Session 2

Inflation & asset prices in the long run

Carolin Pflueger, University of Chicago
Moritz Schularick, Kiel Institute for the World Economy & Sciences Po
Xavier Gabaix, Harvard University

Moderator: Motohiro Yogo, Princeton University
Back to the 1980s or Not? The Drivers of Inflation and Real Risks in Treasury Bonds

Carolin Pflueger

Chicago Harris, NBER, and CEPR

February 2024
Historical Link Between Inflation, Stocks, and Bonds

Nominal bond yields clearly linked to long-term inflation
Inflation was bad for stocks in 1980s, but good in 2000s

Cieslak and Pflueger (2023), Figure 1, data from Robert Shiller
Changing Bond-Stock Comovement

\[ x_{r_{n,t+1}} = \alpha + \beta x_{r_{eq,t+1}} + \varepsilon_{t+1}, \text{ quarterly returns, 5-year rolling windows} \]

Pflueger (2024) Figure 1
Changing Bond-Stock Comovement: Inflation

\[ x_{r_n,t+1} = \alpha + \beta x_{r_{eq},t+1} + \varepsilon_{t+1}, \text{ quarterly returns, 5-year rolling windows} \]

Pflueger (2024) Figure 1

- **Nominal bond-stock betas price “stagflation” risk** (Campbell, Pflueger, Viceira (2020, JPE))
RECENT EVIDENCE
Recent Spike in Inflation...

GDP Inflation (12-month)

q

GDP Inflation (12-month)
...and a “Soft Landing”? 

The recession that never came...

Surprising?

Pflueger (Chicago)
WHAT DO BONDS AND STOCKS PRICE?
DE Shaw &Co (2021)

In short, the safe haven status of Treasury securities was put to a major test, and it passed. (...) As argued in that paper, we believe that the stock-bond correlation depends critically on the type of shocks hitting the economic system.

WSJ

5/22/2022

That hedge has evaporated this year. Investors have dumped both stocks and bonds as the Federal Reserve has embarked on a campaign to raise interest rates to combat inflation, which is at a 40-year high. Even the
Work-Horse New Keynesian Model

- Euler equation:  \( x_t = f^x E_t x_{t+1} + \rho^x x_{t-1} - \psi r_t + \nu_{x,t} \)

- Phillips curve:  \( \pi_t^w = f^\pi E_t \pi_{t+1}^w + \rho^\pi \pi_{t-1}^w + \kappa x_t + \nu_{\pi,t} \)

- Monetary policy rule:  \( i_t = \rho^i i_{t-1} + (1 - \rho^i) (\gamma^x x_t + \gamma^\pi \pi_t) + \nu_{i,t} \)

\( x_t = \text{output gap}, \ \pi_t = \text{inflation}, \ i_t = r_t + E_t \pi_{t+1} \) nominal rate
Higher Risk Aversion in Bad Times

- Large stock response to monetary surprises (Pflueger and Rinaldi (2022))
- Volatile, high, predictable stock returns (Campbell and Cochrane (1999))
COUNTERFACTUAL:
SHOCKS VS. MONETARY POLICY
1980s Calibration: Positive Nominal Bond-Stock Betas...

Change Parameters to 1979.Q4-2019.Q4 Average

- 1980s Baseline
- Shock Volatilities
- MP Rule

Nominal Bond-Stock Beta  Real Bond-Stock Beta
...Change with Shocks or Monetary Policy

Change Parameters to 1979.Q4-2019.Q4 Average

- 1980s Baseline
- Shock Volatilities
- MP Rule

Nominal Bond-Stock Beta
Real Bond-Stock Beta
2000s Calibration: Negative Nominal Bond-Stock Betas...
Positive bond-stock betas harder to generate than one might think

Need interaction: Volatile supply shocks and hawkish monetary policy
Demand shocks ⇒ negative real and nominal bond betas, as in
2000s
Positive real bond betas, nominal bond betas strongly dependent on monetary policy hawkishness!
Role of Endogenous “Flight-to-Safety”

Pflueger (2024), Figure 6

- Nominal bond-stock comovement switches sign even in response to same shock

**Bond-stock betas reflect perceived macroeconomic equilibrium, not realized shocks.**
BACK TO RECENT EXPERIENCE
Breakeven Moved with Stock Market

Pushes nominal bond-stock return beta negative
Positive real bond-stock return beta
Bond-Stock Betas at Inflation Peak

Prices supply shocks + “soft landing”
Back to the 1980s or Not?

\[ xr_{n,t+1} = \alpha + \beta x_{eq}r_{t+1} + \epsilon_{t+1}, \text{ daily returns, 6-month rolling windows} \]

Pflueger (2024)
Conclusion: Bond-Stock Betas Informative about Shocks and Monetary Policy

- Nominal bonds fall with inflation, stocks move with economy
- Nominal bond-stock betas priced stagflation risk in 1980s (Campbell, Pflueger, and Viceira (2020))
- Post-pandemic, bond-stock comovement and inflation risk premia anticipated “soft landing”, i.e. moderate monetary policy response and supply shocks (Pflueger (2024))
- Increase in bond betas after 2023.Q3 likely reflects stronger anticipated monetary responses to future supply shocks
Inflation Surprises and Asset Returns
A Macrohistory Perspective

Chi Hyun Kim
University of Bonn

Lorenzo Ranaldi
University of Bonn

Moritz Schularick
Kiel Institute, Sciences Po and CEPR

JRCPPF Annual Conference
February 23, 2024
The recent inflation surge

Assets reacted negatively during the recent inflation surge

→ Stocks and bonds reacted quickly

→ House prices dropping with some lag (or not at all)
Real assets should be unaffected by inflation under standard assumptions

- We are not the first to notice this phenomenon
- Different explanations in the literature
A long-run perspective

- A macrohistorical perspective on inflation and asset returns
  - 150 years of data for 18 countries from the JST Macrohistory database (www.macrohistory.net)
  - New long-run data on inflation expectations and surprises
    - New source: archival OECD country forecasts for 1965-2022
    - Auxiliary: model-based inflation forecasts for 1870-1965/2020

- Big picture: inflation hedging performance of different assets in the long run
  - Inflation betas and dynamic responses of asset returns
  - Demand vs. supply driven inflation shocks
  - Role of monetary policy response
Construction of inflation surprises
We identify \textit{unexpected changes} in inflation, i.e., inflation surprises $\varepsilon_{it}$:

$$\varepsilon_{it} = \pi_{it} - \mathbb{E}_{t-1}[\pi_{it}]$$

- $\pi_{it}$: inflation of country $i$ at time $t$
- $\mathbb{E}_{t-1}[\pi_{it}]$: 1Y ahead inflation expectations of country $i$ for time $t$

Forecasts from archival OECD Economic Outlook documents

Time-series models
$E_{t-1}[\pi_{it}]$ from OECD archives

- Inflation forecasts from OECD Economic Outlook

- Coverage: 1965-2022, half-yearly frequency (Jun & Dec)

- Indicators: CPI inflation (or GNP/GDP deflator)

- Forecast horizon: 1-year ahead

- 18 Countries: AUS, BEL, CAN, CHE, ESP, FIN, FRA, DNK, DEU, IRL, ITA, JPN, NLD, NOR, SWE, UK, USA
<table>
<thead>
<tr>
<th></th>
<th>1974 current prices billion $</th>
<th>From previous year</th>
<th>From previous half-year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private consumption</td>
<td>885.9</td>
<td>-0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Government expenditure</td>
<td>301.1</td>
<td>0.7</td>
<td>1.3</td>
</tr>
<tr>
<td>Private fixed investment</td>
<td>202.5</td>
<td>-10.0</td>
<td>-13.6</td>
</tr>
<tr>
<td>Residential</td>
<td>54.6</td>
<td>-25.6</td>
<td>-18.1</td>
</tr>
<tr>
<td>Non-residential</td>
<td>147.9</td>
<td>-2.9</td>
<td>-12.0</td>
</tr>
<tr>
<td>Final domestic demand</td>
<td>1389.5</td>
<td>-2.0</td>
<td>-1.1</td>
</tr>
<tr>
<td>*plus change in stockbuilding</td>
<td>9.7a</td>
<td>-0.7</td>
<td>-1.5</td>
</tr>
<tr>
<td>*plus change in foreign balance</td>
<td>7.7a</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>GNP at market prices</td>
<td>1406.9</td>
<td>-1.8</td>
<td>-2.0</td>
</tr>
<tr>
<td>GNP implicit price deflator</td>
<td>9.7</td>
<td>8.8</td>
<td>5</td>
</tr>
</tbody>
</table>

**Memorandum items**

<table>
<thead>
<tr>
<th></th>
<th>1974 current prices billion $</th>
<th>From previous year</th>
<th>From previous half-year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial production</td>
<td></td>
<td>-0.6</td>
<td>-8.9</td>
</tr>
<tr>
<td>Consumer prices</td>
<td></td>
<td>10.5</td>
<td>7.8</td>
</tr>
<tr>
<td>Stockbuilding (actual rate, 1972 prices, billion $)</td>
<td>7.7</td>
<td>-10.5</td>
<td>13.4</td>
</tr>
</tbody>
</table>

* As a percentage of GNP in the previous period.
  a) Actual rate of stockbuilding and foreign balance.
  b) National accounts implicit consumption deflator.
Surprises from OECD 1y-ahead forecasts, half-yearly frequency.
Red dots represent the average surprise across the 18 OECD countries.
$E_{t-1}[\pi_t]$ from time-series models

- Median of inflation forecasts based on 20 forecasting models
  - Univariate: unobserved component, Phillips curve
  - Multivariate: VARs on macro-financial variables
  - Panel (for cross-country spillovers): e.g. Arellano-Bond

- Obtain the distribution of model forecasts (mimick survey of professional forecasters)

- Use Jorda, Schularick & Taylor (JST) Macrohistory database to predict 1-year ahead inflation
  - Coverage: 1870-2020, annual frequency
  - Same 18 countries as OECD forecasts
Surprises from model-based 1y-ahead forecasts, half-yearly frequency. Red dots represent the average surprise across the 18 OECD countries. Gray shades represent the two world wars. We always exclude hyperinflation periods.
OECD and model-based inflation surprise measures are closely correlated (correlation $\approx 0.7$)
Asset returns data

- Stocks: i. Real stock price index; ii. Total returns

- Housing: i. Real house price index; ii. Total returns (rents & prices)
  i. OECD database (half-yearly, 1970-2020), ii. JST (yearly, 1870-2020)

- Bonds: real total returns on long-term (~ 10 years) government bonds, denominated in local currency
  Source: JST (yearly, 1870-2020)

- Macro variables (CPI, GDP, interest rates, exchange rates, ...)
Inflation surprises and asset returns
The graph presents a timeline with the frequency of positive inflation surprises above 5 p.p. across the 18 OECD countries, excluding period of hyperinflation. World wars are presented as blue shaded areas and not used for empirical analyses. Yearly frequency, 1870-2022.
Event study: big inflation surprises and asset returns

- Reaction to large inflation surprises (> 5 p.p.)?

- Entire JST sample (1870-2020), combining OECD and model surprises

- Simple event study approach:

  \[ r_{it} = \alpha + \sum_{j=2}^{J} \beta_j (\text{lag}_j)_{it} + \sum_{k=1}^{K} \gamma_k (\text{lead}_k)_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1) \]

  ⇒ Lead and lag operators around inflation surprises bigger than 5 p.p.

  ⇒ \( r_{i,t} \) is the (log) annual real return for each asset
Event study: big surprises & asset returns

Cumulative returns responses after an inflation surprise bigger than 5 p.p. hits at time 0. Yearly frequency, 1870-2020, using model surprises before 1965 and OECD surprises for 1965-2020. Bands are at 90% confidence level.

- Real stock and bond returns drop by 10 – 15% after a big inflation surprise, housing returns are less affected.
Annual real returns and inflation surprises

Scatter of time $t = 0$ yearly real returns by asset class and inflation surprises, both in percentage points. OECD end-of-the-year inflation surprises, yearly frequency, 1965-2020. Red line presents a linear regression fit.

- Equity and government bond real returns are contemporaneously affected by the surge in inflation

- Housing is not
## Inflation beta for OECD surprises: real and excess returns 1870-2020

### Inflation beta on yearly real returns. 1965-2020, half-yearly frequency. OECD surprises. Controls include: 2 lags of $\varepsilon \pi$, dependent variable, short-term interest rates, GDP growth, real stock price, inflation, world GDP growth & world equity price.

<table>
<thead>
<tr>
<th>Equity</th>
<th>Housing</th>
<th>10Y Gov Bond</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>OECD surprise</td>
<td>-1.62</td>
<td>-1.41**</td>
</tr>
<tr>
<td></td>
<td>(1.60)</td>
<td>(0.64)</td>
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<tr>
<td>Country FE</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>1516</td>
<td>1165</td>
</tr>
</tbody>
</table>

### Inflation beta on yearly excess returns. 1965-2020, half-yearly frequency. OECD surprises. Controls include: 2 lags of $\varepsilon \pi$, dependent variable, short-term interest rates, GDP growth, real stock price, inflation, world GDP growth & world equity price.

<table>
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<tr>
<th>Equity</th>
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</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>OECD surprise</td>
<td>-0.05</td>
<td>-1.24*</td>
</tr>
<tr>
<td></td>
<td>(2.34)</td>
<td>(0.63)</td>
</tr>
<tr>
<td>Country FE</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>1286</td>
<td>1165</td>
</tr>
</tbody>
</table>
Dynamic effects of inflation on asset returns: panel LPs

- Study dynamic effects while controlling for state of the economy, past surprises and market performance

- Panel local projections: impact of a (scaled) 5 p.p. surprise on cumulative real return of each asset $k$:

$$r^k_{i,t+h} - r^k_{i,t-1} = \beta^k_h \varepsilon^\pi_{it} + \psi^k_h(L)X_{i,t-1} + \delta^k_{i,h} + \epsilon^k_{i,t+h} \quad \text{for} \quad h = 0, 1, 2, \ldots$$

⇒ $X_{i,t-1}$: 2 lags of $\varepsilon^\pi$, dependent variable, short-term interest rates, GDP growth, real asset price, inflation, global GDP growth & global stock prices
Impulse responses for cumulative real asset returns through panel-LP across two sources of surprises: OECD surprises and model surprises of 1965-2020. Effects scaled to a 5 p.p. increase in inflation. Yearly frequency, OECD surprises are end-of-the-year. Bands are at the 68% and 90% confidence level.

- In response to a 5 p.p. unexpected increase in inflation:
  - Real equity returns drop $\approx 30\%$ in 3 years after the surprise
  - Houses also lose some value in real terms with 2-3 year lags
Demand vs. supply driven inflation surprises
Disentangle the differential effect of inflation on asset returns depending on the underlying source

- Demand shocks: \( \pi \uparrow \quad \text{output} \uparrow \)

- Supply shocks: \( \pi \uparrow \quad \text{output} \downarrow \)

Following Cieslak and Pflueger (2023) we could expect that:

- Equities react positively to demand-driven inflation and negatively to supply-driven inflation

- Long-term bonds’ real value always declines with rising inflation
Contemporaneous GDP surprises

- Use real GDP forecasts from OECD for 1965-2022
- Derive GDP surprises as:
  \[ \varepsilon_{it}^y = y_{it} - \mathbb{E}_{t-1}[y_{it}] \]
- When positive inflation surprise coincides with growth surprise: demand-driven, otherwise supply-driven
- Estimate panel-LP to identify the additional effect of demand-driven inflation surprises on cumulative real returns of asset k:
  \[ r_{i,t+h}^k - r_{i,t-1}^k = \beta_h^k \varepsilon_{it}^\pi + \gamma_h^k \varepsilon_{it}^y \times \varepsilon_{it}^\pi + \psi_h^k(L)X_{i,t-1} \]
  \[ + \delta_{i,h}^k + \nu_{i,t+h}^k \quad \text{for} \quad h = 0, 1, 2, \ldots \]

Controls: 2 lags of inflation surprises, GDP surprises, short-term interest rate, real GDP growth, inflation, equity price, world GDP growth, world equity price index and country FE
Impulse response on additional effect of demand inflation

Impulse responses of cumulative real asset returns on the additional effect of an inflation surprise due to demand factors. Inflation surprise is scaled to increase inflation by 5 p.p. The black line presents estimates of $\gamma_h$ in the previous panel-LP equation. Bands are at the 68% and 90% confidence level. Half-yearly frequency, 1965-2020, using OECD inflation and GDP growth surprises.

- Equity and housing react more positively to demand inflation, yet overall still negative for equity (+10% vs. baseline − 30%)
Inflation surprises, monetary policy, and asset returns
The role of monetary policy

▶ Does the response of central banks to inflation matter for the asset market response?

⇒ $\pi \uparrow \rightarrow i \uparrow \rightarrow \text{economic activity} \downarrow \text{real cash flows} \downarrow$

▶ Change in inflation can have real economic effects

⇒ Inflation surprise could proxy for overall change in economic conditions and lower future cash as in Fama (1981)

▶ Prominent role for central banks in recent literature on inflation × asset prices: Pflueger and Rinaldi (2022), Bianchi et al. (2022), Caballero and Simsek (2022), Gil de Rubio Cruz et al. (2023)
Test if monetary policy matters for asset response to inflation surprise

Study historical cases where monetary policy is constrained:

- Pegged countries with open capital account: trilemma of international finance, countries with fixed exchange rates lose monetary policy autonomy

- Exploit long history of fixed exchange rate regimes
Return responses in pegs vs. floats

Impulse responses for cumulative real asset returns on inflation surprises in pegged countries (red dash) and in non-pegged countries (navy line). Model & OECD surprises, scaled to a 5 p.p. increase in inflation. Sample of 18 countries from the JST, 1870-2020, yearly frequency. The two lines represent the estimate of \( \beta_{A,h} \) and \( \beta_{B,h} \) in the state-dependent LP. Shaded areas are the 90% and 68% confidence intervals.

► When MP reaction is "muted" (peg), real assets are less affected
Interest rates, GDP, and dividends in pegs vs. floats

Impulse responses for nominal interest rate, real GDP, and real dividends on inflation surprises in pegged countries (red dash) and in float countries (navy line). Model & OECD surprises, scaled to a 5 p.p. increase in inflation. Shaded areas are the 90% and 68% confidence intervals.

⇒ Interest rate barely change in pegs
⇒ No negative output effect of inflation surprises in pegs (slightly positive)
⇒ Real dividends in pegs remain relatively stable
Conclusions: asset prices and inflation surprises

▶ Mixed inflation hedging performance of real assets across history
  ⇒ Housing provides some inflation hedge, but far from perfect
  ⇒ Negative effect on stock returns can be seen over some

▶ Source of inflation matters
  ⇒ Demand- and supply-driven inflation lead to lower asset returns
  ⇒ Effect is less negative for demand-driven inflation

▶ Central role of monetary policy response
  ⇒ Stocks and housing returns respond significantly less if MP is constrained
  ⇒ Evidence for "proxy effect" of Fama (1981)
Appendix
Additional results

- Responses for full historical sample
- The effect of oil shocks on asset returns
- Effects in low vs high inflation
- Pre- and post-WWII
- Asymmetric effects of inflation
Let $P_t$ be stock price.
Since investors care about real cash flows $C_t$, they discount with real discount rate $d_{t,t+j}$ the future nominal cash flows $C_{t+j}(1 + \pi_{t,t+j})$ and future resell price $P_{t+T}(1 + \pi_{t,t+T})$ by cumulated inflation:

$$P_t = E_t \left\{ \sum_{j=1}^{T-1} \frac{C_{t+j}(1 + \pi_{t,t+j})}{(1 + d_{t,t+j})(1 + \pi_{t,t+j})} + \frac{P_{t+T}(1 + \pi_{t,t+T})}{(1 + d_{t,t+T})(1 + \pi_{t,t+T})} \right\}$$

$\implies$ $P_t$ is neutral to inflation rate $\pi$

- To affect stock prices, inflation has to affect real cash flows $C_{t+j}$ (i.e. economic fundamentals) or the discount rate $d_{t+j}$
- For nominal bonds, the nominal cash flows are not rising with $(1 + \pi_{t,t+T}) \implies$ price mechanically decreases with inflation
Let $P_t$ be stock price. Since investors care about real cash flows $C_t$, they discount with real discount rate $d_{t,t+j}$ the future nominal cash flows $C_{t+j}(1 + \pi_{t,t+j})$ and future resell price $P_{t+T}(1 + \pi_{t,t+T})$ by cumulated inflation:

$$P_t = E_t \left\{ \sum_{j=1}^{T-1} \frac{C_{t+j}(1 + \pi_{t,t+j})}{(1 + d_{t,t+j})(1 + \pi_{t,t+j})} + \frac{P_{t+T}(1 + \pi_{t,t+T})}{(1 + d_{t,t+T})(1 + \pi_{t,t+T})} \right\}$$

$\implies P_t$ is neutral to inflation rate $\pi$

- To affect stock prices, inflation has to affect real cash flows $C_{t+j}$ (i.e. economic fundamentals) or the discount rate $d_{t+j}$

- For nominal bonds, the nominal cash flows are not rising with $(1 + \pi_{t,t+T}) \implies$ price mechanically decreases with inflation
## Persistence of OECD surprises

<table>
<thead>
<tr>
<th>OECD surprises</th>
<th>(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation surprise (t-1)</td>
<td>0.14** (0.06)</td>
</tr>
<tr>
<td>Inflation surprise (t-2)</td>
<td>0.24*** (0.05)</td>
</tr>
<tr>
<td>Inflation surprise (t-3)</td>
<td>-0.01 (0.04)</td>
</tr>
<tr>
<td>Inflation (t-1)</td>
<td>69.35*** (7.92)</td>
</tr>
<tr>
<td>Inflation (t-2)</td>
<td>-102.45*** (9.21)</td>
</tr>
<tr>
<td>Inflation (t-3)</td>
<td>34.94*** (6.82)</td>
</tr>
</tbody>
</table>

**Country FE Yes**
**Macro controls Yes**
**Observations 1165**

Diskroll-Kraay panel regression of inflation surprises on lagged variables: surprises, inflation, GDP growth, equity price index, interest rate, world GDP growth, world equity price index. ***,*** are 10, 5 and 1 percent significance level, respectively. The only significant macro control (5 percent level) is lag of interest rate.

- Surprises are persistent and depend on the level of inflation
- Other macro controls rarely help to predict surprises (e.g. interest rates level)
Model surprises until 1965 & OECD surprises afterwards, yearly frequency. Red dots represent the average surprise across the 18 countries.

▶ Spikes concentrated around world wars
▶ Volatility decreased dramatically post-1950
Inflation surprises - Full sample (only model surprises)

Surprises from OECD 1y-ahead forecasts, half-yearly frequency. Red dots represent the average surprise across the 18 OECD countries.

Using model surprises after 1965 is inconsequential
Standard deviation of all model forecasts across all 18 countries.
In most countries, correlation is only mildly positive (< 0.5)

Single big episodes (e.g. Great Inflation) drive up correlation
Problem: No expected inflation before 1960s

→ Surveys (consumers and professionals) or TIPS not available

→ Traded financial instruments include various confounders (e.g. inflation risk premium, default risk, liquidity premium)

**Pooling of forecasts:** estimate several (simple or complicated) models

⇒ Mimick the structure of Survey of Professional forecasters

A model of inflation expectations: Pooling of forecasts

\[ \mathbb{E}_t[\pi_{i,t+1}] = \omega' \ \hat{\Pi}_{t+1|t} = \omega' \begin{pmatrix} \hat{\pi}_{1,t+1|t} \\ \vdots \\ \hat{\pi}_{j,t+1|t} \\ \vdots \\ \hat{\pi}_{n,t+1|t} \end{pmatrix} \]  
(2)

\[ \hat{\pi}_{j,t+1|t} = A' \ X_{t:t-k} + \varepsilon_{j} \]
(3)

For any model \( j = 1, \ldots, n \), \( \omega \) is the vector of weights assigned to each single model (here \( \omega \) is the median), \( \hat{\Pi}_{t+1|t} \) is the vector containing all the inflation forecasts \( \hat{\pi}_{j,t+1|t} \) for each model \( j \) and \( \mathbb{E}_t[\pi_{i,t+1}] \) is the resulting forecast obtained by combining those estimates.
<table>
<thead>
<tr>
<th>Model Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Univariate Models</strong></td>
<td></td>
</tr>
<tr>
<td>ARMA(1,1)</td>
<td>$\pi_t = c + \phi \pi_{t-1} + \epsilon_t + \theta \epsilon_{t-1}$. 30-year rolling window (RW hereafter).</td>
</tr>
<tr>
<td>ARMA(1,1) on transitory $\pi$</td>
<td>As above, with 30-year RW, but using $\hat{\pi}_t = \bar{\pi}_t - \pi_t$, where $\bar{\pi}_t$ is trend inflation and follows a random walk, i.e. $\bar{\pi}<em>t = \bar{\pi}</em>{t-1} + \epsilon_t$</td>
</tr>
<tr>
<td>Backward-looking Phillips Curve</td>
<td>$\hat{\pi}<em>t = \phi_1 \hat{\pi}</em>{t-1} + \phi_2 \hat{y}_{t-1} + \epsilon_t$, where $\hat{\pi}$ and $\hat{y}$ are transitory inflation and output gap, respectively. 30-year RW.</td>
</tr>
<tr>
<td>ARMA(1,1) w/o RW</td>
<td>as ARMA(1,1) above but no RW</td>
</tr>
<tr>
<td>ARMA(1,1) w/o RW on transitory $\pi$</td>
<td>as ARMA(1,1) above but no RW, using $\hat{\pi}$</td>
</tr>
<tr>
<td>Random Walk</td>
<td>$\pi_t = \pi_{t-1} + \epsilon_t</td>
</tr>
<tr>
<td>Unobserved component trend-cycle</td>
<td>$\pi_t = \tau_t + \eta_t$, where $\tau_t = \tau_{t-1} + \epsilon_t$ is trend inflation, as in Stock and Watson (2007).</td>
</tr>
<tr>
<td><strong>Multivariate Models</strong></td>
<td></td>
</tr>
<tr>
<td>Benchmark VAR(2)</td>
<td>$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \nu_t$ where $Y_t = [\text{inflation, output gap, int. rate}]$</td>
</tr>
<tr>
<td>VAR</td>
<td>As above, but using transitory inflation $\hat{\pi}$</td>
</tr>
<tr>
<td>VAR</td>
<td>As the benchmark VAR(2), but using the $r^*$ gap measure of Grimm et al. (2023)</td>
</tr>
<tr>
<td>VAR</td>
<td>As above, but on transitory inflation $\pi$</td>
</tr>
<tr>
<td>VAR on asset prices</td>
<td>$Y_t = [\text{inflation, stock price, gov. bond price}]$</td>
</tr>
<tr>
<td>VAR on asset prices &amp; GDP</td>
<td>$Y_t = [\text{inflation, stock price, house price, GDP growth}]$</td>
</tr>
<tr>
<td>VAR on asset &amp; commodity prices</td>
<td>$Y_t = [\text{inflation, stock price, house price, commodity price}]$</td>
</tr>
<tr>
<td>VAR on GDP components</td>
<td>$Y_t = [\text{inflation, consumption, investment, net exports}]$</td>
</tr>
<tr>
<td>VAR on commodities</td>
<td>$Y_t = [\text{inflation, grains price, metals price, softs price}]$</td>
</tr>
<tr>
<td>Model Name</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Panel Data Models</strong></td>
<td></td>
</tr>
<tr>
<td>Arellano-Bond (A-B), no covariates</td>
<td>$\pi_{it} = \alpha_1 \pi_{i,t-1} + \alpha_2 \pi_{i,t-2} + u_{it}$, 10-year</td>
</tr>
<tr>
<td></td>
<td>rolling window</td>
</tr>
<tr>
<td>A-B on transitory $\pi$</td>
<td>As above, no covariates but using $\hat{\pi}$, while trend inflation follows</td>
</tr>
<tr>
<td></td>
<td>a random walk, i.e. $\bar{\pi}<em>{i,t} = \bar{\pi}</em>{i,t-1} + \nu_{i,t}$.</td>
</tr>
<tr>
<td></td>
<td>Two lags, 10-year rolling window.</td>
</tr>
<tr>
<td>A-B with output gap and int. rate</td>
<td>$\pi_{it} = \sum_{j=1}^{2} \alpha_j \pi_{i,t-j} + \phi X_{i,t-1} + u_{it}$,</td>
</tr>
<tr>
<td></td>
<td>where $X$ is output gap and interest rate. 10-year rolling window.</td>
</tr>
<tr>
<td>A-B with $X$ on transitory $\pi$</td>
<td>As above, where $X$ is output gap and interest rate, but using transitory</td>
</tr>
<tr>
<td></td>
<td>inflation $\hat{\pi}$</td>
</tr>
</tbody>
</table>
Inflation expectations for core countries

Blue bands present the interquartile range and p5-p95 of the distribution of the 20 forecasting model estimates, for each year.

▶ OECD and model forecasts are close (correlation 0.9+)
Model expected inflation vs OECD, part 3

Inflation, %

Year

JPN

NLD

NOR

PRT

SWE

USA

Model expectations

OECD forecast
Vertical dashed black lines represent inflationary episodes from Ari et al. (2023). These episodes are identified as increases in inflation of at least 2 p.p. within a year, excluding re-inflation, hyperinflation and extremely volatile inflation cases. Most episodes concentrated around 1970s’ oil crises.

- **Big & isolated** inflationary episodes: $\Delta \pi > 2\text{p.p.}$ within a year
- Large inflation surprises during inflationary episodes
## Inflation beta - Full sample

<table>
<thead>
<tr>
<th></th>
<th>Equity</th>
<th>Housing</th>
<th>10Y Gov Bond</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(5)</td>
</tr>
<tr>
<td>Surprise</td>
<td>-4.74***</td>
<td>-4.16**</td>
<td>-1.71***</td>
</tr>
<tr>
<td></td>
<td>(1.16)</td>
<td>(1.60)</td>
<td>(0.41)</td>
</tr>
<tr>
<td>Country FE</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Observations</td>
<td>769</td>
<td>706</td>
<td>769</td>
</tr>
</tbody>
</table>

**Inflation beta on yearly real returns.** 1870-2020, yearly frequency. OECD & Model surprises.

<table>
<thead>
<tr>
<th></th>
<th>Equity</th>
<th>Housing</th>
<th>10Y Gov Bond</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(5)</td>
</tr>
<tr>
<td>Surprise</td>
<td>-4.59***</td>
<td>-4.01**</td>
<td>-1.35***</td>
</tr>
<tr>
<td></td>
<td>(1.20)</td>
<td>(1.67)</td>
<td>(0.43)</td>
</tr>
<tr>
<td>Country FE</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Observations</td>
<td>769</td>
<td>706</td>
<td>769</td>
</tr>
</tbody>
</table>

**Inflation beta on yearly excess returns.** 1870-2020, yearly frequency. OECD & Model surprises.
Inflation beta: peg vs. floats

<table>
<thead>
<tr>
<th></th>
<th>Equity</th>
<th></th>
<th>Housing</th>
<th></th>
<th>10Y Gov Bond</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
<tr>
<td>Surprise</td>
<td>-0.96***</td>
<td>-1.56***</td>
<td>-0.52***</td>
<td>-0.66***</td>
<td>-1.10***</td>
</tr>
<tr>
<td></td>
<td>(0.31)</td>
<td>(0.47)</td>
<td>(0.06)</td>
<td>(0.11)</td>
<td>(0.12)</td>
</tr>
<tr>
<td>Peg interaction</td>
<td>0.28</td>
<td>1.18**</td>
<td>0.18</td>
<td>0.22</td>
<td>0.39*</td>
</tr>
<tr>
<td></td>
<td>(0.42)</td>
<td>(0.59)</td>
<td>(0.12)</td>
<td>(0.19)</td>
<td>(0.20)</td>
</tr>
<tr>
<td>Country FE</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Observations</td>
<td>2005</td>
<td>1548</td>
<td>1719</td>
<td>1491</td>
<td>2046</td>
</tr>
</tbody>
</table>

Inflation beta on yearly real returns. Regression: \( r_{it} = \alpha_i + \beta \epsilon_{it} + \gamma \epsilon_{it} \times D_{it} + \delta X_{it} + v_t \), where \( D_{it} \) is a dummy for a country being pegged. 1870-2020, yearly frequency. Model & OECD surprises. Controls include: 2 lags of \( \epsilon^\pi \), dependent variable, peg dummy, short-term interest rates, GDP growth, real stock price, inflation, world GDP growth & world equity price.

▶ In pegged countries, inflation hedging more effective
Simple event study: 10 biggest inflation surprises

- 10 largest surprises within the OECD sample (1965-2020)

Gray lines present the real total return indices for equity, housing and 10Y government bonds for the 10 episodes, normalized to 100 in the period before the inflation surprise hits. The blue thick line presents the median response.

- Persistent negative effect on all asset returns
### Cumulative returns responses

<table>
<thead>
<tr>
<th>OECD surprises</th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity</td>
<td>-28.77</td>
<td>-35.46</td>
<td>-36.44</td>
<td>-36.82</td>
</tr>
<tr>
<td>Housing</td>
<td>-1.07</td>
<td>-4.15</td>
<td>-6.46</td>
<td>-11.67</td>
</tr>
<tr>
<td>10Y Gov Bond</td>
<td>-9.55</td>
<td>-10.68</td>
<td>-6.90</td>
<td>-2.74</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model surprises</th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity</td>
<td>-20.63</td>
<td>-31.32</td>
<td>-36.05</td>
<td>-36.72</td>
</tr>
<tr>
<td>Housing</td>
<td>-2.86</td>
<td>-7.15</td>
<td>-9.78</td>
<td>-11.55</td>
</tr>
<tr>
<td>10Y Gov Bond</td>
<td>-9.41</td>
<td>-12.63</td>
<td>-11.96</td>
<td>-13.01</td>
</tr>
</tbody>
</table>

*Responses in percentage points, surprise scaled to a 5 p.p. increase in inflation*
<table>
<thead>
<tr>
<th></th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OECD surprises</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>-7.67</td>
<td>-13.68</td>
<td>-16.24</td>
<td>-16.45</td>
</tr>
<tr>
<td>Housing</td>
<td>-0.89</td>
<td>-0.81</td>
<td>-0.11</td>
<td>-1.93</td>
</tr>
<tr>
<td>10Y Gov Bond</td>
<td>-3.63</td>
<td>-4.87</td>
<td>-3.39</td>
<td>-5.99</td>
</tr>
<tr>
<td><strong>Model surprises</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Housing</td>
<td>-2.15</td>
<td>-4.86</td>
<td>-6.66</td>
<td>-8.03</td>
</tr>
<tr>
<td>10Y Gov Bond</td>
<td>-7.23</td>
<td>-9.50</td>
<td>-9.46</td>
<td>-10.21</td>
</tr>
<tr>
<td><strong>Ari et al. (2023) episodes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>-21.70</td>
<td>-32.81</td>
<td>-34.48</td>
<td>-38.17</td>
</tr>
<tr>
<td>Housing</td>
<td>3.23</td>
<td>4.97</td>
<td>2.77</td>
<td>-0.55</td>
</tr>
<tr>
<td>10Y Gov Bond</td>
<td>-9.06</td>
<td>-13.55</td>
<td>-17.48</td>
<td>-16.70</td>
</tr>
</tbody>
</table>

*Responses in percentage points, surprise scaled to a 5 p.p. increase in inflation*
Baseline IRF - OECD surprises (halfyearly)

With lagged controls

Only Time FE
Comparison of impulse responses for cumulative real asset returns through panel-LP across two sources of surprises: OECD surprises and model surprises. Yearly frequency, OECD surprises are end-of-the-year. Bands are at the 68% and 90% confidence level.

- **Robustness:** we include country and time fixed effects and exclude the rest of macro controls
  - Including both time FE and controls is unfeasible due to data constraints
- **Responses** are in line with benchmark estimates
Impulse responses on additional effect of demand inflation

Impulse responses of inflation, real GDP and nominal short-term interest rate on the additional effect of an inflation surprise due to demand factors. The black line presents estimates of $\gamma_h$ in the previous panel-LP equation. Bands are at the 68% and 90% confidence level. Half-yearly frequency, 1965-2020, using OECD inflation and GDP growth surprises.

▶ Interpretation: additional effect of a (scaled) 5 p.p. inflation surprise that hits together with a positive real output surprise

▶ Demand shock:
  - Inflation stronger and more persistent
  - Output first reacts positively, then brought down by stronger response of interest rate to higher inflation
Hardly big surprises outside war periods

Expectations are normally off at the start of inflation surges, in line with Blanco et al. (2022)
Persistent effect $\Rightarrow$ Price non-neutrality?

Lower magnitudes than in recent sample (see also Pre-/Post-WW2)

Stock-bond correlation positively affected by the inflation surprise
Mild reaction of int. rate (50 basis point) due to *average* response in the full sample $\Rightarrow$ response in recent sample is around 150 bp

*Average* response of GDP is neutral
Dividends and rents pick up after few years, while prices are hit more persistently.
Are the effects of inflation surprises on asset returns consistent with oil shocks’ effects?

Run LP-IV using Känzig (2021) oil news shocks, as instrument for oil price, on asset cumulative returns
Summed within the half-year, scaled to increase inflation by 1p.p.

Correlation between inflation surprises and oil price shocks from Känzig (2021) is mildly positive (≈ 0.15)
Sign of responses is consistent with IRFs from inflation surprises

Macroeconomic responses are also coherent with previous graph

$\Rightarrow$ Inflation surprises likely driven by fundamental supply shocks
Macroeconomic response to oil shocks

**Similar responses to macroeconomic responses to inflation surprises**
Specification similar to Ramey and Zubairy (2018):

\[ r_{i,t+h} - r_{i,t-1} = \mathcal{I}_{i,t-1} \left\{ \beta_A, h \pi_{it} + \psi_A, h(L)X_{i,t-1} + \delta_{A,i,h} \right\} + (1 - \mathcal{I}_{i,t-1}) \left\{ \beta_B, h \pi_{it} + \psi_B, h(L)X_{i,t-1} + \delta_{B,i,h} \right\} + \epsilon_{i,t+h} \quad h = 0, 1, 2, \ldots \]

where \( \mathcal{I} \) is a dummy that identifies the state of the economy in \( t - 1 \)

The classification of pegs and floats countries follows Jordà et al. (2020) and controls for lagged pegging\(^1\) and Quinn et al. (2011) measure of capital openness

---

\(^1\)To eliminate cases where the decision to peg is endogenous
Asset responses in low vs high inflation

Impulse responses for cumulative real asset returns on inflation surprises in low inflation (red) and in high inflation (blue), defined as below/above 2%. Model & OECD surprises, scaled to a 5 p.p. increase in inflation. Sample of 18 countries from the JST, 1870-2020, yearly frequency. Shaded areas are the 90% and 68% confidence intervals.

- A testable implication of Katz et al. (2017) is that future returns should decrease in high inflation
  - Contrary to what implied by money illusion (Modigliani and Cohn (1979))
- Again, when monetary reaction is "muted", only real assets remain mostly unaffected by inflation
Interest rate response in low vs high inflation

Impulse responses for cumulative real asset returns on inflation surprises in low inflation (red) and in high inflation (blue), defined as below/above 2%. Model & OECD surprises, scaled to a 5 p.p. increase in inflation. Sample of 18 countries from the JST, 1870-2020, yearly frequency. Shaded areas are the 90% and 68% confidence intervals.

- Monetary response is less active in low inflation environments
  - If $\pi < \text{target}$, CB doesn't counteract inflation by raising interest rates
Summary/Brainstorm: Bringing things back together: what do we learn?

- Other literature either provides theory and/or reduced-form analysis to investigate the effect of inflation on asset prices (and the stock-bond relationship). Our macrohistory perspective provides an environment to test in a structural manner various channels that exist in the literature (WHAT IS NEW 1)
  1. Source of inflation: demand- vs supply-driven. Our analysis shows (for the first time) that asset returns decline, irrelevant of the source. Nevertheless, effect is less negative for demand-driven inflation
  2. We confirm the proxy effect of Fama through the lens of MP actions, by exploiting peg vs float regimes (rather unfeasible for other papers due to data limitations in recent period). I.e. we show that the "spurious" negative correlation between inflation and asset returns is due to active MP actions. In a more modern fashion, this is also the central message of Caballero and Simsek (2022).

- Dynamic responses of asset returns to inflation (WHAT IS NEW 2)
  - Complementary to inflation beta analysis, our exercise shows that inflation can have persistent effects on asset prices (cumulative returns stay negative for 3-5 years in many cases)
Before WWII, most countries within the Gold standard → CB does not generally respond to home inflation shocks

After WWII, when monetary policy is more active, all asset returns react negatively
Pre- & Post-WWII responses to inflation

- Before WWII, most countries within the Gold standard → CB does not generally respond to home inflation shocks
- After WWII, when monetary policy is more active, all asset returns react negatively
Positive inflation surprises are more significant and persistent, especially for stock returns.
Asymmetric effects of inflation: positive vs negative surprises

- Only positive surprises trigger strong monetary policy reaction
Dividends and rents are affected negatively on impact, slowly reverting towards zero.
INELASTIC MARKETS: IMPLICATIONS FOR MACRO-FINANCIAL POLICY

Xavier Gabaix

Princeton conference, “Macrofinance in the long run”, February 23 2024
I’ll talk about macro-finance policy, in particular in low inflation regimes: Quantitative Easing

Fed Chairman Ben Bernanke in 2012, “Well, the problem with QE is it works in practice, but it doesn’t work in theory.”
OVERVIEW

I’ll talk about macro-finance policy, in particular in low inflation regimes: Quantitative Easing

Fed Chairman Ben Bernanke in 2012, “Well, the problem with QE is it works in practice, but it doesn’t work in theory.”

Here, integrated view for bonds, stock, etc
Why are financial markets so volatile?

- Key question: Why are financial markets so volatile?
- Common feature across modern behavioral and rational asset pricing models:
  - Markets are macro elastic: E.g., if a sovereign wealth fund buys 10% of the US stock market, equity prices would rise by less than 1%.
WHY ARE FINANCIAL MARKETS SO VOLATILE?

▶ **Key question:** Why are financial markets so volatile?
▶ **Common feature across modern behavioral and rational asset pricing models:**
  ▶ Markets are **macro elastic:** E.g., if a sovereign wealth fund buys 10% of the US stock market, equity prices would rise by less than 1%.
▶ **Practical implications:**
  ▶ Flows in financial markets do not matter
  ▶ Q.E. doesn’t work
  ▶ Central bank interventions in FX, other markets do not matter
  ▶ Differences in beliefs or tastes (e.g., about ESG) matter little quantitatively,

for prices and expected returns.
Why are financial markets so volatile?

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- **Common feature across modern behavioral and rational asset pricing models:**
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- **Practical implications:**
  - Flows in financial markets do not matter
  - Q.E. doesn’t work
  - Central bank interventions in FX, other markets do not matter
  - Differences in beliefs or tastes (e.g., about ESG) matter little, quantitatively, for prices and expected returns.
- **We propose an alternative view:**
  - Markets are *macro inelastic:* Flows have a large impact on prices and future excess returns.
- **We refer to this as the inelastic markets hypothesis (IMH).**
OUR INSIGHTS

▶ A new asset pricing theory of inelastic financial markets:
  ▶ Why are markets inelastic?
  ▶ How to measure flows into the stock market?
▶ New estimate of the elasticity of the aggregate stock market, using a new granular IV estimator

If you buy $1 worth of the aggregate stock market (selling bonds), this increases the valuation of the aggregate stock market by $5.

If you buy 1% worth of the aggregate stock market (selling bonds), this increases the valuation of the aggregate stock market by 5% (where $M = 5$).

This is symmetric between buys and sells.

New measurement of flows into equity markets:

▶ Explore links to prices, macro variables, and survey expectations.

▶ More broadly, a framework to connect prices, fundamentals, and portfolio flows and holdings to understand prices and expected returns across markets and asset classes.
OUR INSIGHTS

- A new asset pricing theory of inelastic financial markets:
  - Why are markets inelastic?
  - How to measure flows into the stock market?
- New estimate of the elasticity of the aggregate stock market, using a new granular IV estimator
- We find that
  - If you buy $1 worth of the aggregate stock market (selling bonds), this increases the valuation of the aggregate stock market by $5
  - If you buy 1% worth of the aggregate stock market (selling bonds), this increases the valuation of the aggregate stock market by 5% (where $M = 5$)
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New measurement of flows into equity markets:
- Explore links to prices, macro variables, and survey expectations.
- More broadly, a framework to connect prices, fundamentals, and portfolio flows and holdings to understand prices and expected returns across markets and asset classes.
Our Insights

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  - How to measure flows into the stock market?
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  - If you buy 1% worth of the aggregate stock market (selling bonds), this increases the valuation of the aggregate stock market by 5% (where $M = 5$)
  - This is symmetric between buys and sells
- New measurement of flows into equity markets:
  - Explore links to prices, macro variables, and survey expectations.
- More broadly, a framework to connect prices, fundamentals, and portfolio flows and holdings to understand prices and expected returns across markets and asset classes.
Overview

▶ We’ll see that the “inelastic markets hypothesis” offers a systematic way to make it work in general
▶ Framework to think about thing like
  ▶ If the Fed does QE on bonds / stocks, what’s the impact on bonds / stocks?
  ▶ If there’s a flow between asset class $i$ to $j$, what’s the impact on all asset classes?
    ▶ What’s a flow anyway?

This is based on several papers:
▶ “In Search of the Origins of Financial Fluctuations: The Inelastic Markets Hypothesis”, G Koijen ’23
▶ “Granular instrumental variables” (GIV), G Koijen ’24, and “Network GIV”, Chodorow-Reich, G Koijen, Viviano ’24, + work with G, Koijen, Yogo
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Why may markets be inelastic?

Many funds are constrained:

- A 100% equity fund provides no elasticity.
- Funds with a fixed-share mandate (70/30 stocks-bonds) is still very constrained.
Why may markets be inelastic?

- Who times the market aggressively?
  - Survey suggests broker dealers or hedge funds.
  - Hedge funds are also small (~5% of market) and reduce allocations in bad times (outflows or risk constraints, Ben-David et al. ’12).
Suppose that the typical fund holds 80% in stocks, 20% in bonds, as a (perhaps self-imposed) mandate.

Then, the elasticity of demand for stocks is $\zeta = 0.2$, and:

$$\Delta q = -\zeta \Delta p + f$$

where $\Delta q =$ change in demanded quantity, $\Delta p =$ change in price, $f =$ flow (change in demand given price).

By market clearing, $\Delta q = 0$, so

$$\Delta p = \frac{1}{\zeta} f = 5f$$

If you buy 1% worth of the aggregate stock market (selling bonds), this increases the valuation of the aggregate stock market by 5% (from $\frac{1}{0.2} = 5$).
The 2-period model generalizes well to an infinite horizon.

Mandate of representative fund:

\[
\frac{P_t Q_t^D}{W_t} = \theta e^{\kappa (\pi_t - \bar{\pi})}
\]

Notations (simplified here; more elaborate in paper):

- \(\bar{P}_t\), \(\bar{W}_t\), \(\bar{D}_t\) baseline values (without flow shocks).
- Deviations from baseline values:
  - \(p_t = P_t - \bar{P}_t\) (P-deviation)
  - \(d_t = D_t - \bar{D}_t\) (D-deviation)
  - \(d_e = E_t d_{t+1}\)

Cumulative flow:

\[f_t = F_t - \bar{F}_t \bar{W}_t\]
INFINITE HORIZON: DEMAND CURVE

- The 2-period model generalizes well to an infinite horizon
- Mandate of representative fund:

\[
\frac{P_t Q_t^D}{W_t} = \theta e^{\kappa(\pi_t - \bar{\pi})}
\]

- Then elasticity is \( \zeta = 1 - \theta + \kappa \delta \), where \( \delta = \frac{D}{P} \)
- Notations (simplified here: more elaborate in paper)
  - \( \bar{P}_t, \bar{W}_t, \bar{D}_t \) baseline values (without flow shocks),
  - Deviations from baseline values:

\[
 p_t = \frac{P_t}{\bar{P}_t} - 1, \quad d_t = \frac{D_t}{\bar{D}_t} - 1, \quad d_t^e = \mathbb{E}_t d_{t+1}.
\]

- Cumulative flow:

\[
 f_t = \frac{F_t - \bar{F}_t}{\bar{W}_t}.
\]
Proposition: Price deviations are given by

\[ p_t = E_t \sum_{\tau=t}^{\infty} \frac{\rho}{(1+\rho)^{\tau-t+1}} \left( \frac{f_{\tau}}{\zeta} + \delta d_{\tau}^e \right), \]

with \( \rho \) is the “effective discount factor,”

\[ \rho = \frac{\zeta}{\kappa} = \delta + (1 - \theta) / \kappa > \delta \]
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We could have “\( \mathbb{E}_t^Q \)”, with risk-adjusted expectation. So bridge well with traditional models.

Permanent inflow \( f_0 \) creates \( \mathbb{E}f_t = f_0 \) for \( t \geq 0 \), so permanently increases price and lowers risk premium:

\[ \Delta p = \frac{f_0}{\zeta}, \quad \Delta \pi = -\delta \Delta p. \]
INFINITE HORIZON: PRICE AS PV OF DIVIDENDS AND FLOWS

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If flows mean-revert at rate \( \phi \) (\( \mathbb{E} f_t = (1 - \phi)^t f_0 \)):

\[ \Delta p_0 = \frac{f_0}{\zeta + \kappa \phi}, \quad \Delta \pi_0 = - (\delta + \phi) \Delta p_0. \]
This was from calibrated theory. Empirically, we use “Granular instrumental variables” (GIV: G. Koijen ’24).

- Use idiosyncratic demand shocks to large investor sectors, to see their impact on the market
- Indeed gives an impact around 5

- General strategy in macro-finance: use idiosyncratic shocks to large players to estimate elasticities of supply / demand etc
Potential policy: government intervention of stock market?

- Take $\frac{1}{\zeta} = 5$.
- Suppose that the government buys $f^G$ percent of the market, and keeps it forever. Then, market increased by

$$p = \frac{f^G}{\zeta} \simeq 5f^G$$

- So, buy 1% of market, (about 1% of GDP), then market goes up by 5%
**POTENTIAL POLICY: GOVERNMENT INTERVENTION OF STOCK MARKET?**

- This may be a potential policy?
- In Aug. 1998, the Hong Kong government (under speculative attack) bought 6% of the HK stock market: 24% abnormal return, not reversed in the next eight weeks. (Caballero ’99)
- The BoJ now holds 5% of Japanese stock market. Bloomberg “The Bank of Japan, sometimes dubbed the Tokyo whale for its huge influence on the country’s stock market, [...] is taking up too much of the pool.”
- (Papers have estimated micro, not macro elasticities in Japan: Barbon Gianinazzi ’19, Charoenwong et al. ’19 estimate)
- Chinese “national team” owns 6% of Chinese stock market (since 2015 crash) [Brunnermeier, Sockin Xiong ’22]
Price Impact of QE for Bonds

- For bonds, the elasticity of the demand for bond is 20 times higher than for stocks, around 4
- ... so the price the impact multiplier is 20 times lower: 0.25 for bonds rather than 5 for stocks.
- Source: QE literature (Koulischer et al. 22, Krishnamurthy Vissing Jorgensen ’21), and one-off regulatory events (Jensen ’23)
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The intuitive reason is the following: if the Fed buys long term bonds, against cash, then lots of funds are happy to substitute LT bonds against ST bonds
**Fuller picture with stocks, bonds, cash**

- Generalize to cash + 2 risky asset classes (can do $K$)
- $q = (q^{\text{Equity}}, q^{\text{Bonds}})$, $p = (p^{\text{Equity}}, p^{\text{Bonds}})$. Then, we have
  \[ \Delta q = -\zeta \Delta p + f \]

  with $\zeta$ is now a matrix,
  \[ \zeta = \begin{pmatrix} 0.2 & -0.15 \\ -0.15 & 4 \end{pmatrix}, \quad \zeta^{-1} = \begin{pmatrix} 5 & 0.2 \\ 0.2 & 0.25 \end{pmatrix} \]

  so by market clearing:
  \[ \Delta p = \zeta^{-1} f \]

- If the Fed buys 1% of stock market
  - the stock market by 5% in value
  - bond prices go up by 0.2%
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- If the Fed buys 1% of bond market
  - bond prices goes up by 0.25%
  - stocks go up by 0.2%
LU CAS CRITIQUE: HOW STABLE ARE THOSE ESTIMATES?

- This is work in progress
- How $\zeta$ changes with policy? (answer: very little)
- How flows change with policy?
  - General issue with behavioral models
  - Fit a “structural behavioral model” of $f$, that responds to incentives (i.e. partial response to rational incentives, plus noise), hence to policy, but in a behavioral manner — not as in the traditional model
  - E.g. if $j_t=$policy, $f_t = f_t^0 + f_j j_t$, and fit a structural-behavioral model of $f_j$
CONCLUSION FOR POLICY NEAR THE ZLB

- When inflation is low and you’re close to the ZLB
- Do QE for assets that are inelastic, and whose price impacts investment / GDP:
  - Stocks
  - Junk bonds
  - MBS
  - Foreign exchange
AN ASIDE: READING MARKET SIGNALS IN INELASTIC MARKETS

- With imperfect financial markets, prices can be persistently “off”
- E.g. the difference between Nominal Yields and TIPS (real) yields, is: Inflation + risk premium, modulated by various “flow disturbances”
- One should be aware of that
- One could try to remove “flow disturbances” from market signals (not easy: cf Bahaj, Reis et al '23)
FROm “The inelastic markets hypothesis”

- We’re industriously working on an updated version of macro-finance
  - with flows and inelasticity at the center, *replacing the Euler equation for risky assets*
  - with empirical guidance with holdings of various assets
  - New measurement of flows into equity markets
  - Explore links to prices, macro variables, and expectations
  - More broadly, a framework to connect prices, fundamentals, and portfolio flows and holdings to understand prices and expected returns across markets and asset classes.

- Question now: how to identify those effects, e.g. estimate the multiplier?
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- That’s where the “granular instrument variables” come in.
INTRODUCING GRANULAR INSTRUMENTAL VARIABLES

▶ “Granular”: idiosyncratic shocks to large firms affect the aggregate in a big way, as most markets aren’t very diversified (G. ’11)
▶ GIVs use idiosyncratic shocks (e.g. in TFP, demand) as instruments:
  ▶ “Purge” data from aggregate shocks to obtain “purified” idiosyncratic shocks.
  ▶ Optimally aggregate idiosyncratic shocks to obtain the most powerful instrument.
▶ Examples:
  ▶ Industry-wide spillovers: if a firm expands, how do other firms react?
  ▶ Sovereign - financial sector doom loops.
  ▶ The impact of intermediaries on asset prices.
  ▶ Growth spillovers (micro-to-macro multiplier).
**Introducing Granular Instrumental Variables**

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  - The impact of intermediaries on asset prices.
  - Growth spillovers (micro-to-macro multiplier).
- G.-Koijen (JPE ’24): for one market (e.g. stocks vs bonds)
- Chodorow-Reich, G., Kojien, Viviano “Network GIV” (WP ’24): for $N$connected markets
Basic setup for new “Network GIV”

- Suppose that the data generating process is iid

\[ y_t = B(\gamma)y_t + C(\gamma)y_{t-1} + \lambda \eta_t + \chi u_t \]

- \( y_t \): vector of outcomes, \( N \times 1 \)
- \( B(\gamma), C(\gamma) \): matrix of propagation, \( N \times N \). Could have \( C = 0 \).
- \( \gamma \): vector of parameters to identify
- \( \lambda \): factor loadings, \( N \times r \)
- \( \eta_t \): aggregate shocks, \( r \times 1 \), unobserved
- \( u_t \): idiosyncratic shocks, \( N \times 1 \), unobserved, uncorrelated with \( \eta_t \)
- \( \chi \): modulator, e.g. for heteroskedasticity
- For a wIf the project exceeds some kind of threshold, cut offRequired to make a certain percentagehile, assume \( C = 0 \). Then,

\[ y_t = A(\gamma)(\chi^{-1}\lambda \eta_t + u_t) , \quad A(\gamma) = (I - B(\gamma))^{-1} \chi \]
Example: Social network

- Example: social networks

\[ y_{it} = \gamma \sum_j G_{ij} y_{jt} + \lambda_i \eta_t + u_{it} \]

then \( Y_t = B(\gamma) Y_t + \lambda \eta_t + \chi u_t, \) \( B(\gamma) = \gamma G, \chi = I. \)

- A “big influencer” \( j \) has a big \( G_{ij} \)
**Example: Social Network**

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- \( G \) assumed to be known, but \( \gamma \) unknown.

- Econometric version:
  - interpret \( y_{it} \) as TFP increase in firm \( i \)
  - so, we can study the productivity spillovers in networks
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Econometric version:

- interpret \( y_{it} \) as TFP increase in firm \( i \)
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What if we don’t know the right \( G \)? The model also admits:

\[ y_{it} = \sum_{k,j} \gamma^{(k)} G_{ij}^{(k)} y_{jt} + \lambda_i \eta_t + u_{it} \]

Then, we allow the \( G \) matrix to be a weighted average of various candidate \( G^{(k)} \) matrices.
EXAMPLE: SUPPLY AND DEMAND

- Take supply and demand with elasticities $\phi^d_i$

  \[ q_{it} = \phi^d_i p_t + \varepsilon_{1t} + u_{it} \]
  \[ p_t = \psi q_{St} + \varepsilon_{2t} \]

- So $Y_t = (q_t, p_t)' = B(\gamma) Y_t + \lambda \eta_t + \chi u_t$, $\gamma = (\phi^d, \psi)$,

  \[ B = \begin{pmatrix} 0 & \phi^d \\ \psi S' & 0 \end{pmatrix}, \chi = \begin{pmatrix} I_{N^u} \\ 0 \end{pmatrix} \]

- We can handle heterogeneous elasticities of demand
EXAMPLES: NEW DYNAMIC MACRO MODEL

- Existing models of networks are typically rather special
  - Long Plosser '83, Acemoglu et al. '12: everything is Cobb-Douglas
  - Carvahlo-G. '13: Things go through a common aggregate good

- We write new model of macro network equilibrium, more flexible different goods have different elasticities

- \( N \) firms, by and sell from each other, with
  \[ F^i \left( (X_{ij})_{j=1...N}, L_i, K_i \right) \] and utility function \( U \left( (C_i)_{i=1...N} \right) \)

- Here, we use a “generalized CES” so elasticity of demand for good \( i \) is \( \sigma_i \)
  - E.g. demand for oil is less elastic than demand for fruit
EXAMPLES: NEW DYNAMIC MACRO MODEL

- Results, with $\hat{p}_t, \hat{y}_t =$ vectors of price, output changes
  
  $\hat{p}_t = A\hat{p}_t + (\tilde{\zeta}^s)^{-1}\hat{y}_t + u^s_t$
  
  $\hat{y}_t = -\zeta^d \hat{p}_t + A^{up}\hat{y}_t + u^d_t$

Matrices of supply and demand elasticities ($\zeta^d, \tilde{\zeta}^s$) depend on underlying industry-level elasticities of supply and demand (and input-output matrix $A_{ij} = \frac{x_{ij}}{y_i}$, and $A^{up}_{ij} = \frac{x_{ij}}{y_i}$)

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EXAMPLES: NEW DYNAMIC MACRO MODEL

- Results, with $\hat{p}_t, \hat{y}_t =$ vectors of price, output changes

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- so $Y_t := (\hat{p}_t, \hat{y}_t) = B(\gamma) Y_t + u_t$

- With some other state variables, e.g. sticky prices (frequency $\phi$ of price change), we have lags:

$$\pi_t = \phi \left( A\pi_t - \Delta \delta^s_t + (\tilde{\zeta}^s)^{-1} \Delta \hat{y}_t + \tilde{\zeta}^s \Delta \pi_{*t} \right) + (1 - \phi) \pi_{t-1}$$

$$\Delta \hat{y}_t = -\zeta^d \pi_t + A^{up} \Delta \hat{y}_t + \Delta \delta^d_t$$

- So form is $Y_t := (\pi_t, \Delta \hat{y}_t)$

$$Y_t = B^0 Y_t + B^1 Y_{t-1} + \chi u_t$$

- Model can identify $\phi$, supply and demand shocks, elasticities, pass-throughs of shocks.
Consider the recovered shock:

$$u_t(\gamma) = A^{-1}(\gamma) y_t$$

and the GDP change created by the units $\neq i$:

$$y_{t|\neq i}(\gamma) := A(\gamma) (u_t(\gamma) - e^i u_{it}(\gamma)) = y_t - Ae^i u_{it}(\gamma)$$

Use the moment, with $\Omega^i = e^i W_{ii} e^{i''}$,

$$h_{it}(\gamma) = (y_t - B(\gamma) y_t)' \Omega^i B_{\gamma}(\gamma) y_{t|\neq i}(\gamma)$$

Then, at the correct $\gamma$, for all $i$: $\mathbb{E}[h_{it}(\gamma)] = 0$.

**Proposition:** The GMM moment holds: $\mathbb{E} [\sum_{i,t} h_{it}(\gamma)] = 0$
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**Proposition**: The GMM moment holds: \( \mathbb{E} [\sum_{i,t} h_{it}(\gamma)] = 0 \)

Typically, error is \( \sim \frac{1}{\sqrt{NT}} \), so low with disaggregated data: useful for “big data” with short time series.
AGENDA FOR RESEARCH, INCLUDING CENTRAL BANKS

- Model and measure elasticities, cross-elasticities
  - Use Granular Instrumental variables (G. Koijen JPE '24), and “network GIV” (WP '24)
- Model and measure reaction functions
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- Model and measure reaction functions
- *Plea for central bankers and other influential people*
- Generalize the 13F data for stocks (i.e. institutions > $100M show their stock positions), which has been so useful since Koijen Yogo ’19, to bonds, FX, and potentially other classes (e.g. derivatives)
- The Fed would have all this information with a very small lag (a few months)
- ... and would release that to academics, perhaps with a 1 month / 5 year lago
- This way, we’ll have a better sense of the market picture, measure systemic risk, and do targeted interventions
- This would have fairly little cost, and would make a huge difference to better policy (and better economic research)
CONCLUSION

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  - Flows in inelastic markets have large impact on prices and risk premia
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- Impact for policy
  - Understanding QE for stocks, for bonds, and impact various asset classes
  - Methodology (GIV)

- Hopefully soon the methodological package will be manageable for central banks
CONCLUSION

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  ▶ Flows in inelastic markets have large impact on prices and risk premia
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  ▶ Understanding QE for stocks, for bonds, and impact various asset classes
  ▶ Methodology (GIV)
▶ Hopefully soon the methodological package will be manageable for central banks
▶ Big plea: release more holdings data (for bonds, FX, derivatives)