Predicting Inflation without Predictive Regressions

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It is extremely difficult to beat the random walk assumption in predicting future inflation rates.

- Faust and Wright (2012): Virtually all predictive regressions (reviewed in the paper) fail to beat random walk out of sample.
- Market surveys work much better.

We propose to do away with any predictive regressions, but just link the inflation rate to the short-term interest rate, and piggy-ride the forward interest rate curve for future inflation forecasts.

- Monetary policy rules, e.g., the Taylor rule, provides a theoretical basis for a strong contemporaneous link between short rates and inflation.
- Relying on expectation hypothesis, we can piggy-ride on the whole forward rate curve to predict future inflation rates over both short and long horizons.

No predictive regressions on run or tested. Only a simple, strong contemporaneous link is estimated: — Out of sample stability is there by design.
The theoretical basis

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

\[
\frac{dP_t}{P_t} = \pi_t dt + \sigma_p dW_t \tag{1}
\]

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 ($r_t$):

\[
r_t = \alpha + \beta \pi_t + x_t \tag{2}
\]

- $x_t$ denotes other policy considerations or policy surprises.
- The less emphasis the policy puts on “other considerations ($x_t$),” the stronger the link between the policy rate and the expected inflation.
- The policy link in (2) translates the problem of forecasting future inflation rate into the problem of forecasting future short-term interest rate.

3. We forecast future policy rates (and hence inflation rate) via the *expectation hypothesis* (EH).
We rely on the expectation hypothesis, with an average bias correction, to generate future short rate forecasts:

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

(3)

- \( f(t, t+h) \) 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 rationale behind the average bias correction

- Risk premium tends to push the forward curve up.
- Convexity effect tends to push the forward curve down.
- The average bias correction in (3) assumes that the two effects are relatively constant over a rolling window period.
The literature on expectation hypothesis

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

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

(4)

- The null of EH is \( a = 0, b = 1 \).
- \( b \neq 1 \) suggests “time-varying risk premium,” the focus of a large strand of literature.
  - The regressions are often used as a way of testing “time-varying risk premium.”
  - Many studies document the regression slope deviations from the null of one (“term premium puzzle”) and many others propose models to accommodate time-varying risk premium.
- We refrain from such (or any) forecasting regressions and only perform an average bias correction for simplicity and out-of-sample stability.
- One can think of (3) as assuming (locally) constant risk and risk premium.
Virtually all methods surveyed by Faust and Wright (2012) rely on some forecasting time-series dynamics specification:

$$E_t [\pi_{t+h}] - \pi_t = a + bX_t$$

where the forecasting variables $X_t$ can be

- past realized inflation rates: AR(1), AR(2), Fixed $\rho$
- hidden states: expected inflation rates, ...
- Interest rates (or their principal components/factors)

The general findings are:

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

Bottom line: \textit{When the relation is weak, estimation errors can dominate, especially out of sample, and more so with more complicated specifications.}
Why should our approach work better?

- The contemporaneous link between interest rate and inflation is a lot stronger by virtue of policy than any forecasting relation on the inflation rate.
  - The estimates for a stronger relation tend to be more stable.
- Forward rates reflect market expectations of the future.
  - Evidence suggests that market expectations work better than statistical dynamics estimation.
- Direct market surveys on future inflation can be useful, but they are spotty (infrequent) and over short horizons.
- Relying on the forward rate curve allows us to generate forecasts at high frequencies and across a wide spectrum of horizons (from months to years).
  - Given the positive evidence, direct market survey forecasts on future inflation rates should be used when available, but such forecasts are sporadic in updating frequency and limited in forecasting horizons.
  - Our reliance on the forward rate curve, if works, can drastically expand both the forecasting frequency and the forecasting horizon.
Implementation details

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

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

   - We use yoy realized inflation rate to smooth over seasonalities and henceforth use \( \bar{\pi}_t \equiv \int_t^{t+1} \pi_s ds \) 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.
Forecast future short rate with the forward rate curve

\[ \mathbb{E}_t [r_{t+h}] = f(t, t+h) - (f(t, t+h) - r_t) \] (7)

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

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

\[ \mathbb{E}_t [\pi_{t+h}] - p_t = \hat{b}_t (\mathbb{E}_t [r_{t+h}] - r_t) , \] (8)

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

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

\[ R^2 = 1 - \frac{(p_{t+h} - \mathbb{E}_t [p_{t+h}])^2}{(p_{t+h} - p_t)^2} = 1 - \frac{MSE_{model}}{MSE_{RW}} . \] (9)

\(R^2 > 0\) if the forecasts beats random walk out of sample.
Forecasting without predictive regressions:

- Estimate a contemporaneous link between inflation and interest rate
  - Contemporaneous relations are often stronger and hence more stable than forecasting relations.
- Use forward rate as forecasts of future interest rates.
  - The forecasting horizon can be as long as the maturity spectrum of the forward curve, much longer and more refined, and updated much more frequently, than any market survey inflation forecasts.
- No forecasting relation is directly specified or estimated.
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 and (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 on CPI and PCE yoy inflation rates.
## Summary statistics

<table>
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<th>Statistics</th>
<th>A. Spot interest rates</th>
<th>B. Yoy realized inflation rates</th>
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<tbody>
<tr>
<td></td>
<td>3m</td>
<td>6m</td>
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<tr>
<td>Mean</td>
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<tr>
<td>$\rho$</td>
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<td>0.87</td>
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<tr>
<td>$c_0$</td>
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<td>1.00</td>
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</tbody>
</table>

- Interest rates statistics are on yoy averages of daily rates.
- “$\rho$” — annual non-overlapping autocorrelation.
- “$c_0$” — cross-correlation with contemporaneous 3m interest rate.
- Interest and inflation rates show similar magnitude, similar variation, similar persistence, and strong cross-correlation.
Interest rates show strong co-movements with inflation rates.
The 4 measures of inflation rates move closely together.
Core inflation rates show less transitory movements.
The sample average of the slope estimates are between 0.44 and 0.67, close to Taylor’s prescription (1/1.5).

The high slope estimates in the 70’s may suggest non-stationarity in the monetary policy at that time.

The low \( \hat{b} \) and \( R^2 \) estimates after 2000 may be the curse of the policy success — The policy has successfully contained the variation of inflation, and has thus made the policy link harder to identify ex post.
Our simple approach dramatically outperforms the random walk assumption in forecasting future inflation rates.

Over horizons from 1 to 5 years, the outperformance averages at 44%, 40%, 41%, 30%, respectively for the four inflation series.
Forecasting based on forecasting dynamics

- Most of the forecasting dynamics specification in the literature can be summarized by the following generic specification:

\[ p_{t+h} - p_t = b \left( X_t - \bar{X} \right) + e_{t+1} \]

- We consider a few examples:
  1. AR(1): \( X_t = p_t \).
  2. AR(2): \( X_t = [p_t, p_{t-1}] \)
  3. One interest rate: \( X_t \) being 3-month rate.
  4. Two interest rates: \( X_t \) being 3-month and 5-year rate.

- We estimate each relation using the same rolling window and perform out-of-sample forecasting exercise.

- One can also directly specify the forecasting dynamics on the inflation rate levels (instead of changes), \( p_{t+h} = b \left( X_t - \bar{X} \right) + e_{t+1} \), but the estimated relation may not even fit the current observed inflation rate.
Out-of-sample forecasting performance

\[ p_{t+h} - p_t = b (X_t - \bar{X}) + e_{t+1} \]

AR(1)

\[ p_{t+h} - p_t = b (X_t - \bar{X}) + e_{t+1} \]

AR(2)

None outperforms random walk!

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Out-of-sample forecasting performance

\[ p_{t+h} = b(X_t - \bar{X}) + e_{t+1} \]

\( \text{AR}(1) \)

None outperforms random walk!

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Revisit the expectation hypothesis

- The literature on expectation hypothesis is huge, mostly saying that various forms of the hypothesis are violated.

- The more recent focus is on the implications of the slope coefficient estimates on the “time-varying” nature of the risk premium specification.

- Our focus is on out-of-sample forecasting performance: If forward rates predict future short rates with high R-squared, they can be used to predict future inflation rates via the link between short rate and inflation.

- Expectation hypothesis regressions often find evidence for “time-varying risk premium”, but evidence is sparse on whether allowing time-varying risk premium generates better *out of sample forecasting performance*. 
Revisit the expectation hypothesis

- We consider two interest-rate forecasting specifications:

\[ (i) : \quad \mathbb{E}_t [r_{t+h} - r_t] = a + b (f_{t,h} - r_t) \]
\[ (ii) : \quad \mathbb{E}_t [r_{t+h} - r_t] = (f_{t,h} - r_t) - f_{t,h} - r_t \]

- Specification (i) is based on a standard EH regression, which allows a free slope coefficient estimated from the regression.
  - A coefficient significantly different from one suggests time varying risk premium.
- Specification (ii) assumes constant risk and constant risk premium so that the forward and the short rate can differ only by a constant, which we estimate using the sample mean of a rolling window.
  - This specification is what we have been using in our inflation forecasting.
  - We can switch to the more flexible specification in (i) if it generates better out of sample forecasting performance.
Expectation hypothesis is hard to beat out of sample!

The rolling-window regression slope estimates are all over the place...
- Either EH is violated, or the estimates have tons of noise in it.
- The slope estimates are closer to one (EH) in more recent period.

The out-of-sample forecasting performance of the regression estimates is a lot worse than simply assuming the expectation hypothesis.
- The expectation hypothesis can beat the random walk over horizons greater than 18 months.
- The regression approach can rarely beat the random walk.

The whole literature on explaining “time-varying risk premium” is all for naught?
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 predictive regression specification.

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

- Some new derivative contracts (e.g. inflation swaps) can be useful, too, when available and reliable.

- 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.
Further research: Specification analysis

Our simple implementation illustrates the power of our 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, but how to choose the rolling window length is up to research/debate...

- 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.
  - The lead/lag relation can also vary across policy regimes, depending on whether the policy is forward or backward looking.

- 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.
Future research: Expansions

- 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.
  - The super-long forecasting horizon can be particularly useful in certain applications.
- Joint prediction of a large array of economic variables
  - Many economic indicators are simply noisy representations of the same underlying economic conditions — inflation, real GDP growth, ...
  - 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.