Predicting Inflation
Without Running Predictive Regressions

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It is difficult to predict, especially the future.— Neils Bohr

- It is extremely difficult to beat the random walk assumption in predicting future inflation rates *out of sample*.
  - Faust and Wright (2012) provide an exhaustive survey of predictive regressions on inflation rates: Virtually all of them fail to beat random walk out of sample.
  - Market surveys work much much better.

- We propose to do away with any predictive regressions, but just link the inflation rate to a short-term interest rate, and rely on the forward interest rate curve for future inflation forecasts.
  - Monetary policy rules provide a theoretical basis for a strong link between policy rate and inflation rate — This is just a bridge.
  - Relying on expectation hypothesis, we use the forward rate curve to predict future interest/ inflation rates across different horizons.

- The success depends on (i) a strong element of inflation targeting in the policy rule and (ii) validity of the expectation hypothesis to some extent.
  - Both have been rejected/rebuffed, but...
Monetary policy rule as a bridge

1. The price index $P_t$ relates to the expected inflation rate ($\pi_t$) by

$$\frac{dP_t}{P_t} = \pi_t dt + \sigma_p dW_t$$

(1)

We predict the future price index level via the prediction of future expected inflation rates.

2. The large literature on monetary policy rules provides the theoretical basis for linking the expected inflation rate to the short-term interest rate ($r_t$):

$$r_t = \alpha + \beta \pi_t + o_t$$

(2)

- $o_t$ denotes other policy considerations or policy surprises.
- The less emphasis the policy puts on “other considerations ($o_t$),” the stronger the link between the policy rate and the expected inflation.

3. The policy rule in (2) allows us to build a bridge to transform the task of forecasting future inflation into the task of forecasting future interest rates:

$$\pi_t = a + br_t + e_t$$

(3)
We rely on the *expectation hypothesis* (EH), with an average bias correction, to generate future short rate forecasts:

\[ \mathbb{E}_t [r_{t+h}] = f(t, t+h) - (f(t, t+h) - r_t) \] (4)

- \( f(t, t+h) \) denotes the time-\( t \), \( h \)-period ahead forward of the short rate.
- \( (f(t, t+h) - r_t) \) denotes the historical average of the spot-forward difference, due to risk premium and convexity effects.

The EH literature often performs a forecasting regression of the type:

\[ r_{t+h} - r_t = a + b (f(t, t+h) - r_t) + \varepsilon_{t+h} \] (5)

- The null of EH is \( a = 0, b = 1 \).
- The regressions are often used as a way of testing “time-varying risk premium.” (\( b \neq 1 \))
- One can think of (4) as assuming “locally stable” risk and risk premium.
Why should our approach work?

- The link between interest rate and inflation is a lot stronger by virtue of the policy rule than any forecasting relation on the inflation rate.
  - The estimates for a stronger relation tend to be more stable out of sample.
- Forward rates reflect market expectations of the future.
  - Market expectations (such as surveys and prices) work better than statistical dynamics estimation – *crowd sourcing*.
- Relying on the forward curves allows us to generate forecasts at high frequencies and across a wide spectrum of horizons (from months to years).
  - Direct market survey forecasts on future inflation rates should be used when available, but such forecasts are sporadic in both horizons and time series.
  - Our reliance on the forward rate curve, if works, can drastically expand the forecasting frequency and forecasting horizon.
Implementation details

1. Convert price indexes into year-over-year (yoy) realized inflation rates:

\[ p_{t+1} \equiv \ln(P_{t+1}/P_t) = \int_t^{t+1} \pi_s ds - \frac{1}{2} \sigma_p^2 + \sigma_p (W_{t+1} - W_t) \]  

We use yoy realized inflation rate to smooth over seasonalities and henceforth use \( \pi_t \equiv \int_t^{t+1} \pi_s ds \) to denote the average expected inflation rate over this period.

2. Estimate a contemporaneous relation between inflation and interest rates:

\[ p_t = a + b \bar{r}_t + e_t \]  

We use the 3-month T-Bill rate to proxy the short rate \( r_t \) and use the annual average of the daily rates (\( \bar{r}_t \)) to match the yoy inflation rate.

We estimate the relation using a 10-year rolling window.

Stationary monetary policy rules suggest that the slope estimate \( \hat{b} \) be positive but less than one.
Implementation details

3. Forecast future short rate with the forward rate curve

\[ E_t[r_{t+h}] = f(t, t+h) - (f(t, t+h) - r_t) \] (8)

- The average bias-correction term \((f(t, t+h) - r_t)\) is estimated over the same 10-year rolling window.

4. Translate the interest-rate forecast into an expected inflation rate forecast:

\[ E_t[p_{t+h}] - p_t = \hat{b}_t (E_t[r_{t+h}] - r_t), \] (9)

- \(\hat{b}_t\) denotes the rolling-window policy link estimate.
- The random walk benchmark (RW) is defined as \(E_t[p_{t+h}] - p_t = 0\).

5. We measure out-of-sample forecasting performance via an R-squared measure defined over the RW benchmark,

\[ R^2 = 1 - \frac{\sum (p_{t+h} - E_t[p_{t+h}])^2}{\sum (p_{t+h} - p_t)^2}. \] (10)

\(R^2 > 0\) if the forecasts beat random walk out of sample.
A cursory survey of the inflation forecasting literature

- Virtually all methods surveyed by Faust and Wright (2012) rely on some forecasting dynamics specification:

\[
E_t [p_{t+h}] - p_t = a + bX_t
\]

where \( X_t \) can be

- past realized inflation rates: AR(1), AR(2), Fixed \( \rho \)
- hidden states: expected inflation rates, ...
- interest rates, their principal components

The general findings:

- It is difficult for any of these forecasting dynamics to beat the simple random walk assumption out of sample.
- The more complicated the dynamics specification, the worse the out of sample performance.
- Market surveys (or specs embedding market surveys) perform better.

Bottom line: *When the relation is weak, estimation errors can dominate, especially out of sample, and more so with more complicated specifications.*
Data

We collect data from different sources over a 50-year sample period from June 30, 1962 to June 30, 2012

- **Interest rates**: Daily (extended) Nelson-Sigel stripped continuously compounded spot rates from the Federal Reserve Board
  - We use the 3-month rate to proxy the short rate $r$ and compute $h$-month forwards of the 3-month rate, with $h$ from 1 to 60 months.
  - At each date, we compute the daily averages over the past year of the spot and forward rates to match the yoy inflation rate.

- **Inflation indexes**: Monthly (core) CPI, (core) PCE deflator from Federal Reserve Bank of Saint Louis
  - We compute yoy realized inflation rates from these prices indexes.
  - We match the interest rates with the frequency of the inflation data for policy-link regressions and out-of-sample forecasts
    - 601 monthly observations
## Summary statistics

<table>
<thead>
<tr>
<th>Statistics</th>
<th>CPI</th>
<th>CCPI</th>
<th>PCE</th>
<th>CPCE</th>
<th>CPI</th>
<th>CCPI</th>
<th>PCE</th>
<th>CPCE</th>
<th>CPI</th>
<th>CCPI</th>
<th>PCE</th>
<th>CPCE</th>
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<td>Auto</td>
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<td>0.79</td>
<td>0.87</td>
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<td>0.92</td>
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<td>CC</td>
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<td>0.90</td>
<td>0.87</td>
<td>0.85</td>
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</table>

Inflation rates are yoy; interest rates are annual averages of daily observations.

Auto’ — annual non-overlapping autocorrelation,
CC — cross-correlation with 3-m spot rate,

- Interest and inflation rates show similar magnitude, similar variation, similar persistence, and strong cross-correlation.
  - Core measures are more persistent than raw measures.
  - Expectations (rates) are more persistent than realizations.
The time series behavior

- The interest rates show strong co-movements with inflation.
- The 4 inflation rates move closely together.
Monetary policy under different regimes

\[ p_t = a + b\bar{r}_t + e_t \]

<table>
<thead>
<tr>
<th>Price Index</th>
<th>( \hat{a} )</th>
<th>( \hat{b} )</th>
<th>( R^2 ), %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td><strong>A. June 1962-June 2012</strong></td>
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<td></td>
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<tr>
<td>CPI</td>
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<td>CCPI</td>
<td>0.37</td>
<td>( 0.45 )</td>
<td>0.66</td>
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<tr>
<td>PCE</td>
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<tr>
<td>CPCE</td>
<td>0.61</td>
<td>( 0.36 )</td>
<td>0.53</td>
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<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>B. June 1962-September 1979</strong></td>
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<tr>
<td>CPI</td>
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<td>( 0.71 )</td>
<td>1.62</td>
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<tr>
<td>CCPI</td>
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<td>1.43</td>
</tr>
<tr>
<td>PCE</td>
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<tr>
<td>CPCE</td>
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<td>( 0.86 )</td>
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<td></td>
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<tr>
<td><strong>C. October 1979-June 2012</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPI</td>
<td>0.82</td>
<td>( 0.60 )</td>
<td>0.50</td>
</tr>
<tr>
<td>CCPI</td>
<td>0.47</td>
<td>( 0.47 )</td>
<td>0.57</td>
</tr>
<tr>
<td>PCE</td>
<td>0.75</td>
<td>( 0.50 )</td>
<td>0.43</td>
</tr>
<tr>
<td>CPCE</td>
<td>0.59</td>
<td>( 0.39 )</td>
<td>0.46</td>
</tr>
</tbody>
</table>

Policy rate response to inflation has been a lot stronger after since Volker.
The rolling-window slope estimates

Slope estimates from the 10y rolling window estimation.

![Graph showing slope estimates over time for various series such as CPI, CCPI, PCE, and CPCE.](image)
Expectation hypothesis regressions revisited

EH at different horizons: \( r_{t+h} - r_t = c^h + d^h(f_{t,h} - r_t) + e_{t+h} \).

10-year rolling window slope estimates

Solid line–1yr horizon; dashed line: 5yr horizon.

- Huge variation around the null.
- Simulation of standard models generate similar results.
Nobody beats the expectation out of sample!

Out-of-sample forecasting R-squared on future interest rates

- Solid line: EH regression: $r_{t+h} - r_t = c^h + d^h(f_{t,h} - r_t) + e_{t+h}$.
- Dashed line: Assume the null of EH holds: $d^h = 1$.
- Implications ...
Dramatically outperforms the random walk assumption in forecasting future inflation rates.
Inflation prediction \textit{with} predictive regressions

A. AR(1)

B. AR(2)

C. 3m rate

D. 3m+5y rate

\textit{Don't do it!}
Future research: Implementation details

Our simple implementation illustrates the power of the basic approach, but devils are in the details.

- Policy can change over time.
  - Rolling window estimation can partially accommodate the relational changes due to regime switches.
  - Add strong priors if you understand the current policy better.

- Different price indexes differ in their construction and hence in their timeliness of capturing the actual inflation.
  - The strongest link between the yoy price change and interest rates may not happen contemporaneously, but can be at different leads or lags for different price indexes.

- Combine market surveys with the forward curve
  - Surveyed forecasts on inflation rates perform very well, but they are updated very infrequently, and available only at a few limited forecasting horizons.
  - New inflation derivative products: inflation swaps
The idea of mapping economic forecasts to the forward interest rate curve can be readily adapted to other economic variables, such as unemployment rate, real GDP growth, mortgage rates, deposit rates, ...

- Unemployment rate is closely related to business cycle and is often a direct target for monetary policy.
- Many commercial rates use the base rate as the benchmark and often expand proportional to the base rate.

Joint prediction of a large array of economic variables in a state-space representation

- Many economic indicators are simply noisy representations of the same underlying economic conditions — inflation, real GDP growth, economic uncertainty
- Linking these economic indicators on the one hand and the interest rate (and credit spread) term structure on the other hand via a low-dimensional economic factor model, one can generate joint predictions on both the underlying economic conditions and the future path of each of these economic indicators.
Concluding remarks

- In the forecasting literature, the general consensus is that market expectations derived from financial security prices or collected via surveys perform better than a pure statistical specification.

- Direct market forecasts are the most direct and simple, but they are not always available.

- We propose to link the inflation rate to the interest rate so that we can lever the forward rate curve to generate timely inflation forecasts across the whole spectrum of horizons.
  - The out-of-sample forecasting significantly outperforms random walk, and much better than most statistical forecasting approaches.

- After thoughts:
  - All risk premiums are “time varying” if you estimate them via in-sample predictive regressions, but whether you can exploit such variation out of sample is a different issue.
  - Ross recovery theorem: One can separate the expectation from the risk premium without running a predictive regression.