DYNAMIC COMMODITY STRATEGIES*

Devraj Basu

SKEMA Business School

60 Rue Doestoevski

Sophia Antipolis 06902

France

devraj.basu@skema.edu

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Executive Summary

Commodity futures entered the investing mainstream in the last decade, with long only indices being the most popular investment vehicle. However the popularity of these indices, while still strong, is slowly beginning to give way to more active approaches. The purpose of this study is to examine the performance of a number of active commodity strategies based on trying to capture normal backwardation in the commodity futures markets. The first set of strategies tries to capture backwardation across individual commodities while the others focus on backwardation at the aggregate level. We examine the out of sample performance of these real-time strategies over the 2002-2009 period and find that they outperform their long only counterparts in most cases.

Our strategies are able to provide downside protection during sharp downturns and their diversification benefits are greater than long only strategies. Overall, our results illustrate the role of backwardation as a driver of commodity futures returns and the importance of being able to capture phases of backwardation.

1. Introduction

The last decade has seen a resurgence of interest in commodity futures as an investment class, particularly from institutional investors. Their allocation to commodities has grown dramatically with total commodity linked assets under management rising to $257 billion in 2009 from $18 billion in 2003, according to Barclays Capital. The vast majority of these investments are linked to long only commodity indices such as the GSCI. The main attraction for institutional investors has been evidence that commodity futures could provide equity like returns while exhibiting low correlation with traditional asset classes (Gorton and Rouwenhorst 2006, Bodie and Rosansky 1980), while also providing an inflation hedge. However, inflation has long been subdued, correlations with traditional asset classes such as stock indices is rising and issues with the shape of the futures curve has meant that indices based on futures have failed to capture rises in spot prices. Although the popularity of long only indices remains strong, there is an increasing awareness that active approaches to commodity investing might perform better[1].

The purpose of this study is to construct and study the performance of a new class of active commodity strategies based on trying to capture normal backwardation in the commodity futures markets. Normal backwardation is a situation in which the expected futures spot price is higher than the current futures spot prices, and hence a long position in the underlying futures contract is likely to generate a positive return. The original hedging pressure hypothesis of Keynes (1930) postulated that commodity futures markets were always in normal backwardation as they served an insurance function, allowing producers to transfer price risks to speculators who would thus earn a risk premium. The extent of normal backwardation has been the subject of considerable debate, and the original hedging pressure

[1] Several new active commodity indices have been launched or announced recently (NYSE:UCI for example) whose focus is to eliminate the return erosion due to the shape of the futures curve.

hypothesis was substantially extended by Cootner (1960) and Anderson and Danthine (1983), culminating in the Generalized Hedging Pressure Hypothesis (GHP) of Hirshleifer (1989, 1990). The GHP postulates an inverse relationship between commodity futures prices and hedging pressure, implying that one should go long when hedging pressure, defined as the percentage of hedgers who are net long, is low and vice versa.

The empirical evidence for this hypothesis goes back to Houthakker (1957) and Rockwell (1967), who found that futures prices tended to be correlated with the positions of hedgers and speculators. Chan (1985) showed that prices tend to rise when speculators are net long and fall when they are net short. The Keynesian hedging pressure hypothesis was shown to be a determinant of the commodity futures risk premium (Carter, Rausser and Schmitz 1983[2]), while there was little empirical evidence for a commodity version of the CAPM (Jagannathan 1985). More recently, Bessembinder (1992) and De Roon, Nijman and Veld (2000) found that both systematic risk and hedging pressure were components of the commodity futures risk premium[3].

Our first set of strategies are long flat and short flat[4] strategies that endeavor to capture periods of backwardation, based on the position of hedgers from the CFTC as a proxy for hedging pressure. These strategies are based on the notion of relative backwardation, which considers current hedging pressure relative to the previous year's hedging pressure[5]. We determine levels of backwardation[6] for each commodity based on three different criteria in order to determine when to go long or short, and our real time strategies are all implemented out of sample. Our long flat strategies go long when relative hedging pressure is low, based

[2] It should be noted that this issue is somewhat controversial (Dusak 1973).
[3] More recent research has connected hedging pressure risk premium with futures prices dynamics arising from the theory of storage (Working 1949, Brennan 1958).
[4] The strategy either go long or short a given commodity futures contract, or do not invest. We assume that all positions are fully collateralized and our implementation of the strategy captures only the return due to the dynamic strategy and may thus be interpreted as an excess return.
[5] Basu and Miffre (2007) implement similar strategies based on the absolute levels of hedging pressure.
[6] This parameter essentially determines what proportion of the time the strategy is long.

on the percentile levels, or stay flat while our short flat strategies go short if relative hedging pressure is high or flat otherwise. Our out of sample period is 2002-2009, consisting mostly of a bull period together with one very sharp bear phase, while the in-sample period is 1994-2001. We consider twelve of the most liquid commodities[7].

Over the 2002-2009 period a buy-and-hold strategy would have delivered high returns and Sharpe ratios in spite of the financial crisis, outperforming most other asset classes, and thus providing a difficult benchmark for the dynamic strategies. However individual commodities have high volatilities and high to very high maximum drawdowns, indicating the potential for sustained losses. Of our dynamic strategies, the long flat strategies perform much better than the short flat, for which most mean returns are negative. Across our long flat and short flat strategies, for 9 out of 12 commodities at least one dynamic strategy outperforms the buy and hold. For 8 out of the 9 it is a long flat strategy and for wheat it is a short flat strategy. Our results suggest that copper, crude, soybeans and sugar are backwardated, while corn, natural gas and wheat are contangoed, with cattle balanced between the two[8]. These findings are consistent with backwardation being a driver of high commodity future performance (Feldman and Till 2006), but it is important to note that even for contangoed commodities it is still the Long Flat strategies that outperform buy and hold for corn and natural gas. Our strategies are better at capturing and perhaps timing backwardation than contango, and we find that even for backwardated commodities with high mean returns, successful timing of backwardation can improve performance. We also consider strategies with backwardation estimates based on three year rolling windows and find that these underperform the strategies above, where parameter estimates are based on the longer in-sample period. This suggests that

[7] These are copper, corn, crude, gold, live cattle, natural gas, silver, soybeans, soybean meal, soybean oil, sugar and wheat.

[8] None of the dynamic strategies are able to outperform the buy and hold strategy for gold which has the highest overall buy and hold Sharpe ratio, but the best performing strategy comes reasonably close and is based on a low backwardation percentile, suggesting gold is a contangoed commodity.

the backwardation parameter is better estimated using a longer horizon and is likely to an intrinsic quality of a commodity. An equally weighted portfolio of long flat strategies outperforms the equally weighted buy and hold in terms of Sharpe ratio, and the year by year performance shows that the portfolios are able to capture much of the bull runs while being able to avoid major losses in 2008.

Our second set of strategies, which are long short, is based on the notion of "aggregate backwardation" across the cross section of commodity futures. The rise of institutional investment in commodity futures over the 2002-2009 has led to greater co-movement in commodities (Tang and Xiong 2009). We create an integer valued predictive variable based on the long flat strategy positions and find that its correlation with the GSCI is considerably higher over the 2002-2009 period than over 1994-2001. We consider index timing long short strategies that go long the GSCI if the lagged predictive variable is above its in-sample median and short otherwise. All of our index timing strategies outperform the GSCI, and in fact successfully decouple from it over the 2002-2009, with low average betas. The year by year performance reveals considerable variation in betas and the percentage of time the strategy is long across years, consistent with a successful timing strategy. The best performing strategy outperforms the GSCI seven years out of eight, with the best performance in 2008 where it is able to time the sharp downturn quite successfully.

The final set of strategies involves momentum in commodity futures markets, with Miffre and Rallis (2007) finding evidence that a strategy that goes long past winners and shorts past losers, similar to that in equity markets, is able to earn abnormal profits. They are able to link winners and backwardation and losers to contango, while Kaplan (2007) suggests that portfolios sorted on past performance could capture part of commodity risk premium. This issue is particularly relevant over the 2002-2009 period with the issues around co-movement across commodities and the aggregate backwardation. Aggregate backwardation and contango

seem to push up the entire cross section of commodities at the same time, creating problems for the momentum effect whose success seems to depend on individual backwardation and contango, uncorrelated across the cross-section (Miffre and Rallis 2007, Feutres, Miffre, and Rallis 2009). Both our winner and loser strategy[9] perform well as stand-alone investment strategies, and the issue of whether long short and long flat winner and/or loser timing is possible thus arises, and it is natural to try the same timing strategy as for index timing. Both long short timing strategies outperform their underlying portfolios with the long short loser timing strategy being the more successful. These results are consistent with losers falling more sharply in periods of aggregate contango and provide further evidence for the role of aggregate backwardation and contango over the 2002-2009 period, a situation that may continue into the future.

The equally weighted long only portfolio and the GSCI index had low correlations with the S&P 500 over the 2002-2005 period, but exhibited substantially higher correlations over 2006-2009, consistent with the "financialization of commodities" (Tang and Xiong 2009) hypothesis, somewhat undermining the diversification benefits. The various long flat strategies show a much smaller increase in correlation across the two periods, while the long short index timing strategies show lower and negative correlation with the S&P in the 2006-2009 period. These timing strategies appear to be able to protect investors during commodity market downturns, by being able to capture shifts in aggregate backwardation, and these results provide further evidence that active strategies are necessary to capture the diversification benefits of commodities. We also explore the implications for strategic asset allocation by adding static portfolios and our dynamic strategies to a portfolio of stocks and bonds. Adding the GSCI results in a small improvement the risk return tradeoff, at the expense of higher maximum drawdown and higher negative skewness. Adding the long short

[9] These are based on sorting our 12 commodities into two portfolios, winners and losers, based on previous three month returns and holding for one month.

index timing strategies leads to a much bigger improvement in Sharpe ratios, together with much lower maximum drawdowns and positive skewness. Thus successfully timing aggregate backwardation significantly improves the strategic asset allocation potential of commodities.

Our strategy weights exhibit high auto-correlation and hence low turnover, and this combined with the low trading costs for commodity futures means that transaction costs have a minimal impact on the profitability of the strategies.

The rest of the paper is organized as follows. The data and strategies are discussed in Section 2, while Section 3 describes the results for the long flat and short flat strategies. The performance of the index and momentum timing strategies are analyzed in Section 4, while correlations and strategic asset allocation implications are discussed in Section 5 and Section 6 concludes.

2. Data and Methodology

2.1 Data and Variables

We consider twelve of the most liquid commodities-copper, corn, crude, gold, live cattle, natural gas, silver, soybeans, soybean meal, soybean oil, sugar and wheat.
The basic data source for hedging pressure data is the CFTC website http://www.cftc.gov. It releases the Commitment of Traders report each Friday (except for public holidays) at 3:30 EST. The positions refer to the Tuesday of that week and the date reflects that. The aggregated data which is available at a weekly frequency since 1993 is now released under the Legacy Reports. For this analysis, we need the number of long positions held by commercial

hedgers and the number of short positions. Commercial Hedging pressure (CHP) is the ratio of long positions to the sum of long plus short positions held by commercial hedgers[10]. The individual commodity futures returns and the commodity index returns are based on end of day prices, aggregated to a weekly frequency. The futures returns are based on the front month contract, except for the expiry month in which the next to front month contract is used. The data source is Bloomberg. The Goldman Sachs Commodity Index (GSCI) currently consists of 24 commodities weighted relative to their world production, while the Continuous Commodity Index (CCI) is an equally weighted index of 17 commodities[11].

Our winner and loser portfolios are constructed by dividing the twelve commodities into two equally weighted portfolios of winner and losers based on the previous three month returns and holding them each for one month.

2.2 Description of the Basic Strategies and the Backwardation Index

We use the notion of "relative" backwardation in designing our strategies[12]. This means we look to go long when commercial hedging pressure is low relative to the recent past. In order to implement this strategy we need to decide a) what constitutes the recent past and b) what level of hedging pressure is considered to be low. The most natural time period based on harvest and storage considerations is one year i.e. 52 weeks. The issue of the what level appropriate level of hedging pressure for a given commodity is low, is based on the Generalized Hedging Pressure hypothesis (Hirshleifer 1990) which implies that commodities that are "essentially backwardated" should be held long more often, and also the notion of

[10] Current reports available at http://www.cftc.gov/MarketReports/CommitmentsofTraders/index.htm. Historical data at http://www.cftc.gov/MarketReports/CommitmentsofTraders/HistoricalCompressed/index.htm.

[11] More details for the GSCI may be found at http://www2.goldmansachs.com/services/securities/products/sp-gsci-commodity-index/tables.html. The CCI is described in detail at http://en.wikipedia.org/wiki/Continuous_Commodity_Index_(CCI).

[12] Strategies based on the notion of absolute backwardation based on hedging pressure less than or greater than 50% are explored in Basu and Miffre (2007).

relative scarcity and convenience yield arising from Working (1949) . We thus examine the proportion of time a given commodity has been in “absolute” backwardation to determine the percentile level. We estimate this percentile level in three ways. The first is the proportion of time commercial hedging pressure has been less than 50%, representing backwardation implied from the position of hedgers. The second is the proportion of time futures returns for the commodity has been positive, representing backwardation implied from the futures market. The third is based on finding the percentile level for each commodity that maximizes the return to the long flat strategy described below, over the in-sample period. For our out od sample implementation, we estimate this percentile level 1) over the in-sample period and use it out of sample and 2) also using a rolling three year window for the first two methods.

Our basic long flat strategy for each method of percentile estimation is as follows: In any given week we consider the level of commercial hedging pressure for a given commodity and compare it to the distribution of commercial hedging pressure over the previous 52 weeks. If current commercial hedging pressure is lower than the percentile level discussed above, we go long the futures contract for the given commodity for the next week, else we do not invest in the futures contract, that is we stay flat. The short flat strategy goes short the futures contract if the current commercial hedging pressure is higher than the percentile level discussed above, else stays flat. As the strategy is executed via futures it is notionally zero cost and the basic assumption is that the investment is fully collateralized with the value of the underlying futures contract. The return to the strategy ignores the return due to the investment in Treasury bills and can thus be interpreted as an excess return. This is consistent with our focus on the timing ability of the strategies, rather than collateralization and our strategy might thus be regarded as a zero-cost strategy. The mean return divided by its standard deviation is thus a Sharpe ratio.

The strategy for percentile levels estimated from positions of hedgers is called the CHP strategy, that from futures markets returns is called the RR strategy, while for the third method it is called the Opt strategy. When the percentile levels for the CHP and RR strategies are estimated using rolling windows, the strategies are referred to as the CHP Rolling and RR Rolling respectively. Our in-sample period is 1994-2001 and our out of sample period is 2002-2009. This choice splits the sample almost evenly and our out of sample period consists of a bull phase (2002-2007) followed by a short lived but deep bear market. Our out of sample period thus consists largely of a bull market, a difficult period over which to beat a long only strategy.

We construct the Backwardation Index, based on the signals for the long flat strategy. We assign a dummy variable which is 1 if the long flat strategy is long in a given week and 0 otherwise. Every week, we sum up these dummy variables across the 12 commodities to obtain an integer valued variable with values between 0 and 12.

2.3 Rational Return Predictability

We then wish to assess whether the performance of these simple active strategies achieves the maximum economic value consistent with rational return predictability, or whether more complex long short strategies might do better. To implement this procedure one first needs an appropriate predictor variable, which is the Backwardation Index. We then run regressions of the weekly returns of the individual commodities on the Backwardation Index[13]. Following Abhyankar, Basu and Stremme (2009), the economic value of return predictability is measured by the difference in maximum Sharpe ratios between active strategies based on this predictive regression and buy-and-hold strategies. The maximum Sharpe ratio (at a weekly frequency) based on return predictability is given by

[13] This is of the form $r_t = \alpha + \beta x_{t-1} + \varepsilon_t$ where r_t denotes the commodity return at time t and x_{t-1} denotes the value of the Backwardation Index in the previous week.

$$\sqrt{\lambda_0^2 + \frac{R^2}{1-R^2}} \tag{1}$$

where R^2 denotes the coefficient of determination of the predictive regression and λ_0 is the Sharpe ratio of the individual commodity. The exact form of the strategy that achieves this maximum Sharpe ratio is described in Abhyankar, Basu and Stremme (2009).

3. Results for the Basic Strategies

We first describe the performance of the long only futures strategy, then discuss the percentile levels for the various strategies and then the out of sample performance of the various strategies over the 2002-2009 period.

3.1 Performance of the Long Only Strategies

The 2002-2009 period consisted of a strong bull phase until 2007 and then a sharp bear phase particularly in 2008 followed by a recovery over the 2009 period. The overall performance of the long only futures positions is shown in Table 1 for the 12 commodities and the annualized returns vary from 3.8% for live cattle to 24.3% for copper. The highest Sharpe ratio is 0.98 for gold and the equally weighted portfolio of the 12 commodities has a high annualized mean of 18.2% with a Sharpe ratio of 1. Thus over this period a buy-and-hold strategy would have delivered high returns and Sharpe ratios in spite of the financial crisis, outperforming most other asset classes, and thus providing a difficult benchmark for the dynamic strategies. However individual commodities have high volatilities and high to very high maximum drawdowns should also be noted, varying from 28% for gold to 76% for natural gas, with the equally weighted portfolio's maximum drawdown being 48%, indicating the potential for sustained losses. These drawdowns suggest the presence of "phases" of backwardation, both

for individual commodities as well as the cross section, and indicate the need for dynamic strategies that might be able to capture these phases.

3.2 Percentile Levels for the Dynamic Strategies

The in-sample percentile levels for the individual commodities for the CHP, RR and Opt strategies are shown in Table 2. Recall that Long Flat strategy goes long if the current hedging pressure level is less than the corresponding percentile of the hedging pressure over the previous 52 weeks and the Short Flat goes short if current hedging pressure is correspondingly higher. A high percentile level suggests that the commodity is "essentially backwardated" and the Long Flat strategy tends to be invested a high proportion of the time, while low percentile levels suggest "essential contango" with the Short Flat strategy being invested a high proportion of the time. There is also a relative aspect to this table, as one can compare the relative percentile levels across commodities assigned by the three strategies. The CHP percentile levels tend to be higher than the other two and vary from 95% for silver to 39% for gold. The RR levels show the lowest variation from 56% for soybean meal to 38% for silver while the Opt levels are from 75% for copper to 20% for soybean oil, wheat and gold. If we split the cross section for each set into halves, the top half relatively backwardated and the bottom relatively contangoed, then only copper is relatively backwardated for all three and soybean oil relatively contangoed for all three. This indicates that the relative rankings across the three sets of strategies are quite different.

The question arises as to whether these percentile levels are best estimated using long horizon or short horizon data. The argument for using long horizon data, for example the entire 1994-2001 in sample period is that this percentile level reflects an essential steady state property of the commodity, while using a shorter horizon such as three years reflects more current information. The CHP and RR percentile levels based on the previous three years, over the

2004-2009 period are shown in Table 3 and Table 4 respectively, to provide a contrast between the long horizon and short horizon percentile levels. We see from Table 3 that there is considerable variation in the three year percentile levels for copper, corn, cattle, natural gas, soybeans and wheat, with levels indicating both backwardation and contango at different points. From Table 4 we see that these variations are lower for the three year RR percentile levels, with the biggest variations for gold and wheat. The CHP Roll and RR Roll strategies use these three year percentile levels and comparing their performance with the CHP and RR strategies will allow us to see which method of percentile estimation is more appropriate.

3.3 Performance of the CHP Strategies

The out of sample performance of the Long Flat and Short Flat CHP based strategies are shown in Table 5. The appropriate measure of comparison is Sharpe ratios as the dynamic strategies are not fully invested and thus have lower volatilities. All of the Long Flat strategies achieve positive mans with eight of the Long Flat strategies achieve higher Sharpe ratios than the corresponding buy and hold[14]. Of these eight, the Long Flat crude, cattle, natural gas, silver and sugar have higher means than the buy and hold strategy and the maximum drawdown is lower, often considerably lower, for all of the individual strategies except wheat. The equally weighted Long Flat portfolio has a higher Sharpe ratio (1.23 relative to 1.02) and a considerably lower maximum drawdown of 20% relative to 48% for the long only. Hence both the individual and equally weighted strategies would have been much safer investments in the sense of volatility as well as maximum drawdown, while delivering higher Sharpe ratios in most cases. The proportion of time each strategy is invested is similar to the percentile level, and the correlations with long only vary from 0.99 for silver to 0.61 for gold. For the five commodities for which the Long Flat strategy achieves a higher mean than long only the correlations range from 0.66 for cattle to 0.94 for sugar, broadly consistent with the

[14] These are copper, corn, crude, cattle, natural gas, silver, soybeans and sugar.

extent of backwardation of these commodities. Overall thus the Long Flat CHP strategies seem to be able to capture backwardation quite successfully over our out of sample period. The relative underperformers are three agricultural commodities (soybean meal, soybean oil and wheat)[15] all of which are in the top half of CHP percentile levels and gold, which was the most contangoed. The Long Flat Sharpe ratios for the three agricultural commodities are the three lowest while that for gold is 0.77, high but not high enough.

The Short Flat strategies are much less successful with only four achieving positive returns, with Sharpe ratios well below the long only, with the equally weighted portfolio achieving a negative return. This methodology is thus virtually unable to capture contango effects, either structurally, with the most Short Flat strategies for the contangoed commodities, corn and gold, both having negative returns[16], or in phases.

3.4 Performance of the RR Strategies

The results for the RR strategies are shown in Table 6. For the Long Flat strategies 10 of the 12 individual strategy means are positive, and the two with negative returns are soybean meal and wheat, both underperformers for the CHP strategy as well. In this case, only 4 strategies outperform their buy and hold counterparts[17], with cattle and natural gas achieving higher mean returns. All of the individual maximum drawdowns are lower, significantly lower in many cases, than the buy and hold strategies, likely as a result lower percentile levels relative to CHP which also leads to slower strategy volatilities. The equally weighted portfolio has a slightly higher Sharpe ratio than the buy and hold (1.08 compared to 1.02) and a much lower maximum drawdown of 11.6% with a low volatility of 8.9%. The percentage invested is again in line with the percentile levels and correlations with long only range from 0.39 for sugar to

[15] These commodities are also three of the four least liquid.
[16] Although the strategy for cattle, also a contangoed commodity, does achieve a positive return.
[17] These are corn, crude, cattle and natural gas, with soybeans and sugar relatively close.

0.72 for corn. The four outperformers have correlations ranging from 0.59 (cattle) to 0.72 (corn) again roughly in line with their percentile levels.

The performance of the Short Flat strategies is again not good, with only four of the twelve achieving positive returns and the equally weighted strategy achieving a negative return. However it is more successful than the CHP in capturing structural contango, with the four Short Flat strategies with positive returns (cattle, natural gas, sugar and wheat) all in the bottom half of percentile levels, and hence to be regarded as contangoed. The Sharpe ratio for the wheat strategy is in fact higher than the buy and hold. Another interesting thing to note is that the sum of the Long Flat and Short Flat returns for natural gas is nearly 42%, suggesting that natural gas strategy works better when it is regarded as a contangoed commodity.

3.5 Performance of the Opt Strategies

The percentile levels of the Opt strategy are in between those of the CHP and RR and the performance of the Opt Long Flat and Short Flat are shown in Table 7. Four Long Flat strategies (copper, crude, cattle and natural gas) outperform the long only in terms of Sharpe ratio with crude (second highest percentile level of 65%) and natural gas (fourth highest percentile level of 45%) achieving higher means. The maximums are all lower than long only and are as low as 9% for cattle and 12% for gold. The equally weighted portfolio has a slightly higher Sharpe ratio than the buy and hold (1.10 compared to 1.02) and a much lower maximum drawdown of 11.6% with a low volatility of 8.7%, all of which are very similar to the RR Long Flat strategy although some of the percentile levels for individual commodities are very different. The four outperformers have correlations with long only ranging from 0.41 (cattle) to 0.68 (crude and natural gas).

The Short Flat strategies again perform poorly with only two (crude and cattle) achieving positive means. The only interesting feature here is the performance of the crude with the sum

of the Long Flat and Short Flat means being 31.8%, with a percentage long investment of 68%.

3.6 Comparison of the Various Strategies

The performance of the Long Flat strategies is consistent with the generalized hedging pressure hypothesis of Cootner (1960) and Hirshleifer (1989, 1990) and extends the empirical literature on normal backwardation (Chang 1985, Kolb 1992, Miffre 2000). Our analysis tries to quantify the notion of "essential backwardation" as an intrinsic aspect of each commodity and also suggests that for several commodities normal backwardation works when hedging pressure is low, that is hedgers are likely to be net short (Rockwell 1967). From an asset pricing viewpoint our results suggest the presence of a commodity risk premium driven by hedging pressure effects as suggested by the theoretical Hirshleifer (1990) analysis and the empirical evidence in Carter, Rausser and Schmitz (1983), Bessembinder (1992) and De Roon, Nijman and Veld (2000). We now provide a comparative analysis across commodities. Overall for 9 out of 12 commodities at least one dynamic strategy outperforms the buy and hold. For 8 out of the 9 it is a Long Flat strategy and for wheat it is a Short Flat strategy. These findings suggest as well that active strategies are better than buy and hold at capturing the commodity risk premium (Erb and Harvey 2006 versus Gorton and Rouwenhorst 2006[18]). The result for wheat is consistent with it being generally regarded as a contangoed commodity (Feldman and Till 2006) and the associated percentile level is 42%. For the eight other strategies the levels are as follows: Copper 75%, Corn 47%, Crude 59%, Cattle 57%, Natural Gas 42%, Silver 95%, Soybeans 68% and Sugar 69%. These findings suggest that copper, crude, soybeans and sugar[19] are backwardated, while corn, natural gas[20] and wheat are

[18] It should be pointed out that Gorton, Rouwenhorst and Hayashi (2007) propose a dynamic strategy, although based on a cross sectional sort rather than commodity by commodity as here.

[19] Copper, crude, silver and sugar are four of the top five commodities in terms of buy and hold returns, while soybeans is number 7.

contangoed, with cattle balanced between the two. These findings are consistent with backwardation being a driver of high commodity future performance (Feldman and Till 2006),but it is important to note that even for contangoed commodities it is still the Long Flat strategies that outperform buy and hold for corn and natural gas. Our strategies are thus better at capturing and perhaps timing backwardation than contango. It is also interesting to note that the correlations of the best performing strategies for copper and crude are 0.66 and 0.75 with long only strategies, indicating that even for backwardated commodities with high mean returns, successful timing of backwardation can improve performance. The best performing gold strategy has a percentile level of 39%, implying contango, and a high Sharpe ratio of 0.77, but is unable to match the very strong buy and hold performance of gold over the 2002-2009 period.

3.7 Performance of the Rolling Window CHP and RR Strategies

We now consider the effect of using CHP and RR percentile levels based on a three year rolling window[21], with the results shown in Table 8 for the CHP and Table 9 for the RR strategy. The individual Sharpe ratios for the Long Flat strategies are lower than those for the CHP strategies for all except copper, and gold, which are slightly higher though with higher maximum drawdowns. The characteristics of the dynamic strategies (correlations and percentage invested) appear to be similar to CHP for most commodities except for gold, where the percentage invested and correlation are both much higher, wheat for which they are both lower and sugar for which the percentage invested is similar but correlation is much lower. The individual Long Flat strategies outperform long only for copper, crude, cattle, silver and sugar and the equally weighted portfolio's Sharpe ratio almost matches that for

[20] The natural gas percentile levels indicate both backwardation and contango. The backwardated strategy beats buy and hold but the best performing strategy is based on a contangoed level (42%).
[21] We do not carry out the same exercise for the Opt strategies as a short window optimization is likely to be seriously affected by outliers.

long only (1.01 versus 1.02) with the maximum drawdown at about the CHP level (22%). The Short Flat strategies do not perform well with only cattle achieving a positive return. Thus, incorporating fixed length rolling windows leads to slightly poorer performance overall for the CHP strategy, indicating perhaps that stability of the CHP percentile level might be desirable.

The results are more nuanced for the RR rolling strategy, for which the variation in percentile levels is not quite as dramatic. For the individual Long Flat strategies the rolling strategy outperforms the RR strategy for copper, gold, cattle, soybean meal, soybean oil and wheat, for all of which the Sharpe ratio is at least 15% higher albeit with higher maximum drawdowns. For all of these commodities, the percentage invested and correlations with long only are not significantly different from the RR strategy, indicating that there may be benefits from using a rolling window for the RR strategy, particularly for the agricultural commodities. The individual strategies outperform long only for corn and cattle and the equally weighted strategy slightly underperforms the buy and hold (0.98 versus 1.01), with a maximum drawdown of 20%, lower than long only but considerably higher than RR (11.5%). The performance of the Short Flat strategy is similar to that of the CHP Rolling.

3.8 Year by Year Performance of the CHP Equally Weighted Portfolio

We now focus on the year by year performance, both absolute and relative, for the best performing dynamic strategy overall, namely the CHP Long Flat strategy. Our relative comparison is with the CCI and GSCI, which had overall Sharpe ratios of 0.81 and 0.32 over the 2002-2009 period. The CCI and GSCI are based on very different weighting schemes, with each of the 17 commodities receiving equal weight, while the GSCI is heavily weighted towards the energy sector. The absolute performance of the equally weighted portfolio is shown in Table 10, with the Sharpe ratio over the 2002-2009 period being considerably higher

than either of the two indices (1.23), and the pattern of yearly Sharpe ratios reflecting the bull and bear phases. The strategy avoided major losses in 2008 with the lowest average percentage overall of investment (46%), with the CCI and GSCI achieving Sharpe ratios of -0.93 and -1.51 respectively. The average percentage invested across the period was 60% and yearly averages are lower than the overall average in 2004, 2005, 2006 and 2008. The year 2005 would qualify as a bull year with the CCI and GSCI achieving Sharpe ratios of 1.61 and 0.95 respectively, and the low investment percentage indicates that the strategy overall did not time backwardation very effectively that year. It outperformed the GSCI in terms of Sharpe ratio every other year, and underperformed the CCI in 2004 and 2009. In 2004 the CCI achieved a Sharpe ratio of 0.94 just higher than the 0.92 for the strategy, so the low investment percentage (50%) indicates a decent timing performance. The CCI had a very high Sharpe ratio of 1.90 in 2009 which the CHP strategy was unable to match although the percentage invested was quite high (74%).

The relative performance relative to the CCI and GSCI is shown in Table 11, with average betas over the period of 0.56 for the CCI and a much lower beta of 0.26 for the GSCI. There is considerable beta variation for both indices, with the lowest betas for both indices, quite interestingly, in 2009 of 0.03 and -0.08, and a maximum of 0.75 in 2002 for the CCI and 0.39 in 2006 for the GSCI. The higher overall betas for the CCI are consistent with the fact that the CCI is equally weighted, and the variation in betas is overall consistent with timing and generally successful timing. The average alpha for the CCI is 8% while that for the GSCI is 14%, again with considerable variation. The highest yearly alpha for the CCI is 18% in 2009[22], while that for the GSCI is 25% in 2006. The lowest alpha for the CCI is -5% in 2005, and 3% for the GSCI also in 2005[23], with alphas for all other years positive for the CCI. The pattern of information ratios is also similar and is overall 0.93 for the CCI and 1.39 for the

[22] The strategy underperforms the CCI in 2009 in an absolute sense.
[23] The strategy underperforms both the CCI and the GSCI in 2005.

GSCI. These results are again consistent with the CCI being harder to beat as it is equally weighted, but also indicates that the equally weighted portfolio scheme performs better both for the buy and hold and dynamic strategies.

3.9 Analysis of the Maximum Theoretical Sharpe Ratio

In Table 12 the maximum in-sample Sharpe ratios, based on the optimal use of the predictability discussed in Section 2.3, between the buy and hold returns for an individual commodity and a dummy variable which is 1 if each dynamic strategy is long for the next week and 0 otherwise[24]. These Sharpe ratios may be achieved by long-short strategies that are also occasionally flat. The point here is to analyze the magnitude of these Sharpe ratios and see if more complicated strategies than the ones analyzed here could exploit this predictability more effectively. There are three commodities for which the maximum theoretical Sharpe ratio across these strategies is more than 20% higher than the maximum out of sample Sharpe ratios of the five strategies, with the same is also true for the equally weighted portfolio[25]. These are crude, gold, natural gas, silver, soybeans and wheat and the biggest differential is for natural gas (around 100%) followed by silver, wheat, soybeans, gold and crude. This indicates that for natural gas, silver, wheat and the equally weighted strategy, a more complex long-short-flat strategy could exploit the predictability more effectively, with the gains being potentially quite large[26].

The other thing we note from Table 12 is that both sets of rolling strategies achieve lower Sharpe ratios than the other strategies, indicating that predictability effects are stronger when percentile levels are estimated using a longer window, providing further evidence that the percentile levels capture a long run aspect of the commodity's price behavior.

[24] The five strategies that we consider are the CHP, RR, Opt, CHP Roll, RR Roll.
[25] In this case the predictive variable is the sum of the dummies for the 12 commodities.
[26] Details of the strategy that captures the maximum Sharpe ratio are described in Abhyankar, Basu and Stremme (2009).

4. Index and Momentum Timing Strategies

We now consider the notion of "aggregate backwardation" based on summing the Long Flat signals and its predictive power for the GSCI index. We then explore the results of long short GSCI timing strategies based on aggregate backwardation.

4.1 Aggregate Backwardation across the In and Out of Sample Periods

The 2002-2009 period was characterized by a sharp increase in institutional index investing, with institutional investing in commodity futures increasing from $18 billion in 2003 to in $250 billion in 2010 according to a recent survey of over 250 institutional investors by Barclays Capital. In Table 13 we provide some evidence for its effects on commodity returns and our strategies. The first row of Table 13 shows that the average covariance across the 12 commodities was three times as high over the 2002-2009 period as over the 1994-2001 period, suggesting that commodities tend to move together more consistent with the findings in Tang and Xiong (2009). We create an aggregate backwardation index by summing up the dummy variables (1 if invested, 0 if not) for each of the commodities. For the in-sample period we use the same percentile levels as for our out of sample[27], thus potentially increasing the predictability due to the in-sample parameter estimation. We then compute the correlations between the GSCI and lagged backwardation index and find that for all five strategies the correlations are considerably higher in the 2002-2009 period than in the in-sample period. The out of sample correlations are higher for the non-rolling strategies consistent with the earlier results, and are at least 90% higher than the corresponding in-sample correlations. These findings thus suggest the rise of "aggregate backwardation", that is

[27] For the rolling strategies we use the same principle, three year rolling windows except for 1994 and 1995 where the window lengths are one and two years respectively.

the greater predictability across the cross-section of commodities over this period. The results are similar for other commodity indices (not reported) and are more likely to be a result of systematic effects than possible index front-running. Our analysis is based on the actions of commercial hedgers, and this group consists of true hedgers as well as index investors who enter via the swap market, neither of whom is likely to want to front run the GSCI during the roll period as it would disrupt their basic activity[28].

4.2 Performance of the Index Timing Strategies

The aggregate backwardation indices for the five strategies exhibit high correlation (over 0.85) with each other and high auto-correlation (over 0.85). The index timing strategies are based on the idea that high values of the backwardation index indicate backwardation across the cross-section of commodities and hence one should go long the GSCI when the lagged backwardation index is high and short when it is low. The simplest measure of high and low in our relative context is the median, and we use the median over the in-sample period (1994-2001) as this level. Our index-timing strategy is thus a real-time strategy, and the performance of the five strategies is shown in Table 14. The GSCI achieves a Sharpe ratio of 0.32 with considerable variation in the year by year performance of the GSCI across this period, with returns ranging from 32% in 2002 to -63% in 2008, with negative returns in 2006 as well. This variation in yearly returns suggests time-variation in aggregate backwardation, even during a bull phase and hence the need for a timing strategy. All five timing strategies outperform the GSCI with Sharpe ratios ranging from 0.40 to 1.32. The performance of the various dynamic strategies is consistent with the correlations from Table 13, with the rolling strategies achieving the lowest overall Sharpe ratios. The RR and Opt strategies are the best performing with Sharpe ratios of 1.31 and 1.32 respectively while the CHP timing strategy

[28] We cannot totally rule out this kind of activity from commercial hedgers, but it is quite unlikely to be systematic in this category.

has a Sharpe ratio of 1.09. The reason for this seems to be the different levels of the median[29], which is lowest for the Opt (4) strategy that consequently has the highest percentage of long positions (73%). The percentage long positions are above 60% for all of the strategies, suggesting that level of the backwardation index is higher over the out of sample period, consistent with the predominance of a bull phase. The average beta for all the strategies is close to zero, and consequently almost all of the returns appear as alpha relative to the GSCI. All of the index timing strategies are thus able to decouple from the index, with the non-rolling strategies able to time both backwardation and contango better.

The year by year performance of the best performing Opt strategy is shown in Table 15 and we see that it outperforms the GSCI seven years out of eight, underperforming in 2002 and 2005[30]. The alphas are negative for both those years as well as for 2005, but are all less than -3%. The positive alphas are mostly quite large, above 25% in five years. There is considerable variation in betas (from 0.97 to -0.45) and percentage long (98% to 48%) across the various years consistent with generally successful index timing. The highest return is in 2008 (103%) when the GSCI index had a return of -63%, although the percentage long is 60%, the second lowest overall. This indicates successful timing, as the sharpest decline in the GSCI was over a relatively short period. The strategy was short continuously from August 2008 to the end of 2008 over which period the GSCI fell 86%. The lowest percentage long was in 2004 with 48%, where the strategy slightly outperformed[31], but achieved an alpha of 29%.

4.3 Momentum Timing

The issue of momentum in commodity futures markets has attracted some attention with Miffre and Rallis (2007) finding evidence that a strategy that goes long past winners and

[29] As the backwardation indices themselves are quite highly correlated.
[30] The best performing equally weighted strategy also underperforms the GSCI in 2005.
[31] Sharpe ratio of 0.86 compared to 0.83 for the GSCI

shorts past losers, similar to that in equity markets, is able to earn abnormal profits. They are able to link winners and backwardation and losers to contango, while Kaplan (2007) suggests that portfolio sorted on past performance could capture part of commodity risk premium[32]. This issue is particularly relevant over the 2002-2009 period with the issues around co-movement across commodities and the aggregate backwardation which we have analyzed. The main issue we wish to analyze first is the effect of aggregate backwardation on the momentum effect. We do this by analyzing the performance of winner and loser portfolios separately.

Our winner and loser portfolios are based on the top six and bottom six of the twelve commodities, sorted on past three month return and held for one month. The year by year performance of these portfolios is shown in Table 16, which shows that for two years (2003 and 2008) the loser portfolio achieved a higher mean return than the winner portfolio. In these two years the momentum portfolio (long winners, short losers) would have returned -45% and -19% respectively[33]. These results overall indicate the effect of aggregate backwardation, as returns to both the winner and loser portfolio were positive every year except for 2008, with the overall return to the momentum strategy being 1.1%. Thus aggregate backwardation and contango seem to push up the entire cross section of commodities at the same time, creating problems for the momentum effect whose success seems to depend on individual backwardation and contango, uncorrelated across the cross-section (Miffre and Rallis 2007, Feutres, Miffre, and Rallis 2009). Both the winner and loser strategy perform well as stand-alone investment strategies, and the issue of whether long short and long flat winner and/or loser timing is possible thus arises, and it is natural to try the same timing strategy as for index timing. We consider both long short and long flat timing strategies and report the year by year

[32] For example, the JP Morgan C-IGAR indices are based on momentum as are the Morningstar Long/Short Commodity and Long/Flat Commodity indices.

[33] The performance in 2008 is consistent with those of the JP Morgan and Morningstar momentum based indices.

results based on the most successful index timing strategy, namely Opt timing in Tables 17 and 18.

From Table 17 we see that overall both long short strategies outperform their underlying portfolios, with the difference being greater for the loser timing strategy (Sharpe ratio of 1.15 relative to 0.71). The winner timing strategy outperforms the winner portfolio five years out of eight while the loser timing outperforms six years out of eight. Both strategies underperform in 2005, with the winner timing strategy achieving a negative return, and the loser timing strategy outperforms winner timing four years out of eight, with an overall higher Sharpe ratio. These results indicate that long short loser timing is more effective than long short winner timing, consistent with losers falling more sharply in periods of aggregate contango. The results for long flat winner timing from Table 18 show a different pattern of results with the winner timing strategy outperforming the loser timing and achieving the highest overall Sharpe ratio of 1.24. The winner timing strategy outperforms the underlying winner portfolio six years out of eight with positive returns every year. The biggest benefit to the strategy is in 2008, and thus the overall benefit arises from avoiding sharp downturns. The loser timing strategy has a lower, but still impressive, Sharpe ratio of 1.08 and underperforming the underlying loser portfolio only in 2003. Timing the losers is overall more beneficial than timing winners, relative to the underlying portfolio.

5. Further Analysis

In this section we will discuss correlations with other asset classes, implications for strategic asset allocation and estimate trading costs and turnover for our dynamic strategies.

5.1 Performance Relative to and Correlations with Other Asset Classes

Over the 2002-2009 period the S&P 500 index had a mean return of around 3%, with a Sharpe ratio of almost zero, while the Lehman Brother's bond index had a return of 5.5%, with a much higher Sharpe ratio of 0.66. An equally weighted combination of the two had a mean return of 4.3% with a low Sharpe ratio of 0.14. Thus the equally weighted portfolios for the CHP, RR and Opt Long Flat strategies outperformed these strategies in terms of Sharpe ratios, by quite a wide margin.We now analyze correlations between the equally weighted portfolio of buy and hold and Long Flat strategies and the S&P 500, the bond index, an equally weighted portfolio of stocks and bonds and TIPS. We analyze these correlations over the 2002-2005 and 2006-2009 period separately in Table 19[34]. This is done in order to separate the bull and bear components of the out of sample period, particularly since correlations are likely to be higher in the bear phase. The correlations with the S&P 500 for all over the equally weighted portfolios are similar and are all fairly low over the 2002-2005 period. Over the 2006-2009 the correlation with the equally weighted buy and hold portfolio rises to 0.35, reflecting the co-movement in commodities and stocks, possibly as a result of massive rise in investment from financial players (Tang and Xiong 2009) and the financial crisis. The correlations of the Long Flat strategies are also higher over this period, but much lower in a relative sense, with a maximum percentage rise of 50% (from 0.12 to 0.18, the highest correlation overall) compared to a 400% rise (0.08 to 0.35) for the buy and hold. The Long Flat strategies thus seem to provide better diversification than buy and hold, even in the face of increasing "financialization" of commodity markets. The correlations with bonds are uniformly low and in fact slightly lower over the 2006-2009 period. The correlations with the equally weighted portfolio of the S&P and the bond index follow a very similar pattern to that with the S&P, and overall suggest that these active strategies provide greater diversification benefits than buy and hold commodity indices. This finding has implications for strategic

[34] For TIPS we report the correlations over the 2003-2005 due to data constraints.

asset allocation which we explore in the next sub-section. Finally the correlations with TIPS provide evidence for whether these strategies, both strategic and dynamic are likely to be good inflation hedges. The evidence is not encouraging as these correlations over both periods are virtually indistinguishable from zero, and is in line with recent evidence (Jeanrett, Molin and Schorz 2011) that neither long only indices nor commodity hedge funds provide overall protection against inflation.

The correlations for the GSCI and the various timing strategies are shown in Table 20. The correlations between the GSCI and S&P display a similar pattern, being slightly negative over the 2002-2005 period (-0.09) and 0.38 over the 2006-2009 period. All of the long short index timing strategies have low positive correlations with the S&P over the 2002-2005 period and negative correlations over the 2006-2009 period, that are higher in absolute value than those over the 2002-2005 period. The negative correlations are due to the presence of short positions, and the higher level of correlations coupled with the performance of these long short strategies suggest successful timing in downturns. These timing strategies appear to be able to protect investors during commodity market downturns, by being able to capture shifts in aggregate backwardation. The rising correlations between commodity and stock indices has been a concern for investors looking for diversification with commodities, and these results provide further evidence that active strategies are necessary to capture the diversification benefits of commodities. The pattern of results with bonds, equally weighted stock and bond index and TIPS is similar to that for the Long Flat strategies. The correlations with TIPS are slightly negative indicating again that these active strategies do not provide an effective inflation hedge.

5.2 Implications for Strategic Asset Allocation

We now consider the implications of adding various static and dynamic commodity portfolios to a stock and bond portfolio. This issue of moving beyond stocks and bonds for strategic allocation has generated considerable recent interest, and commodities are seen as an attractive addition because of their low historical correlations with stocks and bonds, as well as their potential as an inflation hedge. However Erb and Harvey (2006) and Gorton and Rouwenhorst (2006), the two most influential academic studies on this issue, reach opposite conclusions. Gorton and Rouwenhorst (2006) suggest that adding a long only commodity index is the best way to include commodities consistent with the strict Keynesian hedging pressure hypothesis, while Erb and Harvey (2005) suggest different sources of commodity returns, namely the roll return rebalancing, and hence suggest that active strategies are better to capture the long term risk premiums.

We investigate this issue in our context by constructing a portfolio based on the S&P 500, our bond index and then incorporating buy and hold as well as dynamic commodity portfolios. We first consider the various equally weighted portfolios of 12 commodities in Table 21. We first include the buy and hold equally weighted portfolio and then the five Long Flat strategies. The weights on the stock, bond and commodity strategies are based on the market capitalization weights estimated in the Ibbotson (2006) study and are 40%, 24% and 36% respectively. From Table 21 we see that adding the buy and hold commodity portfolio improves the risk return tradeoff considerably (Sharpe ratio increasing to 0.55 from 0.09) over the 2002-2009 period, with a sharp rise in the mean return, with similar standard deviation, negative skewness and maximum drawdown, confirming the findings in Ibbotson (2006). Adding the various Long Flat portfolios leads to a lower standard deviation as one might expect, and a slight improvement in the Sharpe ratio for the CHP strategy. The main

benefits are a reduction in negative skewness as well as a lower maximum drawdown for all of the five dynamic strategies, with the other four achieving slightly lower Sharpe ratios than for the static equally weighted portfolio. Thus at least for the CHP Long Flat strategy we could argue that a dynamic strategic is preferable to a buy and hold for strategic asset allocation purposes.

A more practical strategy from an institutional investor is to add the GSCI index to a stock and bond portfolio. We thus consider this possibility together with the dynamic long short index timing portfolios in Table 22. Adding the GSCI to the stock and bond portfolio improves the Sharpe ratio slightly (0.20 from 0.09) but comes at the expense of higher volatility, higher negative skewness and a considerably higher maximum drawdown, and in this case the benefits of adding commodities is much less clear. However adding the long short strategies is clearly very beneficial for all of the portfolio statistics with the portfolio Sharpe ratio rising as high as 1.07 when the RR long short index timing strategy is added. The greatest overall benefits are when the Opt long short timing strategy is added with the Sharpe ratio rising to 1.05, with the portfolio having higher mean, lower standard deviation, a positive skew of 0.32 and a very low maximum drawdown of 9.7%. This performance arises from the high Sharpe ratio of the index timing strategy and also from the low correlations analyzed in the previous section. The rolling long short strategies achieve the lowest Sharpe ratios for the dynamic strategies but still comfortably outperform the static portfolios in all respected. The portfolio of the dynamic strategies thus completely dominates the static portfolio in all cases and for all of the portfolio statistics, thus clearly pointing to the superiority of the index timing strategies over the GSCI for purposes of strategic asset

allocation[35]. These results also indicate that an equally weighted buy and hold portfolio is better as a static addition in the context of strategic asset allocation than the GSCI.

5.3 Impact of Transaction Costs for the Various Dynamic Strategies

The issue of turnover and trading costs is now addressed. We focus on one set of Long Flat strategies, namely the CHP, and the associated index timing strategy[36]. The transaction costs we estimate are for the dynamic strategy alone and exclude the costs of rolling in the expiry month, which is the transaction cost that the buy and hold strategy would incur. Commodity futures markets have been shown to be subject to quite low transaction costs ranging from 0.0004% to 0.033% (Venkatesh and Locke 1997) and we use the most conservative estimate of 0.033%. For the Long Flat strategies the position changes are from long to flat or flat to long, while for the index timing strategies it is from long to short or short to long, and hence we might expect the index timing strategies to have higher transaction costs. The maximum annualized transaction cost possible for the Long Flat strategies is 1.7%, based on changes every week and 3.5% for the index timing strategy. The estimated average annualized transaction costs for the individual CHP Long Flat strategies, their equally weighted portfolio and the associated GSCI timing strategy over the are shown in Table 22. The costs are quite low varying between 0.10% (6% of the maximum possible) for copper to 0.21% (12% of the maximum possible) for wheat for the Long Flat and 0.7% (20% of the maximum possible) for the index timing strategy. These low transaction costs are due to the strategy signals having relatively high autocorrelation, as shown in Table 22, which indicate that the strategies seem to capture medium to long term trends in commodity futures prices, rather than short term oscillations. Thus the transaction costs would not have made a material impact on the

[35] It should be pointed out that part of the superior performance is attributable to the timing properties of the index timing strategies over the 2008 period, which might be regarded as an exceptional situation.
[36] The various strategy signals are all fairly highly correlated and the results are quite similar for all of the others.

profitability of the strategy, thanks to low turnover and also the low costs associated with futures trading.

6. Conclusion

This paper outlines a set of basic dynamic commodity futures strategies and compares their performance to that of long only indices. This issue is of considerable current interest given the disappointing recent performance of long only indices and recent analysis suggesting that the strategic role of commodity futures is weaker than once thought. These dynamic strategies, which are both long flat and short flat, are motivated by the Generalized Hedging Pressure hypothesis which suggests that investors should take on long commodity futures positions during periods of backwardation and short in times of contango.

We find that at least one of these dynamic strategies outperforms the long only for 9 out of 12 commodities over the 2002-2009 period, most of which was a bull period for commodities. An equally weighted portfolio of our dynamic strategies outperforms the GSCI and equally weighted commodity indices. In particular, these portfolios have low draw downs, offering greater downside protection than long only indices.

Our analysis also leads to measures of “aggregate backwardation”, which may be regarded as a measure of systematic backwardation. This notion is of increasing importance since the “financialization” of commodity markets, that is the entry of various financial institutions into the commodity futures market. We construct a variable that measures this aggregate backwardation and find that it can be used to successfully time the GSCI and is also linked to the momentum effect in commodity futures market.

We find that our dynamic strategies provide diversification benefits where long only indices fail to provide these, and also have the potential to improve strategic asset allocation. Overall our analysis points to the importance of dynamic strategies to capture the benefits of commodity investing, in particular the importance of capturing backwardation.

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	Mean	Sharpe	Max DD
Copper	24.25%	0.78	67.50%
Corn	13.38%	0.42	59.19%
Crude	24.08%	0.58	76.69%
Gold	19.51%	0.98	28.14%
Live Cattle	3.83%	0.20	26.83%
Natural Gas	24.43%	0.42	75.72%
Silver	22.30%	0.68	55.00%
Soybeans	19.40%	0.67	52.65%
Soybean M	14.91%	0.44	56.25%
Soy Oil	15.67%	0.58	58.11%
Sugar	22.98%	0.40	71.01%
Wheat	13.47%	0.40	60.09%
EW	18.18%	1.02	48.10%

Table 1: This table provides the performance of the buy and hold futures strategies over the 2002-2009 period. The mean, Sharpe ratio and maximum drawdown (Max DD) are all annualized. EW is the return on an equally weighted portfolio of the buy and hold strategies for each commodity.

Strategy	CHP	RR	Opt
Copper	78.00%	46.00%	75.00%
Corn	43.00%	47.00%	35.00%
Crude	59.00%	51.00%	65.00%
Gold	39.00%	47.00%	20.00%
Cattle	57.00%	40.00%	30.00%
Nat Gas	79.00%	42.00%	45.00%
Silver	95.00%	38.00%	40.00%
Soybean	68.00%	53.00%	60.00%
Soy Meal	81.00%	56.00%	30.00%
Soy Oil	69.00%	43.00%	20.00%
Sugar	69.00%	42.00%	45.00%
Wheat	80.00%	42.00%	20.00%

Table 2: This table provides the in-sample percentile levels for each of the twelve individual commodities, for the three basic long flat strategies described in Section 2.2. The CHP levels refer to the percentile levels based on the level of backwardation implied from the hedging pressure data, the RR levels are based on the level of backwardation implied by the futures data while the Opt levels are based on in-sample optimization. The in-sample period is 1994-2001.

	2004	2005	2006	2007	2008	2009
Copper	89.68%	97.42%	79.35%	44.14%	27.10%	20.65%
Corn	54.19%	35.48%	47.74%	67.59%	92.26%	80.00%
Crude	71.61%	65.16%	65.16%	66.21%	73.55%	83.87%
Gold	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Cattle	90.32%	80.65%	52.90%	33.79%	25.81%	23.87%
Nat Gas	74.19%	78.71%	83.23%	73.79%	45.16%	16.77%
Silver	100.00%	95.00%	99.00%	100.00%	100.00%	100.00%
Soybeans	81.29%	58.06%	33.55%	51.72%	70.32%	94.84%
Soy Meal	90.97%	83.87%	63.87%	76.55%	80.65%	100.00%
Sugar	72.26%	76.77%	89.03%	79.31%	85.81%	85.81%
Wheat	61.29%	41.94%	16.13%	6.21%	10.32%	10.32%

Table 3: This table provides the percentile levels based on the previous three years for each of the twelve individual commodities, for the CHP Long Flat strategy described in Section 2.2. These percentile levels are based on the level of backwardation implied from the hedging pressure data.

	2004	2005	2006	2007	2008	2009
Copper	55.13%	60.26%	58.97%	63.45%	47.74%	52.26%
Corn	50.64%	48.08%	51.92%	61.38%	58.06%	56.77%
Crude	57.69%	55.77%	56.41%	62.07%	53.55%	59.35%
Gold	55.77%	58.33%	62.82%	71.72%	60.00%	62.58%
Cattle	53.85%	52.56%	50.00%	52.41%	45.81%	49.03%
Nat Gas	48.72%	48.08%	45.51%	51.03%	45.16%	52.26%
Silver	58.33%	58.33%	62.18%	67.59%	59.35%	60.65%
Soybeans	53.85%	51.28%	47.44%	60.69%	54.84%	60.00%
Soy Meal	53.21%	53.21%	48.08%	57.93%	53.55%	61.29%
Sugar	51.92%	46.15%	48.08%	57.93%	53.55%	55.48%
Wheat	49.36%	55.77%	58.33%	55.86%	40.65%	47.74%

Table 4: This table provides the percentile levels based on the previous three years for each of the twelve individual commodities, for the RR Long Flat strategy described in Section 2.2. These percentile levels are based on the level of backwardation implied from the futures price data.

	Mean	Sharpe	Max DD	Corr LO	% Invested	SF Mean	Sharpe	Max DD	Corr LO
Copper	19.76%	0.97	21.59%	0.65	65.30%	-2.98%	-0.13	62.33%	-0.76
Corn	10.26%	0.45	38.78%	0.71	48.43%	-2.26%	-0.10	39.95%	-0.70
Crude	26.72%	0.87	27.11%	0.75	61.20%	1.56%	0.06	38.92%	-0.66
Gold	9.28%	0.77	23.91%	0.61	46.51%	-10.17%	-0.65	32.71%	-0.79
Live Cattle	5.93%	0.48	20.82%	0.66	49.88%	2.09%	0.15	22.03%	-0.75
Natural Gas	27.69%	0.57	58.74%	0.83	66.51%	4.84%	0.15	43.38%	-0.56
Silver	22.84%	0.70	53.35%	0.99	95.42%	-0.68%	-0.16	6.75%	-0.13
Soybeans	15.90%	0.70	40.68%	0.78	60.48%	-2.39%	-0.13	33.78%	-0.63
Soybean M	5.35%	0.18	53.82%	0.88	74.46%	-8.76%	-0.54	39.08%	-0.47
Soy Oil	6.63%	0.39	25.40%	0.62	59.52%	-7.98%	-0.38	41.93%	-0.78
Sugar	27.04%	0.50	69.00%	0.94	64.82%	4.81%	0.25	22.83%	-0.34
Wheat	2.32%	0.08	61.64%	0.89	75.18%	-10.04%	-0.65	35.34%	-0.46
EW	14.98%	1.23	20.02%	0.87	99.28%	-2.66%	-0.28	21.44%	-0.77

Table 5: This table shows the out of sample performance of the CHP Long Flat and Short Flat strategies based on percentile levels given by the percentage of time hedging pressure signaled backwardation during the in-sample period, in the first five columns, and that of the corresponding Short Flat strategy in the last four columns. The Long Flat and Short Flat strategies are described in Section 2.2. The means and Sharpe ratios are annualized and Max DD refers to the annualized maximum drawdown. Corr LO is the correlation of the dynamic strategy with the buy and hold futures strategy while % Invested provides the percentage of time the Long Flat strategy for each commodity was invested over the 2002-2009 period. EW is the return on an equally weighted portfolio of the dynamic strategies for each commodity and % Invested for EW shows the percentage of time the strategy invested in at least one commodity contract. The in-sample period is 1994-2001.

	Mean	Sharpe	Max DD	Corr LO	% Invested	SF Mean	Sharpe	Max DD	Corr LO
pper	10.02%	0.57	23.06%	0.56	46.99%	-12.72%	-0.49	67.55%	-0.83
rn	11.31%	0.49	38.78%	0.72	51.33%	-1.83%	-0.08	39.95%	-0.69
ude	22.05%	0.78	26.98%	0.69	52.77%	-3.11%	-0.10	39.42%	-0.72
ld	9.49%	0.74	19.07%	0.65	52.77%	-9.97%	-0.66	26.06%	-0.76
e Cattle	4.67%	0.42	20.82%	0.59	38.55%	0.84%	0.05	26.66%	-0.81
tural Gas	33.10%	0.85	36.70%	0.67	37.11%	8.67%	0.20	53.34%	-0.75
ver	4.74%	0.23	33.14%	0.63	38.31%	-18.12%	-0.71	43.31%	-0.78
ybeans	12.00%	0.61	37.41%	0.67	49.64%	-6.64%	-0.31	41.90%	-0.74
ybean M	3.17%	0.12	40.39%	0.75	52.29%	-11.48%	-0.52	49.35%	-0.66
y Oil	-2.72%	-0.20	28.50%	0.49	38.07%	-17.33%	-0.74	54.69%	-0.87
gar	8.71%	0.38	49.86%	0.39	42.41%	13.71%	0.26	119.97%	-0.92
heat	-0.76%	-0.04	34.91%	0.66	41.20%	12.97%	0.52	48.72%	-0.75
/	9.65%	1.08	11.63%	0.72	95.18%	-3.75%	-0.33	25.82%	-0.87

Table 6: This table shows the out of sample performance of the RR Long Flat and Short Flat strategies based on percentile levels given by the percentage of positive futures returns (RR) over the in-sample period, in the first five columns, and that of the corresponding Short Flat strategy in the last four columns. The Long Flat and Short Flat strategies are described in Section 2.2. The means and Sharpe ratios are annualized and Max DD refers to the annualized maximum drawdown. Corr LO is the correlation of the dynamic strategy with the buy and hold futures strategy while % Invested provides the percentage of time the Long Flat strategy for each commodity was invested over the 2002-2009 period. EW is the return on an equally weighted portfolio of the dynamic strategies for each commodity and % Invested for EW shows the percentage of time the strategy invested in at least one commodity contract. The in-sample period is 1994-2001.

	Mean	Sharpe	Max DD	Corr LO	% Invested	SF	Mean	Sharpe	Max DD	Corr LO
pper	21.88%	1.06	21.59%	0.66	66.99%		-0.86%	-0.04	61.70%	-0.75
rn	8.65%	0.39	35.36%	0.68	46.51%		-4.36%	-0.19	44.10%	-0.73
ude	24.50%	0.77	30.60%	0.78	67.23%		7.26%	0.38	33.35%	-0.46
ld	4.29%	0.49	11.95%	0.45	27.95%		-15.30%	-0.86	33.36%	-0.89
e Cattle	3.45%	0.45	8.91%	0.41	22.89%		-0.96%	-0.05	29.38%	-0.93
tural Gas	28.61%	0.72	39.20%	0.68	40.00%		3.84%	0.11	49.33%	-0.63
ver	4.40%	0.21	33.14%	0.63	39.28%		-9.81%	-0.58	31.07%	-0.51
ybeans	12.10%	0.59	38.96%	0.71	54.46%		-6.01%	-0.29	44.41%	-0.71
ybean M	6.11%	0.30	34.91%	0.61	31.81%		-7.83%	-0.29	41.42%	-0.79
y Oil	0.12%	0.01	22.25%	0.35	20.96%		-15.70%	-0.66	56.41%	-0.88
gar	5.38%	0.20	45.18%	0.46	44.58%		-16.84%	-0.33	119.97%	-0.89
heat	-4.64%	-0.25	32.82%	0.55	29.64%		-16.99%	-0.61	54.51%	-0.84
/	9.57%	1.10	11.53%	0.72	97.34%		-6.96%	-0.59	26.26%	-0.84

Table 7: This table shows the performance of the dynamic Long Flat and Short Flat strategies based on the optimal percentile levels over the in-sample period in the first five columns, and that of the corresponding Short Flat strategy in the last four columns. The Long Flat and Short Flat strategies are described in Section 2.2. The means and Sharpe ratios are annualized and Max DD refers to the annualized maximum drawdown. Corr LO is the correlation of the dynamic strategy with the buy and hold futures strategy while % Invested provides the percentage of time the Long Flat strategy for each commodity was invested over the 2002-2009 period. EW is the return on an equally weighted portfolio of the dynamic strategies for each commodity and % Invested for EW shows the percentage of time the strategy invested in at least one commodity contract. The in-sample period is 1994-2001.

	Mean	Sharpe	Max DD	Corr LO	% Invested	SF Mean	Sharpe	Max DD	Corr LO
Copper	23.14%	1.12	49.55%	0.67	61.10%	-1.92%	-0.08	47.19%	0.05
Corn	5.37%	0.22	49.67%	0.74	57.52%	-9.12%	-0.42	40.09%	0.07
Crude	20.46%	0.72	44.27%	0.74	65.39%	-4.36%	-0.17	43.38%	0.08
Gold	14.31%	0.79	24.80%	0.91	84.96%	-5.26%	-0.63	18.75%	0.07
Live Cattle	5.81%	0.42	33.66%	0.68	61.58%	1.38%	0.09	33.24%	0.05
Natural Gas	16.06%	0.36	72.34%	0.75	57.04%	-9.86%	-0.25	59.54%	-0.02
Silver	22.52%	0.69	40.35%	0.99	95.47%	-0.60%	-0.15	21.95%	-0.10
Soybeans	10.31%	0.45	38.55%	0.79	68.26%	-4.85%	-0.27	39.24%	-0.03
Soybean M	7.25%	0.23	53.16%	0.90	80.67%	-7.60%	-0.51	41.83%	0.01
Soy Oil	6.00%	0.30	35.33%	0.72	67.06%	-9.80%	-0.51	35.87%	0.00
Sugar	14.70%	0.46	59.90%	0.29	68.50%	-30.63%	-0.29	224.57%	0.17
Wheat	-0.25%	-0.01	54.76%	0.62	44.87%	-14.20%	-0.54	43.34%	0.07
EW	12.14%	1.01	22.04%	0.74	100.00%	-8.07%	-0.60	26.81%	0.10

Table 8: This table shows the out of sample performance of the CHP Rolling Long Flat and Short Flat strategies based on percentile levels given by the percentage of time hedging pressure signaled backwardation during the previous three years, in the first five columns, and that of the corresponding Short Flat strategy in the last four columns. The Long Flat and Short Flat strategies are described in Section 2.2. The means and Sharpe ratios are annualized and Max DD refers to the annualized maximum drawdown. Corr LO is the correlation of the dynamic strategy with the buy and hold futures strategy while % Invested provides the percentage of time the Long Flat strategy for each commodity was invested over the 2002-2009 period. EW is the return on an equally weighted portfolio of the dynamic strategies for each commodity and % Invested for EW shows the percentage of time the strategy invested in at least one commodity contract.

	Mean	Sharpe	Max DD	Corr LO	% Invested	SF Mean	Sharpe	Max DD	Corr LO
Copper	13.29%	0.77	48.28%	0.56	49.88%	-11.77%	-0.46	48.52%	-0.06
Corn	11.24%	0.49	50.85%	0.71	53.22%	-3.14%	-0.14	43.55%	0.06
Crude	14.03%	0.51	35.12%	0.71	58.95%	-10.06%	-0.38	42.44%	-0.04
Gold	12.11%	0.85	32.44%	0.71	59.43%	-7.35%	-0.52	18.84%	-0.06
Live Cattle	7.03%	0.61	30.03%	0.57	47.49%	2.46%	0.15	35.22%	-0.06
Natural Gas	16.14%	0.41	67.20%	0.67	42.24%	-11.93%	-0.28	61.37%	0.01
Silver	5.79%	0.24	39.78%	0.72	51.55%	-17.33%	-0.76	41.62%	-0.03
Soybeans	8.56%	0.44	35.51%	0.67	52.98%	-6.60%	-0.31	40.53%	0.02
Soybean M	9.38%	0.38	41.78%	0.71	49.64%	-5.50%	-0.22	48.03%	0.08
Soy Oil	3.58%	0.26	30.41%	0.50	41.77%	-11.72%	-0.50	40.66%	0.03
Sugar	8.14%	0.30	56.64%	0.24	50.60%	-37.18%	-0.35	218.14%	0.08
Wheat	8.35%	0.35	57.94%	0.70	46.78%	-5.60%	-0.23	40.83%	0.09
EW	9.80%	0.98	19.94%	0.63	96.90%	-10.48%	-0.66	28.92%	0.06

Table 9: This table shows the out of sample performance of the RR Rolling Long Flat and Short Flat strategies based on percentile levels given by the percentage of time futures returns were positive over the previous three years, in the first five columns, and that of the corresponding Short Flat strategy in the last four columns. The Long Flat and Short Flat strategies are described in Section 2.2. The means and Sharpe ratios are annualized and Max DD refers to the annualized maximum drawdown. Corr LO is the correlation of the dynamic strategy with the buy and hold futures strategy while % Invested provides the percentage of time the Long Flat strategy for each commodity was invested over the 2002-2009 period. EW is the return on an equally weighted portfolio of the dynamic strategies for each commodity. The in-sample period is 1994-2001.

CHP	Mean	SDev	Sharpe	CCI SR	GSCI SR	% Invested
2002	21.17%	8.60%	2.46	1	1	78.69%
2003	16.31%	13.10%	1.25	1	1	60.58%
2004	10.00%	10.85%	0.92	0	1	50.00%
2005	9.17%	11.22%	0.82	0	0	56.92%
2006	19.00%	11.81%	1.61	1	1	54.65%
2007	26.10%	9.95%	2.62	1	1	62.82%
2008	-0.68%	15.20%	-0.04	1	1	45.99%
2009	18.83%	15.49%	1.22	0	1	73.56%
	14.99%	12.14%	1.23	1	1	60.40%

Table 10: This table provides the absolute year by year performance of the equally weighted portfolio of the individual dynamic CHP Long Flat strategies described in Section 2.2, for the out of sample period (2002-2009). A 1 in the CCI SR column indicates that the Sharpe ratio of the dynamic strategy was higher than that of the CCI and a 0 indicates it was lower. The GSCI SR column replaces the CCI with the GSCI. The % Invested column shows the average of the percentage of time each individual strategy was invested per year, across the 12 commodities. The final row provides the average across the out of sample period. The mean, standard deviation and Sharpe ratios are annualized. The CCI and GSCI are discussed in Section 2.1.

Rel Per	Beta CCI	Alpha CCI	IR CCI	Beta GSCI	Alpha GSCI	IR GSCI
2002	0.75	4.96%	0.95	0.27	12.62%	1.92
2003	0.41	12.90%	1.04	0.13	13.86%	1.10
2004	0.59	3.26%	0.40	0.19	5.90%	0.61
2005	0.72	-5.42%	-0.81	0.29	2.56%	0.29
2006	0.73	9.08%	1.56	0.39	24.55%	2.97
2007	0.78	11.16%	2.06	0.29	17.40%	2.02
2008	0.39	9.60%	0.92	0.21	12.73%	1.03
2009	0.03	17.94%	1.16	-0.08	20.45%	1.34
	0.56	7.93%	0.93	0.26	13.76%	1.39

Table 11: This table provides the relative year by year performance of the equally weighted portfolio of the individual dynamic CHP Long Flat strategies described in Section 2.2, for the out of sample period (2002-2009). The final row provides the average across the out of sample period. The alphas and the information ratios (IR) are annualized. The CCI and GSCI are discussed in Section 2.1.

Max Theo SR	CHP	RR	Opt	CHP Roll	RR Roll
Copper	1.13	1.11	1.14	0.95	0.81
Corn	0.70	0.67	0.64	0.48	0.58
Crude	1.19	1.16	1.28	0.67	0.62
Gold	1.12	1.12	1.11	1.03	0.96
Live Cattle	0.35	0.23	0.51	0.37	0.56
Natural Gas	1.50	1.70	1.69	0.44	0.61
Silver	1.23	1.23	1.12	0.69	0.76
Soybeans	1.03	0.98	1.07	0.52	0.54
Soybean M	0.54	0.79	0.64	0.55	0.61
Soy Oil	0.71	0.61	0.58	0.67	0.77
Sugar	0.58	0.65	0.62	0.52	0.48
Wheat	0.78	0.65	0.41	0.53	0.46
EW	1.72	1.64	1.60	1.04	1.05

Table 12: This table provides the annualized theoretical maximum in-sample Sharpe ratio for each individual commodity as well as the equally weighted portfolio of the twelve commodities, via the optimal use of return predictability as described in Section 2.3. The five strategies are described in Section 2.2 and the sample period is 2002-2009.

	1994-2001	2002-2009
Returns	7.07E-05	2.14E-04
CHP GSCI	0.04	0.18
RR GSCI	0.03	0.17
Opt GSCI	0.10	0.18
CHP Rl GSCI	0.05	0.11
RR Rl GSCI	0.04	0.09

Table 13: This first row of this table shows the average covariance between the 12 commodities over the 1994-2001 period and the 2002-2009 period. The second to sixthe rows show the correlation between the returns on the GSCI and the lagged backwardation index described in Section 2.2 for five different Long Flat strategies, over the 1994-2001 period and the 2002-2009 period. The five strategies are the CHP, RR, Opt, CHP Rolling, RR Rolling all of which are described in Section 2.2.

	Median	Mean	Sharpe	Beta	Alpha	% Long
GSCI		8.55%	0.32	1	0.00%	100.00%
CHP	7	29.12%	1.09	-0.07	29.72%	66.11%
RR	5	34.86%	1.31	-0.02	35.03%	70.67%
Opt	4	35.04%	1.32	0.03	34.75%	73.32%
CHP Roll	8	11.22%	0.42	-0.04	11.54%	66.59%
RR Roll	6	10.83%	0.40	-0.08	11.53%	61.78%

Table 14: This table shows the performance of the various GSCI long-short timing strategies described in Section 4.2 over the 2002-2009 period. The strategy goes long if the predictor variable, described in Section 2.2 is greater than or equal to the median shown in the first column, for each of the five strategies. The % Long shows the proportion of the time each strategy was long over the 2002-2009 period. The mean, Sharpe ratio and alpha are all annualized.

Ind Tim GSCI

Opt	Mean	SDev	Sharpe	GSCI Cmp	Beta	Alpha	% Long
2002	27.90%	20.43%	1.37	0	0.97	-2.72%	98.08%
2003	57.43%	25.68%	2.24	1	-0.08	59.01%	67.31%
2004	21.63%	25.12%	0.86	1	-0.34	28.91%	48.08%
2005	7.41%	24.06%	0.31	0	0.42	-2.09%	63.46%
2006	-7.77%	22.36%	-0.35	1	0.42	-1.90%	73.08%
2007	32.07%	16.16%	1.98	1	0.93	4.41%	96.15%
2008	102.86%	41.89%	2.46	1	-0.45	74.73%	59.62%
2009	38.78%	28.03%	1.38	1	0.25	33.76%	80.77%
	35.04%	26.56%	1.32	1	0.03	34.75%	73.32%

Table 15: This table shows the year by year performance of the Opt GSCI long-short timing strategies described in Section 4.2 over the 2002-2009 period. The strategy goes long if its predictor variable, described in Section 2.2 is greater than or equal to the median shown in the first column of Table 13. A 1 in the GSCI Cmp column indicates that the Sharpe ratio of the strategy exceeded that of the GSCI while a 0 indicates it was less. The % Long shows the proportion of the time the strategy was long each year over the 2002-2009 period. The last show provides the performance over the entire 2002-2009 period. The mean, Sharpe ratio and alpha are all annualized.

	Win Mean	Sharpe	Los Mean	Sharpe
2002	28.14%	1.86	24.10%	1.89
2003	15.45%	0.93	11.35%	0.57
2004	1.91%	0.09	47.68%	0.92
2005	36.59%	1.86	19.15%	1.28
2006	27.30%	1.25	4.87%	0.25
2007	46.31%	3.00	30.64%	2.35
2008	-27.89%	-0.81	-8.09%	-0.22
2009	34.50%	1.68	23.84%	0.97
	20.29%	0.94	19.19%	0.71

Table 16: This table shows the year by year performance of the winner and loser strategies based on the twelve commodities, described in Section 2.1. The last show shows the overall mean and Sharpe ratios over the 2002-2009 period. The means and Sharpe ratios are annualized.

	Win Mean	Sharpe	Los Mean	Sharpe
2002	24.47%	1.60	25.00%	1.97
2003	15.38%	0.93	0.77%	0.04
2004	3.29%	0.15	56.43%	1.10
2005	-9.60%	-0.47	13.55%	0.90
2006	26.91%	1.23	12.43%	0.63
2007	47.38%	3.08	31.94%	2.46
2008	32.65%	0.95	55.96%	1.59
2009	35.72%	1.74	51.88%	2.18
	22.03%	1.02	31.00%	1.15

Table 17: This table shows the year by year performance of the long short timed winner and loser described in Section 2.1. The strategy goes long or shorts the winner (loser) when the timing indicator is the Opt Backwardation index, described in Section 2.2, is greater than or equal to its median over 1994-2001. The last show shows the overall mean and Sharpe ratios over the 2002-2009 period. The details of the strategy are in Section 4.3 and the means and Sharpe ratios are annualized.

	Win Mean	Sharpe	Los Mean	Sharpe
2002	26.31%	1.74	24.55%	1.93
2003	15.41%	1.45	6.06%	0.32
2004	2.60%	0.18	52.05%	1.04
2005	13.49%	0.83	16.35%	1.29
2006	27.11%	1.41	8.65%	0.50
2007	46.84%	3.05	31.29%	2.41
2008	2.38%	0.10	23.93%	1.54
2009	35.11%	1.75	37.86%	1.73
	21.16%	1.24	25.09%	1.08

Table 18: This table shows the year by year performance of the long flat timed winner and loser described in Section 2.1. The strategy goes long the winner (loser) when the timing indicator is the Opt Backwardation index, described in Section 2.2, is greater than or equal to its median over 1994-2001, and is flat otherwise. The last show shows the overall mean and Sharpe ratios over the 2002-2009 period. The details of the strategy are in Section 4.3 and the means and Sharpe ratios are annualized.

Long Flat	EW	CHP	RR	Opt	CHP Rll	RR Rll
SP 2002-05	0.08	0.12	0.12	0.10	0.11	-0.06
SP 2006-09	0.35	0.18	0.11	0.12	0.16	0.06
Bd 2002-05	0.01	-0.06	-0.02	-0.06	-0.03	-0.05
Bd 2006-09	-0.06	-0.12	-0.13	-0.14	-0.04	-0.03
EW2002-05	0.08	0.11	0.12	0.09	0.11	-0.08
EW2006-09	0.34	0.16	0.09	0.10	0.16	0.06
TIPS 03-05	-0.04	-0.08	-0.05	-0.07	-0.06	-0.04
TIPS 06-09	-0.03	0.02	0.01	0.01	0.01	-0.08

Table 19: This table shows the correlations between the returns on the equally weighted portfolios for the buy and hold and five long flat strategies (CHP, RR, Opt, CHP Rolling and RR Rolling) described in Section 2.2, and those of the S&P 500 index (SP), the Lehman Brothers Bond Index (Bd), a 50% -50% weighted portfolio of the S&P and the Bond Index (EW) and the TIPS. The correlations are over the 2002-2005 and then over the 2006-2009 period except for TIPS for which they are over the 2003-2005 and 2006-2009 period.

Long Flat	GSCI	CHP	RR	Opt	CHP Rll	RR Rll
SP 2002-05	-0.09	0.13	0.13	0.16	0.09	0.10
SP 2006-09	0.38	-0.24	-0.27	-0.25	-0.32	-0.34
Bd 2002-05	0.06	-0.04	-0.05	-0.06	0.04	-0.01
Bd 2006-09	-0.08	0.01	0.03	0.03	-0.02	0.02
EW2002-05	-0.08	0.13	0.13	0.16	0.11	0.11
EW2006-09	0.37	-0.24	-0.26	-0.24	-0.32	-0.33
TIPS 03-05	-0.01	-0.12	-0.14	-0.06	-0.02	-0.12
TIPS 06-09	-0.09	-0.19	-0.08	-0.05	-0.12	-0.12

Table 20: This table shows the correlations between the returns on the equally weighted portfolios for the buy and hold and five index timing long short strategies (CHP, RR, Opt, CHP Rolling and RR Rolling) described in Section 4.2, and those of the S&P 500 index (SP), the Lehman Brothers Bond Index (Bd), a 50% -50% weighted portfolio of the S&P and the Bond Index (EW) and the TIPS. The correlations are over the 2002-2005 and then over the 2006-2009 period except for TIPS for which they are over the 2003-2005 and 2006-2009 period.

	EW SB	EW	CHP	RR	Opt	CHP Rl	RR Rl
Mean	4.06%	9.12%	8.16%	6.17%	6.10%	6.84%	6.07%
SD	11.79%	11.14%	9.28%	8.52%	8.46%	9.21%	8.40%
Sharpe	0.09	0.55	0.56	0.37	0.37	0.42	0.36
Skewness	-0.74	-1.06	-0.44	-0.49	-0.54	-0.71	-0.62
Drawdown	34.34%	33.43%	26.00%	23.49%	23.96%	25.68%	25.09%

Table 21: This table shows the effects of adding the equally weighted buy and hold commodity portfolio to the S&P 500 and a bond index and then the various dynamic Long Flat portfolios. The EW SB portfolio is a portfolio of the S&P and a bond index with weights of 63% and 37% respectively. The weights on the stock index, bond index and commodity strategy (EW) are 40%, 24% and 36% respectively, and more details about this are in Section 5.2. The five Long Flat strategies (CHP, RR, Opt, CHP Rolling and RR Rolling) described in Section 2.2, and the mean, standard deviation and Sharpe ratio are all annualized.

	EW SB	EW	CHP	RR	Opt	CHP Rl	RR Rl
Mean	4.06%	5.66%	13.14%	15.16%	15.08%	6.71%	6.49%
SD	11.79%	13.55%	11.53%	11.40%	11.54%	11.18%	11.14%
Sharpe	0.14	0.20	0.88	1.07	1.05	0.33	0.31
Skewness	-0.74	-1.01	0.25	0.34	0.32	0.44	0.47
Drawdown	34.34%	47.07%	11.70%	12.76%	9.72%	16.15%	16.27%

Table 22: This table shows the effects of adding the GSCI to the S&P 500 and a bond index and then the various dynamic Long Short index timing portfolios. The EW SB portfolio is a portfolio of the S&P and a bond index with weights of 63% and 37% respectively. The weights on the stock index, bond index and commodity strategy (EW) are 40%, 24% and 36% respectively, and more details about this are in Section 5.2. The five long short GSCI timing strategies (CHP, RR, Opt, CHP Rolling and RR Rolling) are described in Section 4.2, and the mean, standard deviation and Sharpe ratio are all annualized.

	CHP Mean	CHP Costs	Autocorr
Copper	19.76%	0.10%	100.00%
Corn	10.26%	0.14%	87.49%
Crude	26.72%	0.17%	82.99%
Gold	9.28%	0.14%	77.48%
Live Cattle	5.93%	0.13%	80.72%
Natural Gas	27.69%	0.21%	74.92%
Silver	22.84%	0.18%	74.52%
Soybeans	15.90%	0.18%	78.27%
Soybean M	5.35%	0.14%	77.66%
Soy Oil	6.63%	0.16%	80.92%
Sugar	27.04%	0.13%	72.89%
Wheat	2.32%	0.21%	85.00%
EW	14.98%	0.16%	
GSCI	29.12%	0.70%	71.41%

Table 23: This table shows the annualized mean and annualized average transaction costs over the 2002-2009 period for the CHP individual Long Flat strategies, the equally weighted portfolio of the individual strategies and the CHP GSCI timing strategies. Details of the estimation of transaction costs is given in Section 5.3 while the individual CHP Long Flat strategies are described in Section 2.4 and the GSCI timing strategy in Section 4.2. The third column shows the autocorrelation of the weights for the various strategy weights over the 2002-2009 period.