FXYI$^{2\ TM}$ – A Foreign Exchange Yield Investing Index

Marc E. Levitt

Silicon Valley Quantitative Advisors

marcl@svquant.com
http://www.svquant.com

ABSTRACT

This paper investigates the design and construction of a Foreign Exchange Yield Investing Index, FXYI$^{2\ TM}$. The premise of the index is to create a transparent and easily replicated benchmark for the major non-trend following component of currency trading managers. FXYI$^{2\ TM}$ is intended to augment the trend following AFX index by Lequeux and Acar (1998), formerly FXDX, in setting a benchmark for active advisors.

Additionally, FXYI^2 is an aid in performing style analysis in the spirit of Sharpe for trading advisors and funds. This assists the asset allocator in determining the "true style", not disclosure document style, of a manager or determine when an advisor is straying from their past trading method(s). A third application of FXYI^2 is in the area of style rotation. Since the FXYI^2 has a contrarian aspect to it, the state of the FX market can be determined by looking at the return differential between AFX and FXYI^2. This FX market state can be used in trading and asset allocation decisions.

Keywords: benchmark, currencies, interest rate, yield, CTA, trading rules, forward rate bias

Table of Contents

1 Introduction 3
2 Current FX Benchmarks 3
2.1 Advisor Based 3
2.2 Transparent Rule Based 4
3 FXYI2 5
3.1 Instruments 5
3.2 Rules 6
3.3 Performance 7
4 Style Analysis 7
5 Style Switching 8
6 Summary 9
Tables 10
Figures 12
References 14

1 Introduction

Since the 1980's the choice of investment opportunities has grown from standard instruments typically stocks, bonds, and mutual funds to include alternate asset classes such as hedge funds, managed futures, and venture capital. Alternate asset class managers, e.g. commodity trading advisors (CTA), use their funds to speculate with leverage in the financial markets. As the assets under management in these programs have grown and wider interest has developed the need for benchmarks has seen parallel growth in interest and development. Benchmarks are important for an asset class helping investors make important decisions regarding advisor allocations, sector allocations, and timing. It is expected that the use of benchmarks will help the institutionalization of the business and further increase assets under management since measurements can be made and allocations determined.

This thinking is not unfounded since the development of such benchmarks and extensions into performance analysis has help build the foundation of the larger allocations to equities from institutional money managers in the 1980's and 1990's. A lesson learned from the equity business is that benchmarks should be well understood and as transparent as possible in order to help their acceptance in the market place. In short, the alternate asset class business needs to develop the rich quantitative framework available in the equities business if allocations are to significantly increase.

The purpose of this paper is to help develop the needed quantitative framework by extending the work previously performed in the area of systematic currency benchmarks to encompass more then the traditional trend-following strategies. This advances the current single factor model of currency fund managers to a multifactor one. Section 2 introduces current currency trading benchmarks in use. Section 3 describes the construction of the new $FXYI^2$ benchmark. Required data, trading rules and performance are presented. This benchmark is then used in Section 4 to extend style analysis of currency managers from a single factor model, based on trend-following, to a multifactor one. Section 5 examines the return differential between the different currency benchmarks and explores if there are any profitable opportunities for exploitation by style or benchmark switching, a.k.a. tilting. The last section summarizes and concludes our results.

2 Current FX Benchmarks

The current state of benchmarking in alternative asset classes breaks down into three areas: passive, manager based, and transparent rule based. In this section we will discuss only manager/advisor and rule based benchmarks. We do not discuss passive benchmarks, such as the US Dollar Index for foreign exchange trading since they are "long" only benchmarks. Long only benchmarks do not capture the ease at which alternative asset managers, particularly CTAs, employ both long and short positions in generating their returns.

2.1 Advisor Based

The first type of benchmark discussed is that of advisor based. There are a multitude of these types of indices in both currency and other alternate asset classes. Advisor based benchmarks are constructed from the performance records of a qualified set of managers or CTAs. Each benchmark owner sets what those qualifications must be and determines the construction of the benchmark based on the qualified set. The most importance difference, in addition to which advisors are included, is whether to weight managers based on assets under management or to equally weight the managers. This decision has important implications when examining a benchmark since each weighting scheme has both pros and cons which are beyond the scope of this paper. To give a reader an overview of the types of

advisor based benchmarks that exist some example indices are presented. This is by no means a comprehensive review of the advisor based indices available in the currency sector.

Parker Global Strategies (1993), a alternative asset consulting and risk management company, has created a performance index to provide objective analysis of the firms that trade currencies for outside clients. The Parker FX Index is equally weighted and represents the average performance of 47 currency programs, with 33 systematic and 14 discretionary traders and assets under management of $13 billion. A second currency index has been developed by the Barclay Trading Group, Fairfield, Iowa. As of January 2000 there are 55 managers included in the index. The composite is equally weighted like the Parker FX index. The final currency index presented has been developed by Managed Account Reports (MAR), a New York City based publisher that monitors the hedge fund and managed futures industry. The MAR currency sub-index is weighted according to assets under management. As of December 1999, the MAR index included 45 currency programs with $5.9 billion under management. Monthly returns are net of fees and expenses and include interest for each currency advisor.

While manager indices are highly correlated, their mean and volatility do substantially differ for one to another. This is mostly influenced by the composition of the index, i.e. weighting scheme and manager universe as previously alluded to. The lack of transparency and potential for survivorship bias hinder acceptance of advisor based benchmarks. Recently a new class of transparent benchmarks have been developed based on the observations most of the money managers, 75% according to the Barclay Trading Group, are systematic traders and a majority of systematic CTAs are trend followers.

2.2 Transparent Rule Based

In order to overcome the shortcomings of both passive indices, i.e. no short positions, and manager based indices, i.e. lack of transparency, attempts have been made to develop systematic indices. The purpose of the systematic indices is to mimic the performance of the majority of managers in advisor based indices. This development has been driven by the large use of trend-following techniques by managers and the hoped for institutionalization of the managed futures industry. Examples of broad commodity indices are the MLM Index™ and the Barclay Futures Index™, Barclay (2000). Both the indices employ a momentum, trend following, strategy based on moving averages over a wide universe of exchange traded commodity contracts.

The Barclay Futures Index, BFI, has a currency sub-index made up only of the currency components of the full BFI. The BFI Currency Index, BFIC, trades 6 currencies against the Dollar based on CME IMM contracts and is re-weighted every month to be equal for all six rates. The six rates are: AUD, GBP, CAD, EUR, JPY, and SFR. They are traded with a 13-week moving average rule in a stop-and-reverse manner that is executed once a month for each contract. No leverage is employed.

The second and more widely known currency index is the FXDX of Lequeux and Acar (1998). This index aimed to capture the systematic and trend following nature that a majority of traders in the currency arena follow. Seven FX pairs are traded based on three moving averages. The FX pairs and their weighting were based on the reported volumes on the Reuters Dealing 2000 system. A leverage of 2.91 is employed in the original work. From their results, the performance and correlation to the Parker FX index and TASS Currency Index were quite good, giving similar performance as these less transparent benchmarks. It was also shown that the correlation to known trend-following CTAs in the currency sector was quite high. The FXDX has been changed to overcome some shortcoming with the original version and has been rechristened AFX. The changes include substituting the Euro for the DMark, using Bank for International Settlements (BIS) volume as weightings for the FX pairs, and removing all leverage inherent in the index. This makes the index even cleaner as a benchmark since

the leverage can be adjusted to match the manager's characteristic of interest that is under evaluation. An example application would be to adjust leverage of AFX until the benchmark and trading advisor reached the same average annual rate of return. Once this is performed then risk measures such as volatility and maximum drawdown can be calculated and compared between the leveraged AFX and manager of interest. One can reverse this procedure and leverage AFX to match on a risk measure of interest and then compare returns between the benchmark and manager. This type of analysis is common in the equity and mutual fund business. A comparison of the construction for the two systematic indices are given in Table 1.

While trend-following is the most common and primary factor in currency manager performance other trading techniques with positive returns exist. These techniques are employed and rumored to be employed by successful managers trading via systematic methods. In order to extract this potential second factor a new transparent benchmark was developed FXYI^2.

3 FXYI^2

The Foreign Exchange Yield Investing Index is heavily influenced by the design of the FXDX and the newer AFX index by Lequeux and Acar (1998). It was designed to augment the trend following nature of AFX with the other major trading method employed by currency managers. While AFX exploits the well know serial correlation in currency returns, or trending nature, FXYI^2 exploits the well know forward rate bias anomaly, Froot and Thaler (1991), and Choie (1993).

3.1 Instruments

The instruments actually traded in the FXYI^2 are the seven major FX rates by volume as reported by the Bank for International Settlements. In order to construct the actual index the interest rate differential between the currency pair is needed. To obtain this yield differential numerous sources are possible to use. These include:

- Implied interests rates from exchange traded short-term instruments, Lequeux (1998).
- Swap rates
- FX forward rates
- Short term Libor-rate quotes

While swap, Libor, and implied interest rates were examined during the development of FXYI2, only the results using implied interest rates are presented. Implied interest rates are used to make the index more transparent since the pricing is based on exchange traded instruments. For exchange traded instruments the closing price is set and published by the exchange. Although we use implied interest rates, the other time series do not significantly alter the results presented here based on our calculations.

The implied interest rate differentials are calculated by looking at short term instruments traded on the SIMEX, LIFFE, and CME. In order to obtain some of the time series it was necessary to mix contracts from different exchanges with different trading and settlement hours. Extreme care was taken as to not data-snoop and look forward in time. In fact, an argument can be made that this process of mixing contracts, i.e. stale quotes, may hurt the results of our work just as easily as help. Table 2 lists the exchanges used for each interest rate differential time series. While some choices may not be obvious, these contracts were selected in order to create the longest time series possible for all seven FX pairs. In order to check that these contract choices did not significantly bias the results, subsamples were calculated based on same exchange contracts. Examples of this would be using the LIFFE Eurodollar contract in place of the CME one, or to use the CME Euroyen and Eurodollar contract for JPYUSD yield differential starting in March 1996 to present. Making substitutions of this nature did not change

the results. For all the work presented in the remainder of this paper only the contract pairs in Table 2 were used.

To construct the actual interest rate differential time series the following steps were employed

- Contracts of the same month were used for both rates
- Contracts used are March, June, September, and December
- Rollovers to the next contract occurred on the same day for all contracts and all exchanges
- Only days when both contracts traded a full day on their respective exchanges were used, all other days were excluded
- Interest rate was determined by $IR_t = 100 - C_t$ where C_t is the settlement price for the futures contract
- Interest rate differential was calculated $IRDiff_t = IR_{currency1,t} - IR_{currency2,t}$

By using the above calculation we are introducing a bias into the interest rate differential calculation. This bias has to do with the slope of the yield curve between the two countries of the FX rate. If the slope is different between the two countries then this difference will directly effect the value of the yield differential. Of course, one could build a yield curve for each interest rate using the Eurofutures contracts and then use the values from these curves to calculate the interest rate differential. This complex method was not pursued since it would hurt the transparency of the benchmark.

The second set of data needed to construct FXYI2 are the actual FX rates that will be traded. All FX times series were constructed from CME contract prices. This has two distinct advantages:

- No need to use tomorrow-next (T/N) rollovers to calculate returns which greatly eases analysis and results generation.
- FX time series settlement price is at the same time or after the calculation of the interest rate differential since the CME is the last exchange open for a given date as the trading day moves from Asia to Europe to North America.

The one disadvantage with using CME contracts as practiced in this paper – the FXYI2 strategy was not tradable during its whole history. This is due to the fact that the cross rates are based on the FX rates and disregard the actual contract sizes. One could not have executed this strategy unless care was taken to continually rebalance the contracts to match the cross-rate, e.g. JPYDEM rate using the JPY and DEM CME contracts. Of course actual implementation of the FXYI2 strategy can occur in the spot FX market using T/N type rolls or using some of the more recently available cross-rate FX contracts available through CME, FINEX, and others. Again, in order to check our results some of these contracts were used starting with their availability, e.g. DEM/JPY on the CME from 1992 – 1998 and EUR/JPY for 1999. Since no biases or errors were found in the methodology all results are based on the CME contracts against the Dollar and their derived cross-rates.

3.2 Rules

The rules for creating the FXYI2 index are simple and based on the ubiquitous moving average. The basic rule looks at the moving average of the interest rate differential and if the interest rate differential is positive a long position is established until the differential drops below the moving average at which time the position is reversed to a short position. For example, if the JPYUSD yield differential, i.e. 3-month Euroyen minus 3-month Eurodollars, was positive then we would go long an CME Yen contract. If the differential was negative then we would sell 2 Yen contracts making us net short. The use of moving averages of yield differentials as trading signals has been supported by previous authors, Lequeux (1998), Bracker and Morran (1999).

To actually construct the FXYI2 three moving averages are used in a similar fashion to FXDX. The moving averages used in this work are 5, 9, and 17 days. This gives us the possible positions of {-1.0,-0.33,+0.33,+1.0} multiplied by their allocations. The allocation to each segment is based on the BIS

data used in the AFX index construction. The weightings are given in Table 1 as a reference. The basic steps in calculating FXYI2 are

- Calculate the yield differential for all currency pairs, YD_t
- Calculate the 5,9, and 17 day moving average of the yield differential, $M_t = 1/m \sum YD_{t-i}$
- If the yield differential is greater then the average then the position is long, i.e. +1, otherwise it is short, i.e. -1. $S_t = 1$ if $YD_t > M_t$ else $S_t = -1$
- Calculate the net position over all three moving averages, should be either –1.00,-0.33,+0.33,+1.00. $P_t = (S_{5,t} + S_{9,t} + S_{17,t})/3$
- Determine the FX return by multiplying the position by tomorrow's return by the allocation weight. $R_{t+1} = P_t \times X_{t+1}$ where $X_{t+1} = \text{Ln}(C_{t+1}/C_t)$ and C_t is the FX rate settlement price on day t

Shorter term moving averages were chosen since the dynamics of the yield differential series are not as volatile as spot FX rates. Thus, the extra transaction costs associated with shorter term moving averages are partially ameliorated. Longer term moving averages were also tried and work well, although the returns available to the trader are less for the added reduction in transaction costs. All other conclusions in this paper hold for the longer moving averages.

3.3 Performance

The performance of FXYI2 is presented in Table 3 and compared to two trend-based indices, AFX and BFI Currency. A graph of FXYI2 performance is given in Figure 1. From the results presented one can see that using the forward rate bias as a trading mechanism has some inherent risks. While raw performance and Sharpe ratio surpass both trend indices the maximum drawndown and its ratio to average yearly return show that based on these measures FXYI2 has significantly more risk. This is not unexpected, as many professional money managers can attest. This is commonly called "event risk" by practitioners, Fung and Hsieh (1993). An event risk occurs when a discrete event changes the nature of the forward rate bias relation. Examples of such event risks are central bank intervention and currency devaluation. It is not uncommon for central bankers to increase short term interest rates in order to fight off speculation and not devalue their currency. In such cases investing in that currency will look attractive to the FXYI2 since the yield differential is large. If the currency devaluation does take place an immediate and large loss occurs. While such event risks have been known to money managers for decades, it has not stopped many from developing models that will suffer when they occur. Since event risk is inherent in the nature of our strategy we did not try to data-mine around this ugly fact.

Correlations between the three indices are presented in Table 4 for the whole time period March 1991 through December 1999. FXYI2 is not correlated with trend-following strategies on the whole, but it is also not a contrarian strategy, i.e. negative correlation. A better picture of FXYI2 can be seen in the rolling 12-month correlation with AFX, Figure 2. FXYI2 has multiple personalities, for most of the time FXYI2 is not correlated with AFX (<0.4) but there are periods of time it is a trend-follower (>0.5) and other periods of time it is a counter-trend strategy (<0).

4 Style Analysis

A straight forward application of FXYI2 is to extend the single factor style model of currency manager analysis into the multifactor domain. This will hopefully allow traders who are systematic, but not necessarily trend followers, to be more accurately analyzed then with AFX alone. Moving style analysis for alternative asset classes, such as currencies, into the multifactor world parallels the development in equity markets. In equity markets it is not uncommon to use at least four factors or indicies in style analysis, Sharpe (1988, 1992). The four equity factors are usually drawn from the universe of small-cap, large-cap, value, and growth. This of course has been extended to different

geographic regions etc. To investigate if FXYI2 would be useful in style analysis, representative currency managers were examined and regressions performed against the two-factor asset model, AFX and FXYI2. To perform the analysis constrained regressions were used. The constraints were that all coefficients are positive. The standard constraint that coefficients sum to unity was not imposed since most managers employ leverage and both indicies do not.

The results for style analysis are quite mixed. While adding the FXYI2 factor was statistically significant and improved the explanation of the model, i.e. R^2, for some advisors the increase was not as large as hoped for. This is true for some managers that are known or suspected to heavily rely on the forward rate bias mechanism for trading profits. We speculate that this lack of fit maybe due to the following reasons

- FXYI2 uses a fixed allocation for each pair and most advisors employing a similar mechanism use some form of portfolio optimization to determine allocations. This can make them much more dynamic then FXYI2.
- FXYI2 is highly nonlinear, i.e. positions are step functions. In FXYI2 positions can take one of four values, {-1.0,-0.33,+0.33,+1.0}, in methods that forecast the return and then use portfolio optimization positions can be much finer grained.
- FXYI2 trades a limited but important set of currencies and does not speculate in the CAD, AUD, NZD currencies amongst others. It is know that some of the funds we attempted to perform style analysis on use these FX rates along with the ones employed by FXYI2.

It is unknown if the three previously mentioned deficiencies in FXYI2 construction alone account for the lack of descriptive power for the benchmark.

5 Style Switching

The final application of FXYI2 is in the area of style switching. Since FXYI2 is not correlated to trend-following strategies overall and there are times of negative correlation looking at the differential return between AFX and FXYI2 can give us a clue to the state of the FX market. Is it trending, non-trending, or counter-trending? Knowing this, a dynamic strategy can be developed that will switch between the two indicies. The value of switching betwwen the two indicies can be seen from examining Figure 3. In the figure the rolling 12-month return differential between AFX and FXYI2 is plotted, where negative values imply FXYI2 is outperforming AFX. Clearly evident are large periods of over and under performance, some lasting greater then a full year. To exploit these stable periods a simple timing rule was developed based on the differential return time series. The timing rule is as follows

- Calculate the 4 period simple moving average of the return differential series. For our work we use the rolling 12-month differential and the period is monthly for the moving average.
- If the moving average is greater then the differential return series then for the next month follow the FXYI2 strategy
- If the differential return series is greater then the moving average then for the next month follow the AFX strategy

This strategy has been named the Dynamic Currency Allocation, DCA. The results of the DCA strategy, a simple 50/50 allocation to AFX and FXYI2, as well as the raw indicies is presented in Table 5. DCA shows superior results in all relevant statistics and is particularly strong in risk-adjusted measures like Sharpe ratio and return to maximum drawndown. Figure 4 shows the returns for all four benchmarks. Of course this performance does not come for free. There are expenses in both administrative overhead and transaction costs that have not been accounted for in this analysis. What is encouraging is that with the proper infrastructure the differences in FXYI2 and AFX can be exploited to deliver better returns and risk-adjusted returns.

6 Summary

The purpose of this paper was to present a new benchmark which is based on a well known currency trading strategy, the forward rate bias. The construction of the benchmark is disclosed and entirely performed using exchange traded contracts and available data. The construction closely follows the FXDX/AFX index and is based on the application of moving averages to the interest rate differential between the short-term instruments of the countries that comprise the FX rate. The benchmark shows significant economic returns. This new benchmark is designed to augment trend-following benchmarks in performing style analysis. Based on our initial look into this area we are still not certain this will come to fruition with such a crude index. Extensions in the number of FX rates covered and construction methodology might need to be explored. This might come at the expense of transparency for the index. A more useful application of the index is in performing style switching between trend-following strategies and yield strategies. By using the return differential between the two indices active strategies with excellent return and risk adjusted return can be developed.

Tables

Table 1: Comparison of AFX and BFI Currency index composition and trading rules.

	AFX	BFI Currency
USDEUR weight	35.62%	16.66%
USDJPY weight	31.65%	16.66%
USDCHF weight	9.02%	16.66%
USDGBP weight	13.12%	16.66%
EURJPY weight	3.45%	0.00%
GBPEUR weight	4.54%	0.00%
EURCHF weight	2.60%	0.00%
USDAUD weight	0.00%	16.66%
USDCAD weight	0.00%	16.66%
Moving Average Length(s)	32, 61, and 117 days	13 weeks
Trading time frame	Daily	Monthly

Table 2: Contracts used to calculate interest rate differentials for currency pairs. For all contracts 3 month Euro-rates are used, e.g. Euroyen, Euroswiss etc.

Interest Rate Differential	Exchange 1	Exchange 2
CHFDEM	LIFFE	LIFFE
CHFEUR	LIFFE	LIFFE
CHFUSD	LIFFE	CME
DEMJPY	LIFFE	SIMEX
EURJPY	LIFFE	SIMEX
DEMUSD	LIFFE	CME
EURUSD	LIFFE	CME
GBPDEM	LIFFE	LIFFE
GBPEUR	LIFFE	LIFFE
GBPUSD	LIFFE	CME
JPYUSD	SIMEX	SIMEX

Table 3: Summary performance of $FXYI^2$ and trend following benchmarks, AFX and BFIC, from March 1991 through December 1999.

	$FXYI^2$	AFX	BFIC
Return %	5.06	3.45	3.80
Volatility %	6.37	7.25	5.16
Sharpe Ratio	0.79	0.48	0.74
Maximum drawdown %	15.3	8.0	6.3
Positive months	60%	49%	61%
Return/MaxDD	0.33	0.43	0.60
P-Value for Return > 0	1.0%	8.0%	1.5%
T-Stat Equal Mean to FXYI2	NA	-0.49	0.45
T-Stat Equal Mean to AFX	-0.49	NA	-0.11

Table 4: Correlation between FXYI2, AFX, and BFI Currency.

	FXYI2	AFX	BFIC
FXYI2	1.00	0.05	0.12
AFX		1.00	0.69
BFIC			1.00

Table 5: Comparison between raw components and two derived portfolios based on simple construction rules, May 1992 – December 1999. 50/50 is an equal allocation between AFX and $FXYI^2$ rebalanced monthly. DCA is a dynamic rule based allocation using the return differential between $FXYI^2$ and AFX. All results do not employ leverage.

	$FXYI^2$	AFX	50/50	DCA
Return %	4.37	3.55	3.96	6.48
Volatility %	6.34	6.25	4.74	5.67
Sharpe Ratio	0.69	0.57	0.83	1.14
Maximum Drawdown	15.3	8.0	8.83	6.32
Positive Months	58%	51%	62%	54%
Return/MaxDD	0.28	0.44	0.45	1.02

Figures

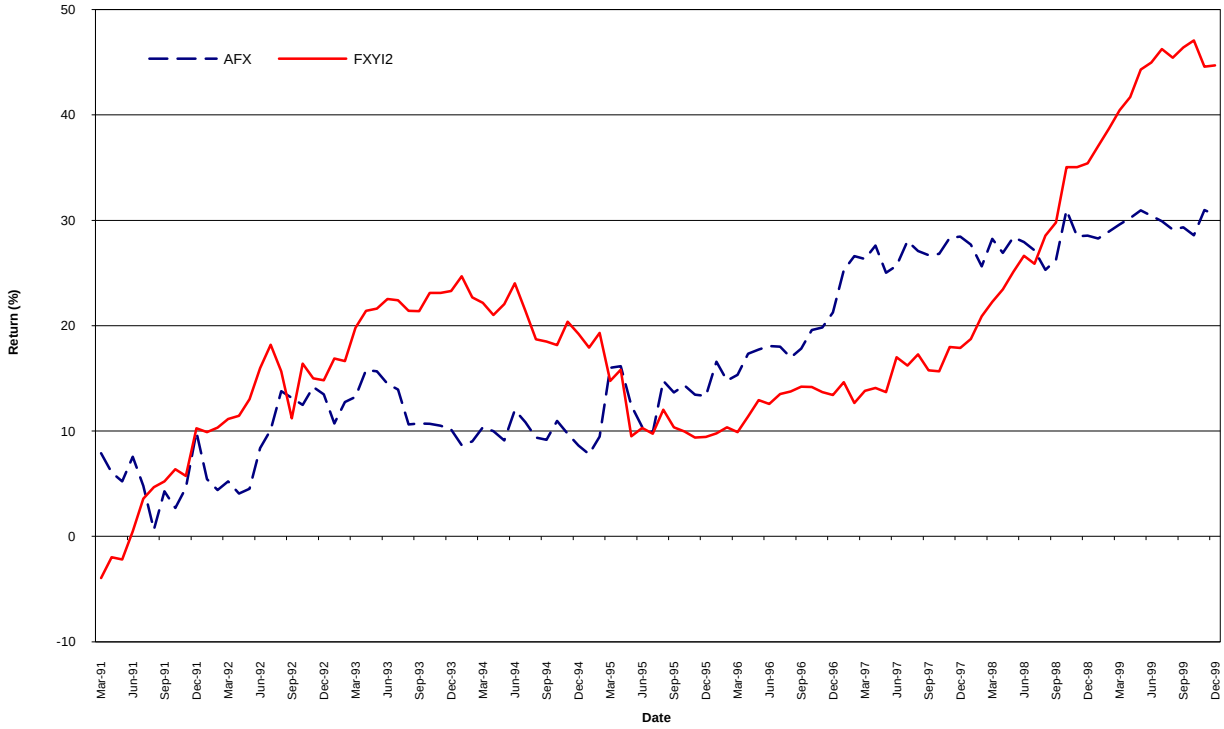

Figure 1: Currency indicies $FXYI^2$ and AFX, March 1991 through December 1999.

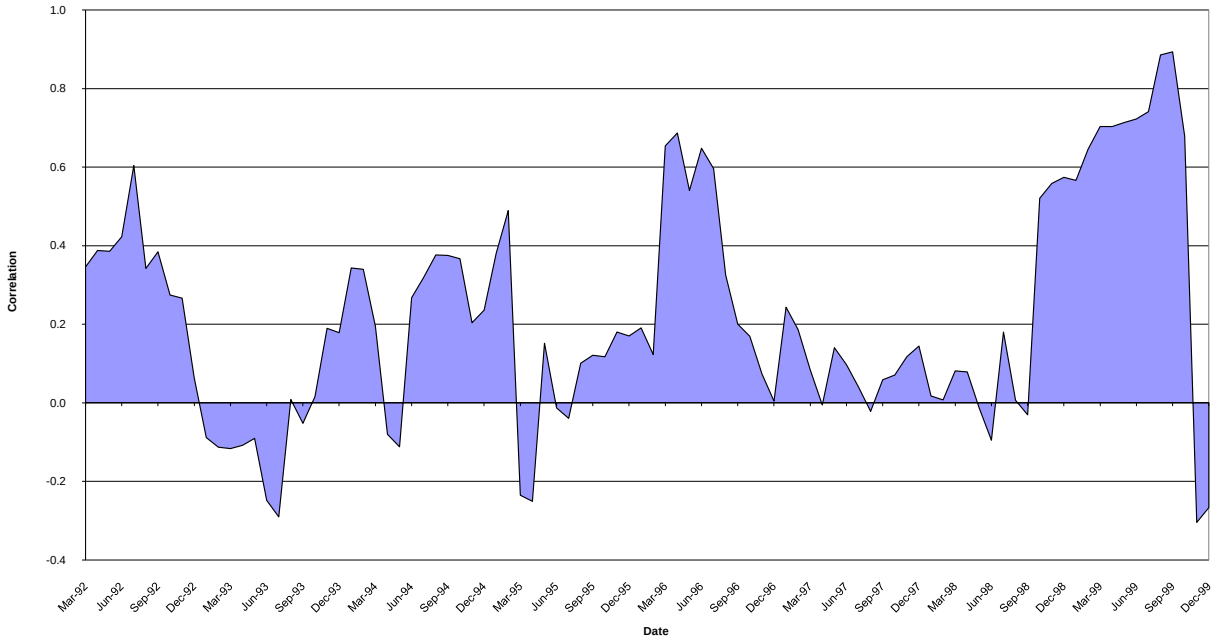

Figure 2: Rolling 12-month correlation between FXYI2 and AFX.

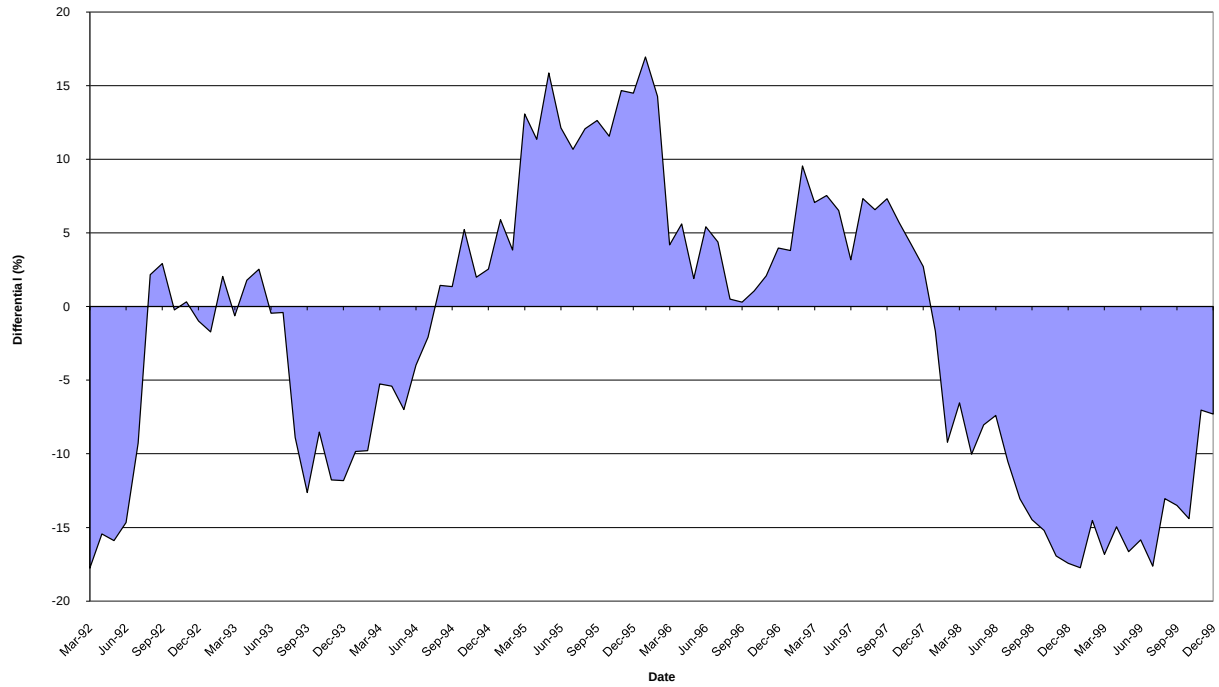

Figure 3: Return differential between AFX and FXYI2 using 12-month rolling returns. Negative numbers indicate FXYI2 is outperforming AFX.

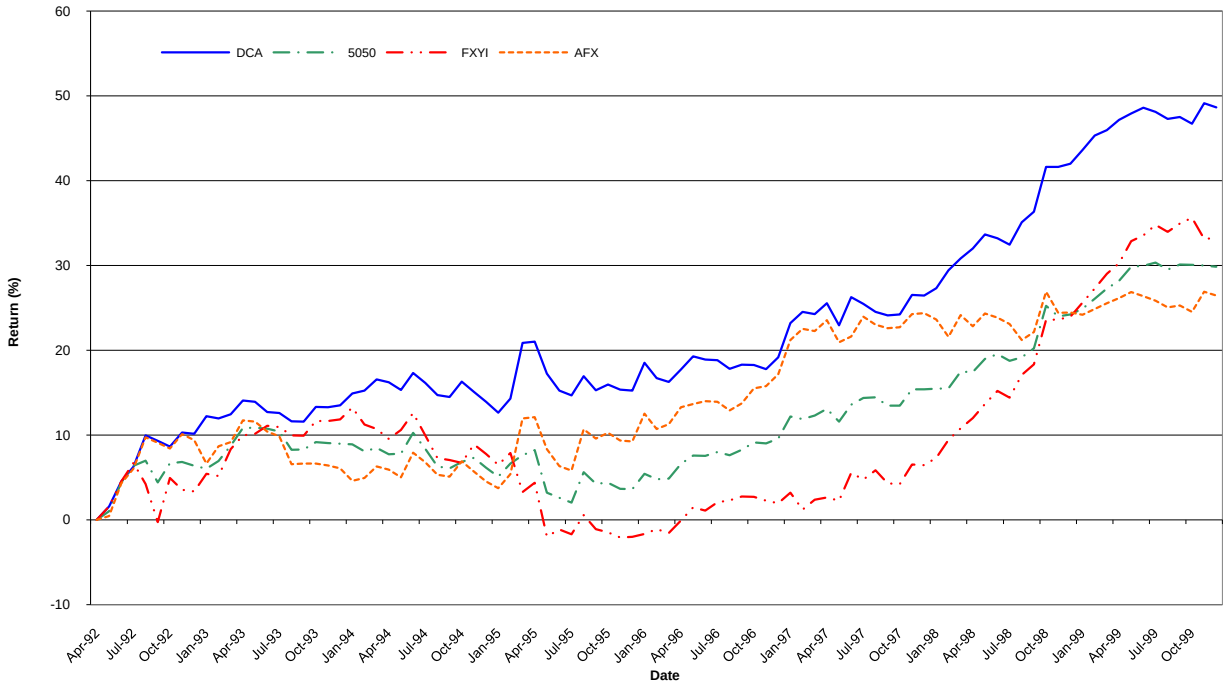

Figure 4: Comparison of currency strategies.

References

Acar, E. and Lequeux, P. (1999) Pursuing the debate on active currency management, Investment Conference, Loch Lomond, Scotland.

Barclay Trading Group, Futures index section, *Barclay Trading Group Web Site*, www.barclaygrp.com.

Billion, O. (1993) Value, yield, and trend: A composite forecasting approach to foreign exchange trading. In *Strategic Currency Investing*, ed. A Gitlin, Probus, Chicago, 366-403.

Bracker, K. and Morran, C. (1999) Tactical currency allocation revisited: Four simple currency trading rules, *The Journal of Investing*, Fall, 65-73.

Choie, Kenneth S. (1993) Currency exchange rate forecast and interest rate differential, *The Journal of Portfolio Management*, Winter, 58-64.

Froot, K. and Thaler, R. (1991) Anomalies: Foreign exchange, *Journal of Economics Perspectives*, Summer, 127-135.

Fung, W. and Hsieh, D. (1993) Exploiting the interest rate differential in currency trading. In *Strategic Currency Investing*, ed. A Gitlin, Probus, Chicago, 260-286.

Lequeux, P. and Acar, E. (1998) A dynamics index for managed currencies funds using CME currency contracts, *The European Journal of Finance*, **4**, 311-330.

Lequeux, P. (1998) Informative spillovers in the currency markets: A practical approach through exogenous trading rules. In *Advanced Trading Rules*, eds. E. Acar and S. Satchell, Butterworth-Heinemann, Oxford, 143-175.

Parker, V. (1993) Profiting from diversified managed currency strategies: An investors perspective. In *Strategic Currency Investing*, ed. A Gitlin, Probus, Chicago, 217-259.

Sharpe, W. (1988) Determining a fund's effective asset mix, *Investment Management Review*, December, 59-69.

Sharpe, W. (1992) Asset allocation: Management style and performance measurement, *The Journal of Portfolio Management*, Winter, 7-19.