Yield curve carry

Carry in various forms is one of the mainstays of the financial world. The idea of borrowing at low interest rates and investing in assets that yield more is applied especially to yield curves within a country and to yield curve spreads between countries. Both of these trades – yield curve carry and currency carry – can be effected using futures and forwards. These are markets in which Newedge is both well informed and highly experienced, and so we are in a position to use readily available market instruments and market prices to construct and publish benchmarks for both trades.

This note focuses on yield curve carry. To be sure, we embarked on this piece of work fully expecting that the resulting benchmark could be used to explain the performance of a wide class of hedge funds that focuses on fixed income markets in general, and fixed income arbitrage strategies in particular. What we found, however, was that:

- While the returns to pure yield curve carry are relatively highly correlated with returns on a global bond portfolio, they are somewhat negatively correlated with global equity returns, and that
- Yield curve carry returns are also somewhat negatively correlated with the returns on fixed-income focused hedge funds and so do not explain the performance of this subset of hedge funds.

At the same time, we did find that:

- Money market futures contracts provide an extremely cost efficient way to capture yield curve carry and without the complications of credit;
- Most of the gains realized by a yield curve carry portfolio over the past 20 years are explained by riding the yield curve and not by falling interest rates;
- Most of the juice in yield curve carry is realized in the front end – that is, the first two or three years – of the yield curve and that investors get paid relatively little, if at all, for taking additional duration risk further out on the curve.

As a result, the main purpose of this note is to describe the construction of a serviceable yield curve carry indicator, whose results are illustrated in the upper panel of Exhibit 1. The net asset value history of this indicator, which produced a Sharpe ratio of 0.87 from 1994 through September 2013, is...
the result of creating a globally diversified portfolio of eight-contract (i.e., two-year) strips of money market futures contracts with equal weight given to each contract and to each country. The average annualized gains for each of the eight contract months for each of the five markets are shown in the lower panel of Exhibit 1. The key points that we cover in this note are these:

- How can futures contracts capture yield curve carry?
- Why use money market futures rather than government note and bond futures?
- Why limit the horizon to two years?
- How does a global portfolio of yield curve carry trades perform?
- What are the risks inherent to a trade like this and how susceptible is the portfolio to changes in interest rates?
- How much of the yield curve carry indicator’s performance can be explained by falling interest rates?
- How correlated are yield curve carry returns to anything else?

**How can futures contracts capture yield curve carry?**

To interpret the results in the following exhibits, the one thing you need to know is that a long position in a Eurodollar futures contract is the financial equivalent – but without any attendant credit risk – of borrowing money with a term equal to the contract’s expiration and lending with a term roughly three months longer. The same is true of its non-dollar counterparts in Europe, Japan, the UK, and Australia. All of the financial algebra behind this statement is provided in the appendix to this note.

From the standpoint of understanding yield curve carry, the beauty of money market contracts is that each contract allows you to isolate carry along a particular three-month segment of the yield curve. As a result, money market contracts provide you with building blocks for constructing carry trades with a wide range of horizons. In this case, we end up constructing two-year strips of money market contracts that are the equivalent of borrowing with a term equal to the lead contract’s expiration (anywhere from zero to three months) and lending with a term roughly equal to two years.

Exhibit 2 shows the results of simple buy-and-hold trades in which one buys a Eurodollar contract, holds it for three months, and then “rolls” the position into the next contract month. For example, you might buy the contract that is next to expire when it has three months

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1 In the 1990s, in response to the increasing popularity of packages of Eurodollar futures that comprise several expirations, the Chicago Mercantile Exchange adopted two useful terms for describing these packages – bundles and strips. A bundle was defined as a collection of contracts with four sequential expirations. The first four expirations would make up the “white” bundle. The next four the “red” bundle, and so forth. Chaining more than four expirations together would produce a “strip.” Thus, a collection that included eight sequential expirations would be a two-year strip.
to expiration, hold it to expiration, and then replace it with the next contract. On Dec. 16, 2013, for example, this would entail first buying the March 2014 contract, holding it until it expires March 17, 2014, and replacing it with the June 2014 contract. This sequence of trades would be like borrowing for three months, lending for six, and then closing out the position at the end of each three-month period.

The results in the top panel of Exhibit 2 show the average annualized gains to riding various segments of the Eurodollar yield curve since 1994. In this exhibit, the numbers along the horizontal axis represent the place of the Eurodollar contract in the expiration cycle – from one to 20, which covers a span of five years. The numbers on the vertical axis represent Eurodollar price points, each of which is the equivalent of 100 basis points. We have annualized the results.

Two things stand out in Exhibit 2. One is that the average gains have tended to be higher for the nearby contracts – those whose expirations fall within three years – than for the more distant contracts. Another is that the average gains to these trades have actually been higher since the 2008 financial crisis, even though the general level of interest rates in the U.S. has been very, very low.

The next two panels of Exhibit 2 provide insights into risk adjusted returns. The middle panel, for example, shows the annualized volatility of gains and losses for each of the contract months. The bottom panel shows the ratios of average gain to annualized risk. And given that the average gains are pure excess gains, the resulting ratios in the bottom panel are true Sharpe ratios. Although the post-crisis Sharpe ratios have been much higher than for the full history from 1994 on, it is still true that most of the juice in the trade on a risk-adjusted basis is in the range of expirations from three months to two years.

The four panels of Exhibit 3 show the average gains to holding each of the first eight contracts in Euribor, Euroyen, Short Sterling, and the Australian 3-month bill markets. It is apparent from a comparison of these four sets of results that the term structure of payoffs to riding the yield curve is different for each of these countries. In Euribor and Euroyen, for example, the payoff seems to get larger the further out one goes on the curve, at least out to two years. The Short sterling and Australian 3-month bill market payoffs more closely resemble the pattern we see in the U.S. market. It is also interesting to note that Japan was the one country of these five in which riding the yield curve was less
Why use money market futures rather than government note and bond futures?

While doing the research behind this note, we learned that one could generate similar results for the U.S. market using Treasury note and bond futures. The Sharpe ratios shown in Exhibit 4 are what you would have realized from 1994 through September 2013 if you had simply been long the lead contract in each of these four markets. And, as shown in Exhibit 5, you would have realized almost identical performance from a rolled long position in two-year note futures as from a rolled two-year strip of Eurodollar futures.

Why limit the horizon to two years?

One reason to limit our horizon to two years stems from what we continue to learn about the behavior of carry in the U.S. dollar market. For whatever reasons, we have always found that most of the performance – both absolute and risk adjusted – is produced by the front end of the curve.\(^2\) These results

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\(^2\) What we find here is wholly consistent with what Antti Ilmanen reported in a July 1995 Salomon Brothers monograph called Does Duration Extension Enhance Long-Term Expected Returns?, which was part 3 of a series he called Understanding the Yield Curve. In it, he concluded that, for the most part, one was not very well compensated, if compensated at all, for taking duration risk beyond two years.
are actually reinforced by the Sharpe ratio produced by the four Treasury contracts (See Exhibit 4). At first glance, it seems that all four contracts – from two-year notes to long-term Treasury bonds – produced satisfactory risk-adjusted returns. But if you try to improve the performance of the two-year note contract by adding five-year, 10-year, or long-term bond futures, you find that you cannot. For example, given the 0.92 correlation between returns on the two-year and five-year contracts, the five-year contract would need to deliver a Sharpe ratio of at least 0.85 before adding them to a portfolio of two-year contracts would produce a better risk-adjusted return. As it was, the five-year contract’s Sharpe ratio of 0.77 did not meet this minimum requirement.\(^3\) The same is true for the 10-year and long-term bond futures contracts.

A second reason is availability. There is ample open interest in the Eurodollar, Euribor, and Sterling contracts to go further out on the curve. But in the Euroyen and Australian three-month bill contracts, one finds adequate open interest only in the first eight contract months.

How does a global portfolio of yield curve carry trades perform?

Performance statistics and correlations for yield curve carry in the five markets are shown in Exhibit 6. Each of the five markets produced respectable returns and free-standing Sharpe ratios. The best single outcome was in Japan, which produced a Sharpe ratio of 0.83. Second best was the U.S. with a Sharpe ratio of 0.75. The cross correlations are relatively low.

In constructing the portfolio, we settled at last on an equally weighted index, or average, of gains and losses expressed in index points. We considered other weighting schemes including size of their respective economies and sizes of their respective money supplies. But the results were all roughly the same so we chose equal weighting for its simplicity.

Note that to do this in practice would involve some kind of tracking error. For example, one must deal in whole contracts, which produces some rounding errors. And one must translate gains and losses realized in the five different currencies into a common currency. As one would expect, rounding errors become relatively less important as the overall size of the position increases. Exhibit 7, for example, shows the decimal and whole-contract positions that one would have held for positions that would have been roughly equivalent to $100 million and $1 billion of two-year notes. In these portfolios, given currency prices for Jan. 17, 2014, the objectives are to give equal notional dollar weights to the contracts in each market. For the smaller $100 million portfolio, the target would

\(^3\) If you are interested in the break-even Sharpe ratios for the entire Treasury complex, please contact Lianyan Liu at lianyan.liu@newedge.com.
be $20 million notional for each market. For the larger $1 billion portfolio, the target would be $200 million notional for each market. Given the rounding required by the need to trade whole contracts, we find that we have to very slightly overweight or underweight the four non-dollar markets. And overall, we find that the resulting notional value of the smaller portfolio would have been $100,341,868, while the notional value of the larger portfolio would have been $1,000,461,192. The dollar value of the mismatch is about the same, but the relative mismatch in the larger portfolio is about one-tenth of that in the smaller portfolio.

Similarly, a daily sweep program that converts all gains and losses into a common currency would reduce currency exposure to nearly zero. Because daily sweeps would be bothersome, however, one likely would settle for the residual currency exposure and risk that would result from sweeping less frequently.

As shown in Exhibit 6, the resulting Sharpe ratio for the portfolio of carry trades was 0.87 for the period from 1994 through September 2013. Exhibit 8 shows how the global portfolio would have compared with a pure Eurodollar portfolio. The Eurodollar portfolio produced a larger overall gain, but with higher risk and deeper drawdowns.

What are the risks?
Exhibits 6 and 8 already have provided some insight into the risks involved. Exhibits 9 and 10 flesh out these risks by providing detail on the history of quarterly gains and losses and on the relationship between the portfolio's value and the level of interest rates. Exhibit 9, for example, shows the sequence of quarterly gains and losses from 1994 to date. Exhibit 10 shows a comparison of the performance of the global carry portfolio and the average level of global money market rates. It is easy from these two histories to see that the portfolio's returns are negatively correlated with changes in the level of rates.

How much of the yield curve carry indicator's performance can be explained by falling rates?

We have had a bull market in bonds for the past 30 years and 20 of them are captured in this work. On average, money market rates ended up about five percentage points lower than where they began 20 years ago. In the mid 1990s, the average level of money market rates was around 6%. Now, in 2013,
the average level of rates is around 1%.

It is natural to ask, therefore, how much of the gains produced by the carry portfolio can be explained by falling rates. The answer is a lot less than you might think. In Exhibit 11, we show the results of parsing each period’s gain or loss into that part that could be explained by changes in the level of rates (i.e., level change), and that part that could be explained by carry or riding the yield curve (i.e., risk premium). In the upper part of the chart, you see a history of the two types of gains and losses. From these histories, we can conclude two things:

- First, roughly two-thirds of the total gain on a Euro-dollar carry portfolio was explained by risk premium, carry, or riding the yield curve. Only one-third was explained by the fact that rates fell.
- Almost all of the risk in the trade, though, stems from changes in rates. The standard deviation of gains and losses associated with changes in the level of rates was roughly six times that for risk premium gains or losses.

The reason for this kind of lopsided outcome is explained by the history of the slope of the curve, which is shown in the lower part of the chart.

The other four markets produced nearly identical results. In summary, the distribution of gains for the five markets looked like this:

<table>
<thead>
<tr>
<th></th>
<th>Level</th>
<th>Carry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eurodollar</td>
<td>34%</td>
<td>66%</td>
</tr>
<tr>
<td>Euribor</td>
<td>33%</td>
<td>67%</td>
</tr>
<tr>
<td>Euroyen</td>
<td>34%</td>
<td>66%</td>
</tr>
<tr>
<td>Short sterling</td>
<td>45%</td>
<td>55%</td>
</tr>
<tr>
<td>Australian 3-month bill</td>
<td>35%</td>
<td>65%</td>
</tr>
</tbody>
</table>

So the only market that departed even slightly from the rule was in the UK.

**How correlated are the yield curve carry returns with anything else?**

The last item of business is the question of correlation. How correlated are yield curve carry returns with returns on anything else? For this question, we chose global bonds, global equities, and a collection of hedge fund indexes that focus in one way or another on fixed income strategies. Six of these were HFRI Relative Value indexes including the Total, Asset Backed, Convertible Arbitrage, Corporate, Multi-Strategy and Yield Alternatives. The other two were the Dow Jones Credit Suisse Fixed Income Arbitrage Hedge Fund Index and the Barclay Fixed Income Arbitrage Index.

4 Again, if you want to see the detail for these markets, please contact Lianyan Liu.
The results for global bonds and global equities were not surprising. A return scatter for global bond returns versus the carry portfolio’s gains and losses in provided in Exhibit 12. Over this period, the correlation between the two was 0.74, which is relatively high, but is far from one because of differences in duration and credit exposures. And, as shown in Exhibit 13, the correlation of carry returns with global equity returns was slightly negative at -0.27.

For us, the truly surprising results came from the correlation of our carry returns with the returns on the eight hedge fund indexes. We even went so far as to hold an internal contest in which each of us in the Advisory Group ranked each of the eight hedge funds by what we thought their respective correlations would be. The sorry outcome was that we were all wrong. In fact, as shown in Exhibit 14, what we found was that all of the correlations were slightly negative, and the only differences were that some were slightly more negative than others.

A close examination of the pair-wise correlations shown in Exhibit 15 suggests that, if anything, these eight groups of fixed-income hedge funds are more closely aligned with equities than with bonds. The average of the correlations of the eight hedge fund series’ returns with global bond returns was 0.05. Zero for all practical purposes. In contrast, the average return correlation with equities over this period was 0.51. Their average pair-wise return correlations amongst themselves was slightly higher at 0.57. So, if anything, the main driver behind fixed-income hedge fund returns appears to be more closely related to the forces that determine equity returns than to anything related to interest rate carry or bonds.

### Summary and conclusions

At this point, we find ourselves in the following situation. Our initial belief that yield curve carry might provide a useful insight into the returns of fixed-income focused hedge funds appears to have been completely unfounded. Rather, fixed-income focused hedge funds look more like equities than like debt.

But the exercise was far from a dead loss. In fact, we have come out of this piece of work with some very useful and potentially profitable insights into ways to capture yield curve carry cheaply and efficiently. We’ve found that money market futures provide a nearly ideal vehicle for capturing yield curve carry – for riding the yield curve – without the need to own a bank or to take credit risk. We’ve shown that the most profitable part of the yield curve for extracting carry appears to be at the front of the curve – at least in the dollar market. And we’ve found that a globally diversified portfolio of money market contracts can deliver returns with a respectable Sharpe ratio and with relatively low drawdowns.

And, lastly, we’ve learned that most of the portfolio’s gains came from carry, or from riding the yield curve, and not from the general decline in interest rates over the past 20 years. This lesson suggests that carry trades could well make money – although much less money – even in a rising rate environment. For that matter, what we have found here suggests that anyone who tries to make money shorting notes or bonds faces a serious head wind from carry and would have to be extremely skillful at timing trades to beat the odds.
Appendix

Riding the yield curve with cash and with futures

The material in this appendix has been lifted from pages 59 through 63 of Burghardt, The Eurodollar Futures and Options Handbook, McGraw-Hill, 2003. The examples show the equivalence between riding the yield curve in the cash market – that is, actually borrowing and lending – and riding the yield curve using Eurodollar futures. These pages were written in response to the question, “What is the Sharpe ratio of a Eurodollar futures contract?” – a question that was raised by one of the participants in the course on Eurodollar futures that we used to run.

One of the valuable lessons learned from these examples is that a forward rate is a break-even rate. You can also find on page 64 of the Eurodollar book what Exhibit 2 in this note looked like when constructed using price data from 1987 through March 2002. In these examples, we used an actual/360 money market convention and assumed 91 days in each of the three-month periods. Except for possible differences in day-count or tick-value conventions, the same logic applies to other money market contracts.

The fact that you can approximate these results using government bond futures can be derived using the logic laid out in Chapter 11 of the Eurodollar book, which deals with term TED spreads. The difference between using money market futures and government bond futures would stem mainly from changes in the credit spread (i.e., term TED spread). The results shown in this note suggest that these differences have proven to be relatively small.

Example: Evaluate the performance of a “positive carry” trade

On June 17, 2002, a bank is able to borrow $100,000,000 for three months at 1.83% and lend $100,000,000 for six months at 1.97%. Because the bank earns 1.97% on its six-month asset and pays 1.83% on its three-month liability, it is said to have positive carry. How will this trade perform if three months from now, the three-month rate:

1. Remains at 1.83%?
2. Goes to 2.10%, which is the forward rate implied by today’s term deposit rates?

Yield Curves for Roll-Down and Break-Even Scenarios

![Yield Curve Diagram](image)
(1) The three-month rate three months from now is 1.83%

The banker would make $68,638 if the three-month rate is 1.83% three months from now.

The refinancing rate at which a trade like this breaks even is the fair value of the forward rate at the beginning of the trade.

Since we know that borrowing short term and lending long term is like being long a forward asset, we know that we should be able to reproduce the gains on this trade by buying an appropriate number of the right Eurodollar contract. In this example, rather than borrowing for three months and lending for six, we can simply buy the September 2002 futures contract. To compare the results of the two approaches, we need to compare what the two approaches make on the same day.

With the September 2002 futures, we will know what we have made when the contract expires on Sept. 16, 2002 (value date of Sept. 18). We need, then, a way to find what we have made on the cash and carry trade on that day.

To do this, we need to rearrange the information we used to reckon the gain or loss in December to find the present value of our gain or loss as of September. That is, if we divide the December values of the asset and liability by \([1 + \text{Sep LIBOR}]/360\), we can compare the present value of the long-term asset with the September value of the original three-month liability. Notice in the following example that if we do this, we find that the net value of our position would be $68,322, which, as it happens, is simply the present value of the $68,638 that was our net gain in December. That is, $68,322 = \$68,638 / [1 + 0.0183(91/360)].
Example: Cash flows from a “positive carry” trade

To present value the cash flows to Sept. 18, divide the maturity value on Dec. 18 by the invested value of $1 from Sept. 18 to Dec. 18.

(1) The three-month rate 3 months from now is 1.83%

\[ \text{Asset}_{18\text{Sep}02} = \frac{100,000,000 \left[ 1 + 0.0197 \left( \frac{91}{360} \right) \right]}{1 + 0.0183 \left( \frac{91}{360} \right)} = 100,530,905 \]

\[ \text{Liability}_{18\text{Sep}02} = \frac{100,000,000 \left[ 1 + 0.0183 \left( \frac{91}{360} \right) \right] \left[ 1 + 0.0183 \left( \frac{91}{360} \right) \right]}{1 + 0.0183 \left( \frac{91}{360} \right)} = 100,462,583 \]

\[ \text{Income}_{18\text{Sep}02} = 100,530,905 - 100,462,583 = 68,322 \]

The banker would make $68,322 as of Sept. 18.

(2) The three-month rate three months from now is 2.10%

\[ \text{Asset}_{18\text{Sep}02} = \frac{100,000,000 \left[ 1 + 0.0197 \left( \frac{91}{360} \right) \right]}{1 + 0.0210 \left( \frac{91}{360} \right)} = 100,462,655 \]

\[ \text{Liability}_{18\text{Sep}02} = \frac{100,000,000 \left[ 1 + 0.0183 \left( \frac{91}{360} \right) \right] \left[ 1 + 0.0210 \left( \frac{91}{360} \right) \right]}{1 + 0.0210 \left( \frac{91}{360} \right)} = 100,462,583 \]

\[ \text{Income}_{18\text{Sep}02} = 100,462,655 - 100,462,583 = 72 \]

The banker will just about break even.

Now we are ready to show how a positive carry trade can be replicated with futures.

Example: Replicate the positive carry trade with futures

Borrowing for three months at 1.83% and lending for six months at 1.97% on June 17, 2002, is akin to buying September 2002 Eurodollar futures at a fair value of 97.90 (= 100 – 2.10).

How would the futures position perform three months later on Sept. 16 (its expiration date) if:

1. The three-month rate comes in at 1.83%?
2. Futures settle at their fair value of 2.10%?

On June 17:

- Buy 101 September 2002 futures at 97.90

On September 16:

1. 3-month LIBOR = 1.83%

   - September 2002 futures = 98.17 (= 100 – 1.83)
   - Gain = 101 [98.17 – 97.90] $2,500 = $68,175

2. 3-month LIBOR = 2.10%

   - September 2002 futures = 97.90 (= 100 – 2.10)
   - Gain = 101 [97.90 – 97.90] $2,500 = 0

The futures trader comes very close to matching the cash trade in the previous example under the two interest rate scenarios. The cash trade income was $68,322 when the three-month rate was starting in three months was 1.83%. At a rate of 2.10%, the income was $72.
Newedge Snapshots

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- A review of currency hedging in index construction
- A window into the world of futures market liquidity
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- There are databases
- Got liquidity, volatility and low transaction costs
- How many trades are there currently?
- Riding the yield curve

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- It’s the autocorrelation stupid
- Two benchmarks for momentum trading
- Correlations and holding periods
- There are known unknowns
- Superstars versus teamwork
- Measuring market impact and liquidity