The NYBOT US Dollar Index as an Investment and Hedging Vehicle

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I. Introduction

Since end of the Bretton Woods exchange rate system in 1971, a number of economic and market events have increased interest in exchange rates both as an investment as well as a hedging vehicle. First, while the U.S. Dollar has remained the major unit of exchange in world trade, the rapid globalization of trade has resulted in increasing growth in corporate based foreign exchange (FX) transactions and the potential for exchange rates as a hedging vehicle. Secondly, international global stock and bond investment has also risen dramatically resulting in an increased demand for exchange rate based produces for managing the risk of international investment portfolios. Third, the size and liquidity of international exchange rate markets have created opportunities for pure currency investment and trading. Even with the introduction of a single European currency, which has reduced the variety of foreign exchange exposures, foreign exchange markets operate at a level of complexity which offers investment opportunities to international investors.

In short, the increased growth in international trade as well as international investment has spurred the creation of a variety of currency instruments, such as the US Dollar Index, which offer investors new currency risk management and investment opportunities. The New York Board of Trade (NYBOT) US Dollar Index (USDX®; DX for short) represents the value of the US Dollar in terms of a basket of six major foreign currencies: Euro (57.6 %), Japanese Yen (13.6 %), UK Pound (11.9 %), Canadian Dollar (9.1 %), Swedish Krona (4.2 %) and Swiss Franc (3.6 %). There exist a futures contract and an option contract on the DX, traded on the FINEX (a division of NYBOT). The DX provides a convenient method for direct investment in the US Dollar as well as a tool for hedging FX exposure relative to the Dollar. This paper looks at the investment and risk management benefits of the DX as a part of a diversified portfolio of international equity, bond and currency assets.

In the next section, we present a brief review of the academic literature on currency investing and risk management. Section III describes the data and methodology used in this study, while section IV presents major findings as they relate to the performance of the DX as an investment and a risk management tool. Results show that the DX provides both investment and risk management benefits, especially for investors in diversified global investment portfolios. Section V summarizes the results.

II. Foreign Exchange Risk Management and Investment: An Overview

A large body of academic research exists in the area of foreign exchange risk management as well as investment. In this paper we analyze the benefits of the DX as a risk management instrument and investment vehicle. It is not possible to cover in detail all the aspects addressed in this research. In this section we briefly summarize the major academic research on foreign exchange rates as an investment medium as well as a risk management tool.

A. Foreign Currency as an Investment Medium

Academics are fond of pointing out that, in an efficient market, all relevant information should be immediately reflected in asset prices such as exchange rates. Moreover, for exchange rates in a risk-neutral world, the forward exchange rate should be the best predictor of the future spot rate. For instance, if one denotes $F_{t,t+1}$ as the forward rate quoted at time t for maturity $t+1$ and f_t as its percentage deviation from the spot exchange rate S_t, then

$$f_t = \frac{F_{t,t+1} - S_t}{S_t}$$

is also called the forward premium (discount) and is equal to the interest rate differential. The forecast error of the exchange rate movement is given by:

$$\varepsilon_{t+1} = \frac{S_{t+1} - S_t}{S_t} - \frac{F_{t,t+1} - S_t}{S_t}$$

where the quantity $\frac{S_{t+1} - S_t}{S_t}$ is called the domestic currency depreciation (appreciation).

Under the theory of rational expectations, the above error should not be significantly different from zero or, equivalently, if one runs a regression on the equation

$$\frac{S_{t+1} - S_t}{S_t} = \alpha + \beta \frac{F_{t,t+1} - S_t}{S_t},$$

one should find that α is equal to zero and β is equal to 1. Empirically, numerous studies [Solnik, 2000] have found the slope coefficient to be significantly negative. This means that one would have benefited from betting against the forward exchange rate. In short, when a currency quotes with a forward premium, it should depreciate rather than appreciate. Since the forward premium (discount) is equal to the interest rate differential, the currency with the highest interest rate has had a tendency to appreciate. These results imply that expected exchange rate movements vary over time in a somewhat predictable fashion as a function of the interest rate differential.

Another empirical finding is that the forecast errors appear to be positively correlated over short time periods. That is, exchange rates follow trends. Academic research has also investigated if active currency trading provides excess risk-adjusted returns. Generally, the academic literature offers evidence that technical trading rules do result in positive excess returns. For example, Levich and Thomas [1991] find that technical trading rules yield profits significantly higher than what would be consistent with random series of exchange rates which they generate via a bootstrap. Tests reveal a significant autocorrelation in the data which is in accord with the profitability of filter rules. Taylor [1994] also finds profits to simple technical trading rules employed in the foreign currency market. Osler and Chang [1995] find evidence that use of "Head and Shoulders" trading rules (identified when the second of three peaks is higher than the first and third, which presages a trend reversal)

resulted in profitable trading for several international currencies. More recently, LeBaron [2000] has reexamined technical trading rule profitability in foreign exchange markets in the 1990's and finds evidence of a regime shift and decreased profitability in the British Pound and Deutsche Mark markets. With a caveat as to the significance of these results due to a small sample, he attributes them to decreased foreign exchange market intervention, decreased transactions costs and increased market efficiency. Sosvilla-Rivero, Andrada-Felix and Fernandez-Rodriguez [2002] examine the profitability of technical trading rules in USD-DM and USD-JY markets. Results show that such profitability exists and that it is enhanced by central bank intervention.

More advanced trading systems have also shown evidence of profitability. Neely, Weller and Dittmar [1997] use genetic algorithms to find technical trading rules which they apply to six foreign exchange markets over the 1981-1995 period. Strong evidence of profitability of technical trading is found in all six markets. Further, they find no evidence that the technical trading profits are rewards for bearing systematic risk. Mueller [2001] has explored a variety of filtering procedures that potentially provide means to access profitable trends in currency markets. Possible explanations for the persistence in technical trading profits are central bank intervention and excessive speculation both of which may cause temporary continuation of price trends beyond fundamental values.

Another possible explanation for the autocorrelation of forecast errors is the existence of a time-varying risk premium; that is, the forward exchange rate could deviate from the future expected value of the spot exchange rate by a risk premium (RP) which can change over time.

$$\frac{F_{t,t+1} - S_t}{S_t} = \frac{S_{t+1} - S_t}{S_t} + RP_t$$

The forecast errors becomes

$$\varepsilon_{t+1} = \frac{S_{t+1} - S_t}{S_t} - \frac{F_{t,t+1} - S_t}{S_t} + RP_t$$

Dumas and Solnik [1995] have applied an international Asset Pricing Model (APM) to equities and currencies from major markets to conclude that foreign exchange risk premia are a significant component of securities returns. Dukas, Fatemi, and Tavakkol [1996] find evidence of the presence of foreign exchange exposure and priced foreign exchange risk premia using an Arbitrage Pricing Theory (APT) specification. Tien [2002] finds evidence that foreign exchange risk premia are present and closely related to hedging demand. Tien uses a model based on the need of some agents to hedge cash flows. He finds that hedgers tend to lose money at the expense of speculators and that changes in hedging demand Granger cause changes in speculative demand. This evidence suggests that foreign exchange risk premia are induced by the hedgers and provide a reward to speculators willing to bear risk.

In short, while empirical research has not fully solved the basis behind the positive risk-return tradeoff for currency investment, historical positive risk-return opportunities are consistent with various economic explanations (e.g., both the existence of time-varying risk premia and market induced pricing patterns in exchange rates) which provide a basis for active currency investment.

B. Foreign Currency Risk Management

International asset management in both the corporate and investment world also entails the management of currency risk.[1] International firms as well as international portfolio managers face domestic asset price volatility and foreign exchange rate risk. In the following

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[1] The international finance literature distinguishes between three types of FX risk exposure: translation exposure, transaction exposure, and economic exposure. Translation exposure results from translating local currency denominated financial statements of foreign subsidiaries to the currency to be used for group financial statements. Transaction exposure is generally viewed as exposure to unexpected changes in exchange rates on contracted short term currency flows. Economic exposure may be characterized as the value change of all future cash flows due to changes in exchange rates.

equation, the volatility of a foreign asset is expressed in terms of the standard deviation of the returns of the local asset (or cash flow), the standard deviation of the embedded currency exposure and the correlation between the two:

$$\sigma_{FA}^2 = \sigma_L^2 + \sigma_C^2 + 2\rho_{LC}\sigma_L\sigma_C.$$

It is important to point out that even if the correlation between local (non US) currency denominated asset returns and currency returns are low or negative hedging may still be of value. As pointed out by Kritzman [2000], the relevant correlation for gauging the diversification effect of currency exposure is the correlation between the investor's base currency denominated asset returns and the embedded currency returns. This correlation is much higher because a large part of a foreign asset return is the currency return.

There are a number of means (money market hedges, options, forwards, futures, swaps) as well as approaches (naïve hedges, beta based minimum variance) to hedge currency exposure [Solnik, 2000]. However, regardless of the means or method used, most studies [Solnik, 2000] have shown that the gains from international diversification in developed capital markets are enhanced by using derivatives to hedge foreign currency risk. In fact, the "Free Lunch" argument of exchange risk management [Perold and Schulman, 1988] points out that if today's forward rate is an unbiased forecast of the future spot rate then , by hedging, one decreases expected exchange rate volatility with no change in expected returns.[2] Even at the corporate level, academic research has indicated the positive impact of currency hedging on firm value. For example, Allayannis and Weston [1998] study the use of currency derivatives by 720 large U.S. firms and find a positive relationship between hedging and firm value. Specifically, they estimate that the hedging premium (the difference in value between firms that hedge and firms that do not hedge) is 5.7% on average.

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[2] It is important to point out that it is not always the case that one will choose to minimize volatility without regard to the cost of achieving risk reduction. Academic theory points out that investors will attempt to maximize expected utility, with both risk reduction and cost (e.g. return reduction) taken into consideration.

The most commonly cited argument against currency hedge is the assertion that

foreign exchange risk averages out in the long run (e.g., Froot, 1993). However, even if the

mean reverting nature of exchange rates reduces the potential long run benefits of currency

hedging, it does not necessarily result, that one should dismiss the volatility resulting from

currency exposure. For instance, Kritzman [2000] points out that one's view as to the

importance of currency risk management at the corporate or investment level depends on how

one perceives risk. In brief, while there may be little difference in risk of loss between an

optimally hedged and unhedged portfolio at the end of a long horizon, optimal hedging

significantly reduces the risk of loss during a long investment process. Over very short

horizons, the risk of loss at any point and the risk of loss at a terminal point are similar. In

short, currency hedging matters.

III. Data and Methodology

In this paper we analyze the benefits of the DX as a risk management instrument and

investment vehicle. The return for a domestic investor with an investment denominated in

foreign currency can written as

$$r_{DC} = r_{FC} + c$$

where r_{DC} is the return expressed in the domestic currency, r_{FC} is the foreign-currency return

on the investment and c is the percentage change in the domestic-currency price of foreign

exchange. The currency component of the foreign investment return can be hedged away by

borrowing in home currency and lending in the foreign currency. The domestic currency

return to such a hedge is

$$h = c + i_{FC} - i_{DC}$$

where i_{DC} and i_{FC} represent the rate of interest on the domestic and foreign currencies,

respectively. This hedge return can be synthesized in foreign exchange futures markets by

rolling over contracts which are about to expire since futures prices already incorporate the interest rate differential between domestic and foreign currencies.

The total return to the hedged investment is

$$r_{DC}^H = r_{DC} - \theta h$$

where θ is the hedge ratio. $\theta = 1$ represents a complete start-of-period hedge in which the domestic investor borrows an amount in foreign currency equal to her initial investment, while $\theta = 0$ means no hedging. Hedging can be *static* or *dynamic*. Under *static* hedging, θ is constant over time, while under *dynamic* hedging the value of θ is periodically adjusted. When hedging non-U.S. dollar denominated investments with the DX, the above is equivalent to going long the index.

We use futures contracts data from Bloomberg to construct daily time series representing the DX and its component currencies (Euro, Japanese Yen, British Pound, Canadian Dollar, Swedish Krona and Swiss Franc). These series incorporate the interest differential and thus represent total return. The time series are constructed using a continuous roll strategy. We hold positions in the two nearby contracts, and each day sell some of the front contract and roll the position into the next-out contract. The roll strategy is linear -- if there are 90 days between the start of the nearby expiration month and the start of the next-out expiration month, then 1/90 of the position will be rolled each day (3/90 will be rolled over the weekend). The proportion of each contract held in the nearby contract on date t is given by

$$p_t = \frac{Number\ of\ Days\ until\ First\ Day\ of\ Nearby\ Contract\ Expiration\ Month}{Number\ of\ Days\ from\ Last\ Expiration\ until\ Next\ Expiration}$$

and the proportion held in the next out contract is $1 - p_t$. At the end of each day $p_{t-1} - p_t$ is rolled from the nearby contract to the next-out contract. If *NB* denotes the nearby contract and *NX* is the next-out contract, then the spot index on date t is given by

$$Spot_t = p_t NB_t + (1 - p_t) NX_t$$

The 1-day spot index return is calculated as

$$Spot\,return_t = \frac{Spot_t - Spot_{t-1}}{Spot_{t-1}}$$

The roll return for each day is

$$Roll\,return_t = (NX_t - NB_t)(p_{t-1} - p_t)$$

The total return is equal to the index return plus the roll return.

In addition, we use daily data on a number of spot currencies, interest rates, equity and bond indices. Spot currency data were obtained from Datastream Inc.; S&P500 and MSCI bond index data were obtained from Bloomberg; MSCI equity index data were obtained from MSCI; and Dow Jones STOXX index data were obtained from STOXX Ltd. Additional data series used in the analysis were constructed from the above listed series as described below.

IV. Research Results

A. The DX as an Investment Asset

In this section we analyze the benefits of direct investment in the US Dollar through the DX over the period from January 1991 through April 2002. The time period was chosen subject to data availability. Exhibit 1 contains comparative performance statistics on the DX and all the currencies in the MSCI EAFE Index. The returns on the DX, the Japanese Yen, the Euro, the British Pound, the Canadian Dollar and the Swiss Franc are futures-based. The rest of the currency returns are spot returns plus an interest rate differential.

Over the sample period, the dollar has appreciated versus most of the EAFE currencies. This indicates that an investment in the DX futures[3] would have been beneficial over this particular period. The average annualized return on the DX is 1.32 % with an

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[3] Returns are given on a non-collateralized basis and thus represent a risk premium above the risk-free rate.

annualized standard deviation of 8.82 percent. The DX's volatility is lower than the volatility of 20 of the 23 currencies analyzed. Its Sharpe ratio is higher than the Sharpe ratios of 22 out of the 23 currencies analyzed[4]. Thus, for a dollar-based currency investor, investment in the DX would have been very attractive.

EXHIBIT 1

Performance: January 1991 - April 2002

	DX	Australian Dollar	Austrian Schilling Since 9/91	Belgian Franc	British Pound	Canadian Dollar	Danish Krona	Euro Since 1/99
Average Annual Return	1.32%	-1.55%	-1.55%	-2.39%	-1.43%	-2.17%	-1.39%	-7.79%
Standard Deviation	8.82%	9.52%	10.43%	10.61%	9.80%	5.25%	10.43%	10.94%
Sharpe Ratio	0.15	-0.16	-0.15	-0.23	-0.15	-0.41	-0.13	-0.71
Corr DX	1.00	-0.12	-0.62	-0.63	-0.75	-0.04	-0.62	-0.90
Corr SP500	0.11	0.03	-0.11	-0.09	-0.07	0.13	-0.09	-0.22
Corr Russell 1000	0.11	0.03	-0.12	-0.09	-0.07	0.13	-0.09	-0.22
Corr Europe STOXX 50 USD	-0.32	0.08	0.06	0.12	0.28	0.12	0.13	0.18
Corr Euro STOXX 50 USD	-0.33	0.07	0.09	0.15	0.23	0.13	0.15	0.21
Corr MSCI EAFE Price USD	-0.25	0.18	0.22	0.27	0.18	0.13	0.26	0.17
Corr Lehman Govt./Corp. Bond	-0.06	-0.06	0.04	0.06	0.05	0.06	0.06	0.13
Corr MSCI Europe Bond	-0.65	0.17	0.91	0.92	0.36	-0.02	0.92	0.70
Corr MSCI Euro Bond	-0.64	0.17	0.89	0.90	0.40	-0.02	0.91	0.69
Corr MSCI EAFE Bond	-0.67	0.19	0.84	0.84	0.38	-0.02	0.84	0.62

	Finnish Markka	French Franc	German Mark	Greek Drachma Since 8/94	Hong Kong Dollar	Irish Punt	Italian Lira Since 3/91	Japanese Yen
Average Annual Return	-3.71%	-1.97%	-2.60%	0.55%	0.92%	-1.96%	-2.24%	-2.82%
Standard Deviation	11.34%	10.29%	10.67%	10.04%	0.51%	10.42%	10.50%	12.25%
Sharpe Ratio	-0.33	-0.19	-0.24	0.05	1.81	-0.19	-0.21	-0.23
Corr DX	-0.56	-0.65	-0.65	-0.65	-0.07	-0.60	-0.60	-0.56
Corr SP500	-0.06	-0.09	-0.08	-0.10	0.02	-0.08	-0.08	-0.04
Corr Russell 1000	-0.07	-0.09	-0.09	-0.11	0.01	-0.08	-0.09	-0.04
Corr Europe STOXX 50 USD	0.14	0.14	0.13	0.06	0.02	0.14	0.15	0.15
Corr Euro STOXX 50 USD	0.16	0.16	0.16	0.09	0.03	0.15	0.17	0.14
Corr MSCI EAFE Price USD	0.25	0.27	0.27	0.20	0.05	0.26	0.26	0.27
Corr Lehman Govt./Corp. Bond	0.03	0.06	0.06	0.00	0.01	0.07	0.06	-0.08
Corr MSCI Europe Bond	0.90	0.93	0.92	0.86	0.05	0.86	0.89	0.22
Corr MSCI Euro Bond	0.89	0.92	0.90	0.85	0.06	0.86	0.88	0.21
Corr MSCI EAFE Bond	0.81	0.84	0.84	0.78	0.09	0.77	0.77	0.55

	Netherlands Guilder	New Zealand Dollar	Norwegian Krona	Portuguese Escudo Since 2/91	Singapore Dollar	Spanish Peseta Since 3/91	Swedish Krona Since 12/92	Swiss Franc
Average Annual Return	-2.71%	0.27%	-0.49%	-4.13%	-1.86%	-2.73%	-3.16%	-4.60%
Standard Deviation	10.63%	9.33%	10.13%	9.65%	5.77%	10.57%	9.98%	12.16%
Sharpe Ratio	-0.25	0.03	-0.05	-0.43	-0.32	-0.26	-0.32	-0.38
Corr DX	-0.65	-0.17	-0.59	-0.70	-0.25	-0.60	-0.52	-0.89
Corr SP500	-0.08	0.04	-0.06	-0.14	0.05	-0.08	-0.04	-0.16
Corr Russell 1000	-0.09	0.04	-0.06	-0.15	0.05	-0.09	-0.04	-0.16
Corr Europe STOXX 50 USD	0.13	0.10	0.17	0.04	0.11	0.12	0.17	0.21
Corr Euro STOXX 50 USD	0.16	0.11	0.19	0.07	0.12	0.15	0.18	0.22
Corr MSCI EAFE Price USD	0.27	0.19	0.30	0.16	0.25	0.25	0.30	0.14
Corr Lehman Govt./Corp. Bond	0.06	-0.02	0.04	0.02	-0.04	0.06	-0.02	0.05
Corr MSCI Europe Bond	0.92	0.25	0.78	0.93	0.17	0.92	0.71	0.60
Corr MSCI Euro Bond	0.90	0.25	0.77	0.92	0.17	0.91	0.72	0.59
Corr MSCI EAFE Bond	0.84	0.29	0.73	0.84	0.34	0.83	0.65	0.58

The investment benefits of the DX, however, are better understood in a portfolio setting. Exhibit 2 shows the performance of the DX relative to a number of US and international equity and bond indices as well as a part of both domestic and international diversified portfolios. Here we have added collateral return to the DX return for comparison to other assets. We have also included the performance of an active trading strategy applied to the DX (DX Active). The strategy applies a simple trendfollowing rule to the raw DX

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[4] The HK Dollar is the only exception. The value of the HK Dollar is pegged to the U.S. Dollar; the positive return to the HK Dollar represents the premium of HK interest rates over U.S. interest rates. The volatility of this premium is small, hence the high Sharpe ratio.

series and dynamically assumes long and short positions in the DX. A detailed description of the strategy can be found in the Appendix.

EXHIBIT 2-a

Performance: January 1991 - April 2002

	DX*	S&P 500	Russell 1000	STOXX 50 USD Europe	STOXX 50 USD Euro-Zone
Average Annual Return	6.10%	13.43%	13.56%	12.29%	12.00%
Standard Deviation	8.82%	15.67%	15.56%	17.48%	18.95%
Sharpe Ratio	0.17	0.56	0.57	0.44	0.39
Corr DX	1.00	0.11	0.11	-0.32	-0.33
Corr DX Active	0.10	-0.02	-0.03	-0.10	-0.09
Corr SP500	0.11	1.00	0.99	0.36	0.34
Corr Russell 1000	0.11	0.99	1.00	0.37	0.35
Corr Europe STOXX 50 USD	-0.32	0.36	0.37	1.00	0.96
Corr Euro STOXX 50 USD	-0.33	0.34	0.35	0.96	1.00
Corr MSCI EAFE Price USD	-0.25	0.31	0.32	0.73	0.71
Corr Lehman Govt./Corp. Bond	-0.06	0.14	0.13	0.07	0.07
Corr MSCI Europe Bond	-0.65	-0.10	-0.11	0.08	0.11
Corr MSCI Euro Bond	-0.64	-0.10	-0.10	0.08	0.11
Corr MSCI EAFE Bond	-0.67	-0.10	-0.11	0.06	0.08

	DX Active*	Lehman US Govt./Cred.	MSCI EAFE Bond Index Since 1/94	MSCI Europe Bond Index Since 1/94	MSCI Euro Bond Index Since 1/94
Average Annual Return	6.01%	8.08%	3.57%	4.01%	4.51%
Standard Deviation	7.25%	4.44%	8.25%	9.95%	9.32%
Sharpe Ratio	0.19	0.78	-0.13	-0.06	-0.01
Corr DX	0.10	-0.06	-0.67	-0.65	-0.64
Corr DX Active	1.00	-0.03	-0.07	-0.12	-0.12
Corr SP500	-0.02	0.14	-0.10	-0.10	-0.10
Corr Russell 1000	-0.03	0.13	-0.11	-0.11	-0.10
Corr Europe STOXX 50 USD	-0.10	0.07	0.06	0.08	0.08
Corr Euro STOXX 50 USD	-0.09	0.07	0.08	0.11	0.11
Corr MSCI EAFE Price USD	-0.05	0.00	0.23	0.17	0.17
Corr Lehman Govt./Corp. Bond	-0.03	1.00	0.08	0.16	0.18
Corr MSCI Europe Bond	-0.12	0.16	0.87	1.00	0.99
Corr MSCI Euro Bond	-0.12	0.18	0.87	0.99	1.00
Corr MSCI EAFE Bond	-0.07	0.08	1.00	0.87	0.87

* Riskless Rate Added to DX Return for Comparison Purposes

The statistics in Exhibit 2-a suggest that the DX would have been a useful addition to equity and bond portfolios during the sample period, both domestically and internationally. The DX has low positive correlation to U.S. equity indices and a low negative correlation to U.S. bonds. This is demonstrated in Exhibit 2-b, where the DX is added (with a weight of 20%) to equally-weighted portfolios (1 & 2) of U.S. stocks (S&P 500 or Russell 1000 indices) and bonds (Lehman Government/Corporate Bond index). As a result, the Sharpe ratios of the portfolios (3 & 4) increase slightly, even though average DX returns are low. The DX Active is uncorrelated with U.S. stocks and bonds and thus improves the Sharpe ratios of the portfolios (5 & 6) even further.

EXHIBIT 2-b

Performance: January 1991 - April 2002

	Portfolio 1 S&P500 & Lehman Bond	Portfolio 2 Russell 1000 & Lehman Bond	Portfolio 3 S&P500, Lehman Bond & DX*	Portfolio 4 Russell 1000, Lehman Bond & DX*	Portfolio 5 S&P500, Lehman Bond & DX Active*	Portfolio 6 Russell 1000, Lehman Bond & DX Active*
Average Annual Return	11.04%	11.13%	10.15%	10.22%	10.12%	10.20%
Standard Deviation	8.43%	8.36%	7.11%	7.07%	6.85%	6.80%
Sharpe Ratio	0.76	0.78	0.78	0.79	0.80	0.82
Corr DX	0.09	0.09	0.33	0.34	0.11	0.11
Corr DX Active	-0.03	-0.03	0.00	0.00	0.18	0.18
Corr SP500	0.97	0.96	0.94	0.94	0.94	0.94
Corr Russell 1000	0.96	0.96	0.94	0.94	0.94	0.94
Corr Europe STOXX 50 USD	0.35	0.36	0.25	0.26	0.32	0.33
Corr Euro STOXX 50 USD	0.33	0.34	0.23	0.24	0.30	0.32
Corr MSCI EAFE Price USD	0.29	0.30	0.21	0.22	0.28	0.29
Corr Lehman Govt./Corp. Bond	0.39	0.39	0.35	0.35	0.38	0.37
Corr MSCI Europe Bond	-0.05	-0.06	-0.19	-0.19	-0.07	-0.08
Corr MSCI Euro Bond	-0.04	-0.05	-0.18	-0.18	-0.06	-0.07
Corr MSCI EAFE Bond	-0.07	-0.08	-0.21	-0.21	-0.09	-0.09

* Riskless Rate Added to DX Return for Comparison Purposes
Assets in Portfolios 1 through 5 with weights 50% and 50%, respectively
Assets in Portfolios 6 through 15 with weights 40%, 40% and 20%, respectively

The portfolio benefits of the DX, however, can truly best be appreciated in an international setting. The DX exhibits high in magnitude negative correlations with international stock (STOXX 50 and MSCI EAFE) indices (over -0.30) and, especially, international bond (MSCI Europe, Euro and EAFE) indices (over -0.65). This is a result of the positive correlations between those assets' returns and their local currencies, whose returns, of course, have the opposite signs to DX returns.

EXHIBIT 2-c
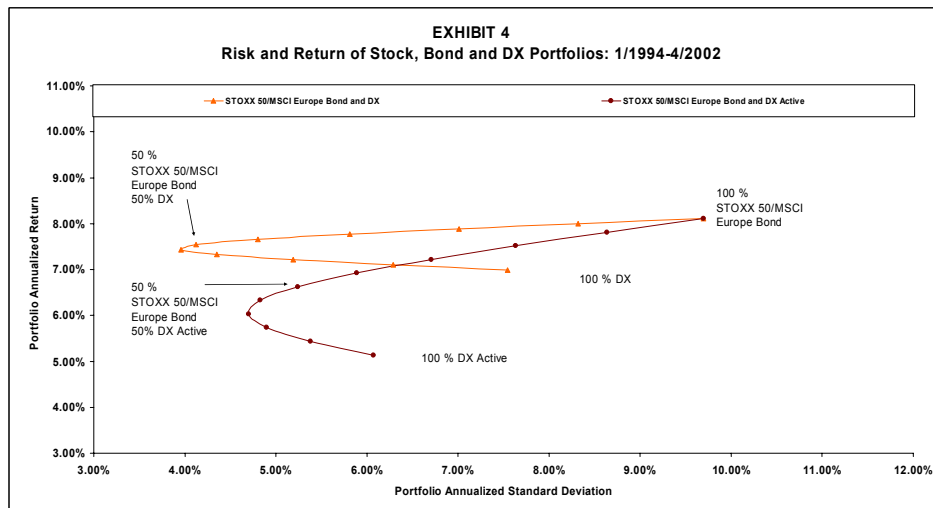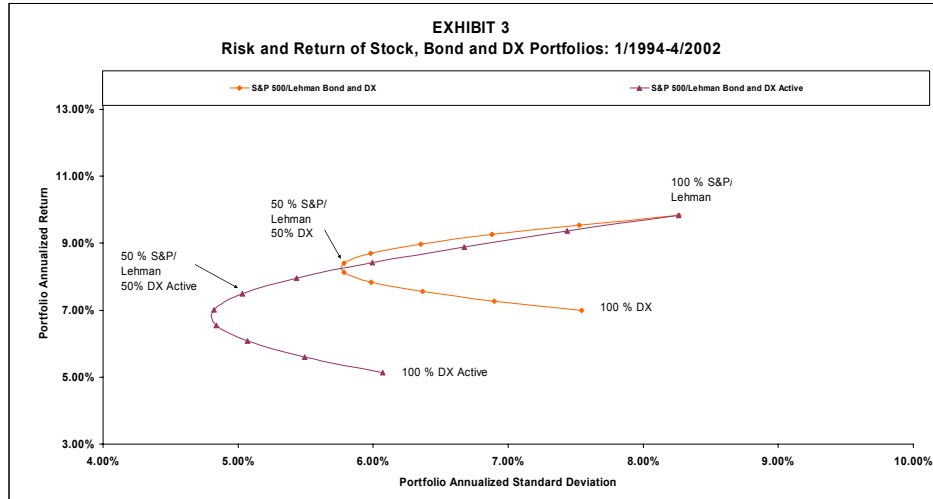
Performance: January 1991 - April 2002

	Portfolio 7 STOXX 50 Europe & MSCI EAFE Bond Since 1/94	Portfolio 8 STOXX 50 Europe & MSCI Europe Bond Since 1/94	Portfolio 9 STOXX 50 Euro-Zone & MSCI Euro Bond Since 1/94	Portfolio 10 STOXX 50 Europe, MSCI EAFE Bond & DX* Since 1/94	Portfolio 11 STOXX 50 Europe, MSCI Europe Bond & DX* Since 1/94	Portfolio 12 STOXX 50 Euro-Zone, MSCI Euro Bond & DX* Since 1/94	Portfolio 13 Europe STOXX 50, MSCI EAFE Bond & DX Active* Since 1/94	Portfolio 14 Europe STOXX 50, MSCI Europe Bond & DX Active* Since 1/94	Portfolio 15 Euro-Zone STOXX 50, MSCI Euro Bond & DX Active* Since 1/94
Average Annual Return	7.80%	8.06%	8.38%	7.83%	8.05%	8.32%	7.39%	7.60%	7.87%
Standard Deviation	10.17%	10.65%	11.35%	7.55%	7.88%	8.46%	8.11%	8.47%	9.03%
Sharpe Ratio	0.31	0.32	0.33	0.43	0.44	0.44	0.34	0.35	0.36
Corr DX	-0.45	-0.48	-0.46	-0.28	-0.31	-0.31	-0.44	-0.47	-0.45
Corr DX Active	-0.10	-0.12	-0.11	-0.08	-0.11	-0.10	0.07	0.04	0.04
Corr SP500	0.29	0.27	0.26	0.35	0.32	0.31	0.29	0.27	0.26
Corr Russell 1000	0.30	0.28	0.27	0.36	0.33	0.32	0.30	0.27	0.27
Corr Europe STOXX 50 USD	0.91	0.89	0.87	0.94	0.92	0.89	0.90	0.88	0.86
Corr Euro STOXX 50 USD	0.89	0.87	0.91	0.91	0.89	0.94	0.88	0.86	0.91
Corr MSCI EAFE Price USD	0.78	0.73	0.72	0.80	0.75	0.73	0.77	0.73	0.72
Corr Lehman Govt./Corp. Bond	0.05	0.09	0.09	0.06	0.10	0.10	0.05	0.09	0.09
Corr MSCI Europe Bond	0.42	0.53	0.50	0.32	0.44	0.42	0.40	0.52	0.49
Corr MSCI Euro Bond	0.43	0.53	0.50	0.32	0.44	0.42	0.41	0.52	0.49
Corr MSCI EAFE Bond	0.46	0.46	0.43	0.35	0.36	0.33	0.45	0.45	0.42

* Riskless Rate Added to DX Return for Comparison Purposes
Assets in Portfolios 1 through 5 with weights 50% and 50%, respectively
Assets in Portfolios 6 through 15 with weights 40%, 40% and 20%, respectively

In effect, adding the DX to portfolios (7, 8 & 9) of international stocks and bonds hedges out part of the currency component inherent in those returns and thus decreases volatility. As shown in Exhibit 2-c, while average portfolio returns remain roughly unchanged after the addition of the DX, the reduction in volatility helps increase the Sharpe ratios by up to 36 % (portfolios 10, 11 & 12). Correlations between the DX Active and international stock and bond indices are still negative but much lower in magnitude. Hence, inclusion of the DX Active increases Sharpe ratios only by 9 % (portfolios 13, 14 & 15).

The above results suggest that the DX is a valuable investment vehicle, both on its own and as a part of a diversified domestic or international portfolio. A further illustration of this is given in Exhibits 3 and 4 where the efficient frontiers of portfolios including domestic and international stocks and bonds as well as the passive and active DX are depicted. It should be noted, however, that these conclusions are specific to our sample period during

which the U.S. Dollar had a strong performance against other currencies. Past results are not indicative of future performance.

EXHIBIT 3
Risk and Return of Stock, Bond and DX Portfolios: 1/1994-4/2002

EXHIBIT 4
Risk and Return of Stock, Bond and DX Portfolios: 1/1994-4/2002

We also consider the performance of technical trading rules as applied to the DX. As already discussed, the series DX Active is generated by such a technical trading rule. We also applied the same trading rule to all of the component currencies of the DX. We formed baskets of the component currencies, both passive and active, using the DX weights. Active indices take both long and short positions in the underlying series and their performance is, therefore, less dependent on the direction of trends in the underlying markets than the

existence of the trends per se. Exhibit 5 shows performance for both the passive and the active currency series.

The results are encouraging. The average returns are similar before and after the rule is applied. Due to taking partial positions in the DX, however, volatility is reduced, which in turn helps increase the Sharpe ratio slightly. The rule does not seem to add significant value to trading the British Pound either, although both the average return and volatility improve marginally. However, investment in all other currencies in the basket would benefit greatly from the technical trading rule. The trading rule allowed us to turn the historical negative Dollar-term returns on the Japanese Yen, the Euro and the Swiss Franc into positive returns while decreasing volatility at the same time. The Canadian Dollar's negative return is sharply reduced in magnitude and so is its volatility. These effects are also seen at the basket level as the basket's average changes from -3.96 % to 3.10 % while its volatility drops from 10.11 % to 7.66 %. In conclusion, the evidence suggests that technical trading rules add value.

EXHIBIT 5

Performance: January 1991 - April 2002

	DX	Basket of DX Components*	Japanese Yen	Euro	British Pound	Canadian Dollar	Swedish Krona**	Swiss Franc
Average Annual Return	1.32%	-3.40%	-2.82%	-4.42%	-1.43%	-2.17%	-3.16%	-4.60%
Standard Deviation	8.82%	8.73%	12.25%	11.07%	9.80%	5.25%	9.98%	12.16%
Sharpe Ratio	0.15	-0.39	-0.23	-0.40	-0.15	-0.41	-0.32	-0.38
Corr DX	1.00	-0.98	-0.56	-0.96	-0.75	-0.04	-0.52	-0.89
Corr DX Active	0.10	-0.09	0.00	-0.10	-0.09	-0.05	-0.08	-0.06
Corr SP500	0.11	-0.11	-0.04	-0.12	-0.07	0.13	-0.04	-0.16
Corr Russell 1000	0.11	-0.11	-0.04	-0.13	-0.07	0.13	-0.04	-0.16
Corr Europe STOXX 50 USD	-0.32	0.31	0.15	0.29	0.28	0.12	0.17	0.21
Corr Euro STOXX 50 USD	-0.33	0.32	0.14	0.32	0.23	0.13	0.18	0.22
Corr MSCI EAFE Price USD	-0.25	0.25	0.27	0.20	0.18	0.13	0.30	0.14
Corr Lehman Govt./Corp. Bond	-0.06	0.05	-0.08	0.07	0.05	0.06	-0.02	0.05
Corr MSCI Europe Bond	-0.65	0.66	0.22	0.67	0.36	-0.02	0.71	0.60
Corr MSCI Euro Bond	-0.64	0.65	0.21	0.65	0.40	-0.02	0.72	0.59
Corr MSCI EAFE Bond	-0.67	0.68	0.55	0.61	0.38	-0.02	0.65	0.58

	DX Active	Basket of DX Components Active*	Japanese Yen Active	Euro Active	British Pound Active	Canadian Dollar Active	Swedish Krona Active**	Swiss Franc Active
Average Annual Return	1.23%	3.07%	5.81%	3.64%	-1.15%	-0.78%	0.22%	5.04%
Standard Deviation	7.25%	6.58%	10.12%	8.88%	7.82%	4.17%	7.89%	9.67%
Sharpe Ratio	0.17	0.47	0.57	0.41	-0.15	-0.19	0.03	0.52
Corr DX	0.10	0.10	-0.02	0.11	0.08	0.02	0.12	0.03
Corr DX Active	1.00	0.89	0.34	0.86	0.57	0.06	0.35	0.73
Corr SP500	-0.02	-0.04	-0.03	-0.04	-0.04	-0.05	-0.01	-0.05
Corr Russell 1000	-0.03	-0.04	-0.02	-0.03	-0.05	-0.05	-0.01	-0.05
Corr Europe STOXX 50 USD	-0.10	-0.09	0.00	-0.08	-0.09	-0.07	-0.09	-0.08
Corr Euro STOXX 50 USD	-0.09	-0.09	-0.01	-0.08	-0.07	-0.07	-0.09	-0.08
Corr MSCI EAFE Price USD	-0.05	-0.06	0.00	-0.06	-0.03	-0.07	-0.09	-0.06
Corr Lehman Govt./Corp. Bond	-0.03	-0.03	-0.01	-0.03	-0.03	-0.03	-0.01	-0.04
Corr MSCI Europe Bond	-0.12	-0.14	-0.02	-0.15	-0.03	0.00	-0.14	-0.07
Corr MSCI Euro Bond	-0.12	-0.14	-0.02	-0.15	-0.03	0.00	-0.13	-0.07
Corr MSCI EAFE Bond	-0.07	-0.09	0.00	-0.10	-0.02	0.00	-0.09	-0.03

*   Weighted average of the component currencies of the DX using actual DX weights
    Data before 12/2/1992 does not include the Swedish Krona; Weights prior to 12/2/1992 are scaled appropriately
** Data available since 12/2/1992

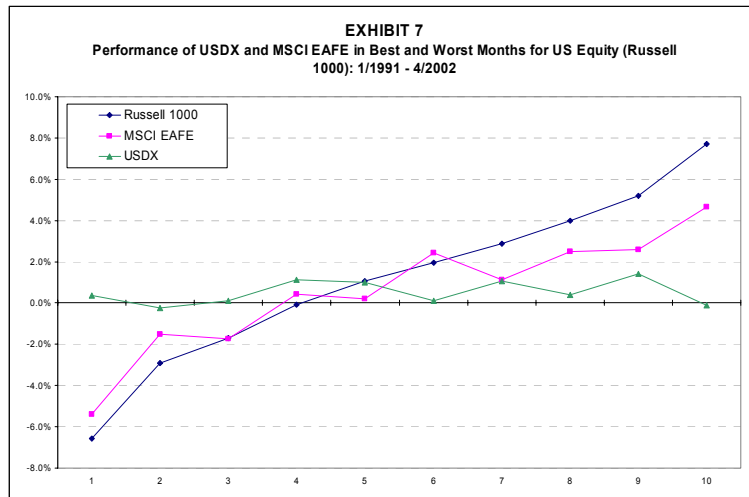EXHIBIT 6

Correlations: January 1991 - April 2002

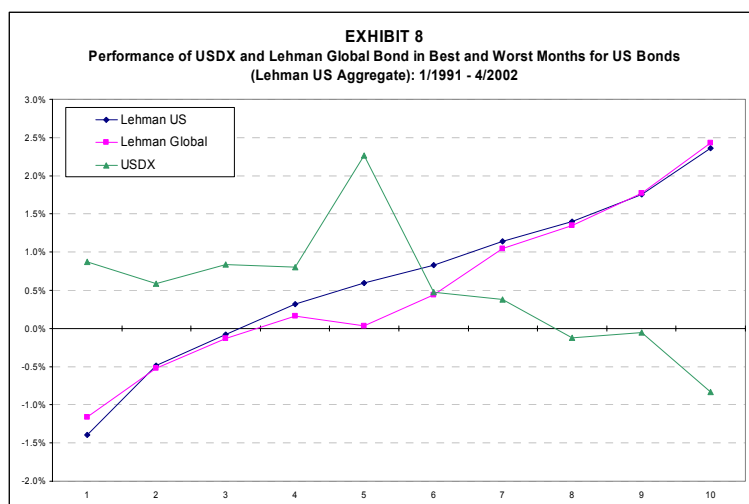|	DX	Basket of DX Components*	Japanese Yen	Euro	British Pound	Canadian Dollar	Swedish Krona**	Swiss Franc
DX	1.00							
Basket of DX Components	-0.98	1.00						
Japanese Yen	-0.56	0.58	1.00					
Euro	-0.96	0.97	0.42	1.00				
British Pound	-0.75	0.74	0.32	0.67	1.00			
Canadian Dollar	-0.04	0.04	-0.01	-0.03	0.04	1.00		
Swedish Krona**	-0.52	0.53	0.19	0.50	0.31	0.06	1.00	
Swiss Franc	-0.89	0.90	0.43	0.90	0.64	-0.01	-0.01	1.00
DX Active	0.10	-0.09	0.00	-0.10	-0.09	-0.05	-0.05	-0.06
DX Basket Active	0.10	-0.10	-0.01	-0.10	-0.08	-0.05	-0.05	-0.07
Japanese Yen Active	-0.02	0.02	0.05	0.01	0.00	0.00	0.00	0.03
Euro Active	0.11	-0.11	-0.02	-0.12	-0.07	-0.05	-0.05	-0.08
British Pound Active	0.08	-0.07	-0.01	-0.06	-0.14	0.01	0.01	-0.03
Canadian Dollar Active	0.02	-0.03	-0.01	-0.01	-0.04	-0.22	-0.22	-0.02
Swedish Krona Active**	0.12	-0.11	-0.03	-0.11	-0.09	-0.04	-0.04	-0.08
Swiss Franc Active	0.03	-0.03	0.02	-0.04	-0.01	-0.03	-0.03	-0.02

	DX Active	Basket of DX Components Active*	Japanese Yen Active	Euro Active	British Pound Active	Canadian Dollar Active	Swedish Krona Active**	Swiss Franc Active
DX								
DX Basket								
Japanese Yen								
Euro								
British Pound								
Canadian Dollar								
Swedish Krona**								
Swiss Franc								
DX Active	1.00							
Basket of DX Components Active	0.89	1.00						
Japanese Yen Active	0.34	0.43	1.00					
Euro Active	0.03	0.96	0.23	1.00				
British Pound Active	0.57	0.59	0.15	0.49	1.00			
Canadian Dollar Active	0.06	0.14	0.07	0.49	0.02	1.00		
Swedish Krona Active**	0.35	0.34	0.03	0.49	0.13	0.06	1.00	
Swiss Franc Active	0.73	0.79	0.24	0.77	0.47	0.04	0.23	1.00

* Weighted average of the component currencies of the DX using actual DX weights
  Data before 12/2/1992 does not include the Swedish Krona; Weights prior to 12/2/1992 are scaled appropriately
** Data available since 12/2/1992

B. Performance of USDX during Market Extremes

In recent years academic research has focused more on the behavior of assets and asset classes during market extremes. Experiences such as the 1994 bond meltdown and the 1998 liquidity crisis reinforced the notion that correlation between asset classes may be different during market extremes than during periods of relative calm. This is particularly true for the currency markets, as currencies are highly liquid and certain currencies are considered safe havens during periods of global turmoil.

EXHIBIT 7
Performance of USDX and MSCI EAFE in Best and Worst Months for US Equity (Russell 1000): 1/1991 - 4/2002

EXHIBIT 8
Performance of USDX and Lehman Global Bond in Best and Worst Months for US Bonds
(Lehman US Aggregate): 1/1991 - 4/2002

Legend: Lehman US, Lehman Global, USDX

Exhibits 7 and 8 show the performance of the US Dollar Index during periods of extreme movements in the US financial markets. To measure performance during extremes, we sort monthly returns for stock and bond indices into deciles and then report the average performance of asset classes during those months. Decile #1 is the average performance I the worst 10% of months (out of 148 observations) and decile #10 is average performance in the best months. In Exhibit 7, the deciles are created using returns for the Russell 1000 equity index. In addition to the Russell 1000 average performance, we also report performance of the MSCI Europe Asia Far East (EAFE) index and the Dollar Index during those months. Exhibit 7 indicates that there is little difference between the performance of US and foreign stocks during the largest market declines. The average performance of the EAFE and Russell 1000 are very similar during the lowest three deciles. This exhibit also indicates that the performance of the USDX is relatively insensitive to changes in US equity markets. Returns are a bit lower in the best and worst months than the middle months, but returns are positive for the USDX in eight out of ten Russell 1000 deciles.

Exhibit 8 repeats this analysis for bonds. The Lehman Aggregate Bond index is used to create the deciles. Performance in these deciles is compared to the performance of the Lehman Global Bond index (a composite of US, European, and Far East bonds measured in US Dollars) and the USDX. Exhibit 8 shows that a globally diversified portfolio of bonds

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had very similar returns to US bonds, on average, during market extremes. The USDX

returns are clearly lower during the largest positive returns for US bonds, and higher during

months when US bonds are declining in value. This suggests that an allocation the USDX

would reduce the volatility of both domestic and global bond portfolios.

C. The DX as a Hedging Instrument

The DX can be used to hedge FX risk exposure by both U.S. Dollar based investors

with non-U.S. currency exposure and non-U.S. Dollar investors holding Dollar-denominated

assets. The former would hedge their exposure by going long the DX, while the latter would

do so by going short the DX. We examined the hedging performance of the DX from a U.S.

Dollar-based investor's perspective. The high absolute values of the correlations between the

DX and most foreign currencies in Exhibit 1 suggest that the DX can serve as a useful

hedging tool for exposure in those currencies. We consider investment in five different

international equity indices – Europe STOXX 50, Euro-Zone STOXX 50[5], MSCI EAFE

(price return), MSCI Emerging Markets Europe/Middle East (price return) and MSCI

Emerging Markets Asia (price return)[6].

Exhibit 9 demonstrates the hedging benefits of the DX. For each index, the exhibit

contains performance statistics in terms of its local currency basket, in U.S. dollar terms

without hedging and in U.S. Dollar terms hedged with the DX. Clearly, a Dollar-based

investor in these indices would have experienced a drop in performance due to the currency

effect. The Sharpe ratios on the Europe STOXX 50 index and the Euro-Zone STOXX 50

decreased by 36 % and 38 %, respectively, as a result of the currency translation. The Sharpe

ratio on the MSCI EAFE, EM Europe/M.E. and EM Asia indices went from near zero to -

0.12, from 0.79 to -0.09 and from -0.04 to -0.25, respectively. It is interesting to note that the

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[5] The Euro-Zone STOXX 50 index includes large stocks from countries that are part of the European Monetary Union; the Europe STOXX 50 index also includes stocks from the United Kingdom, Sweden and Switzerland.
[6] We could not obtain a sufficiently long series of daily total return data for the MSCI indices. Using price returns is unlikely to affect the results of the analysis significantly.

currency exposure does not affect the volatility of returns as much as it decreases the average return. This, of course, is the result of the Dollar's strength vis-à-vis the other currencies in the baskets underlying the indices over the sample period.

EXHIBIT 9

Performance: January 1992 - April 2002

|	STOXX 50 Europe Local	STOXX 50 Europe USD Unhedged	STOXX 50 Europe USD Hedged with DX	STOXX 50 Europe USD Hedged with Currency Basket		STOXX 50 Euro-Zone Local	STOXX 50 Euro-Zone USD Unhedged	STOXX 50 Euro-Zone USD Hedged with DX	STOXX 50 Euro-Zone USD Hedged with
Average Annual Return	15.91%	11.55%	16.64%	16.09%		15.90%	11.54%	16.69%	16.56%
Standard Deviation	17.95%	17.38%	17.07%	18.99%		18.74%	18.74%	18.16%	20.37%
Sharpe Ratio	0.63	0.40	0.71	0.61		0.61	0.37	0.67	0.59
Corr DX	0.20	0.15	-0.28	0.15		0.16	-0.29	0.17	0.06
Corr Europe STOXX 50 USD	0.83	0.34	1.00	0.34		0.82	0.96	0.86	0.84
Corr Euro STOXX 50 USD	0.76	0.32	0.96	0.32		0.84	1.00	0.89	0.87
Corr MSCI EAFE Price USD	0.60	0.30	0.72	0.30		0.60	0.70	0.61	0.53

	MSCI EAFE Price Local	MSCI EAFE Price USD Unhedged	MSCI EAFE Price USD Hedged with DX	MSCI EM Eur./M.E. Price Local	MSCI EM Eur./M.E. Price USD Unhedged	MSCI EM Eur./M.E. Price USD Hedged with DX	MSCI EM Asia Price Local	MSCI EM Asia Price USD Unhedged	MSCI EM Asia Price USD Hedged with DX
Average Annual Return	4.81%	2.83%	7.38%	21.03%	2.41%	6.88%	3.74%	-0.54%	3.54%
Standard Deviation	13.98%	14.45%	15.00%	20.86%	22.64%	23.24%	18.21%	20.12%	21.96%
Sharpe Ratio	0.02	-0.12	0.19	0.79	-0.09	0.10	-0.04	-0.25	-0.04
Corr DX	0.12	-0.23	0.35	0.05	-0.12	0.25	0.04	0.01	0.40
Corr Europe STOXX 50 USD	0.71	0.72	0.54	0.35	0.36	0.24	0.22	0.22	0.09
Corr Euro STOXX 50 USD	0.68	0.70	0.51	0.35	0.36	0.24	0.23	0.23	0.10
Corr MSCI EAFE Price USD	0.86	1.00	0.83	0.39	0.44	0.34	0.34	0.36	0.24

Exhibit 9 also shows the performance of the five portfolios hedged with the DX. The hedge in all cases is complete (hedge ratio is equal to 1). The effect of the hedge on portfolio performance is significant. The Sharpe ratios on the two European indices increase by 76 % and 79%, respectively, while those of the MSCI indices jump to 0.19, 0.10 and -0.04, respectively. In some cases, these results mark an improvement even over the performance in local currency. It is encouraging to see that the DX performs well as a hedging tool for emerging market currency exposure. This is beneficial to investors with such exposure as it provides them with a liquid alternative to hedging the underlying currency exposure directly which may be costly or otherwise impractical. Certainly, such hedges are not perfect.

In order to compare the benefits of hedging currency exposure with the DX versus individual currencies, we constructed baskets of the currency components of the two STOXX 50 indices. We used the historical country weights for the indices which were kindly provided by STOXX Ltd. The returns to these baskets include spot currency returns and interest rate differentials. Then we shorted the baskets and added the returns to the respective indices. The results are presented in Exhibit 9. The risk-adjusted performance of the basket-

hedged indices is very close to that in local currency and inferior to the performance of the indices hedged imperfectly with the DX. Exhibit 10 shows all the Sharpe ratios in graphic format.

The DX seems to provide good hedging benefits for U.S. Dollar based investors in foreign currency denominated assets. Over the specific sample period, it not only eliminates the adverse currency exposure but also adds to performance through pure Dollar return. In addition, the DX index provides a one-stop hedging solution to investors holding multiple currency denominated portfolios who would otherwise need to enter multiple markets in order to hedge their foreign exchange exposure and would likely incur higher costs in the process, particularly in less liquid emerging currency markets.

EXHIBIT 10
Sharpe Ratios (January 1992 - April 2002)
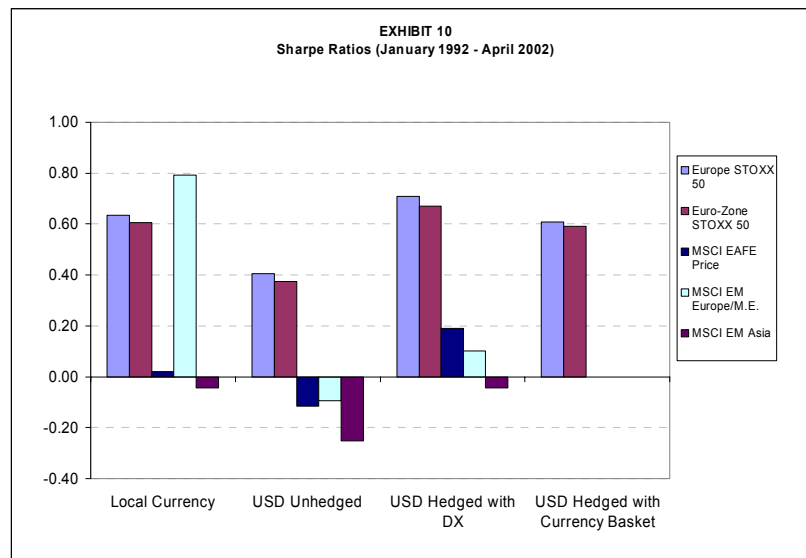
V. Summary

This study has analyzed the potential benefits of the NYBOT Dollar Index as an investment and risk management vehicle. Results presented in this article indicate that investment in the DX would have increased the risk-adjusted return of diversified portfolios

of domestic and international stocks and bonds over the sample period. The improvement is due either to increased return, reduced risk or both.

The performance of the DX during periods of extreme movements in stock and bond prices was analyzed. We found that the DX is negatively correlated with bond prices during market extremes, an attractive property from a diversification perspective. The DX is relatively uncorrelated with equity returns in both market extremes and periods of relative calm. The DX was shown to be an effective tool for hedging foreign currency exposure for dollar-based investors. Finally, technical trading rules applied to the DX were shown to yield some economic value.

Appendix

Trendfollowing Strategy

Long and short positions in each market are determined by a momentum the trading rule. An x-day momentum strategy takes a long position in a futures market on date t if the total return to the contact between dates t and t-x is positive. Otherwise the strategy takes a short position. Three separate momentum strategies are traded in each market. The numbers of days used to compute the momentum trading rules are 15, 27, and 55. Each momentum rule has an equal weight, so the index will either be 100% long, 33% long, 33% short, or 100% short in a given contract, depending on the signals of the three strategies.

Bibliography

Allayanis, G. and J. Weston, "The Use of Foreign Currency Derivatives and Firm Market Value", Working Paper, University of Virginia, 1998.

Dukas, S., A. Fatemi and A. Tavakkol, "Foreign Exchange Exposure and the Pricing of Exchange Rate Risk", *Global Finance Journal*, 7, 1996.

Dumas, B. and B. Solnik, "The World Price of Foreign Exchange Risk", *The Journal of Finance*, 50, 1995, 445-479.

Frankel, J. and K. Froot, "The Rationality of the Foreign Exchange Rate: Chartists, Fundamentalists and Trading in the Foreign Exchange Market", *AEA Papers and Proceedings*, May 1990.

Froot, K., "Currency Hedging Over Long Horizons", NBER Working Paper No. 4355, 1993.

Kritzman, M., "Currency Hedging and the Risk of Loss", *Journal of Alternative Investments*, Winter 2000, 27-32.

LeBaron, B., "Technical Trading Rule Profitability and Foreign Exchange Intervention", Journal of International Economics, 49, 1999, 125-143.

LeBaron, B., "Technical Trading Profitability in Foreign Exchange Markets in the 1990's", Working Paper, Brandeis University, 2000.

Levich, R. and L. Thomas, "The Significance of Technical Trading-Rule Profits in the Foreign Exchange Market: A Bootstrap Approach", NBER Working Paper No. 3818, 1991.

Mueller, U., "The Olsen Filter for Data in Finance", Consulting Document, Olsen & Associates, 2001.

Neely, C., P. Weller and R. Dittmar, "Is Technical Analysis in the Foreign Exchange Market Profitable?: A Genetic Programming Approach", *Journal of Financial and Quantitative Analysis*, 32, 1997, 405-426.

Osler, C. and P. Chang, "Head and Shoulders: Not Just a Flaky Pattern", *Federal Reserve Bank of New York Staff Reports*, No. 4, 1995.

Perold, A. and E. Shulman, "The Free Lunch in Currency Hedging: Implications for Investment Policy and Performance Standards", *Financial Analysts Journal*, May/June, 1988.

Solnik, B., International Investments, 4th Edition, Addison Wesley, 2000.

Sosvilla-Rivero, S., J. Andrada-Felix and F. Fernandez-Rodriguez, "Further Evidence of Technical Trading Profitability and Foreign Exchange Intervention", *Applied Economic Letters*, Forthcoming.

Taylor, S., "Trading Futures Using a Channel Rule: A Study of the Predictive Power of Technical Analysis with Currency Examples", Journal of Futures Markets, 14, 1994, 215-235.

Tien, D., "Hedging Demand and Foreign Exchange Risk Premia", Working Paper, UC Berkeley, 2002.