The Layman's Summary of The Expected Bond Return Literature

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January 9, 2016

Expected returns are what we expect to earn over the next year if we choose to invest today. The expected return is not plucked out of thin air, but is modeled by our hero: The Econometrician. In scholastic seminars, he explains how to interpret expected bond returns, and in client emails, the intuition behind why he expects his models to work for the foreseeable future. He takes the time to review how to decompose expected returns into a real, inflation, liquidity and monetary policy risk premium. He is the hero because he is able to effectively communicate his ideas and expand his framework when new predictors emerge in the literature. Two such predictors include the banks' income gap, put forth by Haddad and Srear (2015), and a related measure, mortgage duration as championed by Hanson (2014). He also finds ways to work in older ideas by establishing simple strategies to look at how other variables related to bond yields influence changes in the shape of the curve. The Econometrician embraces clarity and would argue that, despite its growing popularity among academetricians, the affine term structure model provides absolutely no gain in understanding the source of expected returns for common men.

The surprisingly short-life of the asset pricing literature has produced an equally surprising long list of synonyms for expected bond returns: term premium, term premia, ex-ante returns, bond risk premia, bond risk premium and expected return. This should immediately help remove part of the confusion you have been experiencing. Expected returns are *forecasts,* not *realizations*. A tabled history of what excess Treasury returns have averaged *are not* expected returns, but *ex-post returns*. Ex-post returns are never totally *expected* before hand.

Treasury returns are forecastable and investors should try to learn about the models available to them. Although there may be benefits to short-term momentum strategies, there are larger gains to knowing where returns are expected to come from.[2] In my short series of notes, I have attempted to clearly explain how to forecast returns, provided out-of-sample evaluations and a reliable framework for understanding the building blocks. They are sufficiently rigorous, provide an opportunity to have a benchmark, and most importantly are easily accessible to those familiar with basic regressions. This note is mainly a summary of those efforts. Yet my pursuit of knowledge also gives rise to a criticism of the rising popularity of a certain class of term structure models.

The term structure literature has a stubborn reliance on affine term-structure models (AFTSMs). The benefits they provide to in-sample fit are more than sacrificed when considering intellectual accessibility. I don't think practical investors will ever use them, and might not even know *of* them, mainly because purely statistical AFTSMs lack intuition. There

[1] I am currently working for Dynex Capital, although the thoughts expressed in this note do not apply to the firm, it's internal methodologies for forecasting returns, or anything else. This note is solely my enterprise and does not express the views of DX in anyway, shape or form. Email: sabol.steven@gmail.com

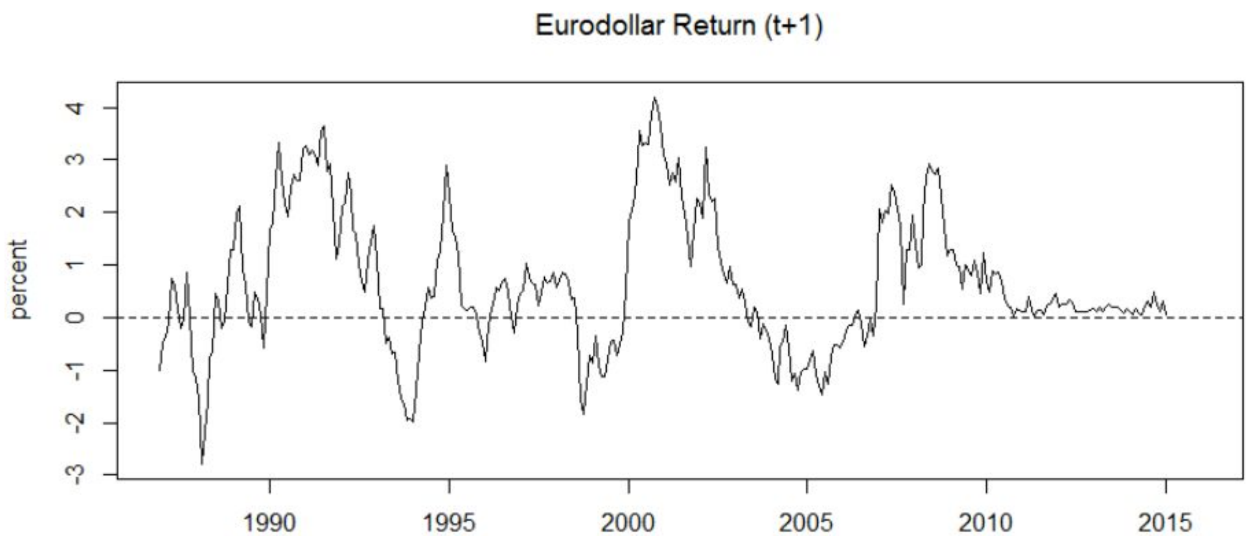
[2] Momentum is a purely statistical factor which does not make much sense in a model of expected Treasury returns. It is not a real risk faced by any market participant, and if it was it would be interpreted as the following: The returns from momentum are expected to be non-zero when current momentum is different from that expected after conditioning on some fundamental variable. Since that statement doesn't make any intuitive sense, neither does momentum.

may only be a few blank stares when job candidates present their particular version of this class of model at the Federal Reserve. Yet those blank stares approach unity when the same paper is presented to a group of sophisticated investors. My beef is not with models that use surveys and other observables to ground them in reality. Although many are out there, I chose to empirically compare my approach with that of the popular Adrian, Crump and Moench (2013) model. Despite the failure of a few academics to use parsimonious models, there are a few outstanding authors that proved invaluable to my understanding. I provide a short-list of my favorite papers in the appendix for anyone interested in getting into this literature.

Before I take you on this carpet ride through expected return land, I think it is important to know *why* I think that the models presented here work, and will continue to do so in the future. My view is that predictability in bond returns is mainly the result of the heated friction between The Rogue Econometrician and the market. The news media is on the side of the market.

The news media is The Econometricians' best friend. They propagate and mislead the blind into assigning importance to noise. They help create predictability in both short and long-term bonds. The Econometrician thanks you, CNBC. It is mentally stimulating to think about the role the media plays, writing stories about headline figures and often failing to dig deeper. The consumer of financial news is partly to blame, they love the hedgehogs. The one-sided views often shared create an overly confident financial news consumer.

One-sided views are frequently observed in the eurodollar futures market. Practitioners know that eurodollar futures move everyday to the rhythm of macro news surprises in domestic and international markets. Yet the news flow and inattention cause the market to make persistent one-sided errors about the future course of monetary policy.



Consider a world in which the market perfectly forecasted the Fed: returns on eurodollar contracts would be random and normally distributed. As the figure above shows, even for a one-year ahead contract, randomness is clearly not the case, and so returns by way of the Fed are somewhat predictable.

Perhaps the market is not paying enough attention to The Econometrician. The Econometrician is well aware that the Fed has historically placed the greatest weight in its reaction function on a few key variables, and these predict the Fed's behavior. He has a specific framework in mind: one that is motivated by theory and empirical evidence. He wears a forest green cardigan with leather elbow patches and his internet history is filled with past visits to the websites of the major federal government statistical agencies. The interpretation of the facts are solely up to him and he trusts no one. He knows that if he succumbs to the human biases and emotions brought about by talking heads - he will lose his edge - and concepts like group think are things he has read about. He is familiar with the literature findings on the impact the news media has on asset returns.

There are many studies about the news creating predictability in financial markets. Hedgehog financial journalists tend to amplify equity price movements in the same direction as their green-tinted views.[3] The stock market reacts to stale news if it is reported in the media, because it gives the impression of being “new” news.[4] There is even an aggregation effect in news stories - stories that are aggregated into a more complex one lead equity prices to jump, despite the fact that the aggregated stories contain stale news.[5] This article uses the aggregation effect: It brings together separate strands of literature on bond returns, and shows they’re not so separate.

Perhaps the most egregious example of stale news moving markets pertains to equity and Treasury futures markets reacting to “surprises” in the monthly release of the Leading Economic Indicators (“LEI”).[6] The market fails to “expect” correctly the LEI, despite the fact that all of its sub-components are available before the official release! The response of The Econometrician is to calculate the LEI before the release, check the expectation, and trade the “surprise”. The evidence suggests to The Econometrician that people are not paying sufficient attention to publically available information.

A well cited paper about expectational errors being forecastable is Bacchetta, Mertens, and Van Wincoop (2009).[7] They find that predictable expectational errors forecast returns in foreign exchange, stock and bond markets. Like The Econometrician, they condition their expectational errors forecasts on a few key sources of fundamental information. Sometimes less really is more. They only focus on the fundamental information, and thus are sufficiently distanced from the noise. I am not saying models are perfect representations of reality, but if they are realistic - and contain most of the important

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[3] Dougal, C, J Engelberg, and D Garcia. "C. Parsons, 2012, Journalists and the stock market." *Review of Financial Studies* 25: 639-679.

[4] Pinnuck, Matthew. "The New York Times and Wall Street Journal: Does Their Coverage of Earnings Announcements Cause “Stale” News to Become “New” News?." *Journal of Behavioral Finance* 15, no. 2 (2014): 120-132.

[5] Fedyk, Anastassia and Hodson, James, Aggregation Effect in Stale News (November 18, 2014). Available at SSRN: http://ssrn.com/abstract=2433234

[6] Kogan, Shimon and Gilbert, Thomas and Lochstoer, Lars A. and Ozyildirim, Ataman, Investor Inattention and the Market Impact of Summary Statistics (July 27, 2011). Management Science, Forthcoming. Available at SSRN:http://ssrn.com/abstract=1108050

[7] Bacchetta, Philippe, Elmar Mertens, and Eric Van Wincoop. "Predictability in financial markets: What do survey expectations tell us?." *Journal of International Money and Finance* 28, no. 3 (2009): 406-426.

attributes inherent in the real world - they will work well. The models presented in this paper will only fail if there is a *drastic* change in the behavior and attitudes of market participants.

Perhaps the best empirical evidence on why models grounded in the fundamentals perform so well is provided by Altavilla, Giannone, and Modugno (2014).[8] They find that macro news explains about one-third of the quarterly variation in long-term bond yields. When focusing on a higher frequency, i.e. daily, the share drops to one-tenth! They state: *“Non-fundamental factors, instead, substantially influence the day-to-day movements of bond yields, but their effects are short-lived and mean-reverting.”* There is value in conditioning bond forecasts on fundamental information and avoiding the noise - the noise washes out.

It is also well documented that after large swings in oil prices longer-term market inflation expectations comove with oil prices.[9] Yet there is no empirical support for oil price fluctuations impacting inflation past an annual horizon.

As a bond investor, you are bombarded every single day with emails about short-term curve strategies, momentum, the Fed, liquidity updates, and tracking estimates of economic growth. But how on earth do you process all this information? Why are you expected to magically consume the whole internet - as if you are the great English detective Sherlock Holmes or IBM’s WATSON - and draw clear conclusions?

The place to start is to first come up with a simple, yet flexible model, for thinking about things. Keeping things parsimonious is the key to understanding. The adjective, *parsimonious*, means unwilling to use resources; to be stingy or frugal. We have to be stingy in modeling, that is the only way normal people with average intelligence can grasp it. An intuitive model will enable you to anticipate its potential failures when events outside the model unfold. What do nominal bond yields reflect?

The Building Blocks	Reflect Market Expectations about	Also reflect institutional aspects
Nominal yields =	Real interest rates, expected inflation, expected bond returns, and expected short-term rates	Market-wide liquidity premiums; sensitivity to changes in interest rates
+ Real Yields	Real expected growth	Bond buying programs
+ Breakeven Inflation	Expectations for inflation	Liquidity differential between TIPS and nominal Treasuries; positive correlation with oil after large moves in oil prices
+ Liquidity yield	Fear in the market place	Convenience of funding Treasuries and low bid-ask spreads
+ Expected Bond Returns	Returns from inflation, real yields, predictable changes in liquidity conditions, changes in the stance of monetary policy	

[8] Altavilla, Carlo, Domenico Giannone, and Michele Modugno. "The Low Frequency Effects of Macroeconomic News on Government Bond Yields." 2014-52 (2014).
[9] Lumsdaine, Robin L. "The relationship between oil prices and breakeven inflation rates." *Available at SSRN 1529487* (2009).

The building blocks are shown in the table above. The human mind is a powerful tool, and yours is the best defense against overfitting, unreasonable forecasts, and even your own cognitive biases.

The Source of Excess Returns: Econometrician vs. The Market

The source of expected returns are inherently the consequence of a difference of opinion. Whose opinion are you going to trust? The Econometrician or the status quo of the market? If it's the market then your work is already done and you can go home. Market expectations are baked into nominal yields, real yields, breakeven inflation and eurodollar futures. Nominal yields reflect expectations for real growth, inflation and bond returns. Real yields reflect expected real growth. Breakeven inflation reflects expected inflation and is contaminated by market wide liquidity conditions. It sometimes captures the misunderstandings of market participants about the relationship between large moves in oil prices and longer-term inflation. Market expectations about the future path of short-term interest rates, and thus the Fed, are hashed out in fed funds and eurodollar futures markets. As any market participant will tell you, asset prices reflect many views and institutional frictions.

The Building Blocks of Expected Returns Expected Return =	Source of Expected Return	Variables Used By The Econometrician
+ Inflation Risk Premium	When breakeven inflation deviates from survey expectations of inflation; This is the expected return from the expected change in breakeven inflation	Condition BEI on survey measures of inflation expectations; for conviction look for increased correlation between BEI and oil prices
+ Real Interest Rate Risk Premium	When real rates deviate from those predicted by expected real rates; or a proxy for expected real rates such as trend real GDP per capita	Condition real interest rates on trend real GDP per capita
+ Liquidity Risk Premium	When current liquidity conditions deviate from expected liquidity conditions, represents the temporary convenience of holding nominal Treasuries for funding in the repo markets	Since liquidity is unobservable extract liquidity component from BEI using off-the-run Treasury spread and a measure of financial conditions
+ Monetary Policy Risk Premium	The predictable return from deviations in market expected short-term rates from those eventually realized; This is the expected return on short-term bonds from forecasting the Fed better than the market	Condition returns on one-year ahead Eurodollar contracts with variables important to the Fed; Nonfarm payroll growth, core inflation and lagged values of the term spread

The Econometrician sets aside the day-to-day news and uses only a limited set of information. In fact, one could easily remark that The Econometricians' model is substantially less complicated than the markets. The piece of advice that all experienced forecasters will gladly dispense is that simple models often perform considerably better out-of-sample than those weighed down by complexity. Interestingly enough, he relates the level of yields to only one variable, trend nominal GDP growth. He deduces that he can forecast the return from breakeven inflation by using one survey based measure of inflation expectations. He also conditions his forecast of the Fed on cyclical variables that explain the Fed's past behavior: non-farm payroll growth and core inflation. The table above summarizes the sources of expected bond returns.

The Econometrician considers only a handful of variables, and his model is arguably less complicated and noisy than the markets. The end result of his efforts are that he accurately predicts excess bond returns, which means he routinely beats the market forecast. This guy is not super intelligent, and would never be capable of processing the amount of information made available to him. But his mind is focused and he sticks to what he knows. If what he knows fails, he learns to update his model by reading constantly. While outside his model, he doesn't fail to think about a few other variables thought to be linked to bond returns:

Other variables considered by The Econometrician	Link to bond returns	Institutional considerations
Supply Rate of Treasuries	A greater rate of issuance of long term bonds than short-term bonds leads to a steeper yield curve, for any constant demand	Fiscal supply shocks from automatic stabilizers such as unemployment insurance; Capital gains taxes from a equity market performance
Foreign Demand for Treasuries	Volatility in exchange rates lead to intervention by foreign central banks	Survey responses by foreign central banks on FX reserve management
Average Maturity of the debt held by the public	A lengthening of the average maturity of the public debt leads to a steepening yield curve as more supply needs to be absorbed by long-term bond holders.	Treasuries issuance choice; often driven by the decisions of the Federal Reserve; the demand for specific assets in short-supply by market participants
Mortgage Duration	Mortgage duration drives aggregate fixed-income durations, thus it drives rapid changes in interest rate risk	The propensity for holders of fixed-rate MBS to engage in hedging with interest-rate swaps and Treasuries
Banks' Income Gap	The sensitivity of bank assets and liabilities to changes in interest rates	A study of bank behavior when reacting to changes in interest rates
VIX	The gauge of world wide fear, and it's link to the preference for short-term bills over other assets	The VIX reflects worldwide anxiety and anticipated deterioration in financial conditions, thus is predicts if rates will be lower in the future

How does it all work? It helps to think about what describes most of the variation in interest rates: the level of the yield curve.

The intuition

Should we care about the level of interest rates? Yep. The level of rates is the return on the bond over its life. It's also the cushion that protects investors from price fluctuations over shorter horizons. The higher the initial yield, the greater the chances the ex-post return will be positive over the next year. A lower initial yield provides less cushion and translates to a lower expected return. The *ex-ante*, or expected return, is the total return you receive from the initial yield (coupon) plus the expected price appreciation over a given year. To understand anything, we must begin our intellectual discovery with the definition of ex-post bond returns

$$ret_{t+1}^{(n)} = y_t^{(n)} + (n-1)[y_t^{(n)} - y_{t+1}^{(n-1)}]$$

where the superscript, n, refers to the maturity. The bond return over the next period is the sum of two things:

1. The initial yield, i.e. the coupon, and you will receive this no matter what
2. The second term is the price return + rolldown $[y_t^{(n)} - y_{t+1}^{(n-1)}]$

In the next year your $y_t^{(n)}$ bond will turn into an $y_{t+1}^{(n-1)}$ bond. If the yield curve is upward sloping, the bond will "roll down" the yield curve as it gets closer to maturity, and will naturally pick up yield as its price *converges* to yield.[10] Secondly, the bond will fluctuate in price with movements in the yield curve. We take *expectations* to get our *expected* ex-ante return

$$E_t\left[ret_{t+1}^{(n)}\right] = y_t^{(n)} + (n-1)\left(y_t^{(n)} - E_t\left[y_{t+1}^{(n-1)}\right]\right).$$

After staring for about a minute, we come to the realization that two of the components of this equation are already available to us: $y_t^{(n)}$ and $(n-1)$. The only thing we need to forecast is where $y_t^{(n)}$ will be one year from today, i.e. $y_{t+1}^{(n-1)}$. This is the unknown. How are we supposed to come up with a reasonable forecast?

It is helpful to consider "fair value". A fair value model helps answer the question: Where should $y_t^{(n-1)}$ be? Technically, we care about $y_{t+1}^{(n-1)}$, but philosophically a fair value estimate of $y_t^{(n-1)}$ is a forecast of what we would expect $y_t^{(n-1)}$ to become. We *expect* that the current value of $y_t^{(n-1)}$ moves towards its fundamental value, $E_t\left[y_{t+1}^{(n-1)}\right]$, and on average,

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[10] For a great explanation of convergence to yield please see Homer, Sidney, Martin L. Leibowitz, Anthony Bova, and Stanley Kogelman.*Inside the yield book*. J. Wiley & Sons, 2013.

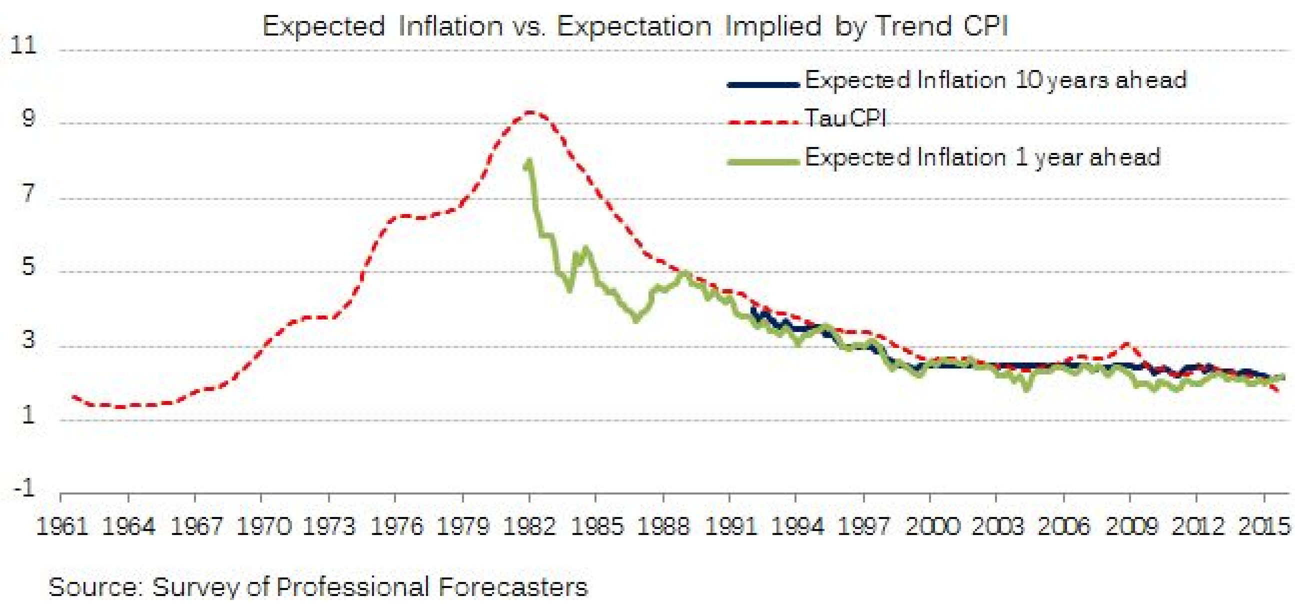
equals it at some point over the next year. If our model says that $y_t^{(n-1)}$ is lower than $E_t\left[y_t^{(n-1)}\right]$ then we - at a minimum - expect $y_t^{(n-1)}$ to rise towards the fundamental value.

What then is a good measure of fair value? Anything that relates fundamentally to the level of interest rates would be a reasonable start. One possibility is relating $y_t^{(n-1)}$ to trend nominal GDP growth

$$y_t^{(n-1)} = \gamma_0^{(n-1)} + \gamma_1^{(n-1)} * \tau_t^{GDP}.$$

The simple linear relation above says that the level of rates is related to the level of trend nominal GDP growth. Nominal GDP captures inflation, π_t, and real growth, r_t. Trend nominal GDP empirically proxies for how expectations are formed. In this case, trend inflation proxies for inflation expectations, which is slow moving and changes only gradually, and trend real GDP captures real rate expectations, which corresponds to the expected real rate of growth.[11]

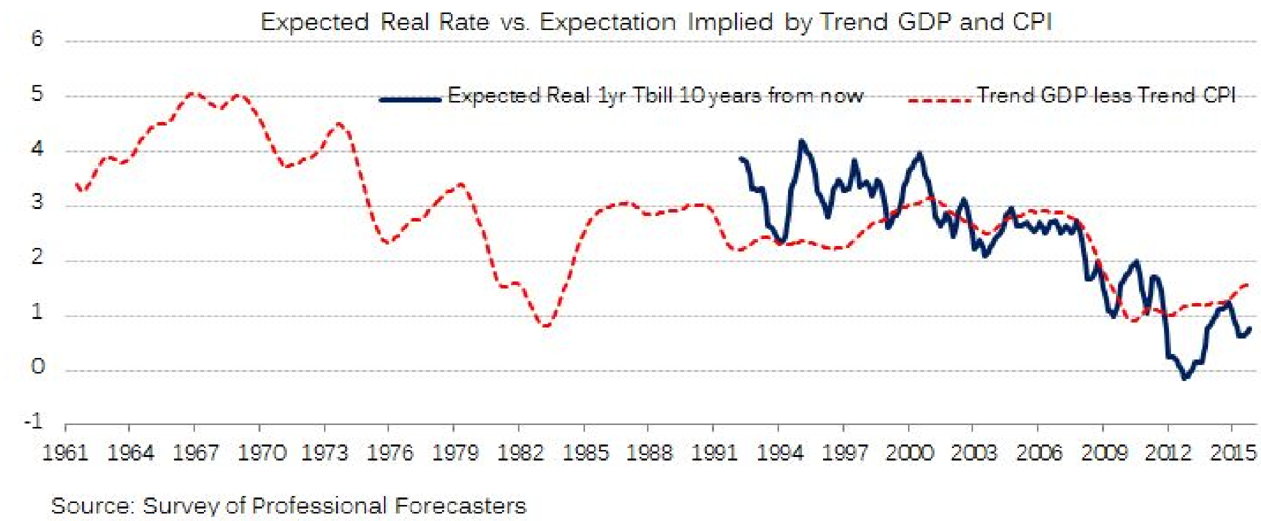
The figures show the survey expectations for inflation and real interest rates of professional forecasters. These expectations are proxied well by the two components of trend nominal GDP growth: trend inflation and trend real GDP growth. Therefore, The Econometrician is reasonably confident that these empirical measures satisfy the measurement of expectations and capture the level of the yield curve.



Yields reflect expectations, so incorporating a proxy for those expectations is essential. A discounted moving average proxies for these expectations because it changes gradually, placing the greatest weight on the most recent observations, and discounting more heavily past observations. People are most likely to remember the recent past. This relation

[11] To everyone trying to forecast bond returns with the latest annual inflation rate: stop. Let me just point out that the current inflation rate is absolutely *not* expected inflation and thus not a predictor of the level of the yield curve. It follows that it is not a proxy for expected inflation either.

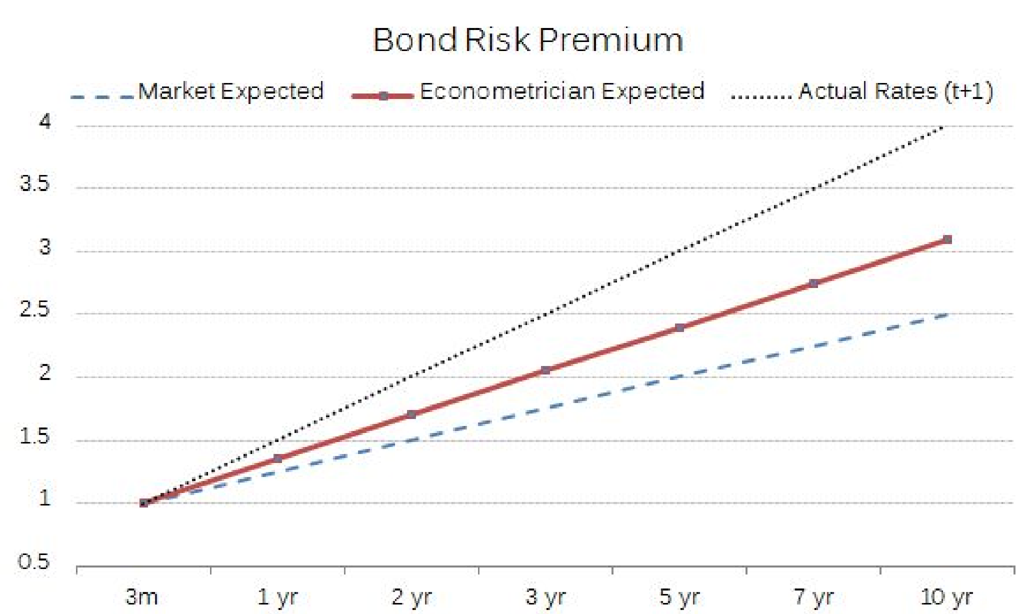
captures the level of rates and is the fisher equation. *The fisher equation is the most basic building block to understanding return predictability.*



The expected excess return relation is then,

$$E_t\left[rx_{t+1}^{(n)}\right] = y_t^{(n)} + (n-1)\left(y_t^{(n)} - [\gamma_0^{(n-1)} + \gamma_1^{(n-1)}\tau_t^{GDP}]\right) - y_t^{(1)}$$

The only difference in excess returns is the $-y_t^{(1)}$ which proxies for the cost of funding a leveraged bond position. As an illustration, the market expected, Econometrician expected and actual yield curve one year from now are depicted in the figure below. The market expects the 10 year to be 2.5% (blue-dashed line) and The Econometrician expects a little over 3% (red line). The realized ten year is 4% (black-dotted line). If The Econometrician is correct and the 10 year is greater than what the forwards are pricing in, he will receive compensation from shorting the 10 year.

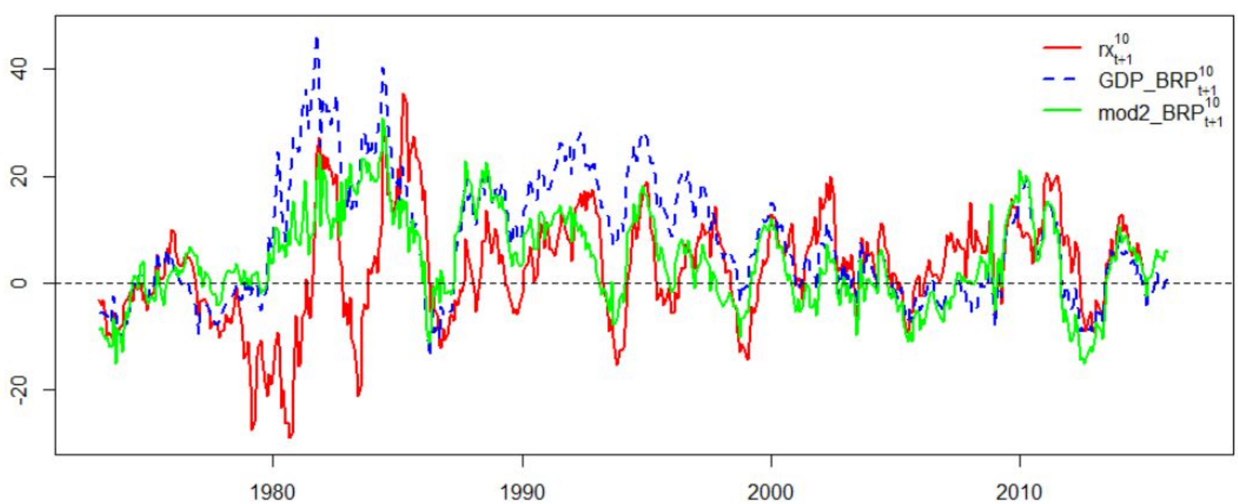


He will not only earn the expected return (the difference between the red and blue-dashed line), but also the truly unexpected return (the difference between the black-dotted and red line). The key is that he is on the right side of the yield change - not that he guessed the magnitude of the yield change correctly.

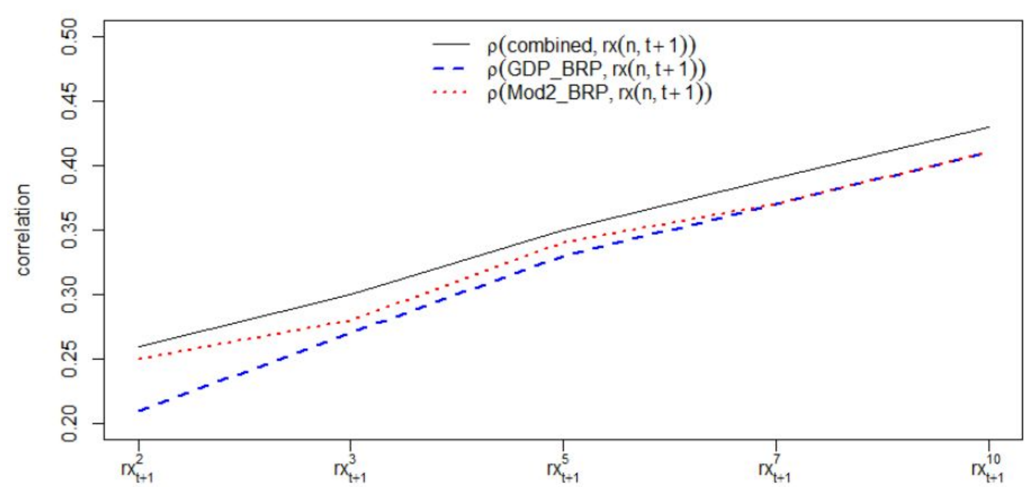
The returns to The Econometrician will be increasing in maturity, as the term premium is increasing in maturity. This simply means that forecasting the level of rates better than the market will lead to better forecasts of longer duration bond returns. This result is reflective of the statistical property that long-term rates are less volatile than short-term rates, and thus are easier to forecast.

The direct out-of-sample forecast from the GDP based model and another model called Mod 2 (not discussed here) is shown in the figure below. I use out-of-sample forecasts, whenever I can, because they are obviously more realistic and useful than in-sample fits. The figure clearly shows that anchoring the level of interest rates with the fundamentals has merit.

Bond Risk Premium as the Excess Return Forecast for the 10 year



Correlations of Direct Return Forecasts with Excess Returns



excess returns (t+1). Out-of-sample from Jan/1973 to Dec/2014, n=504

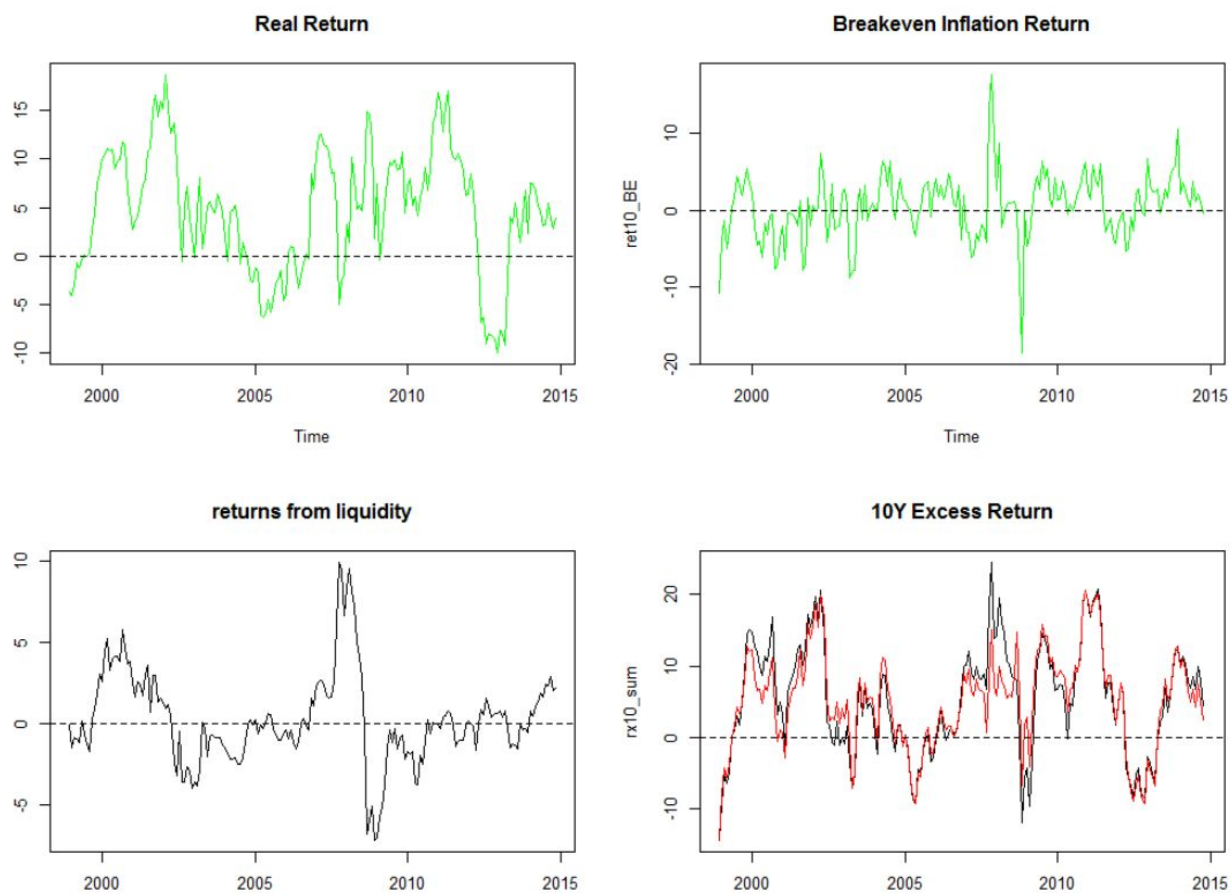
The correlation of expected returns with ex-post returns are increasing in maturity as the term premium is more important for returns on longer duration bonds (see figure above for out-of-sample correlations).

A Stylish Return Decomposition[12]

One possible decomposition of bond yields is represented by the following stylized equation:

$$y_t^{(n)} = E[Inflation_t^{(n)}] + E[Real\ Rate_t^{(n)}] + Liquidity\ Premia_t^{(n)} + IRP_t^{(n)} + RBRP_t^{(n)}$$

From this we see that the bond risk premium, or expected return, comes from three distinct sources: Inflation, $IRP_t^{(n)}$, liquidity, $Liquidity\ Premia_t^{(n)}$, and real interest rate risk, $RBRP_t^{(n)}$. We can thus decompose the 10 year return into a return from breakeven inflation, real interest rates and liquidity (see figure below). I will discuss what these sources of return mean when we decompose each in turn.



[12] The actual version of the model that produced the figures and tables in this section are from an earlier paper: Sabol, Steven. "Decomposing Expected Bond Returns." *Available at SSRN* (2015). The point of this section is to only show a *stylized* decomposition of expected bond returns, not necessarily any particular decomposition. Much of this section could not be made possible without the work of Carolin Pflueger and Luis Viceira (2014).

From January 1999 through November 2015, the 10 year return decomposition is provided below.

Arithmetic Mean Annual Returns from	10 year return decomposition
Liquidity return	.26
Real return	4.65
Breakeven Inflation return	.45

Explaining breakeven inflation

The difference between TIPS and nominal Treasury rates is called the “breakeven” inflation rate

$$BEI_t^{(n)} = y_t^{\$(n)} - y_t^{TIPS(n)} = E[Inflation_t^{(n)}] + IRP_t^{(n)}$$

which equals expected inflation and the inflation risk premium. We also have to account for the liquidity premium built into nominal treasuries and this is a good place to do just that. The liquidity premium represents the yield give up for being able to easily finance on-the-run treasuries in the repo market. They’re easy to finance when everything else is not. We can empirically come up with a fundamental estimate of the breakeven inflation rate using

$$BEI_t^{(n)} = \beta_1^L\, FinCon_t + \beta_2^L\, OTR_t^{Avg\ 5-to-10} + \beta_1^{Inf} E[Inflation_t^{SPF(10)}] + \beta_2^{Inf\ spread} \left[E[Inflation_t^{SPF(10)}] - E[Inflation_t^{SPF(1)}]\right] + \varepsilon_t^{(n)}$$

where,

$OTR_t^{Avg\ 5-to-10} = \frac{\sum_{n=5}^{10} y_t^{ACM\ Fitted,\, n}}{6} - \frac{\sum_{i=5}^{10} y_t^{USGGnYR}}{6}$ is the average on-the-run/ off-the-run spread and $FinCon_t$ is the normalized Goldman Sachs financial conditions index.

The on-the-run/ off-the-run spread reflects the liquidity premium people will pay to have an on-the-run security over an off-the-run security. This spread can be dramatic, and it proxies for market wide liquidity risk.[13] The loadings on $BEI_t^{(10)}$ is provided below.

Loadings from January 1999 through November 2015	$BEI_t^{(10)}$
$\beta_1^L\, FinCon_t$	-.17
$\beta_2^L\, OTR_t^{Avg\ 5-to-10}$	-.78
$\beta_1^{Inf} E[Inflation_t^{SPF(10)}]$	.97

[13] I use the ACM fitted yields which are very similar to the GSW yields and Bloomberg for the on-the-run yields.

$\beta_2^{Inf\ spread}$	.68

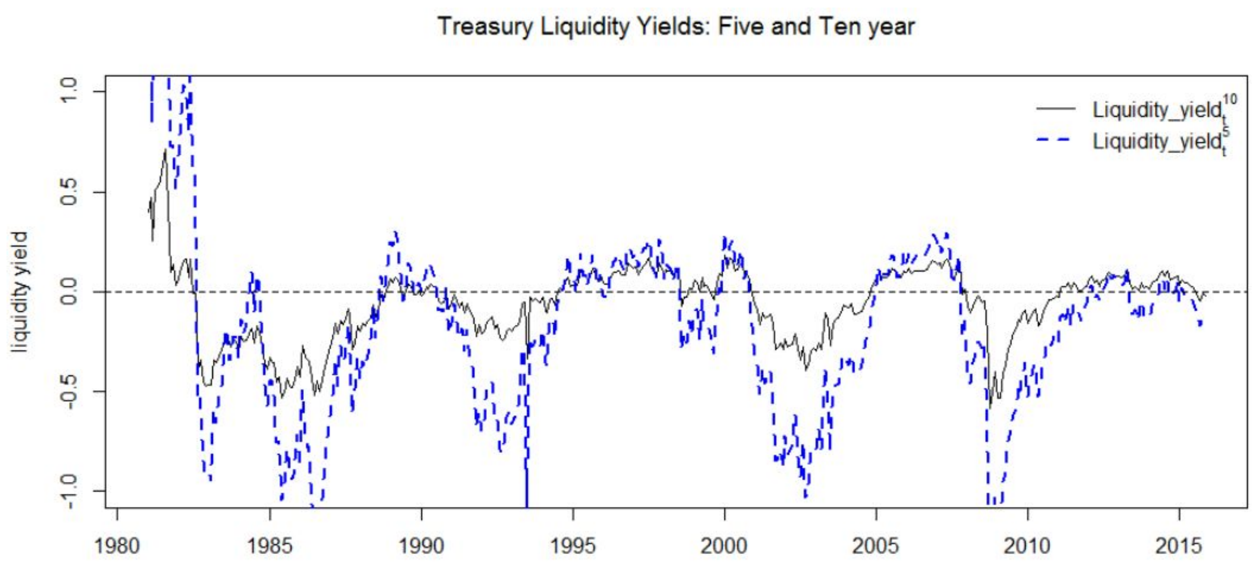
When liquidity conditions and financial conditions deteriorate, we have lower breakevens than that implied by survey based measures of inflation expectations. The loading on expected inflation is approximately one, meaning breakevens should move about one-for-one with expected inflation. The inflation expectations spread, has a positive loading, which captures that higher expected inflation in the distant future over that expected in the next year should lead to a higher breakeven.

What is the liquidity return and risk premium?

The liquidity return is the reward received for holding the most liquid fixed-income securities. The liquidity risk premium is the expected return from changes in expected financial conditions. The liquidity yield, $L_t^{(n)}$, is that part of the breakeven inflation that is explained by financial conditions and the off-the-run spread. When liquidity deteriorates, the yields on nominal treasuries fall by $L_t^{(n)}$ relative to less liquid securities. The reasoning is that when $L_t^{(n)} < 0$, Treasury holders accept a lower yield for the *convenience* of being able to fund the security in the repo market and also for the ability to sell the Treasury without much trouble. The liquidity component equals

$$L_t^{(n)} = \beta_1^L FinCon_t + \beta_2^L OTR_t^{Avg\ 5-to-10}.$$

The figure below shows the estimated liquidity yields for the five and ten year Treasuries. There is a much larger liquidity benefit to holding the shorter duration five year than there is the ten year.



Pflueger and Viceira (2011) find that the component of TIPS returns due to liquidity is

$$r_{t+1}^{L\,(n)} = -(n-1)\,L_{t+1}^{(n-1)} + n\,L_t^{(n)}$$

I suppose the liquidity risk premium would be the expected return from liquidity and this may follow some autoregressive process

$$L_{t+1}^{(n-1)} = a_0 + \phi_1 L_t^{(n-1)} + \phi_2 L_{t-1}^{(n-1)}$$

What is the real return and real bond risk premium?

The real return is the return from the level and changes in real rates. The real bond risk premium is the expected real return when real rates deviate from expected real rates. Adjusting real rates for liquidity allows us to calculate liquidity-adjusted real excess returns

$$TIPS_t^{Adj\,(n)} = TIPS_t^{(n)} + L_t^{(n)}$$

$$rx_{t+1}^{TIPS-L\,(n)} = n \times TIPS_t^{Adj(n)} - (n-1)\, TIPS_{t+1}^{Adj\,(n-1)} - \ TIPS_t^{(1)}$$

where the real short-rate is proxied by

$$TIPS_t^{(1)} = y_t^{\$(1)} - E[Inflation_t^{SPF(1)}].$$

Estimating the expected return from real rates involves conditioning real liquidity adjusted rates on a measure of real expected GDP growth per capita, τ_t^{RGDP} . The reasons I use trend real GDP per capita are that it:

A. produces great bond return forecasts
B. is a fundamental input to the fisher equation
C. is easy to interpret and can be decomposed further

Therefore, we estimate a linear model that directly links the level of real rates to our proxy for real expected interest rates.

$$TIPS_t^{Adj(n-1)} = \beta_0^{(n-1)} + \beta_1^{(n-1)}\tau_t^{RGDP}.$$

The fitted value of the above regression is our expectation of the real yield, $E_t\left[TIPS_{t+1}^{Adj\,(n-1)}\right]$, which we substitute into the real excess return relation. The expected real return is thus

$$E_t\left[rx_{t+1}^{TIPS-L\,(n)}\right] = n \times TIPS_t^{Adj(n)} - (n-1)E_t\left[TIPS_{t+1}^{Adj\,(n-1)}\right] - \ TIPS_t^{(1)}.$$

But we can also indirectly estimate the real bond risk premium. One way to accomplish this is by taking the difference between the current real yield and that predicted by the fundamental counterpart, τ_t^{RGDP}

$$RBRP_t^{(n)} = TIPS_t^{Adj(n)} - (\beta_0^{(n)} + \beta_1^{(n)}\tau_t^{RGDP}).$$

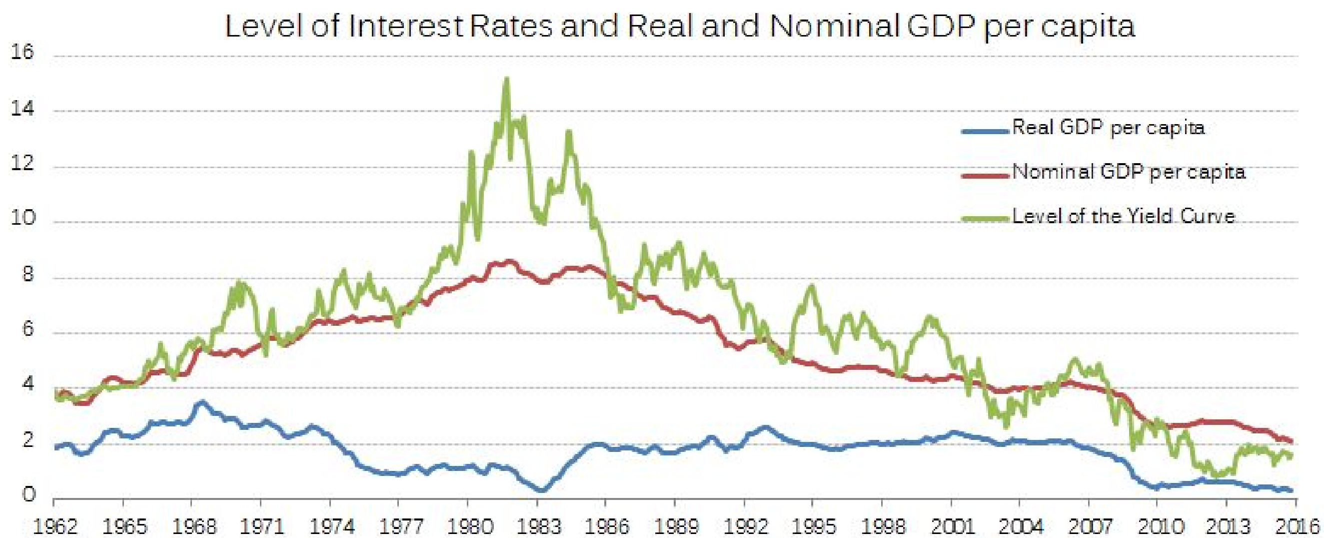
After which we can stick $RBRP_t^{(n)}$ in a forecasting regression to scale it up.

When real rates, $TIPS_t^{Adj(n)}$ are lower than the fundamentally predicted value by τ_t^{RGDP} the returns from real rates are expected to be negative. When real rates are higher than that predicted by trend real growth, then the real return is expected to be positive.

To understand what *drives* the predicted real rate, it is helpful to decompose real GDP per capita. Real GDP per capita can be decomposed into employment rate growth, labor force participation rate growth, and productivity growth:

$$\frac{Real\ GDP_t}{Pop_t} = \frac{Real\ GDP_t}{E_t} + \frac{E_t}{LF_t} + \frac{LF_t}{Pop_t}$$

Akin to instant espresso we've suddenly laid down a tasty foundation for thinking about the level of interest rates. To convince you, I plot the level of interest rates (simple average of 2 year to 10 year treasury) against 10 year annualized real and nominal GDP per capita (see below).[14] Nominal GDP per capita growth tracks the level of rates quite well.

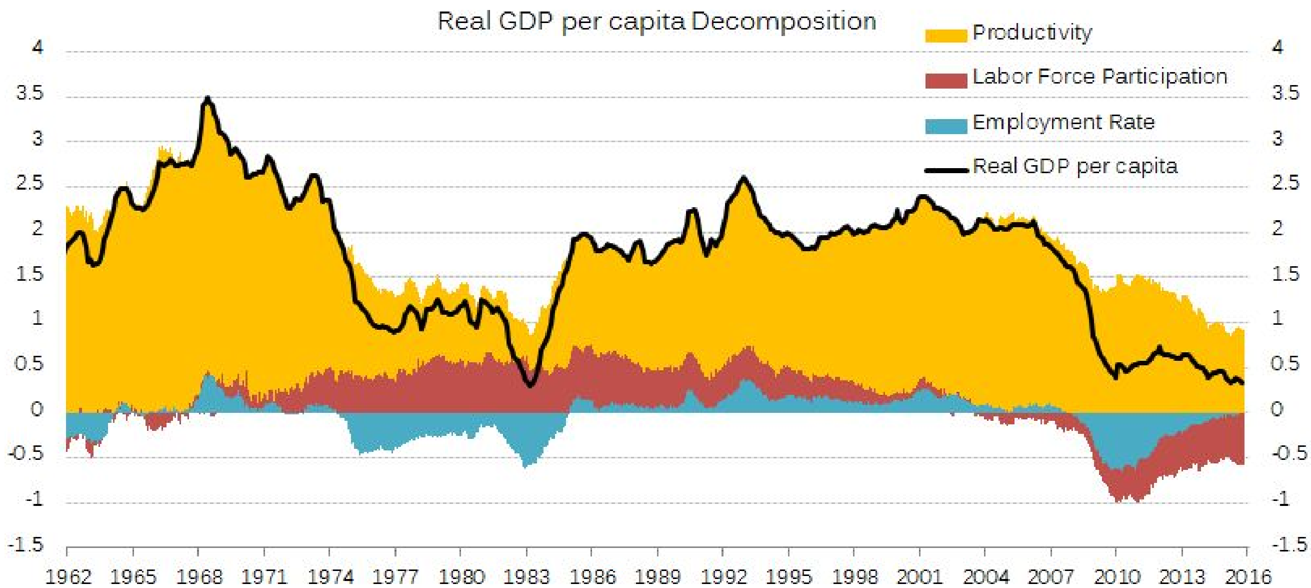


Note: 10 year annualized Real GDP per capita and Nominal GDP per capita. Level of the yield curve is the average of the 2 year through 10 year treasury rate.

The decomposition allows us to investigate the drop in real rates that occurred from 2007-2010.[15] The figure below shows the full decomposition. The decline in the real rate of growth was attributable to declines in all three of its sub-components. Yet the unprecedented magnitude and low level of trend growth is largely the result of the decline in labor force participation. The dramatic decline in participation has been deemed mostly structural and is almost entirely accounted for by the demographic composition of the labor force.[16] The only

[14] 10 year annualized growth rates end up looking a lot like the discounted moving average measures of trend.
[15] Please see Lecznar, Jonathan, Robert Sharp, and Pierre-Daniel G. Sarte. "Characterizing the Unusual Path of US Output During and After the Great Recession." *Economic Quarterly* 3Q (2013): 163-192.
[16] Please see Kudlyak, Marianna. "A Cohort Model of Labor Force Participation." *Economic Quarterly* 99, no. 1 (2013): 25-43.

thing pushing the real rate of growth up today is employment growth. Productivity growth has been sluggish in recent years.



Note: 10 year annualized Real GDP per capita decomposition.

Where do breakeven returns come from and what *is* the inflation risk premium?

For newcomers and oldtimers alike, the concept of a "breakeven return" is not easy to wrap your head around. What is it? The return from breakeven inflation is most simply the difference between the return on nominal treasuries and return on real rates

$$rx_{t+1}^{BEI\ (n)} = rx_{t+1}^{\$\ (n)} - rx_{t+1}^{TIPS-L\ (n)} .$$

We will learn that the inflation risk premium is the expected return on breakeven inflation and that this is driven by breakeven inflation deviating from expected inflation, π_t^e. To see what the source of breakeven return is, start by decomposing $rx_{t+1}^{BEI\ (n)}$ further

$$rx_{t+1}^{(n)} - rx_{t+1}^{TIPS-L\ (n)} = ny_t^{(n)} - (n-1)\,y_{t+1}^{(n-1)} - y_t^{(1)} - nTIPS_t^{Adj(n)} + (n-1)\ TIPS_{t+1}^{Adj\ (n-1)} + \ TIPS_t^{(1)}$$

We group the terms to see that the return on the breakeven is the initial breakeven

$$nBEI_t^{(n)} = ny_t^{(n)} - nTIPS_t^{Adj(n)}$$

less the (n-1) breakeven one year from today

$$-(n-1)BEI_{t+1}^{(n-1)} = \ -1 \times \left[(n-1)y_{t+1}^{(n-1)} - (n-1)TIPS_{t+1}^{Adj(n-1)}\right]$$

less

$$-BEI_t^{(1)} = \ -1 \times \left[y_t^{(1)} - TIPS_t^{(1)}\right]$$

and since $TIPS_t^{(1)} = y_t^{\$(1)} - E[Inflation_t^{SPF(1)}]$, we can substitute this in for $TIPS_t^{(1)}$

$$= \; -1 \times \left[y_t^{(1)} - y_t^{(1)} + \pi_t^{e,1yr} \right].$$

$y_t^{(1)} - y_t^{(1)}$ cancels out and we end up subtracting expected one-year ahead inflation

$$= \; -\pi_t^{e,1yr}.$$

The return from breakeven inflation is therefore

$$rx_{t+1}^{BEI\ (n)} = nBEI_t^{(n)} - (n-1)BEI_{t+1}^{(n-1)} - \pi_t^{e,1yr}.$$

Components of Breakeven Returns

Building Blocks of Breakeven Returns	Formula	Verbal Description
$nBEI_t^{(n)}$	$ny_t^{(n)} - nTIPS_t^{Adj(n)}$	initial breakeven
$-(n-1)BEI_{t+1}^{(n-1)}$	$-1 \times \left[(n-1)y_{t+1}^{(n-1)} - (n-1)TIPS_{t+1}^{Adj(n-1)} \right]$	less the (n-1) breakeven one-year from today
$-\pi_t^{e,1yr}$	$-1 \times \left[y_t^{(1)} - TIPS_t^{(1)} \right]$	less expected inflation one-year from now

The inflation risk premium is the predictable change in breakeven inflation that arises from the difference between the current $BEI_t^{(n)}$ and the expected breakeven, $E_t\left[BEI_{t+1}^{(n-1)}\right]$. We estimate this change by first adjusting breakevens for liquidity

$$BEI_t^{Adj\ (n)} = BEI_t^{(n)} - L_t^{(n)}.$$

Then we regress expected inflation on the (n-1)-yr liquidity-adjusted breakeven

$$BEI_t^{Adj\ (n-1)} = \beta_0^{(n-1)} + \beta_1^{(n-1)} E[Inflation_t^{SPF(10)}]$$

We end up with a fundamental value for breakeven inflation. The fitted value from the above regression is our expected breakeven inflation given surveyed inflation expectations, $E_t\left[BEI_{t+1}^{(n-1)}\right]$. The Econometrician anticipates this breakeven. Analogous to what we did for the real expected return, we can substitute the expected breakeven into the definition of breakeven returns for the inflation risk premium

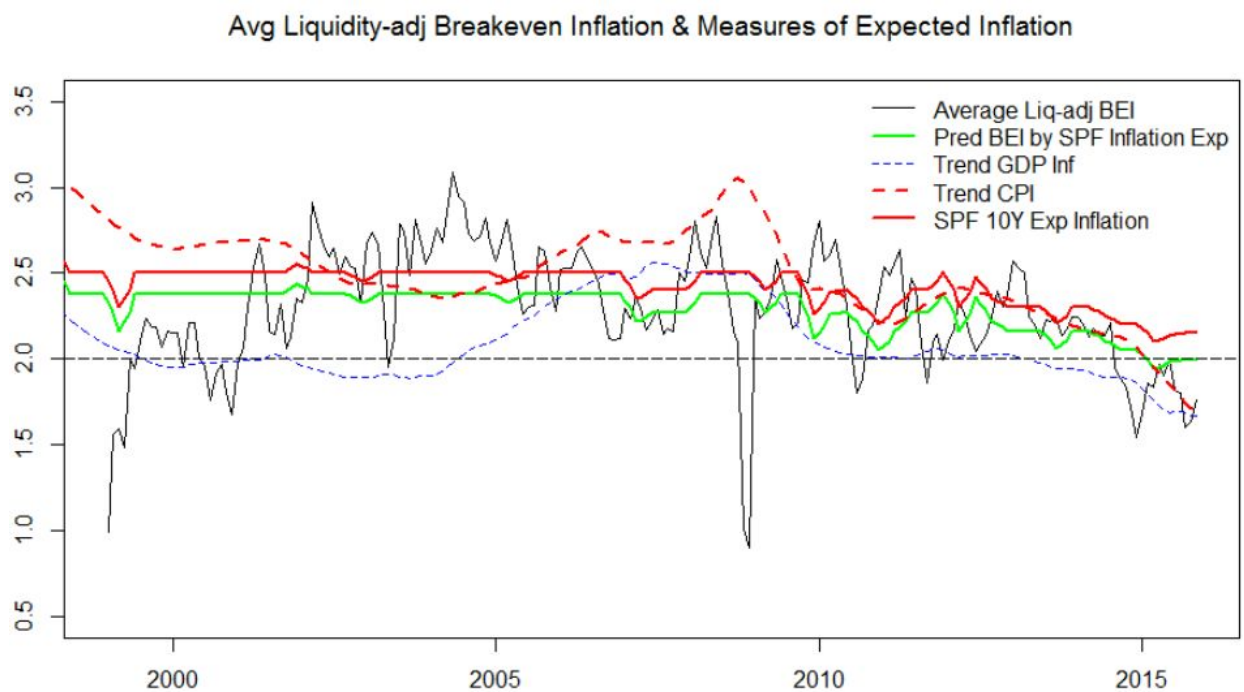
$$E_t\left[rx_{t+1}^{BEI\ (n)}\right] = nBEI_t^{(n)} - (n-1)E_t\left[BEI_{t+1}^{(n-1)}\right] - \pi_t^{e,1yr}.$$

Alternatively (although not equivalently), we could estimate the inflation risk premium as the difference between the breakeven today and that predicted by survey expectations of inflation

$$IRP_t^{(n)} = BEI_t^{Adj\ (n)} - (\beta_0^{(n)} + \beta_1^{(n)} E[Inflation_t^{SPF(10)}]).$$

After which we can use $IRP_t^{(n)}$ in a forecasting regression to scale it to breakeven excess returns.

When $BEI_t^{Adj\ (n)}$ is less than that predicted by inflation expectations we are not being compensated for inflation expectations, and the expected return from this component is negative. Conversely, if breakeven inflation is greater than inflation expectations, then we are being more than compensated as breakeven inflation should fall towards those values predicted by inflation expectations. The figure below shows the liquidity-adjusted 10 year breakeven and various measures of inflation expectations.



Over the past 15 years, the mean return on breakevens has been 45 basis points, suggesting that breakeven inflation has been too high and failed to account for lower expected inflation as measured by survey data from professional forecasters.

The inflation risk premium is earned by those disciplined enough to recognize that breakeven inflation should equal surveyed inflation expectations. Deviations from expected inflation are opportunities. One peculiar opportunity arises after a large move in oil prices. Large swings in oil prices are followed by a prolonged comovement between breakevens and crude oil. Robin Lumsdaine documents that the larger the move in oil, the greater the fraction of days that breakevens move in the same direction.[17]

[17] Lumsdaine, Robin L. "The relationship between oil prices and breakeven inflation rates." *Available at SSRN 1529487* (2009). pg. 10

The market's confidence in its assertion that oil prices are linked with breakevens is somewhat of a mystery to The Econometrician. The Econometrician knows that in order for a contemporaneous link to exist oil shocks should persist. The empirical evidence suggests they don't and instead follow a random walk. Christopher Neely shares in the confusion: "It is puzzling why large monthly or quarterly oil price changes predict very small changes in the CPI but daily oil prices predict large changes in breakeven inflation."[18] Why does this comovement exist?

Lumsdaine puts forward two possible explanations. The financial markets may believe there is a closer link than has been found empirically because of the greater focus by the news media on the inflation implications of large oil price swings. The correlation between breakevens and oil prices may also increase in response to a common exogenous factor. The common factor could be deteriorating financial conditions or a soggy outlook for global growth.

So far we have estimated sources of return predictability by using TIPS data. Unfortunately, the TIPS market is still in its infancy and consequently we lack the ability to perform an out-of-sample forecasting evaluation. Also, longer sample data does not exist for TIPS with maturities less than 5 years. Shorter maturity real yields would be particularly useful for estimating the returns from forecasting the Fed correctly. If it is true that the market makes forecasting errors about real short-term rates then we should incorporate the expected forecasting errors into the real bond risk premium equation. As long as the Fed controls the short-end of the yield curve, expectational errors about the Fed matter most for forecasts of short-term bond returns.

The Monetary Policy Risk Premium

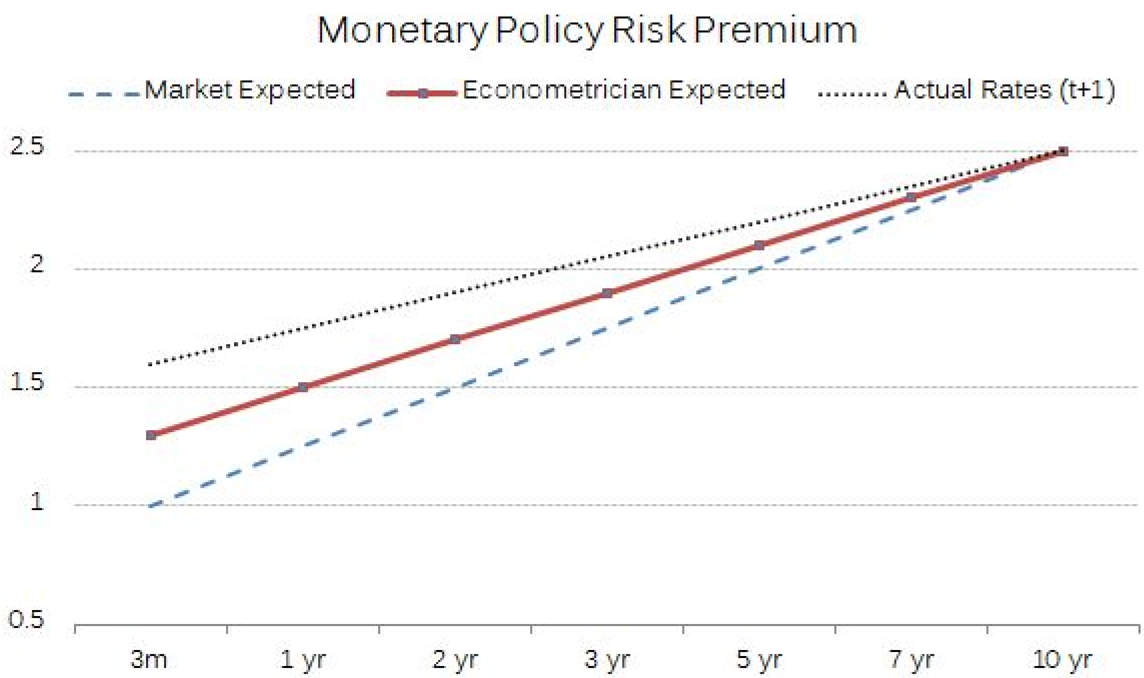
Excess returns are available at the short-end of the yield curve for those able to anticipate the Fed. In my opinion, the two papers most prominent in this area are Piazzesi and Swanson (2008) and Cieslak and Povala (2014). The monetary policy risk premium is the forecastable return in short-maturity bonds, and the source of the predictability stems from explicitly considering the likely actions of the Fed based on the current state of the business cycle. Accounting for the predictable behavior of the Fed, $MP_t^{(n)}$, yields

$$rx_{t+1}^{(n)} = IRP_t^{(n)} + Liquidity_t^{(n)} + RBRP_t^{(n)} + MP_t^{(n)} + Truly\ Unexpected_{t+1}^{(n)} .$$

Expected return - as I have previously defined it - does not take into account the current state of the business cycle and thus the likely evolution of monetary policy. Before we go and try to estimate the monetary policy risk premium directly, it is helpful to think about where it fits in a model of expected returns. Cieslak and Povala (2014) argue that the monetary policy risk premium is the result of forecasting errors made about real short-term interest rates. It therefore may be advantageous to consider $MP_t^{(n)}$ as a building block in expected real excess returns.

[18] Neely, Christopher J. "How Much Do Oil Prices Affect Inflation?." *Economic Synopses* 2015, no. 2015-05-11 (2015).

Say the market expected the blue-dashed yield curve to be realized one year from today (see figure below). The black-dotted line represents the actual outcome. The difference between the blue-dashed and black-dotted line is the forecasting error made by the market and is an unexpected return. In this case it would be a negative return. Further suppose that The Econometrician came up with a yield forecast somewhere in between the market and the actual outcome. His forecast would lead him to be short eurodollar futures and Treasury futures. If he is on the right side of the forecasting error - as in the picture above - he gains not only the expected return (the difference between the blue-dashed and red line) but also the truly unexpected return (the difference between the red and black-dotted line). How fortuitous![19]



The returns to expecting the Fed correctly are largest at short maturities and become smaller the farther up the maturity ladder we travel. This is because the Fed has less reign over longer-term interest rates. Although graphical explanations are always welcome, we continue to present some math for clarity.

The monetary risk premium and real rates

To make the equations light and more general, I replace the notation I have previously used for liquidity-adjusted real rates - $TIPS_t^{Adj\,(n)}$ with $r_t^{(n)}$. Let us first define real short-term rates

$$r_t^{(1)} = y_t^{(1)} - \pi_t^{e,1yr}$$
$$r_t^{3m} = y_t^{3m} - \pi_t^{e,3m}$$

[19] In the forecasting exercise that follows we do not accredit The Econometrician with the surprise returns.

where $\pi_t^{e,3m}$ and $\pi_t^{e,1yr}$ are 1Q ahead and 1-yr ahead inflation expectations from a survey such as the SPF. $y_t^{(1)}$ could be the one-year ahead Eurodollar contract that pays 3m libor at time t+1, $y_{t+1}^{(3m)}$. Therefore, $y_t^{(1)}$ is the expected 3m libor rate, one-year from today. The return from the Fed setting the real short-term rate one-year from today is

$$rx_{t+1}^{MP} = r_t^{(1)} - r_{t+1}^{3m}$$

The real excess return on an n-year real bond can be expressed as the sum of rx_{t+1}^{MP} and the difference between $rx_{t+1}^{TIPS-L\,(n)}$ and rx_{t+1}^{MP}

$$rx_{t+1}^{TIPS-L\,(n)} = rx_{t+1}^{MP} + \left(rx_{t+1}^{TIPS-L\,(n)} - rx_{t+1}^{MP}\right).$$

We can decompose this relation further by substituting in their respective excess return definitions

$$\begin{aligned} rx_{t+1}^{TIPS-L\,(n)} &= \left[r_t^{(1)} - r_{t+1}^{3m}\right] + \left(\left[nr_t^{(n)} - (n-1)\,r_{t+1}^{(n-1)} - r_t^{(1)}\right] - \left[r_t^{(1)} - r_{t+1}^{3m}\right]\right) \\ &= \left[r_t^{(1)} - r_{t+1}^{3m}\right] + \left(nr_t^{(n)} - (n-1)\,r_{t+1}^{(n-1)} - 2r_t^{(1)} + r_{t+1}^{3m}\right) \end{aligned}$$

So we have two distinct sources of real returns: one is from the evolution of monetary policy, and the other of which is orthogonal to the Fed. The expected returns from short-term bonds comes from conditioning forecasts on the cyclical variables important to the Fed, such as non-farm payroll growth and core inflation. The expected real return orthogonal to rx_{t+1}^{MP} should be based on a forecast of expected real rates, which are not cyclical. I will not go down this path, although it is clearly possible to do so.

Incorporating the monetary risk premium in the expected bond return decomposition

We can also incorporate the monetary risk premium into our earlier decomposition of expected bond returns. In what follows, we only show how to include the monetary policy risk premium in the real interest-rate risk component, although it is also possible to perform the same decomposition for the inflation risk premium. If we take the difference between the real liquidity-adjusted ex-post return and the real expected return, we end up with the "unexpected" return

$$Unexpected_{t+1}^{(n)} = rx_{t+1}^{TIPS-L\,(n)} - E_t\left[rx_{t+1}^{TIPS-L\,(n)}\right]$$

The unexpected return is broken up into two parts: A. what everybody missed; and B. what the market missed about the Fed, but The Econometrician was able to anticipate

$$Unexpected_{t+1}^{(n)} = E_t\left[rx_{t+1}^{MP\,(n)}\right] + Truely\ Unexpected_{t+1}^{(n)}.$$

The change in monetary policy that was unanticipated by markets is often called a "monetary policy shock." In our world, this simply refers to forecasting errors made by the market about Fed policy. The Econometrician anticipates these and earns the "monetary policy risk premium" by conditioning his return forecasts of short-dated interest-rate futures contracts with variables that would coincide with a taylor rule. In the literature, a monetary policy shock is also sometimes characterized as the residual from a taylor rule. The returns from this type of shock would truly be unanticipated, even by The Econometrician, since he is already using a similar taylor rule to forecast the Fed. To extract the monetary policy risk premium, we first regress variables important to the Fed on $Unexpected_{t+1}^{(n)}$

$$Unexpected_{t+1}^{(n)} = \gamma_0 + \gamma_1 \Delta NFP_{t-7,t-1} + \gamma_2 Core\ Pce_{t-1}$$

The fitted value from this regression is our estimate of the monetary risk premium, $E_t\left[rx_{t+1}^{MP\ (n)}\right]$. The truly unexpected component would be

$$Truely\ Unexpected_{t+1}^{(n)} = Unexpected_{t+1}^{(n)} - E_t\left[rx_{t+1}^{MP\ (n)}\right]$$

Unfortunately, we don't currently have enough data to implement this procedure or variations of it. However, Abrahams et al (2015) have found that monetary policy shocks (our version of $Unexpected_{t+1}^{(n)}$) primarily affect the inflation risk premium (at intermediate horizons) and real expected bond returns (at longer horizons)[20].

Incorporating the Monetary Risk Premium in Practice

For further intuition, it serves us well to think about excess eurodollar returns (see figure below). Excess return is the eurodollar rate today for *n* months from now, $f_t^{(n)}$, minus the actual three-month Libor rate *n* months from now, r_{t+n}

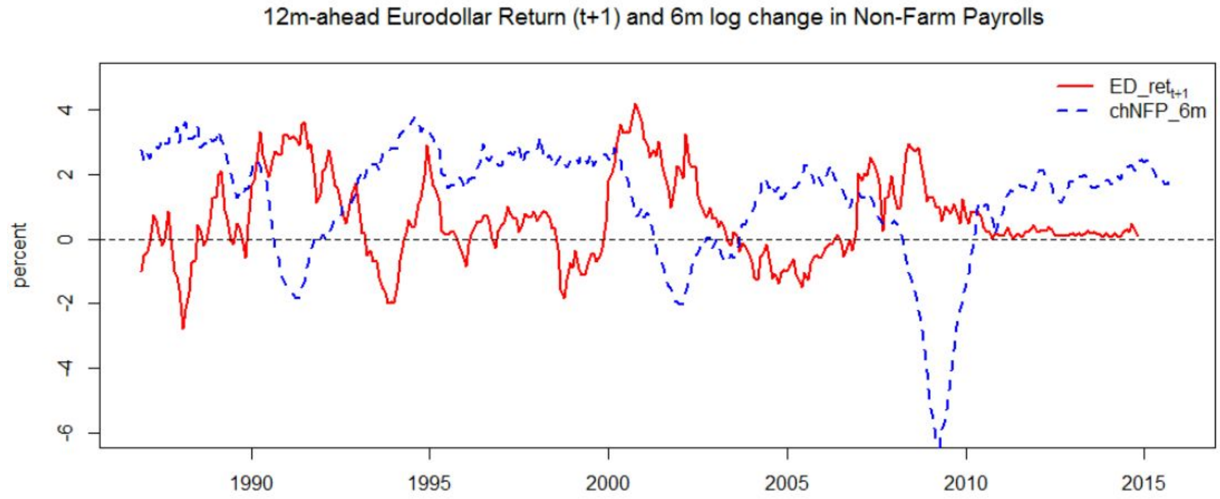
$$rx_{t+n}^{(n)} = f_t^{(n)} - r_{t+n}$$

Excess returns are by definition the consequence of a forecasting error made about Federal Reserve policy. The existence of an excess return for each horizon of eurodollar contract implies the market is making forecasting errors about the path of short-term interest rates. It therefore follows that our goal should be to predict future rates better than the market.

Returns from Fed policy should be conditioned on the stage of the business cycle. Excess returns are *countercyclical*. Piazzesi and Swanson (2006) find that expected excess returns are about 3 to 5 times higher in recessions than in expansions. That is why picking a predictor which tracks the business cycle well can predict excess returns. Excess returns are mainly driven by forecasting errors during recessions, and are in fact much smaller in expansions as market participants have less uncertainty during tightenings.

[20] Abrahams, Michael G., Tobias Adrian, Richard K. Crump, and Emanuel Moench. "Decomposing real and nominal yield curves." In *Midwest Finance Association 2013 Annual Meeting Paper*. 2012.

Since 1994, the Fed has become considerably more transparent about its intentions, thus creating significantly less opportunity for earning a monetary policy risk premium over a hiking cycle.



One way to estimate the monetary policy risk premium is to forecast the return on the fourth eurodollar contract directly. We can do this using a support vector machine such as[21]

$$rx_{t+1}^{ED4} = SVM\left(Libor_t^{3m}, ED_t^4, \Delta NFP_{t-7,t-1}, \Delta UR_{t-7,t-1}, Core\,Pce_{t-1}, YC_{t-1}\right)$$

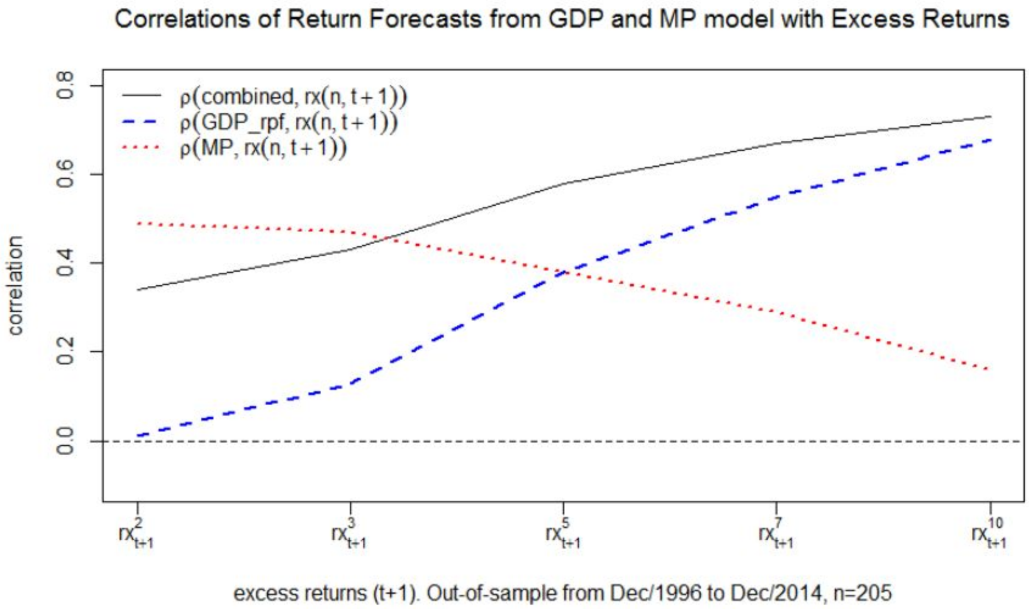
where $rx_{t+1}^{ED4} = ED_{t-12}^4 - Libor_t^{3m}$

The fitted value is the monetary policy risk premium, $E_t\left[rx_{t+1}^{ED4}\right]$. We then use $E_t\left[rx_{t+1}^{ED4}\right]$ and scale it up using the regression

$$rx_{t+1}^{(n)} = \beta_0^{(n)} + \beta_1^{(n)} E_t\left[rx_{t+1}^{ED4}\right].$$

The fitted value from this regression is the expected return from forecasting the expected path of interest rates better than the market. As anticipated, the out-of-sample correlations are decreasing in maturity, whereas the correlations with the expected bond risk premium from the GDP model are increasing in maturity (see figure below). To reiterate, the monetary policy risk premium captures the expected returns from forecasting the Fed, and since the Fed controls short-term interest rates, most of this gain accrues to shorter maturity bond returns.

[21] I use the ksvm function from the R package kernlab.



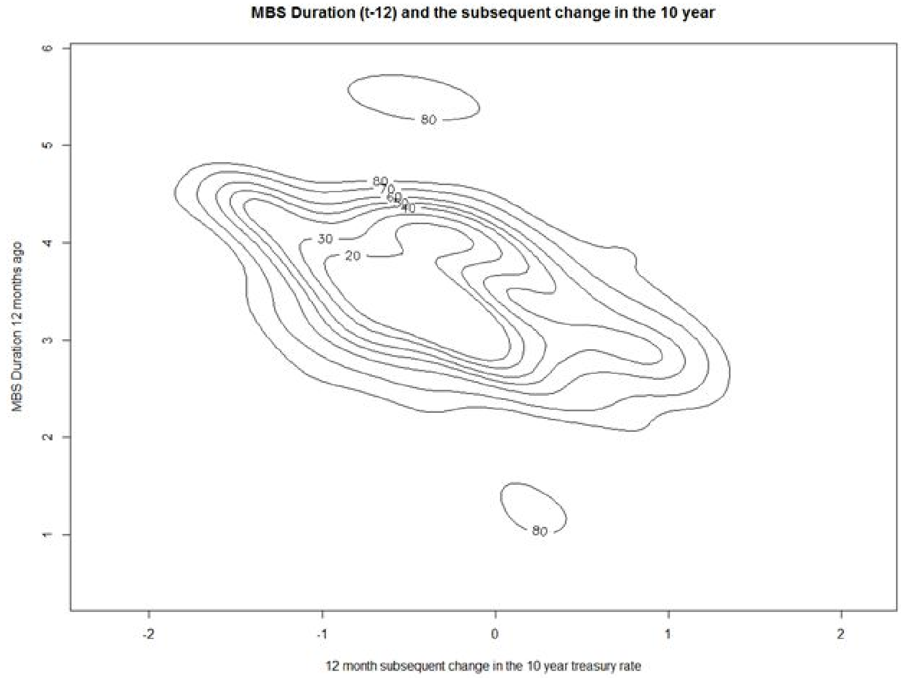
Mortgage Duration and Banks Net Interest Gap

MBS duration is a quantity based indicator that predicts bond returns. Although this finding was first publically observed as early as 1994[22] (with the work of Julia Fernald, Frank Keane and Patricia Mosser - that investors seeking to hedge MBS duration amplified movements in the yield curve), it was Sam Hanson (2014) of Harvard Business School that really firmed up ideas and put this predictor of excess returns on the map. When MBS duration is high, bond returns are also expected to be high. MBS duration exhibits mean reversion, and if it is already high, it probably won't extend much further, thus reducing the demand by hedgers for swaps. If duration is low, a duration extention with rising rates is more likely and MBS investors will demand more protection by selling swaps when rates start to move. Duration, as an amplifier, crucially depends on the amount of MBS outstanding relative to other fixed income securities and the amount of capital deployed by leveraged investors relative to non-leveraged investors in MBS. It was more relevant when GSEs were much larger and the Fed wasn't the dominant player in fixed-rate mortgages.

The figure below shows a contour plot of MBS duration versus the subsequent 12 month change in the 10 year.[23] It illustrates that the 10 year tends to fall after duration is high and rise when duration is low.

[22] Fernald, Julia, Frank Keane, and Patricia C. Mosser. *Mortgage security hedging and the yield curve*. Vol. 26, no. 10. Federal Reserve Bank of New York, 1994.

[23] The contour plot is analogous to a topographical map. The highest density of observations is akin to a mountain peak.

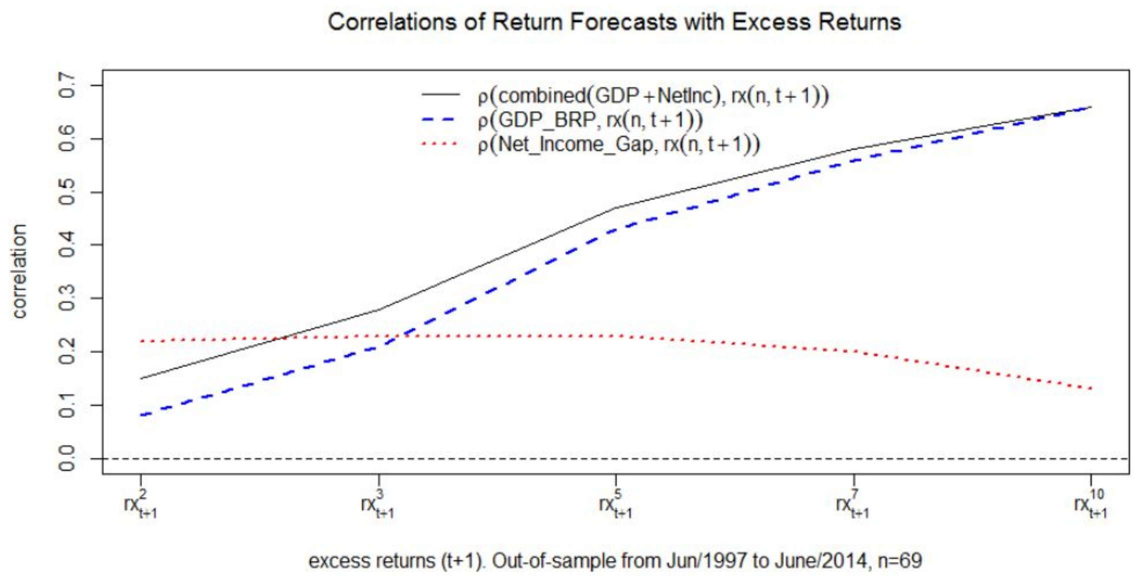


A cousin of MBS duration, bank's income gap, reflects exposure to the quantity of interest rate risk. First identified by Haddad and Sraer (2015), the income gap quantifies banks' exposure to fluctuations in interest rates, and not only forecasts Treasury excess returns but also the future levels of yields.

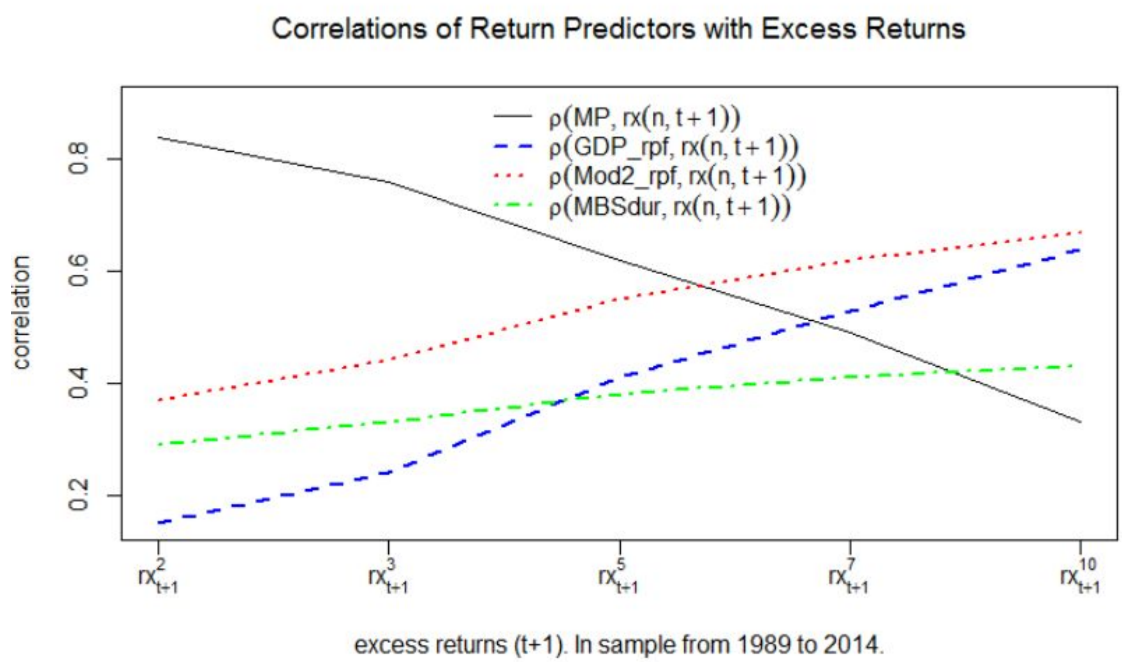
As Haddad and Sraer (2015) explain, financial institutions are large intermediaries in the market for interest rate risk. When borrowers in the economy increase their demand for long-term or fixed-rate loans, banks have to hold assets that are more exposed to interest rate risk. Accordingly, when savers increase their supply of saving deposits or variable-rate bonds, the value of banks' liabilities has to become less exposed to interest rate risk. Banks only accommodate these shifts in the demand and supply of interest rate risk if they are compensated. An increase in banks' average exposure to interest-rate risk should thus forecast higher bond returns.

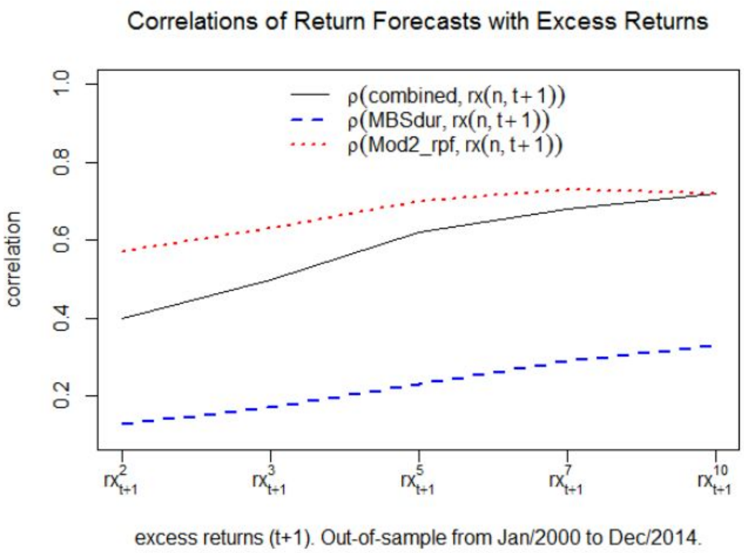
The *income gap* is used as the measure of exposure to interest rate risk and is defined as the difference between the book value of all assets that either reprice or mature within one year and the book value of all liabilities that either reprice or mature within one year. The figure below shows the out-of-sample correlation between the forecast of bond returns produced by the income gap and the direct forecast from the GDP model. The authors find that the forecasting ability of the income gap is the highest for bonds of maturity 3 to 5 years and then decreases with the bond's maturity. I find they are half-right, with the exception being that the out-of-sample correlations are relatively flat up to the five year.

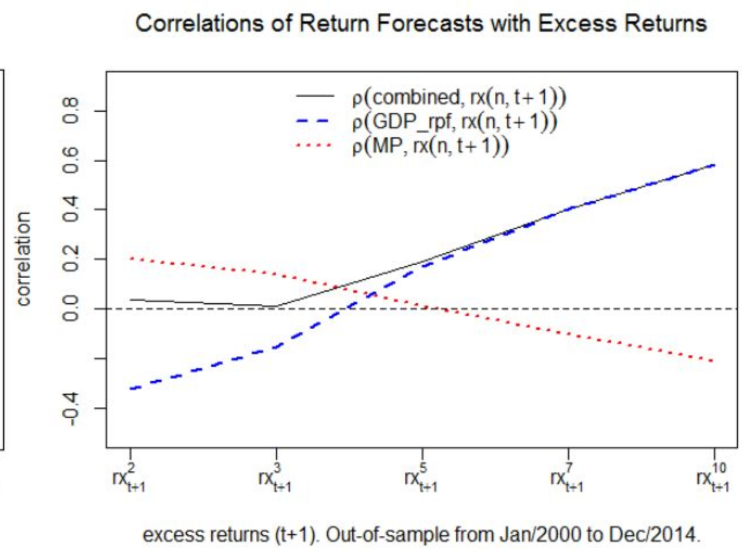
In contrast to the income gap, the in-sample and out-of-sample correlations between the contribution of MBS duration to total fixed income duration and excess returns are increasing in maturity. Both feature a relatively flat correlation line as compared to the other return predictors.



The short out-of-sample sample we do have probably will not allow us to be definitive - but just as a tease - the figure below compares the out-of-sample correlations of returns predicted by MBS duration contribution, Mod 2 BRP, the monetary policy premium, and GDP BRP. The out-of-sample correlations look similar to the in-sample results. The correlations between MBS duration contribution and shorter-duration bond returns is much higher than that of the GDP based return forecasts, yet GDP based bond risk premia tends to dominate MBS duration at the longer-end.







MBS duration is a measure of the term premium, thus I would place it directly into a forecasting regression of bond returns. Malkhozov et al (2014) find the dollar amount of duration relates to both the return on real liquidity-adjusted returns and nominal bond returns, with 60% of the impact on real returns and 40% of the impact on the nominal component.[24] However, I am hesitant to agree with them, because it is not clear why MBS duration would relate to returns on breakeven inflation.

Average Maturity, Net Supply Rates, and the VIX

There are a plethora of theoretically motivated variables that are useful for developing a holistic view, and some of them don't exactly fit into the mold of the expected return measures we presented earlier. Nevertheless, I still want to assess how various indicators in the literature relate to the shape of the yield curve. Measures of bond demand and supply are challenging to deal with, and the empirical work is plagued with identification issues.

If we look at the average difference in impact coefficients from forecasting regressions we find theoretically pleasing relationships (see the table below). I introduce a methodology that allows us to abstract from the sign differences in coefficients that arise when looking at one rolling regression in isolation. For changes in the shape of the curve, it is the *relative difference* that matters - not the impact on one particular rate. I run the following regression over 120m rolling windows

$$\Delta y^{(n)}_{t,t+12} = \beta^{mat\,(n)}_t AvgMat_t + \beta^{supply\,(n)}_t Supply^{Net}_t + \beta^{Dur\,(n)}_t MBS^{DurC}_t + \beta^{yc\,(n)}_t YC_t + \beta^{Refi\,(n)}_t Refi\,Inc_t + \beta^{vix\,(n)}_t VIX_t + \varepsilon^{(n)}_t$$

$AvgMat_t$ = Average maturity of marketable debt held by the public.[25]

$Supply^{Net}_t = Supply^{Treasury}_t - Demand^{Foreigners}_t$

[24] Malkhozov, Aytek, Philippe Mueller, Andrea Vedolin, and Gyuri Venter. "Mortgage risk and the yield curve." *Available at SSRN 2235592* (2014).

[25] Special thanks to Andrew Austin and Joe Johnson for helping me get this data.

where $Supply_t^{Treasury} = \frac{\Delta Treasury\ Supply(t,t-12)}{Treasuries\ Outstanding_{t-13}}$, $Demand_t^{Foreigners} = \frac{\Delta Foreign\ Purchases(t,t-12)}{Treasury\ Outstanding_{t-13}}$

$MBS_t^{DurC} =$ MBS duration contribution to total duration as defined by Hanson (2014)

$Refi\ Inc_t =$ A proxy for the incentive to refinance, defined as the difference between the current coupon on outstanding fixed-rate mortgages and the 30 year mortgage rate.

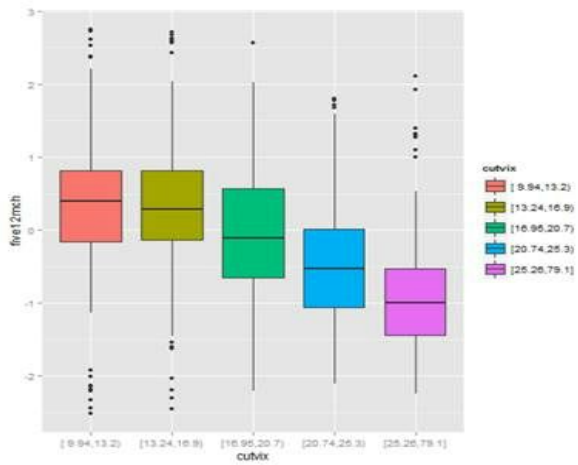
Summary Statistics of Bond Predictors

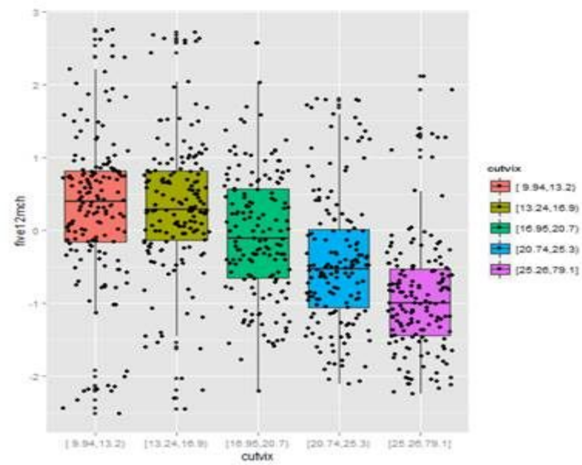
series	time sample	mean	σ	min	max
$AvgMat_t$	Jan 1975 - May 2015	58	11.5	29	74
$Supply_t^{Net}$	July 1985 - May 2015	0.25%	0.69%	-.90%	2.48%
MBS_t^{DurC}	Jan 1989 - Nov 2015	1.10	0.29	0.20	1.78
$Refi\ Inc_t$	Jan 1989 - Mar 2015	-0.18	0.66	-1.70	1.30
YC_t	Jan 1985 - Nov 2015	1.17	0.88	-0.41	2.83
VIX_t	Jan 1990 - Nov 2015	19.88	7.57	10.42	59.89

After estimating the 197 regressions from Jan 1989 through March 2015, I take the difference between the loadings on adjacent maturities, i.e. $\beta_t^{mat\,(n)} - \beta_t^{mat\,(n-1)}$. I then take the average of these differences. The resulting measure tells us the average relative change in $y_{t,t+12}^{(n)}$ relative to $y_{t,t+12}^{(n-1)}$ over the next year, for a given increase in $AvgMat_t$. This empirical strategy helps us look through any possible sign changes in the coefficients and enables a theoretically plausible interpretation. Furthermore, by using a rolling window regression, we are able to avoid any time-specific results.

For example, the table below shows this average difference in the impact coefficients for average maturity over all of rolling forecasting regressions. A one standard deviation increase in the average maturity of privately held Treasury debt increases two year yields on average by 12.5 basis points *relative* to one year yields over the following twelve month period. When we sum over the rows in this column we find that a one standard deviation increase in average maturity leads to a 68 basis point increase in the ten year treasury rate *relative* to the one year over the following twelve months. In other words, an increase in average maturity causes the yield curve to widen. Exactly as would be predicted a priori.

Importantly, the impact of the VIX is highly non-linear. The figure below shows one year ahead changes in the five year for various levels of the VIX.





High values of the VIX imply a much larger decline in interest rates one year from today. A one percent increase in the VIX causes the 2 year to increase *relative* to the 1 year by .63 basis points over the following year. This is consistent with the high demand for very short maturities when things go poorly.

A one standard deviation increase in MBS duration contribution decreases 2 year yields by 5 bps on average *relative* to the 1 year yield. Across the whole yield curve, a one standard deviation increase causes the 10 year to decline *relative* to the 1 year by about 15 basis points. A rise in MBS duration thus causes the curve to flatten.

The table below also includes net supply and demand which is the difference between the supply rate of Treasuries and the rate of absorption by foreign investors. The net supply rate quantifies how much new supply the market has to absorb, and therefore proxies for the amount of new interest rate risk. New debt (rather than older debt) carries more interest rate risk with price effects representing a larger portion of the return. As bonds age, the return on the bond converges to its initial yield, thus becoming more dependent on the coupon.

The yield curve is increasing in the supply rate and flattening in the foreign demand rate. A one standard deviation increase in the net supply rate causes the 10 year to increase relative to the 1 year by 27 basis points over the following year. The distribution of relative impacts is “hump-shaped”: The largest change occurs when the 4 year rises by 5.1 basis points relative to the 3 year.

A one standard deviation increase in the term spread causes the 2 year to fall by 27 basis points relative to the 1 year. This makes sense since the yield spread captures the mean reversion inherent in expectations about short-term interest rates. Similar to mortgage duration, an increase in the term spread cause the curve to flatten over the next year.

Average difference in Impact Coefficients across the Term Structure

Based off of the following regressions:

12 month future change in yields for maturity,m = Beta1*Lag(avg maturity,12)+Beta2*Lag(Net Supply/Demand,12)+Beta3*Lag(Duration Contribution,12)+Beta4*Lag(Term Spread1,12)+Beta5*Lag(REFI Incentive,12)+Beta5*Lag(VIX,12)

units:	sd	sd	sd	sd	no-adj	no-adj
in basis points	Avg Maturity of Privately held Treasury debt	Net Supply/Demand	Duration Contribution	Term Spread	Refi Incentive	VIX
2 year -1 year	12.54	0.84	-4.99	-26.76	12.78	0.63
3 year -2 year	10.81	5.02	-3.06	-20.83	2.48	0.31
4 year -3 year	9.41	5.13	-2.02	-14.82	-1.13	0.13
5 year -4 year	8.19	4.31	-1.44	-10.42	-2.31	0.03
6 year -5 year	7.12	3.45	-1.10	-7.48	-2.57	-0.01
7 year -6 year	6.19	2.77	-0.87	-5.53	-2.50	-0.04
8 year -7 year	5.38	2.25	-0.71	-4.21	-2.32	-0.05
9 year -8 year	4.69	1.85	-0.58	-3.29	-2.11	-0.05
10 year -9 year	4.10	1.55	-0.49	-2.64	-1.90	-0.05
change in the 10 year relative to the 1 year in the next twelve months	68.43	27.16	-15.26	-95.98	0.41	0.91

Notes: The table presents differences in impact coefficient estimates in basis points, sample size for each difference =197, based on 120 month window rolling forecasting regressions on 12 month-ahead changes in yields, from 1989/01-2015/03.

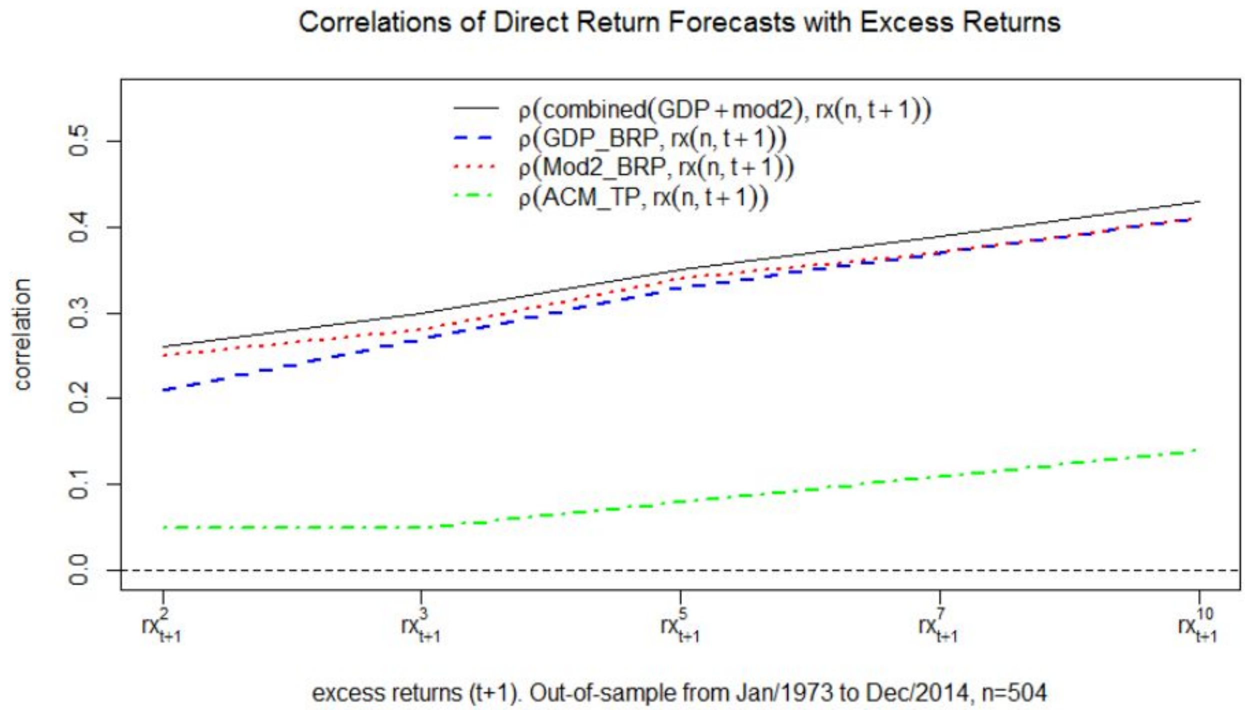
The empirical record of the ACM Term Premium

One measure of excess returns is the term premium estimate provided by the Adrian, Crump and Moench (2013) decomposition (ACM for short).[26] The estimates are updated daily on the NY Fed website and this ease of access has lead to it being frequently cited by policy makers and its use by Michael R. Rosenberg in his quarterly publication on Bloomberg.[27] The ACM model uses no survey data on inflation expectations and while it produces a good in-sample fit of bond yields, the in-sample forecasts of excess returns are somewhat lacking. As Antti Ilmanen explains, term structure models that at least proxy for inflation expectations and expectations of real growth tend to produce more realistic estimates of term premia than purely statistical models (see the out-of-sample correlations below).[28]

[26] Adrian, Tobias, Richard K Crump, and Emanuel Moench. "Pricing the term structure with linear regressions." *Journal of Financial Economics* 110.1 (2013): 110-138. The estimate is updated daily on the NY Fed website and is available on Bloomberg.

[27] See Financial Conditions Watch, FCW <GO>

[28] Ilmanen, Antti. *Expected returns: An investor's guide to harvesting market rewards*. John Wiley & Sons, 2011. See the chapter on expected bond returns.



The ACM model is not out-of-sample as it is refitted every month. The other measures are real time estimates of expected bond returns, so it's not exactly a fair fight. An ocular regression of the out-of-sample estimates of term premia confirm that the ACM TP has had more trouble fitting ex-post returns, despite the fact it has been estimated in-sample (see below)! Fortunately for its customers, the past 10 years have been forgiving as the ACM 10 year TP *has* more closely tracked the other models and ex-post returns.

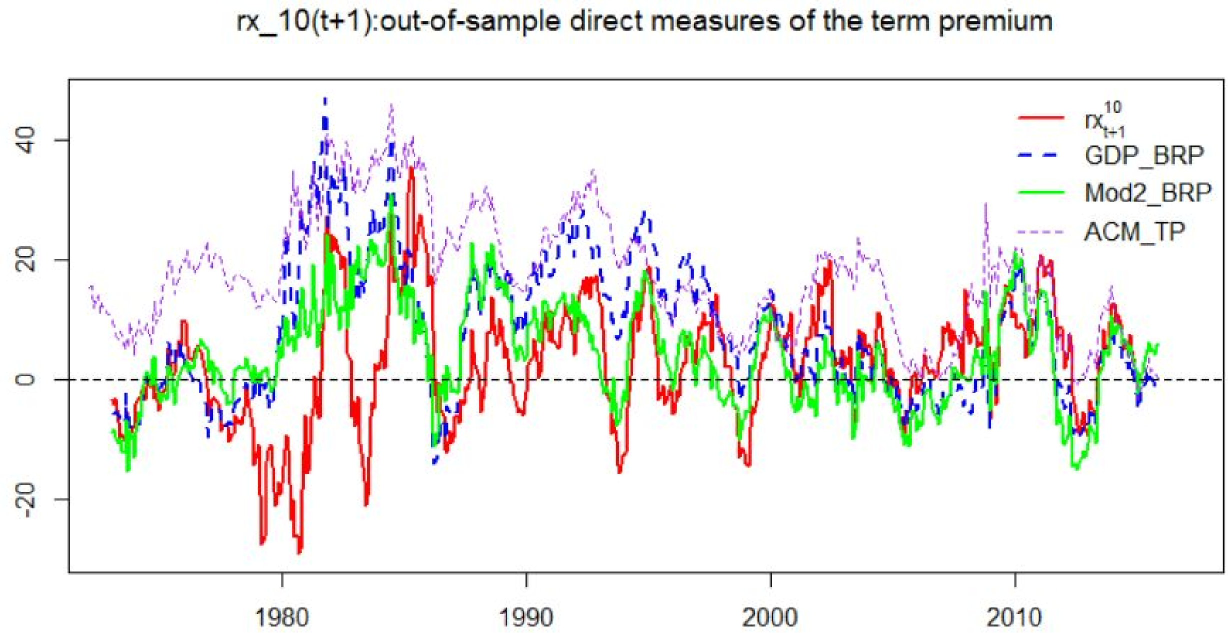
The advantage to the ACM TP is that it is updated daily, yet it fails miserably for ease of understanding, when contrasted to the bond return decomposition I presented earlier. For example, we have no idea if it's the inflation risk premium, real bond risk premium, or monetary policy risk premium that are driving expected returns. As a purely statistical estimate there is no easy way to understand if the model could even be wrong. We at least know that the source of return in the trend GDP model is based on a fair value estimate of the level of rates.

To be fair, an expanded version of their paper does include a complete decomposition of the sources of expected return.[29] But the estimates are not updated daily like the earlier version, and they have trouble *interpreting* the inflation risk premium. The authors state (pg. 22):

"It is difficult to directly interpret dynamics of the inflation risk premium implied by our model as it is a linear combination of the factors which do not all have a clear-cut economic meaning."

[29] Abrahams, Michael G., Tobias Adrian, Richard K. Crump, and Emanuel Moench. "Decomposing real and nominal yield curves." In *Midwest Finance Association 2013 Annual Meeting Paper*. 2012.

The ambiguity that plagues their interpretation of the inflation risk premium is not present in the model I have described. The inflation risk premium is the consequence of breakeven inflation deviating from survey expectations of inflation. This deviation often occurs when the news media overstates the importance of large moves in oil prices for future inflation.



Concluding thoughts

Comprehensive models do exist for common men, and I have presented one that falls outside the affine term structure pedagogy - yet historically has outperformed the most "popular" measure of the term premium. Studying these models, although interesting and *required* for the master-hand academic, is too onerous from the perspective of the layman. The barriers to entry for understanding the models, including the problem of coding them up, are too high for even quantitatively oriented practitioners. As someone that has transitioned from the Federal Reserve to a bond fund, I cannot stress enough the lack of serious interest in affine term structure models. There are a few outlier firms that may care, but I don't know who they are: "Hello, is there anybody out there?"

Academics want people to read their work and put what they've found into practice. If the implied audience consisted of laymen, as opposed to other economists and journal referees, then the field would see a greater rate of progress. The few academics that have followed this simple principle are certainly reaping the benefits.

I hope that academics will take what I have outlined here and continue to build upon it, and maybe even find where the income gap and MBS duration fits in the return decompositions.

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Sabol, Steven. "Decomposing Expected Bond Returns." *Available at SSRN 2704213* (2015).

Sabol, Steven. "The Monetary Policy Risk Premium and Expected Bond Returns." *Available at SSRN 2708336* (2015).

My short-list of papers that are definitely worth a weekend read:

1. Rebonato, Riccardo. "Return-Predicting Factors for US Treasuries: On the Similarity of ‘Tents’ and ‘Bats’." *Available at SSRN 2443291* (2014).
2. Rebonato, Riccardo. "An Interpretation of the Cieslak-Povala Return-Predicting Factor." *Available at SSRN* (2015).
3. Fernald, Julia, Frank Keane, and Patricia C. Mosser. *Mortgage security hedging and the yield curve*. Vol. 26, no. 10. Federal Reserve Bank of New York, 1994.
4. Hanson, Samuel G., and Jeremy C. Stein. "Monetary policy and long-term real rates." *Journal of Financial Economics* 115, no. 3 (2015): 429-448.
5. Hanson, Samuel G. "Mortgage convexity." *Journal of Financial Economics* 113, no. 2 (2014): 270-299.
6. Turner, Philip. "Benign neglect of the long-term interest rate." (2013).
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9. Cochrane, John H., and Monika Piazzesi. "Decomposing the yield curve." In*AFA 2010 Atlanta Meetings Paper*. 2009.
10. Expected Returns - Antti Ilmanen
11. Piazzesi, Monika, and Eric T. Swanson. "Futures prices as risk-adjusted forecasts of monetary policy." *Journal of Monetary Economics* 55, no. 4 (2008): 677-691.
12. Cieslak, Anna, and Pavol Povala. "Understanding bond risk premia."*Unpublished working paper. Kellogg School of Management, Evanston, IL*(2011).
13. Cieslak, Anna, and Pavol Povala. "Expecting the Fed." *Available at SSRN 2239725* (2014).

Data Appendix

Backcasted 10 year TIPS synthetic breakevens:
Backcasts of the TIPS real rates and implied inflation breakeven rates, constructed using the approach described in the Liberty Street Economics blog post "Creating a History of U.S. Inflation Expectations" by Jan Groen and Menno Middeldorp.
http://www.newyorkfed.org/medialibrary/media/research/blog/groen_tips/Synthetic_TIPS_Breakeven_Rates.xlsx

Newer tips data can be found at
http://www.federalreserve.gov/econresdata/researchdata/feds200805.xls

ACM yields can be found at
https://www.newyorkfed.org/medialibrary/media/research/data_indicators/ACMTermPremium.xls

Survey of Professional Forecasters Inflation Expectations data
https://www.philadelphiafed.org/-/media/research-and-data/real-time-center/survey-of-professional-forecasters/historical-data/inflation.xls?la=en

Kim-Wright Term Premium Data
http://www.federalreserve.gov/econresdata/researchdata/feds200533.xls

GSW (2006) yields are found here
http://www.federalreserve.gov/econresdata/researchdata/feds200628.xls