AQR CAPITAL MANAGEMENT

Brian Hurst
Principal

Yao Hua Ooi
Principal

Lasse H. Pedersen, Ph.D.*
Principal

Fall 2012

A Century of Evidence on Trend-Following Investing

Executive Summary

We study the performance of trend-following investing across global markets since 1903, extending the existing evidence by more than 80 years. We find that trend-following has delivered strong positive returns and realized a low correlation to traditional asset classes each decade for more than a century. We analyze trend-following returns through various economic environments and highlight the diversification benefits the strategy has historically provided in equity bear markets. Finally, we evaluate the recent environment for the strategy in the context of these long-term results.

* Brian Hurst and Yao Hua Ooi are at AQR Capital Management, and Lasse Heje Pedersen is at New York University, Copenhagen Business School, and AQR Capital Management. We are grateful to Cliff Asness and John Liew for helpful comments, and to Ari Levine, Haitao Fu, and Vineet Patil for excellent research assistance.

Section 1: Introduction

As an investment style, trend-following has existed for a very long time. Some 200 years ago, the classical economist David Ricardo's imperative to "cut short your losses" and "let your profits run on" suggests an attention to trends. A century later, the legendary trader Jesse Livermore stated explicitly that the "big money was not in the individual fluctuations but in… sizing up the entire market and its trend."[1]

The most basic trend-following strategy is time series momentum – going long markets with recent positive returns and shorting those with recent negative returns. Time series momentum has been profitable on average since 1985 for nearly all equity index futures, fixed income futures, commodity futures, and currency forwards.[2] The strategy explains the strong performance of Managed Futures funds from the late 1980s, when fund returns and index data first becomes available.[3]

This paper seeks to establish whether the strong performance of trend-following is a statistical fluke of the last few decades or a more robust phenomenon that exists over a wide range of economic conditions. Using historical data from a number of sources, we construct a time series momentum strategy all the way back to 1903 and find that the strategy has been consistently profitable throughout the past 110 years.[4] We examine the strategy's decade-by-decade performance, its correlation to major asset classes, and its performance in historical equity bull and bear markets. The wealth of data also provides context for evaluating the recent environment for the strategy. We consider the effect of increased assets in the strategy as well as the increased correlations across markets since the credit crisis. We also review a number of developments that are potentially favorable for the strategy going forward, such as lower trading costs, lower fees, and an increased number of tradable markets.

Section 2: Constructing the Time Series Momentum Strategy

Trend-following investing involves going long markets that have been rising and going short markets that have been falling, betting that those trends continue. We create a time series momentum strategy that is simple, without many of the often arbitrary choices of more complex models. Specifically, we construct an equal-weighted combination of 1-month, 3-month, and 12-month time series momentum strategies for 59 markets across 4 major asset classes – 24 commodities, 11 equity indices, 15 bond markets, and 9 currency pairs – from January 1903 to June 2012. Since not all markets have return data going back to 1903, we construct the strategies using the largest number of assets for which return data exist at each point in time. We use futures returns when they are available. Prior to the availability of futures data, we rely on cash index returns financed at local short rates for each country. Appendix A lists the markets that we consider and the source and length of historical return data used.

For each of the three time series momentum strategies, the position taken in each market is determined by assessing the past return in that market over the relevant look-back horizon. A positive past return is considered an "up trend" and leads to a long position; a negative past return is considered a "down trend" and leads to a short position. Therefore, each strategy always holds either a long or short position in every market. Each position is sized to target the same amount of volatility, both to provide diversification and to limit the portfolio risk from any one market. The positions across the three strategies are aggregated each month, and scaled such that the combined portfolio has an annualized ex-ante volatility target of 10%.[5] The volatility scaling procedure ensures that the combined strategy targets a consistent amount of risk over time, regardless of the number of markets that are traded at each point in time.

Finally, we subtract transaction costs and fees. Our transaction cost estimates are based on current estimates of average transaction costs in each of the four asset classes, as well as an estimate of how much higher transaction costs were historically compared to the present, based on Jones (2002). To simulate fees, we apply a 2% management fee and a 20% performance fee subject to a high-water-mark, as is typical for Managed Futures managers.[6] Details on transaction costs and fee simulations are given in Appendix B. Our methodology follows that of Moskowitz, Ooi, and Pedersen (2012) and Hurst, Ooi, and Pedersen (2012). These authors find that time series momentum captures well the performance of the Managed Futures indices and manager returns, including the largest funds, over the past few decades when data on such funds exists.

1 Ricardo's trading rules are discussed by Grant (1838) and the quote attributed to Livermore is from Lefèvre (1923).
2 Moskowitz, Ooi, and Pedersen (2012).
3 Hurst, Ooi, and Pedersen (2012).
4 Our century of evidence for time series momentum complements the evidence that cross-sectional momentum (a closely related strategy based on a security's performance relative to its peers) has delivered positive returns in individual equities back to 1866 (Chabot, Ghysels, and Jagannathan, 2009) and has worked across asset classes (Asness, Moskowitz, and Pedersen, 2012).
5 A simple covariance matrix estimated using rolling 3-year equally weighted monthly returns is used in the portfolio volatility scaling process.
6 While a 2/20 fee structure has been commonplace in the industry, some managers charged higher management and performance fees in earlier time periods. On the other hand, there are also managers that charge lower fees for the strategy today.

Exhibit 1: Hypothetical Performance of Time Series Momentum

Strategy performance after simulated transaction costs both gross and net of hypothetical 2-and-20 fees.

Time Period	Gross of Fee Returns (Annualized)	Net of 2/20 Fee Returns (Annualized)	Realized Volatility (Annualized)	Sharpe Ratio, Net of Fees	Correlation to S&P 500 Returns	Correlation to US 10-year Bond Returns
Full Sample:						
Jan 1903 - June 2012	20.0%	14.3%	9.9%	1.00	-0.05	-0.05
By Decade:						
Jan 1903 - Dec 1912	18.8%	13.4%	10.1%	0.84	-0.30	-0.59
Jan 1913 - Dec 1922	17.1%	11.9%	10.4%	0.70	-0.12	-0.11
Jan 1923 - Dec 1932	17.1%	11.9%	9.7%	0.92	-0.07	0.10
Jan 1933 - Dec 1942	9.7%	6.0%	9.2%	0.66	0.00	0.55
Jan 1943 - Dec 1952	19.4%	13.7%	11.7%	1.08	0.21	0.22
Jan 1953 - Dec 1962	24.8%	18.4%	10.0%	1.51	0.21	-0.18
Jan 1963 - Dec 1972	26.9%	19.6%	9.2%	1.42	-0.14	-0.35
Jan 1973 - Dec 1982	40.3%	30.3%	9.2%	1.89	-0.19	-0.40
Jan 1983 - Dec 1992	17.8%	12.5%	9.4%	0.53	0.15	0.13
Jan 1993 - Dec 2002	19.3%	13.6%	8.4%	1.04	-0.21	0.32
Jan 2003 - June 2012	11.4%	7.5%	9.7%	0.61	-0.22	0.20

Source: AQR. Please read important disclosures at the end relating to hypothetical performance and risks.

Section 3: Performance over a Century

Exhibit 1 shows the performance of the time series momentum strategy over the full sample since 1903 as well as for each decade over this time period. We report the results net of simulated transaction costs, and consider returns both before and after fees.

The performance has been remarkably consistent over an extensive time horizon that includes the Great Depression, multiple recessions and expansions, multiple wars, stagflation, the Global Financial Crisis, and periods of rising and falling interest rates. Skeptics argue that managed futures has benefited mainly from the long secular decline in interest rates. While the strategy did perform well over the past 30 years, the best performing decade for the strategy occurred during the 1973-1982 period, when US 10 year treasury yields rose from 6.4% to 10.4% with extreme volatility in between.

Our long-term out-of-sample evidence suggests that it is unlikely that such price trends are a product of statistical randomness or data mining. Indeed, the first eight decades of data is out-of-sample evidence relative to the literature and the performance is strong in each of these decades. Trends appear to be a pervasive characteristic of speculative financial markets over the long term. Trend-following strategies perform well only if prices trend more often than not. A large body of research[7] has shown that price trends exist in part due to long-standing behavioral biases exhibited by investors, such as anchoring and herding, as well as the trading activity of non-profit seeking participants, such as central banks and corporate hedging programs. For instance, when central banks intervene to reduce currency and interest-rate volatility, they slow down the rate at which information is incorporated into prices, thus creating trends. The fact that trend-following strategies have performed well historically indicates that these behavioral biases and non-profit seeking market participants have likely existed for a long time.

The returns to the strategy have exhibited low correlations to stocks and bonds over the full time period, as well as in the majority of sub-periods, as shown in **Exhibit 1**. Even more impressively, the strategy has performed best in large equity bull and bear markets. **Exhibit 2** shows the annual hypothetical returns to the strategy, plotted against the returns to the S&P 500 from 1903-2011. The "smile" shows that trend-following has done particularly well in extreme up or down years for the stock market. This strong performance in bear markets over the century extends the evidence that has been documented since the 1980s, as exemplified most recently with the strong performance of trend-following during the Global Financial Crisis.

7 Barberis, Shleifer, and Vishny (1998), Daniel, Hirshleifer, Subrahmanyam (1998), De Long et al. (1990), Hong and Stein (1999) and Frazzini (2006) discuss a number of behavioral tendencies that lead to the existence of price trends.

Exhibit 2: Time Series Momentum "Smile"

The annual net of fee returns of a time series momentum strategy versus the S&P 500, 1903-2011.

Source: AQR. Time Series performance is hypothetical as described above. Please read important disclosures at the end relating to hypothetical performance.

As another way to evaluate the diversifying properties of trend-following investment during extreme events, we consider the performance during peak-to-trough drawdowns for the typical 60-40 portfolio.[8] **Exhibit 3** shows the performance of the time series momentum strategy during the 10 largest drawdowns experienced by the traditional 60-40 portfolio over the past 110 years. We see that the time series momentum strategy experienced positive returns in 9 out of 10 of these stress periods and delivered significant positive returns during a number of these events. The valuable hedging benefits that trend-following strategies delivered during the Global Financial Crisis 2007-2009 do not look unusual when you consider how the strategy has behaved in other deep equity bear markets. Why have trend-following strategies tended to do well in bear markets? The intuition is that the majority of bear markets have historically occurred gradually over several months, rather than abruptly over a few days, which allows trend-followers an opportunity to position themselves short after the initial market decline and profit from continued market declines. In fact, the average peak-to-trough drawdown length of the ten largest 60/40 drawdowns between 1903 and 2012 was approximately 18 months.

Given its attractive returns and diversifying characteristics, allocating to a time series momentum strategy would have significantly improved a traditional portfolio's performance over the past 110 years. Specifically, **Exhibit 4** shows the simulated effect of allocating 20% of the capital from a 60/40 portfolio to the time series momentum strategy. We see that such an allocation would have helped reduce the maximum portfolio drawdown, lowered portfolio volatility, and increased portfolio returns.

Exhibit 4: Diversifying 60/40 with an Allocation to Time Series Momentum

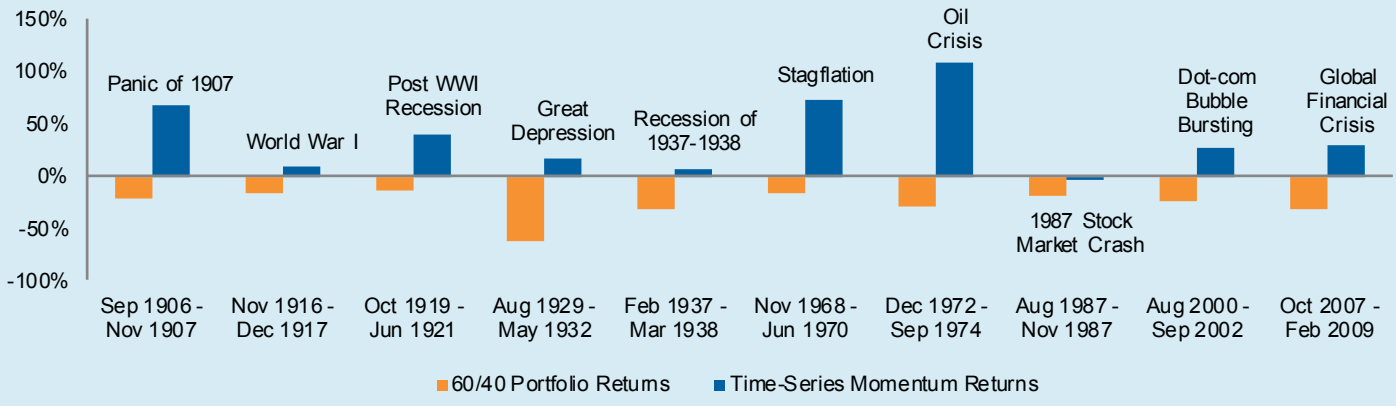
Performance characteristics of the 60/40 portfolio and a portfolio with 80% invested in the 60/40 portfolio and 20% invested in the time series momentum strategy, from January 1903 to June 2012.

	Total Net of Fee Returns (Annualized)	Realized Volatility (Annualized)	Sharpe Ratio, Net of Fees	Maximum Drawdown
60/40 Portfolio	8.0%	11.1%	0.34	-62%
80% 60/40 Portfolio, 20% Time Series Momentum Strategy	9.5%	9.0%	0.57	-52%

Source: AQR. Time Series performance is hypothetical as described above.

8 The 60/40 portfolio has 60% of the portfolio invested in the S&P 500 and 40% invested in US 10-year bonds. The portfolio is rebalanced to the 60/40 weights at the end of each month, and no fees or transaction costs are subtracted from the portfolio returns.

Exhibit 3: Total Returns of U.S. 60/40 Portfolio and Time Series Momentum in the Ten Worst Drawdowns for 60/40 between 1903 and 2012



Source: AQR. Time Series performance is hypothetical as described above.

Exhibit 5: The 10 Largest Drawdowns of Time Series Momentum between 1903 and 2012

The 10 largest peak-to-trough drawdowns of the time series momentum strategy, calculated using net of fee returns.

Rank	Start of Drawdown (Peak)	Lowest Point of Drawdown (Trough)	End of Drawdown (Recovery)	Size of Peak-to-Trough Drawdown	Peak-to-Trough Length (Months)	Trough-to-Recovery Length (Months)	Peak-to-Recovery Length (Months)
1	Mar-1947	Dec-1948	Mar-1954	-26.3%	21	63	84
2	May-1939	Jun-1940	Jul-1941	-20.7%	13	13	26
3	Oct-1913	Mar-1914	Oct-1914	-15.2%	5	7	12
4	Feb-1937	Apr-1937	Dec-1937	-14.4%	2	8	10
5	Oct-1916	Apr-1917	Nov-1917	-13.8%	6	7	13
6	Feb-2009	Jun-2009	Jul-2011	-13.5%	4	25	29
7	Jul-1910	May-1911	Dec-1912	-11.3%	10	19	29
8	Nov-1956	Mar-1957	Jul-1957	-11.2%	4	4	8
9	Oct-2001	Apr-2002	Jul-2002	-10.8%	6	3	9
10	Dec-1907	May-1909	Jul-1910	-10.4%	17	14	31

Source: AQR. Time Series performance is hypothetical as described above.

Section 4: Strategy Outlook

While trend-following strategies have performed well over the past 110 years, recent drawdowns have led to some concerns about the current environment for the strategy. First, the assets under management in these strategies have grown rapidly over the past two decades and competition could potentially lower future returns. Second, over the past three years there has been a lack of clear trends – and even a number of sharp trend reversals – which raises the question of whether the current economic environment is simply worse for the strategy. We try to evaluate each of these issues in turn.

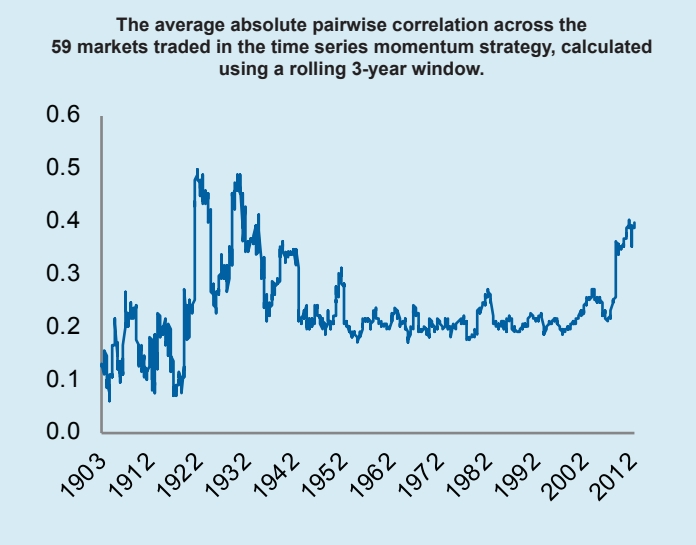
To evaluate the effect of increased assets in the strategy, consider BarclayHedge's estimate that the assets managed by systematic trend-followers has grown from $22B in 1999 to over $260B in 2012.[9] While this growth is substantial, the size of the underlying markets has also grown over the past decade. We estimate that the aggregate size of positions held by trend-followers remains a small fraction of the markets that they are invested in. If we assume that all trend-following managers employ the identical simple strategy we described, the average positions held would amount to approximately 0.2% of the size of the underlying equity markets, 3% of the underlying bond markets, 5% of the underlying commodity markets, and 0.2% of the underlying currency markets. Appendix C provides details on the data used to estimate the aggregate size of the different markets. Even with the significant growth in assets under management, trend-followers appear to remain a modest fraction of the markets that they invest in. It seems unlikely that their trading activity would have a material effect on the markets' trend dynamics.

Following very strong performance in 2008, trend-following strategies have experienced a few drawdowns from 2009-2012. Does this recent performance imply that the environment today is meaningfully worse for trend-following investing? **Exhibit 5** shows the 10 largest historical drawdowns experienced by the strategy since 1903, including the amount of time the strategy took to realize and recover from each drawdown. We compute the drawdown as the percentage loss since the strategy reached its highest-ever cumulative return (its high-water mark). When evaluated in this long-term context, the drawdowns experienced within the past 3 years do not look unusually large. While recent strategy performance has been disappointing, we do not find any evidence that the recent environment has been anomalously poor for the strategy relative to history.

While the performance of trend-following investing over the past few years does not appear to be outside the normal range, it is also useful to consider the potential effects the current economic environment may have on the strategy. Over the past few years, the "risk-on/risk-off" macroeconomic environment has led to higher correlations both within and across asset classes. **Exhibit 6** plots the average pairwise correlation across all the markets used in our strategy, showing how correlations have increased meaningfully across markets since 2007, when the Global Financial Crisis began. As markets have become more correlated, the strategy has had fewer available independent trends to profit from, potentially lowering its risk-adjusted returns, as is true for many investment strategies.

9 www.barclayhedge.com/research/indices/cta/mum/Systematic_Traders.html

Exhibit 6: Average Pairwise Asset Correlations



Source: AQR. Time Series performance is hypothetical as described above.

However, even if the future Sharpe Ratio is expected to be lower than historically observed, the strategy's attractive diversification characteristics continue to make it a potentially valuable addition to a traditional portfolio. For instance, suppose we make a very conservative assumption that the strategy will only realize a Sharpe Ratio of 0.4 net of fees and transaction costs, meaning that trend-following returns are less than half of what we have observed historically.[10] Under this assumption, allocating 20% of a 60/40 portfolio to trend-following leaves portfolio returns unchanged, lowers portfolio volatility from 11% to 9%, increases the overall portfolio's Sharpe ratio from 0.34 to 0.44, and reduces the maximum drawdown from 62% to 53%.[11]

Moreover, there are a number of positive developments that could benefit the strategy going forward. More competition among market makers in the equity markets has vastly reduced transaction costs.[12] Over the last few years, there have been changes in the currency and futures markets which have enabled expanded competition for market making in those markets as well. This should continue to help reduce trading costs going forward for managers willing and able to invest in the proper trading infrastructure. Second, while correlations have been high recently, they are not inconsistent with several episodes in the past, after which they did return to more normal levels. Furthermore, even if the major markets remain more correlated than in the past, there are also now considerably more markets to diversify amongst than throughout most of history, which should benefit trend-following. For example, trend-followers can now invest in emerging equity markets and emerging currency markets, which are much more liquid than they were in the past. In addition, investors can now access these strategies at lower fees than the 2 and 20 fee structure we assumed in our strategy returns. Lastly, while the example above assumes that the 60/40 portfolio will perform as well as it has historically, given the current low real yield on bonds and the high valuation of stocks, there are strong reasons to believe that the 60/40 portfolio will not perform as well going forward, which further makes the case for allocating a portion of one's portfolio to trend-following.

Section 5: Conclusion

Trend-following investing has performed well consistently over more than a century, as far back as we can get reliable return data for several markets. Our analysis provides significant out-of-sample evidence beyond the substantial evidence already in the literature (Moskowitz, Ooi, and Pedersen, 2012). This consistent long-term evidence indicates that trends are pervasive features of global markets.

Markets have tended to trend more often than not because of investor behavioral biases, market frictions, hedging pressures, and market interventions by central banks and governments. Such market interventions and hedging programs are still prevalent, and investors are likely to continue to suffer from the same behavioral biases that have influenced price behavior over the past century, setting the stage for trend-following investing going forward.

Despite a century of very strong performance of trend-following investing and the continued presence of biases and interventions, the strategy's expected return going forward may nevertheless be hurt by several factors: increased assets under management in the strategy, high fees, and higher correlations across markets. However, the returns to investing in the strategy can be improved if asset managers offer lower fees, invest in trading infrastructure and strategy implementation that reduce transaction costs, and obtain broader diversification by expanding the set of tradable futures and forward contracts. The diversification benefits of the strategy remain strong and we think offer a compelling case for a modest allocation in an investor's portfolio.

10 While it is difficult to gauge with certainty, we feel that a 0.4 Sharpe Ratio assumption is likely overly pessimistic for the strategy going forward. The main message here is that even with very conservative expectations for returns to the strategy, investors' portfolios can still significantly benefit due to the powerful diversification characteristics of the strategy.

11 Here we assume that the return distribution of the 60-40 portfolio is as in the past century while time series momentum returns are lowered by a constant amount such that returns average half of what they actually delivered.

12 Weston (2000), O'Hara and Ye (2009).

Appendix A: Markets and Data Sources

We use historical returns data from the following 59 markets in order to construct the time series momentum strategy:

Equity Indices

The universe of equity index futures consists of the following 11 developed equity markets: SPI 200 (Australia), S&P/TSE 60 (Canada), CAC 40 (France), DAX (Germany), FTSE/MIB (Italy), TOPIX (Japan), AEX (Netherlands), IBEX 35 (Spain), FTSE 100 (U.K.), Russell 2000 (U.S.) and S&P 500 (U.S). Futures returns are obtained from Datastream and Bloomberg. We use MSCI country level index returns and returns from Ibbotson and Global Financial Data (GFD) prior to the availability of futures returns.

Bond Indices

The universe of bond index futures consists of the following 15 developed bond markets: Australia 3-year Bond, Australia 10-year Bond, Euro Schatz (2yr), Euro Bobl (5yr), Euro Bund (10yr), Euro Buxl (30yr), Canada 10-year Bond, Japan 10 year Bond (TSE), Long Gilt, US 2-year Note, Italian 10-year Bond, French 10-year Bond, US 5-year Note, US 10-year Note and US Long Bond. Futures returns are obtained from Datastream. We use country level cash bond returns from Morgan Markets and Global Financial Data (GFD) prior to the availability of futures returns. We scale monthly returns from GFD to a constant duration of 4 years, assuming a duration of 2 years for 2 and 3-year bond futures, 4 years for 5-year bond futures, 7 years for 10-year bond futures and 20 years for 30-year bond futures.

Currencies

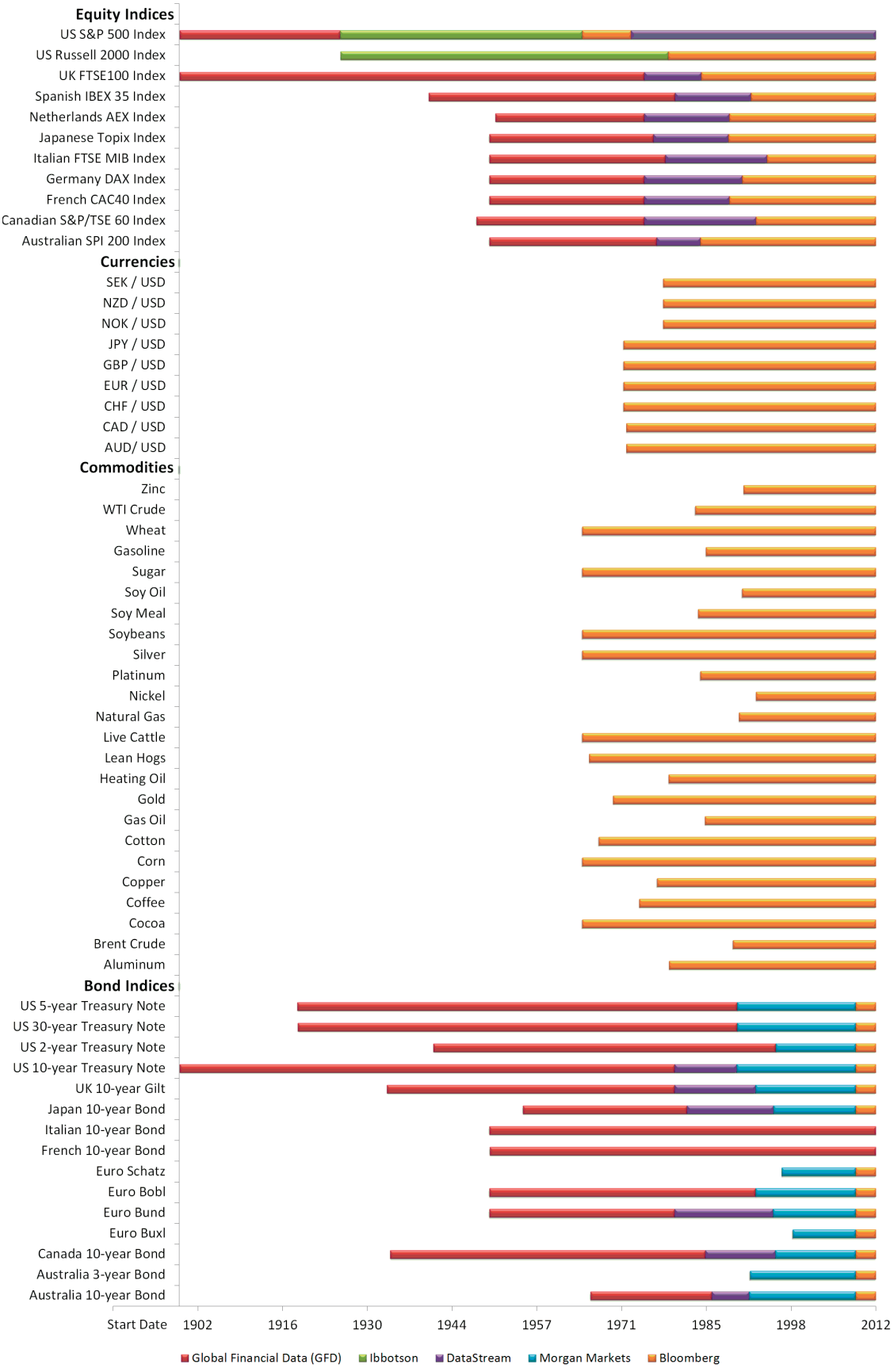
The universe of currency forwards covers the following 9 exchange rates:, Australia, Canada, Germany spliced with the Euro, Japan, New Zealand, Norway, Sweden, Switzerland, U.K., all versus the US dollar. We use spot and forward interest rates from Citigroup to calculate currency returns going back to 1989 for all the currencies except for CAD and NZD, which go back to 1992 and 1996. Prior to that, we use spot exchange rates from Datastream and IBOR short rates from Bloomberg to calculate returns.

Commodities

We cover 24 different commodity futures. Our data on Aluminum, Copper, Nickel, Zinc is from London Metal Exchange (LME), Brent Crude, Gas Oil, Cotton, Coffee, Cocoa, Sugar is from Intercontinental Exchange (ICE), Live Cattle, Lean Hogs is from Chicago Mercantile Exchange (CME), Corn, Soybeans, Soy Meal, Soy Oil, Wheat is from Chicago Board of Trade (CBOT), WTI Crude, RBOB Gasoline spliced with Unleaded Gasoline, Heating Oil, Natural Gas is from New York Mercantile Exchange (NYMEX), Gold, Silver is from New York Commodities Exchange (COMEX), and Platinum from Tokyo Commodity Exchange (TOCOM).

Appendix A: Markets and Data Sources

The following chart shows the length and source of data for each individual market:



Appendix B: Simulation of Fees and Transaction Costs

In order to calculate net-of-fee returns for the time series momentum strategy, we subtracted a 2% annual management fee and a 20% performance fee from the gross-of-fee returns to the strategy. The performance fee is calculated and accrued on a monthly basis, but is subject to an annual high-water mark. In other words, a performance fee is subtracted from the gross returns in a given year only if the returns in the fund are large enough that the fund's NAV exceeds its high water mark from the previous year.

The transactions costs used in the strategy are based on AQR's current estimates of average transaction costs for each of the four asset classes, including market impact and commissions. The transaction costs are assumed to be twice as high from 1993 to 2002 and six times as high from 1903-1992, based on Jones (2002). The transaction costs used are as follows:

Asset Class	Time Period	One-Way Transaction Costs (as a % of notional traded)
	1903-1992	0.36%
Equities	1993--2002	0.12%
	2003-2012	0.06%
	1903-1992	0.06%
Bonds	1993--2002	0.02%
	2003-2012	0.01%
	1903-1992	0.60%
Commodities	1993--2002	0.20%
	2003-2012	0.10%
	1903-1992	0.18%
Currencies	1993--2002	0.06%
	2003-2012	0.03%

Appendix C: Estimation of the Size of Managed Futures Positions Relative to Underlying Markets

The current estimate of assets under management in the BarclayHedge Systematic Traders index is $260B. We then looked at the average monthly holdings in each asset class (calculated by summing up the absoluate values of holdings in each market within an asset class) for our time series momentum strategy, run at a NAV of $260B, and compared them to the size of the underlying cash or derivative markets. For equities, we use the total global equity market capitalization estimate from the World Federation of Exchanges (WFE) 2011 Market Highlights report. For bonds, we add up the total government debt outstanding for 18 of the most liquid government bond markets, using Datastream data. For currencies, we use the total notional outstanding amount of foreign exchange derivatives which are US dollar denominated in the first half of 2011 from the Bank for International Settlements (BIS) November 2011 report. For commodities, we use the total notional of outstanding commodities derivatives, excluding options, in the first half of 2011 from the BIS November 2011 report.

	Average Position Size in $260B Time Series Momentum Portfolio (bn)	Total Market Size (bn)	Percentage of Total Market
Commodities	114	2,300	5.0%
Equities	93	47,000	0.2%
Bonds	598	23,000	2.6%
Currencies	107	54,000	0.2%

References

Asness, C. (1994), "Variables that Explain Stock Returns," Ph.D. Dissertation, University of Chicago.

Asness, C., J. Liew, and R.L. Stevens (1997), "Parallels between the cross-sectional predictability of stock and country returns," *The Journal of Portfolio Management* 23, 79–87.

Asness, C., T. Moskowitz, and L.H. Pedersen (2012), "Value and Momentum Everywhere," *The Journal of Finance*, forthcoming.

Chabot, B., E. Ghysels, and R. Jagannathan (2009), "Momentum Cycles and Limits to Arbitrage: Evidence from Victorian England and Post-Depression US Stock Markets," working paper, Yale University.

Cutler, D.M., J.M. Poterba, and L.H. Summers (1991), "Speculative dynamics," *Review of Economic Studies* 58, 529–546.

Erb, C., Harvey, C. (2006), "The tactical and strategic value of commodity futures," *Financial Analysts Journal* 62, 69–97.

Fung, W., and D. Hsieh (2001), "The risk in hedge fund strategies: theory and evidence from trend followers," *Review of Financial Studies* 14, 313–341.

Gorton, G.B., F. Hayashi and K.G. Rouwenhorst (2008), "The Fundamentals of Commodity Futures Returns," Unpublished working paper, Yale ICF.

Grant, J. (1838), "The Great Metropolis, vol. II", Philadelphia, E.L. Carey & A. Hart.

Hurst, B., Y.H. Ooi, and L.H. Pedersen (2012), "Demystifying Managed Futures," working paper, AQR Capital Management and New York University.

Jegadeesh, N. and S. Titman (1993), "Returns to buying winners and selling losers: implications for stock market efficiency," *Journal of Finance* 48, 65–91.

Jones, C.M. (2002), "A Century of Stock Market Liquidity and Trading Costs," working paper, Columbia Business School.

Moskowitz, T., Y.H. Ooi, and L.H. Pedersen (2012), "Time Series Momentum," *Journal of Financial Economics*, 104(2), 228-250.

Rouwenhorst, K.G. (1998), "International momentum strategies," *The Journal of Finance* 53, 267–284.

Shleifer, A. and L.H. Summers (1990), "The noise trader approach to finance," *Journal of Economic Perspectives* 4, 19–33.

Disclosures

The information set forth herein has been obtained or derived from sources believed by the author and AQR Capital Management, LLC ("AQR") to be reliable. However, the author and AQR do not make any representation or warranty, express or implied, as to the information's accuracy or completeness, nor does AQR recommend that the attached information serve as the basis of any investment decision. This document has been provided to you for information purposes and does not constitute an offer or solicitation of an offer, or any advice or recommendation, to purchase any securities or other financial instruments, and may not be construed as such. This document is intended exclusively for the use of the person to whom it has been delivered by AQR and it is not to be reproduced or redistributed to any other person. AQR hereby disclaims any duty to provide any updates or changes to the analyses contained in this presentation.

Hypothetical performance results (e.g., quantitative backtests) have many inherent limitations, some of which, but not all, are described herein. No representation is being made that any fund or account will or is likely to achieve profits or losses similar to those shown herein. In fact, there are frequently sharp differences between hypothetical performance results and the actual results subsequently realized by any particular trading program. One of the limitations of hypothetical performance results is that they are generally prepared with the benefit of hindsight. In addition, hypothetical trading does not involve financial risk, and no hypothetical trading record can completely account for the impact of financial risk in actual trading. For example, the ability to withstand losses or adhere to a particular trading program in spite of trading losses are material points which can adversely affect actual trading results. The hypothetical performance results contained herein represent the application of the quantitative models as currently in effect on the date first written above and there can be no assurance that the models will remain the same in the future or that an application of the current models in the future will produce similar results because the relevant market and economic conditions that prevailed during the hypothetical performance period will not necessarily recur. There are numerous other factors related to the markets in general or to the implementation of any specific trading program which cannot be fully accounted for in the preparation of hypothetical performance results, all of which can adversely affect actual trading results. Discounting factors may be applied to reduce suspected anomalies. This backtest's return, for this period, may vary depending on the date it is run.

Diversification does not eliminate the risk of experiencing investment losses.

Past performance is not an indication of future performance.

There is a risk of substantial loss associated with trading commodities, futures, options, derivatives and other financial instruments. Before trading, investors should carefully consider their financial position and risk tolerance to determine if the proposed trading style is appropriate. Investors should realize that when trading futures, commodities, options, derivatives and other financial instruments one could lose the full balance of their account. It is also possible to lose more than the initial deposit when trading derivatives or using leverage. All funds committed to such a trading strategy should be purely risk capital.