# International Spillovers: Real and Financial Channels

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# Plan of Talk

- An overview of key elements of the research agenda
- Empirical motivation
- Description of methodology and approach to identification
- Some illustrative (very) preliminary results based on small data set

# The Big Issues

- Old methodological challenges and new angles
- Common shocks vs. spillovers of country-specific shocks
- Strong interactions between the real economy and financial sector
- Financial shocks can have real effects
- Broader measures of real and financial fluctuations using multiple indicators
- Advanced economies and emerging markets both matter

# Common Shocks and Spillovers

- Challenge is to separate common shocks from propagation of country-specific shocks through different channels

- Direct versus indirect spillovers

  US → Brazil

  US → World → Brazil

  US → China → Brazil

- Spillovers between financial and real sectors of economy

- Not important for characterizing comovement; important for understanding sources of shocks, policy responses

# Financial-Real Spillovers

- Strong interactions between the real economy and financial sector
- Theory and empirical evidence
- High correlations between real and financial variables within and across countries
- Costs associated with asset and credit booms/busts
- Adverse effects of financial crises on macro aggregates

# Theory and Evidence

- Role of financial factors (credit and asset prices) in driving real outcomes in theory

  Bernanke and Gertler (1989); Kiyotaki and Moore (1997)

- Procyclical nature of real and financial variables

  Burns and Mitchell (1946); Backus and Kehoe (1992)

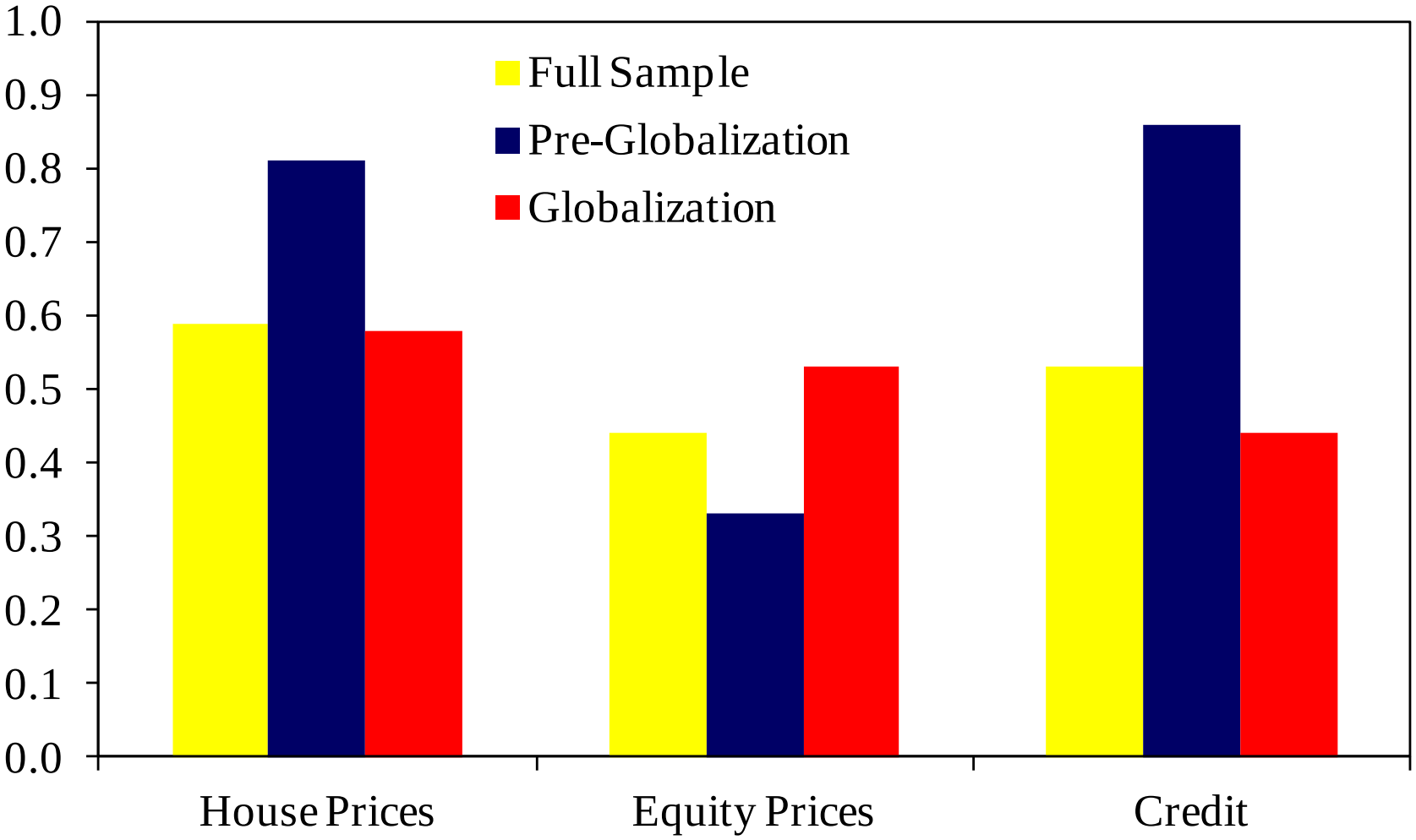
- Implications of financial crises for the real economy

  Kindleberger (1978); Reinhart and Rogoff (2009)

- Recent empirical work

  Kose, Prasad, and Otrok (2012); Hirata, Kose, Otrok, and Terrones (2012); Claessens, Kose, and Terrones (2012)

# Correlations with Output




Source: Hirata, Kose, Otrok and Terrones (2012)

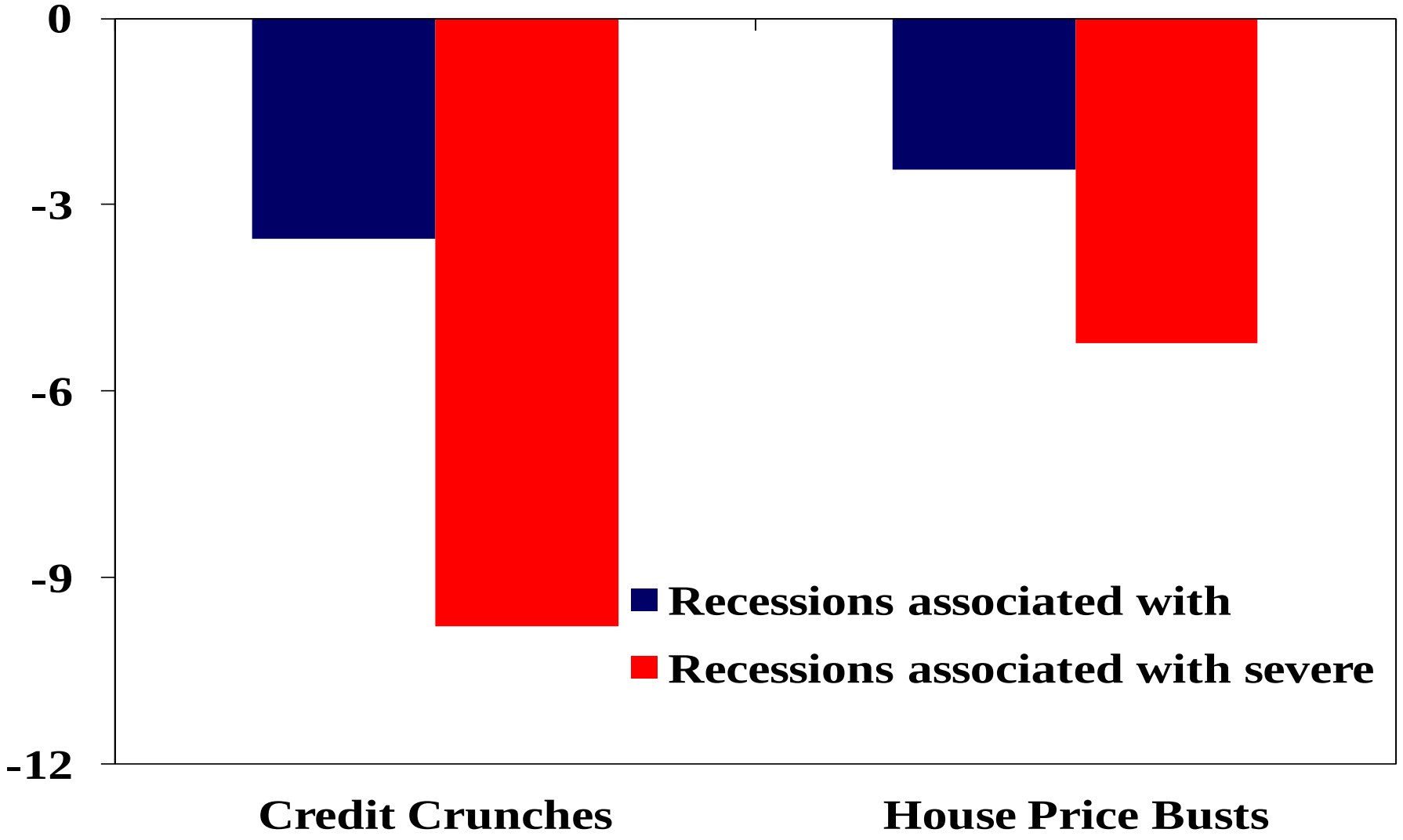
# Cross-Country Correlations

| | Full Sample | Pre-Globalization | Globalization |
|---|---|---|---|
| Output | 0.43 | 0.32*** | 0.52 |
| House Prices | 0.18 | 0.14*** | 0.23 |
| Equity Prices | 0.56 | 0.43** | 0.64 |
| Credit | 0.26 | 0.24*** | 0.30 |

Source: Hirata, Kose, Otrok and Terrones (2012)

# Recessions w/ Crunches and Busts Deeper

*(percent, cumulative loss)*




Source: Claessens, Kose, and Terrones (2012)

# Issues in Empirical Analysis of Spillovers

- Need to analyze multiple countries simultaneously to allow for possibility of second-round spillovers

  US → Brazil

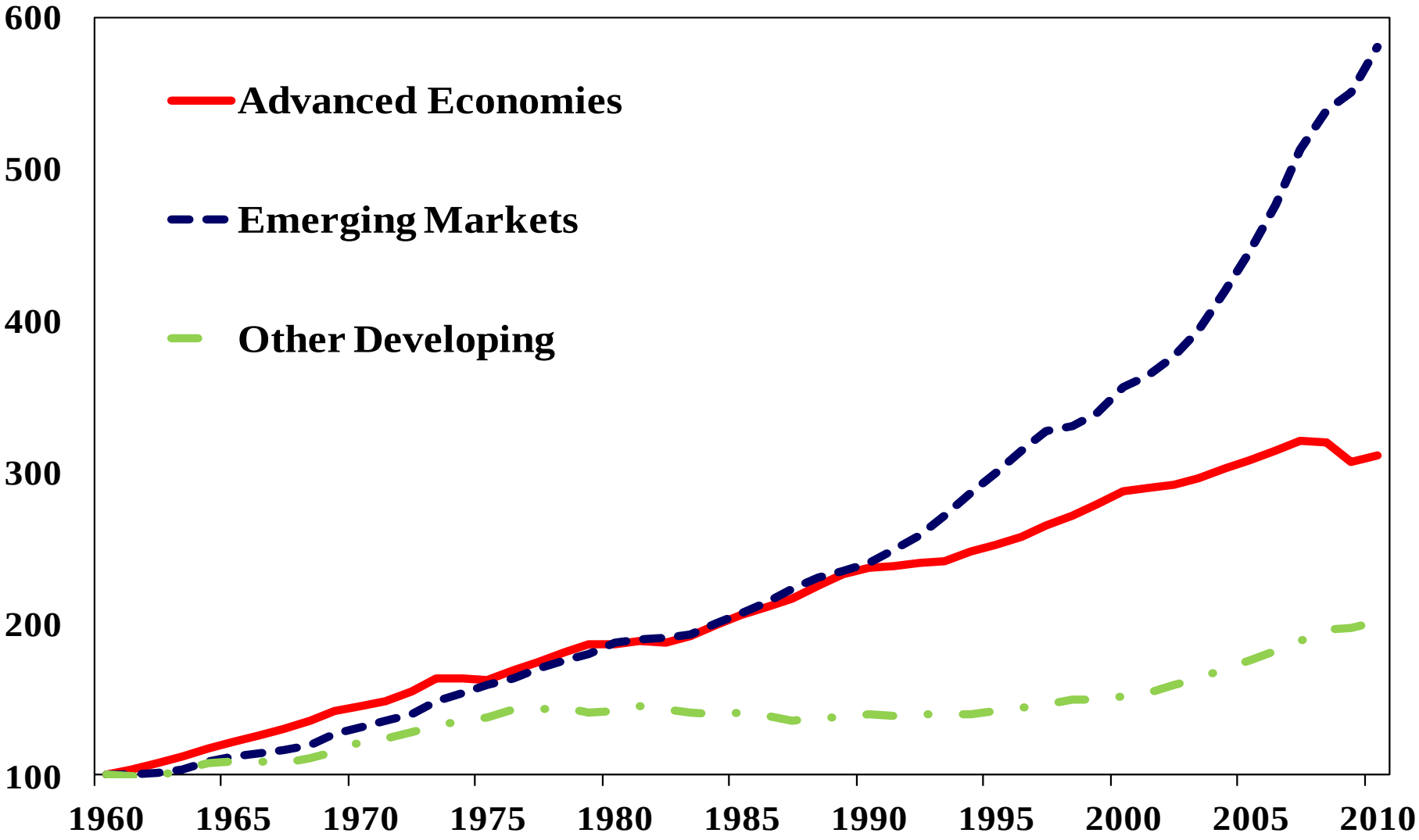
  US → China → Brazil

- Emerging markets play an increasingly important role in world economy, so jointly analyze advanced economies and emerging markets

- Financial market spillovers between advanced and emerging market economies seem greater than real spillovers—to be tested

# Evolution of GDP of Different Groups

*(1960-2010, per capita, PPP weighted, index, 1960=100)*




Source: Kose and Prasad (2010)

# Measuring Real and Financial Cycles

- Output by itself inadequate measure of business cycle
- NBER uses multiple indicators but difficult to operationalize at high frequency for large group of countries; likewise for Stock-Watson approach
- Real variables
  - Output
  - Consumption
  - Investment
- Financial variables
  - Equity prices
  - House prices
  - Interest rates
  - Credit

# Measuring Spillovers

- Typical approach to measuring cross-country spillovers:
  - VAR or GVAR approach: For example, trace impact of US output growth shock on other countries
  - Multiple indicator approaches

- Limitations:
  - Multiple sources for output growth fluctuations in U.S.
  - Not clear if global or country-specific factors driving business cycles
  - Not easy to include multiple countries to allow for second round spillovers
  - Multiple indicator models—can't distinguish between common shocks and spillovers

# A Dynamic Factor Model Approach

- Unobservable Index Model
  - Index of Common Economic Activity
  - A few 'factors' drive many time series
  - Sargent and Sims (1977): *"Business Cycle Modeling Without Pretending to Have Too Much A Priori Economic Theory"*

- Dynamic factor model can be seen as a reduced-form solution of a standard open economy DSGE model (data generated from the DSGE model has an approximate representation as a dynamic factor model; Crucini, Kose, and Otrok, 2011)

# Dynamic Multi-factor Models

The multi-factor model decomposes macroeconomic fluctuations in the growth rates of output, consumption, and investment into the following factors:

(i) **A global factor**: picks up fluctuations that are common across all variables and countries

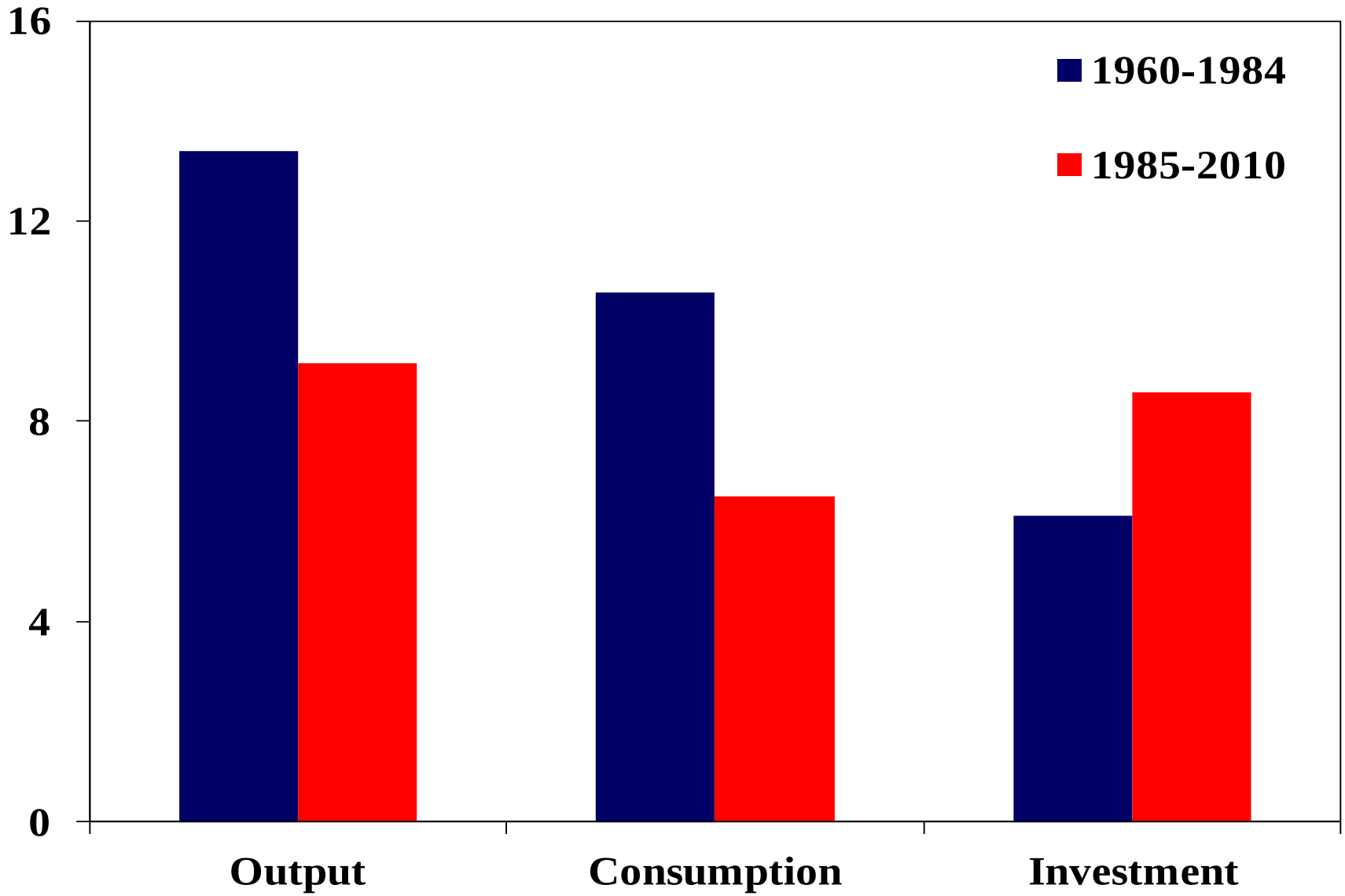
(ii) **Region-specific factors:** capture fluctuations that are common to all variables and all countries in a given region

(iii) **Country factors**: common across aggregates in given country

(iv) **Idiosyncratic factors** specific to each variable.

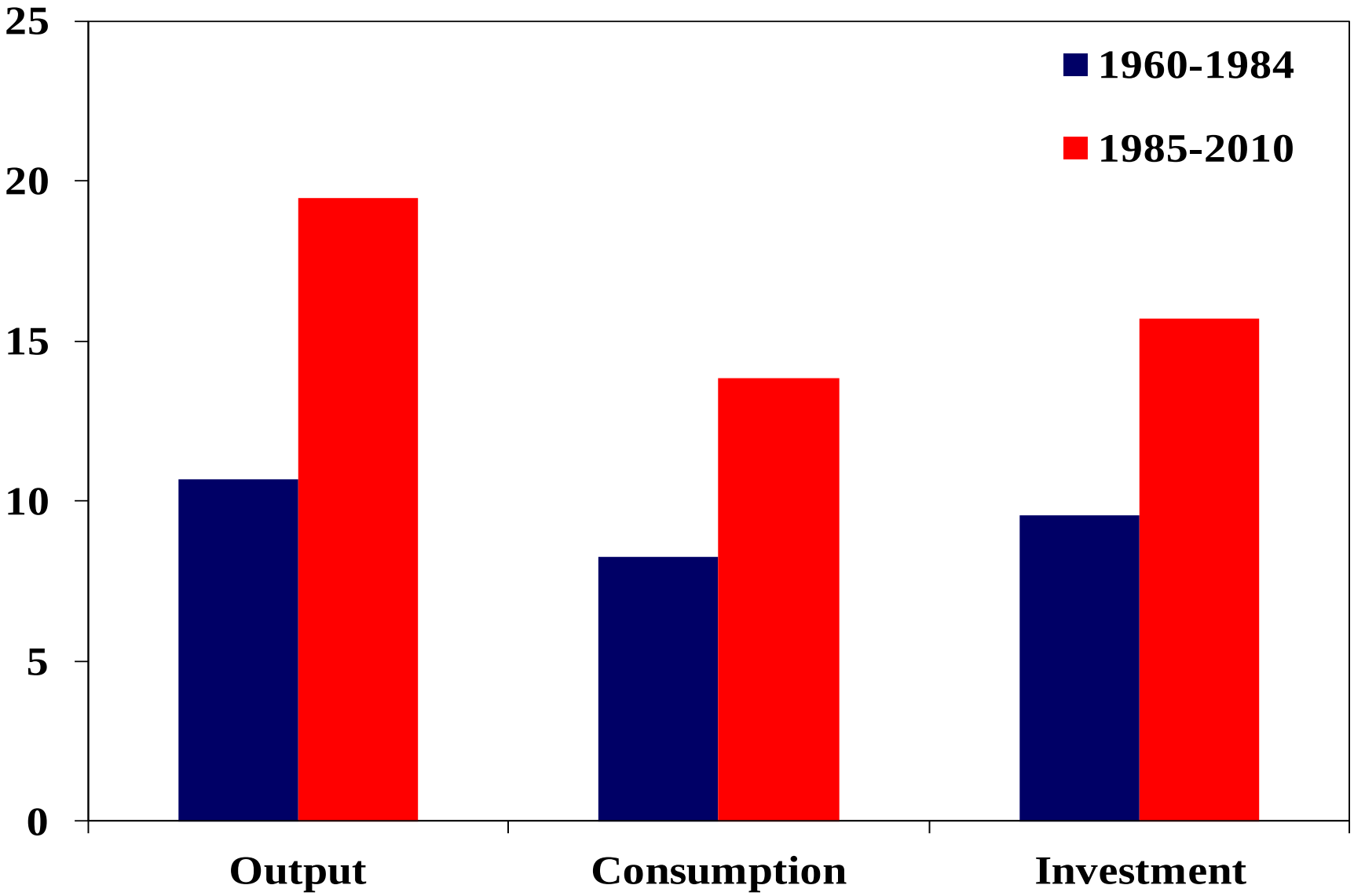
# Variance Contribution of Global Factor -- World

*(fraction of variance explained, mean, in percent)*



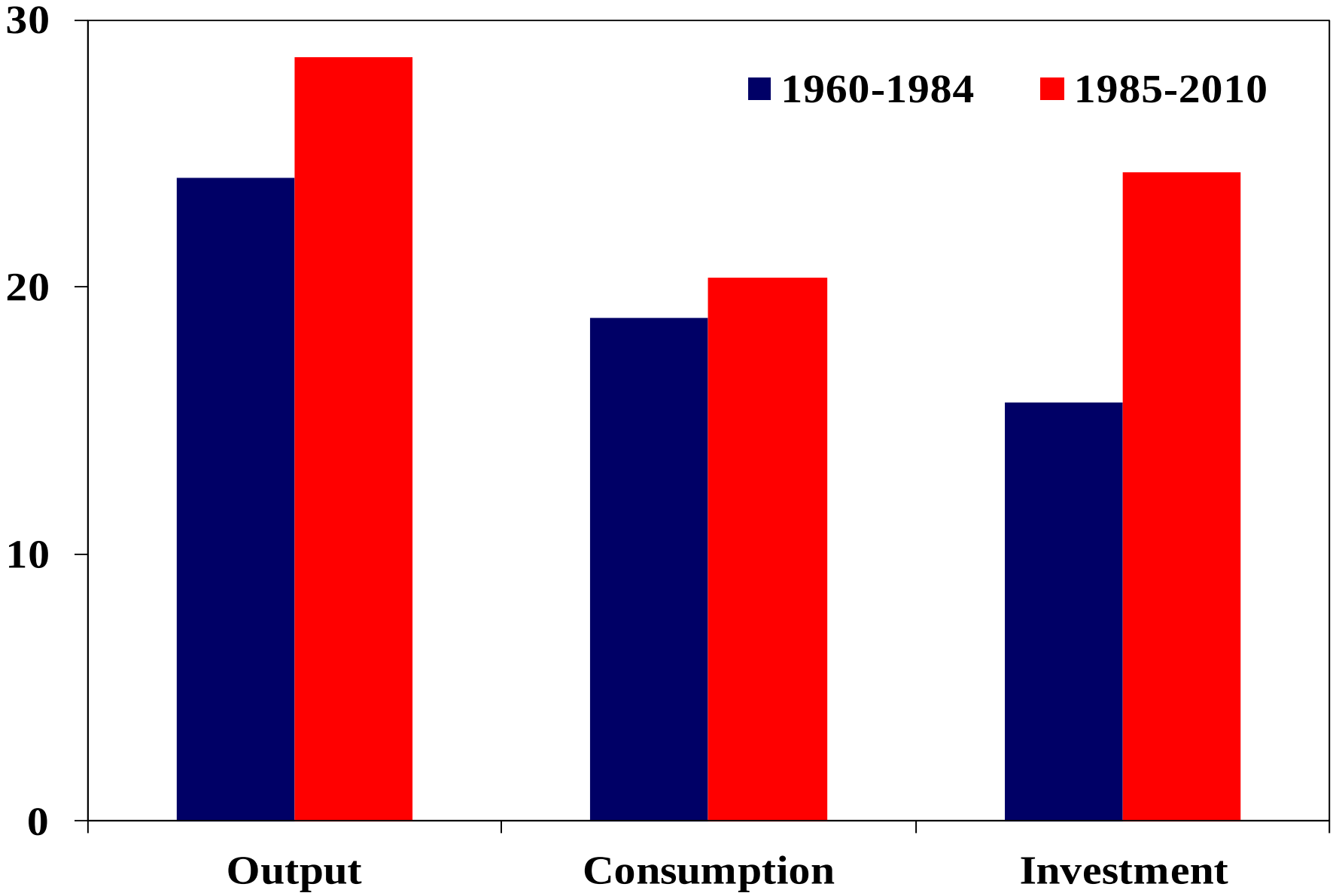
# Variance Contribution of Regional Factors -- World

*(fraction of variance explained, mean, in percent)*



# Variance Contribs. of (Global + Regional) Factors -- World

*(fraction of variance explained, mean, in percent)*



# Our Approach

- Measure spillovers in a framework that separates out these component at the same time that it is measuring the spillover
- We study how country-specific movements are transmitted to the world

## Benefits

- Allows us to distinguish between common global shocks and spillovers
- Can handle large data set (multiple countries, multiple real and financial indicators)
- Multiple indicators give us better handle on real and financial cycles

# Factor Model

$$Y_t = \beta F_t + \Gamma_t,$$

$$\Gamma_t = \Psi(L)\Gamma_{t-1} + U_t \quad \text{with} \quad E(U_t U_t') = \Omega,$$

$$F_t = \Phi(L)F_{t-1} + V_t \quad \text{with} \quad E(V_t V_t') = I_k.$$

- Observable data responds to common factors
- Factors evolve as a restricted VAR
- Restrictions on factor evolution allow us to capture and measure spillovers
- $\Phi(L)$ is typically block diagonal. Relaxing this restriction allows for spillovers

# Factor Loadings

$$\begin{bmatrix}
b^{G7}_{US,Y} & 0 & 0 & b^{US}_{US,Y} & 0 & 0 & 0 & \cdots & 0 \\
b^{G7}_{US,C} & 0 & 0 & b^{US}_{US,C} & 0 & 0 & 0 & \cdots & 0 \\
b^{G7}_{US,I} & 0 & 0 & b^{US}_{US,I} & 0 & 0 & 0 & \cdots & 0 \\
b^{G7}_{Fr,Y} & 0 & 0 & 0 & 0 & 0 & b^{Fr}_{Fr,Y} & \cdots & 0 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
b^{G7}_{UK,Y} & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & b^{UK}_{UK,Y} \\
b^{G7}_{UK,C} & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & b^{UK}_{UK,C} \\
b^{G7}_{UK,I} & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & b^{UK}_{UK,I}
\end{bmatrix}$$

- We impose zero restrictions on the factor loadings to identify the world and country factors

# Model 1: Country Factor Spills Over to World

$$\begin{bmatrix}
\phi_1^{w,w} & \phi_2^{w,w} & \phi_3^{w,w} & \phi_1^{W,US} & \phi_2^{W,US} & \phi_3^{W,US} & \cdots & \cdots & \cdots & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & \cdots & \cdots & \cdots & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & \cdots & \cdots & \cdots & 0 \\
0 & 0 & 0 & \phi_1^{US,US} & \phi_2^{US,US} & \phi_3^{US,US} & 0 & \cdots & \cdots & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & \cdots & \cdots & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & \cdots & \cdots & 0 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \cdots & \cdots & \cdots & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & \cdots & \phi_1^{UK,UK} & \phi_2^{UK,UK} & \phi_3^{UK,UK} \\
0 & 0 & 0 & 0 & 0 & 0 & \cdots & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 1 & 0
\end{bmatrix}$$

- US as an example
- Country-specific shocks affect global common cycle
- Interpretation: country shocks have global implications

# Model 2: Country Factor Spills Over to Other Country Factors

$$\begin{bmatrix}
\phi_1^{w,w} & \phi_2^{w,w} & \phi_3^{w,w} & 0 & 0 & 0 & \cdots & \cdots & \cdots & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & \cdots & \cdots & \cdots & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & \cdots & \cdots & \cdots & 0 \\
0 & 0 & 0 & \phi_1^{US,US} & \phi_2^{US,US} & \phi_3^{US,US} & 0 & \cdots & \cdots & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & \cdots & \cdots & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & \cdots & \cdots & 0 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \cdots & \cdots & \cdots & 0 \\
0 & 0 & 0 & \phi_1^{UK,US} & \phi_2^{UK,US} & \phi_3^{UK,US} & \cdots & \phi_1^{UK,UK} & \phi_2^{UK,UK} & \phi_3^{UK,UK} \\
0 & 0 & 0 & 0 & 0 & 0 & \cdots & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 1 & 0
\end{bmatrix}$$

- This version allows for asymmetries in spillovers
- Spillovers may occur only across countries with closer ties

# Model 3: Both Types of Spillovers

$$
\begin{bmatrix}
\phi_1^{w,w} & \phi_2^{w,w} & \phi_3^{w,w} & \phi_1^{w,us} & \phi_2^{w,us} & \phi_3^{w,us} & \cdots & \cdots & \cdots & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & \cdots & \cdots & \cdots & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & \cdots & \cdots & \cdots & 0 \\
0 & 0 & 0 & \phi_1^{US,US} & \phi_2^{US,US} & \phi_3^{US,US} & 0 & \cdots & \cdots & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & \cdots & \cdots & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & \cdots & \cdots & 0 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \cdots & \cdots & \cdots & 0 \\
0 & 0 & 0 & \phi_1^{UK,US} & \phi_2^{UK,US} & \phi_3^{UK,US} & \cdots & \phi_1^{UK,UK} & \phi_2^{UK,UK} & \phi_3^{UK,UK} \\
0 & 0 & 0 & 0 & 0 & 0 & \cdots & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 1 & 0
\end{bmatrix}
$$

- Full decomposition of spillovers

# Estimation

- Estimation is Bayesian with a Gibbs sampler
  - Factors drawn with state-space setup (Kim and Nelson, 1998)
  - Parameters drawn using conditional distributions (Otrok and Whiteman, 1998)
  - We use 2 and 3 lags in the autoregressive structure
  - Priors are fairly diffuse, except for imposing stationarity
- Estimates of ‘World’ and ‘Country’ Factors are the same as in a model with no spillovers
  - We decompose factors in a new way. For example, we determine how much of the world factor is due to innovations that are global vs. the part can be attributed to a certain country. The ‘sum’ is the still the same.
  - The large literature on factor analysis suggests this result robust, as estimates of factors tend to be robust to minor misspecifications and even parameter instability

# Variance Decompositions

Variance decompositions constructed using the parameters of the model

- We construct variance decompositions at different horizons using standard VAR formulas (though coefficients are restricted to 0 in many cases)
- As horizon gets large, we have unconditional variance decompositions

# Variance Decompositions

Start with 1–step ahead forecast of factors, idiosyncratic component:

$E_t\left(G_{t+1}\right) = \Upsilon(L)G_t$ with associated forecast error $E_t(U_{t+1}U_{t+1}') = W$

$E_t\left(F_{t+1}\right) = \Phi(L)F_t$ with associated forecast error $E_t(V_{t+1}V_{t+1}') = I$

The forecast of the observable variable is then: $E_t(G_{t+1}) = \Upsilon(L)G_t$

$E_t Y_{t+1} = E_t \beta F_{t+1} + E_t G_{t+1}$ with one step ahead forecast error $Var_t(Y_{t+1}) = W + \beta I \beta'$

Forecast error decomposed into:

Component due to the innovations to the global factor and the country factor ($\beta$ is 2x1)

Innovations to the idiosyncratic component

# Variance Decompositions

To get contribution of global factor to the one-step ahead forecast error of the first observable variable, divide the forecast error contribution of world factor by forecast error for the observable time series:

$$\frac{b_{1,w} I_1 b_{1,w}'}{W_{1,1} + b_1 I_2 b_1'}$$

$\beta_{1,w}$ : factor loading on global factor for first variable
$\beta_1$ : 2-dimensional vector with factor loadings on global factor and relevant country factor for first variable

Similar fraction calculated for contrib. of country factor
Idiosyncratic component is the remainder

# How is Our Approach Different?

- Can be viewed as a general equilibrium type estimation
- A “partial equilibrium” approach would:
  - Take US output as given, see how shocks to it are transmitted to the world
  - See how shocks to a financial variable (or world aggregate) affects a given economy
- We allow for mutual feedback from real to financial sectors, and from country to world
- We parse out the individual components with a factor structure to isolate country and world cycles in real and financial variables. We then study how innovations from these factors spillover onto other variables.
- Our world factor is not a simple aggregate of underlying data, but an estimate of what is common across variables,
- US factor is not a measure of the US data rather it captures movements in US data after ‘removing’ global component

# Real and Financial Spillovers

- Exercise 1: Measuring spillovers in the real economy
  - Use data on output, consumption, investment for G7 countries
  - Estimate country ‘business cycle’ factors as well as the global business cycle
  - Question 1: Are global business cycles due to common shocks, or spillovers from a dominant country?
  - Question 2: What is the nature by which spillovers occur? Globally or only between certain countries?

- Exercise 2: Measuring spillovers in financial sector
  - Use data on equity prices, interest rates, house prices, and credit
  - Estimate country ‘financial cycle’ factors as well as the global financial cycle
  - Question 1: Is there a common financial cycle?
  - Question 2: Do we see similarities between real spillovers and financial spillovers?

# Real and Financial Spillovers

- Exercise 3: Measuring spillovers between the financial sector and real economy
  - Model has two global factors—1 real, 1 financial
    - (Our preliminary work suggests that there is not one common factor for real and financial variables)
  - 2 Country factors-one real, one financial
  - Spillovers now extended to allow financial cycles to respond to lagged real variables and vice versa
  - Spillovers from country to world can be through both real and financial cycles
  - Still in progress as we refine estimates to Exercise 2

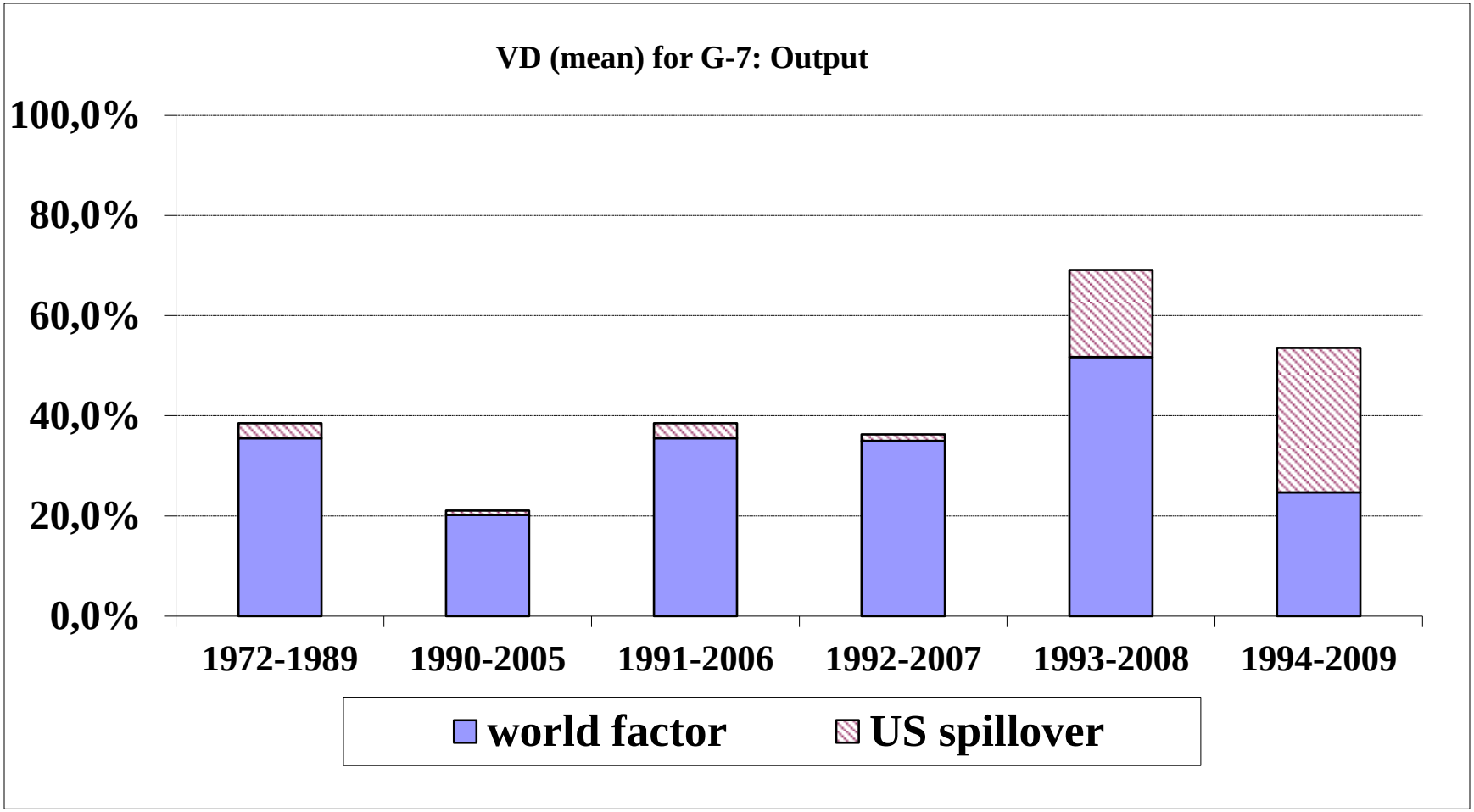
# Data for First Illustrative Exercise

- G-7 countries
- Quarterly data: 1972-2009
- Real variables only—output, consumption investment

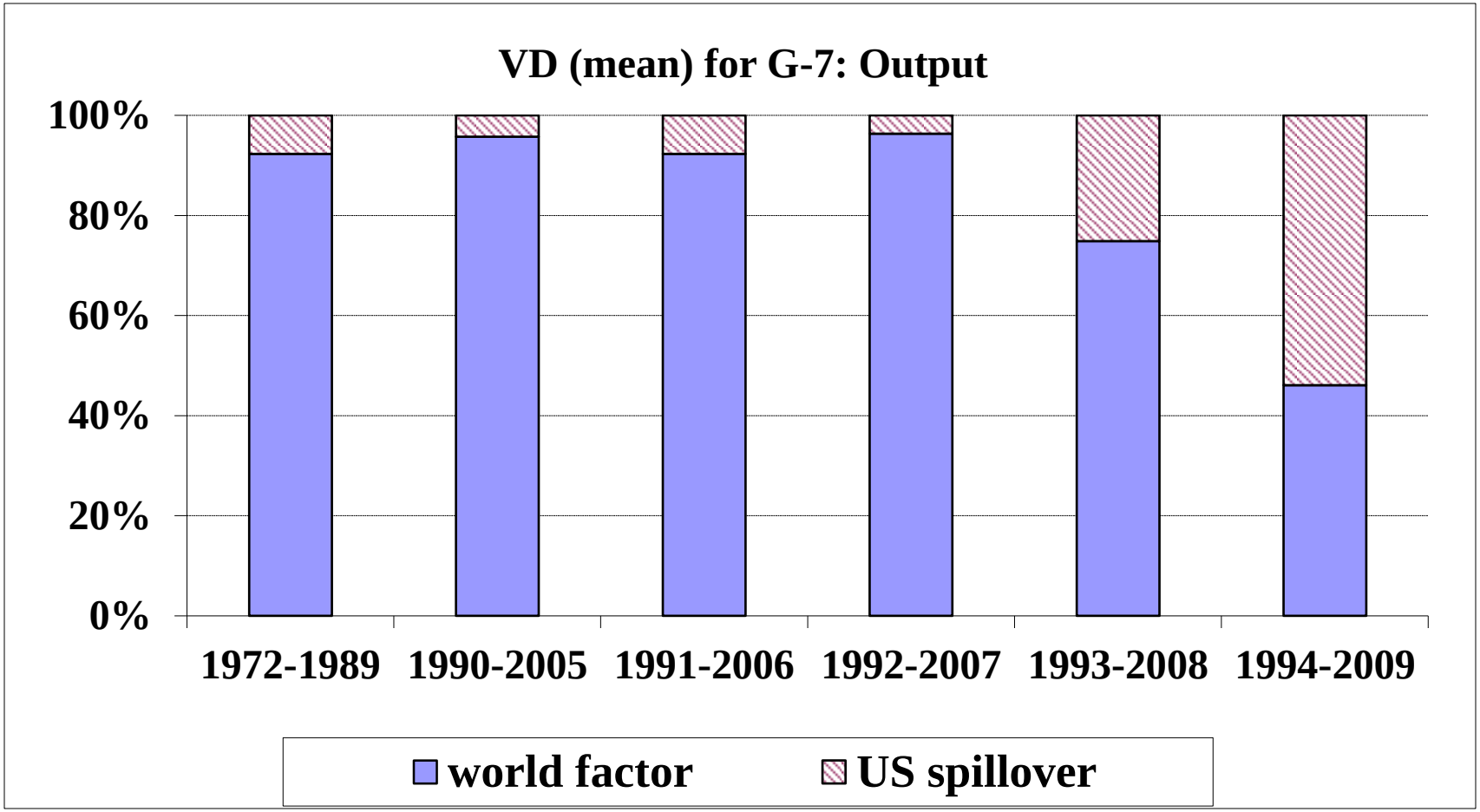
## Features of results

- Important common cycle
- Spillovers are small during normal times
- Spillovers are quite important in explaining the variance of output fluctuations during the latest global recession

# Average Variance (G-7)



# Average Variance (G-7)



# Data for Second Illustrative Exercise

- G-7 countries
- Quarterly data: 1972-2009
- Financial variables: equity prices, house prices, short-term interest rate, credit

## Features of results

- Common G7 cycle is primarily for stock market
- When estimated with just one variable, there is a global house price cycle, global credit cycle
- Stock market cycle is largest 'principal component'
- Stock prices, house prices do not have a common cycle

# Next Steps

- Combine real and financial variables
- Use expanded dataset with larger set of countries
- Determine which variable best captures financial cycle within and across countries
- Characterize direction of real and financial spillovers
- Evaluate match between empirical facts and new theoretical models of real-financial and cross-country spillovers