0.11                 | 0.53        | <b>0.03</b>   | 0.67                 |
| <b>Fr</b>                               |             |      |                      | <b>0.57</b><br>(.00) | <b>0.32</b><br>(.00) | 0.25<br>(.09)        |             | 0.18<br>(.07) |                      |
| <b>Ger</b>                              |             |      |                      |                      |                      |                      |             |               |                      |
| <b>It</b>                               |             |      | <b>0.49</b><br>(.00) | <b>0.09</b><br>(.05) |                      | <b>0.52</b><br>(.00) |             |               | <b>0.23</b><br>(.00) |

- Only significant joint causality tests for international VAR indicate causality from Euro Area:

UK 1960-1973, Canada 1973-1991, US 1991-1999

- Also test whether individual coefficients change over sub-periods

### Nature of breaks in Euro Area VAR coefficients

|     | 60/72-72/85 |     |       | 60/72-85/06 |     |          | 72/85-85/06 |     |          |
|-----|-------------|-----|-------|-------------|-----|----------|-------------|-----|----------|
|     | Fr          | Ger | Italy | Fr          | Ger | Italy    | Fr          | Ger | Italy    |
| Fr  | <b>U</b>    | U   |       |             |     |          | <b>D</b>    |     |          |
| Ger |             | U   |       |             |     |          | U           |     |          |
| It  |             |     |       |             |     | <b>D</b> | D           |     | <b>D</b> |

Direction of coefficient changes significant at 10% (5%)

- Breaks may relate only to own-persistence

## Nature of breaks in international VAR coefficients

|           | Can         | EA | UK | US | Can         | EA | UK | US | Can         | EA | UK | US |
|-----------|-------------|----|----|----|-------------|----|----|----|-------------|----|----|----|
|           | 60/73-73/91 |    |    |    | 60/73-91/99 |    |    |    | 60/73-99/06 |    |    |    |
| Canada    |             |    |    |    | U           |    |    |    | U           | U  | U  |    |
| Euro Area | U           | U  | D  |    |             | D  | D  | U  |             |    | D  |    |
| UK        | U           |    | U  |    |             | D  |    |    |             | D  |    |    |
| US        | D           |    |    | U  |             | U  |    |    | D           |    |    |    |
|           | 73/91-91/99 |    |    |    | 73/91-99/06 |    |    |    | 91/99-99/06 |    |    |    |
| Canada    | U           |    |    |    | U           | U  | U  | U  |             |    |    | U  |
| Euro Area |             | D  |    |    |             | D  |    |    |             |    |    |    |
| UK        |             |    | D  |    | D           | D  | D  |    |             | D  |    |    |
| US        |             |    |    | D  | D           | D  |    | D  | D           |    |    |    |

- Changes in interactions in 1973 & 1999
- Own-persistence only changes in 1991

## System conditional volatility

Construct VAR residuals:

- Allow breaks in univariate means & VAR coefficients
- Impose causality based on sub-sample results
  - Individual coefficients not significant at 5% set to zero & VAR re-estimated
  - No restrictions across sub-samples
- Test for volatility breaks in each residual series, allowing possible ARCH effects (Sanso *et al.*, 2004)

## Conditional volatility breaks

|   | <u>International VAR</u> |         |      |        | <u>Euro Area VAR</u> |         |  |
|---|--------------------------|---------|------|--------|----------------------|---------|--|
| Canada                                    | Euro                     | UK      | US   | France | Germany              | Italy   |  |
| <b>Break dates in residual volatility</b> |                          |         |      |        |                      |         |  |
|   | 1965.07                  |         |      |        |                      | 1964.05 |  |
|   |                          | 1972.03 |      |        |                      | 1973.08 |  |
|   |                          | 1980.08 |      |        |                      | 1981.01 |  |
|   |                          |         |      |        |                      | 1986.02 |  |
|   |                          | 1993.01 |      |        |                      | 1995.07 |  |
| <b>Standard deviation of shocks</b>       |                          |         |      |        |                      |         |  |
| 0.24                                      | 0.21                     | 0.26    | 0.20 | 0.17   | 0.24                 | 0.37    |  |
|   | 0.13                     |         |      |        |                      | 0.17    |  |
|   |                          | 0.39    |      |        |                      | 0.47    |  |
|   |                          | 0.25    |      |        |                      | 0.24    |  |
|   |                          |         |      |        |                      | 0.12    |  |
|   |                          | 0.15    |      |        |                      | 0.09    |  |

- Is inflation uncertainty transmitted internationally?
  - Test for volatility causality
- Standardize residuals using sub-sample volatility estimates
  - Form break-adjusted residual series for whole sample
- Tests based on assumption of GARCH process
- Apply as causality tests in VAR for squared residuals
- We do not find any joint tests significant
  - May be a power issue

## Volatility causality tests in international VAR

|                  | Lags  | Canada      | Euro Area   | UK          | US          |
|------------------|-------|-------------|-------------|-------------|-------------|
| <b>Canada</b>    | 1-3   | 0.84        | 0.14        | 0.21        | 0.46        |
|                  | 4-6   | 0.59        | 0.28        | 0.78        | 0.94        |
|                  | 7-9   | 0.82        | 0.99        | 0.41        | 0.80        |
|                  | 10-12 | <b>0.00</b> | 0.60        | <b>0.00</b> | 0.46        |
| <b>Euro Area</b> | 1-3   | 0.07        | 0.08        | <b>0.02</b> | 0.68        |
|                  | 4-6   | <b>0.01</b> | 0.41        | 0.45        | 0.20        |
|                  | 7-9   | 0.21        | <b>0.02</b> | 0.94        | 0.51        |
|                  | 10-12 | 0.80        | 0.25        | 0.34        | 0.99        |
| <b>UK</b>        | 1-3   | 0.59        | 0.27        | 0.61        | 0.73        |
|                  | 4-6   | 0.46        | <b>0.00</b> | 0.90        | 0.96        |
|                  | 7-9   | 0.95        | 0.97        | 0.56        | 0.37        |
|                  | 10-12 | 0.89        | 0.54        | <b>0.00</b> | 0.70        |
| <b>US</b>        | 1-3   | <b>0.05</b> | 0.29        | 0.07        | <b>0.00</b> |
|                  | 4-6   | 0.73        | <b>0.01</b> | 0.75        | <b>0.04</b> |
|                  | 7-9   | 0.85        | <b>0.00</b> | 0.24        | 0.06        |
|                  | 10-12 | <b>0.00</b> | 0.49        | 0.37        | <b>0.01</b> |

## Volatility causality tests in Euro Area VAR

|                | Lags  | France      | Germany     | Italy       |
|----------------|-------|-------------|-------------|-------------|
| <b>France</b>  | 1-3   | <b>0.03</b> | 0.35        | 0.22        |
|                | 4-6   | 0.61        | 0.96        | <b>0.03</b> |
|                | 7-9   | 0.93        | 0.27        | 0.71        |
|                | 10-12 | <b>0.00</b> | <b>0.05</b> | 0.36        |
| <b>Germany</b> | 1-3   | 0.22        | 0.31        | 0.92        |
|                | 4-6   | 0.10        | 0.31        | 0.52        |
|                | 7-9   | 0.54        | 0.98        | 0.20        |
|                | 10-12 | 0.97        | 0.76        | 0.84        |
| <b>Italy</b>   | 1-3   | <b>0.03</b> | <b>0.01</b> | 0.11        |
|                | 4-6   | 0.76        | 0.36        | 0.19        |
|                | 7-9   | 0.58        | 0.60        | 0.44        |
|                | 10-12 | 0.31        | 0.96        | 0.11        |

## Conclusions

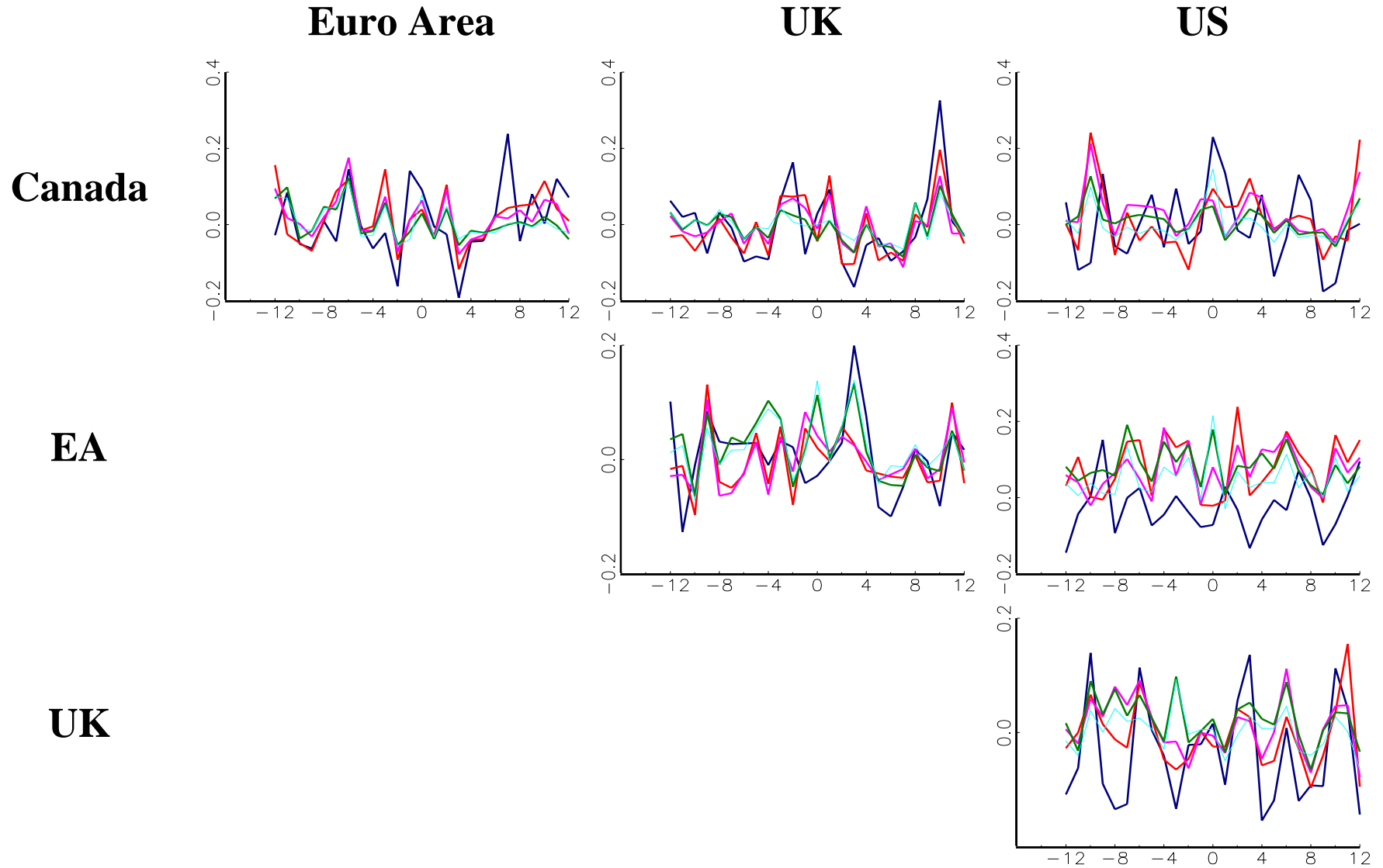
We find:

- Evidence of breaks in international transmission of inflation, especially in 1973 & 1999
- Changes in the volatility of inflation shocks for only UK, Euro Area & Italy
- Evidence of transmission of inflation uncertainty to all countries except US

Do the changes account for temporal shifts in cross-correlations?

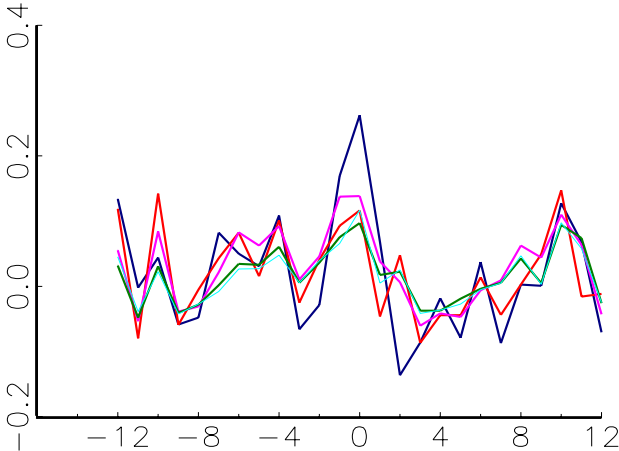
- Qualified “yes”

# International Inflation Shock Correlations by Decade

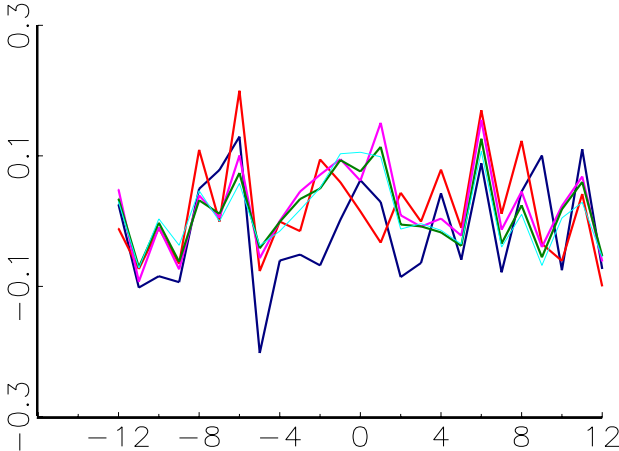


**Euro Area Inflation Shock Correlations by Decade**

**Germany**



**Italy**



**France**

**Germany**

