The Impact of Financialization on the Benefits of Incorporating Commodity Futures in Actively Managed Portfolios

Ramesh Kumar Adhikari
Department of Economics & Finance
University of New Orleans
New Orleans, LA 70148
Cell: 504-223-4035
Fax: 504-280-6397
Email: rkadhik1@uno.edu

Kyle James Putnam
Department of Economics & Finance
University of New Orleans
New Orleans, LA 70148
Cell: 503-708-4176
Fax: 504-280-6397
Email: kjputna1@uno.edu

Neal Maroney, Ph.D.
Department of Economics & Finance
University of New Orleans
New Orleans, LA 70148
Cell: 504-914-5270
Fax: 504-280-6397
Email: nmaroney@uno.edu

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Ramesh Adhikari[*a], Kyle Putnam[a], and Neal Maroney[a]

Abstract

This paper examines the return performance and diversification benefits of both buy-and-hold and tactical portfolios of commodity futures. We fuse together both of these highly desired investment benefits of the unique asset class to provide a thorough analysis of the commodities market given the changes it has undergone over the last decade due to the rapid increase in investor participation. We find that tactical portfolios based on basis and net speculation offer the highest potential returns. However, in the post-2000 era, the risk-adjusted returns of many of the commodity portfolio examined are insignificant. Furthermore, we find the diversification properties of these commodity portfolios have largely broken down for investors of traditional buy-and-hold benchmark portfolios, and to a lesser extent actively managed equity-based benchmark portfolios, since the early 2000's. This breakdown has been much less severe for the international buy-and-hold portfolios when compared to the US domestic buy-and-hold counterpart.

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[*] Correspondent Author

[a] Department of Economics and Finance, University of New Orleans

1. Introduction

Recent studies, such as Irwin and Sanders (2011), Singleton (2013), Tang and Xiong (2012), Silvennoinen and Thorp (2013), and Henderson et al. (2012) examine different aspects of the "financialization" of the commodity futures market—that is, how increased participation via large flows from speculators and other market participants have impacted the price dynamics of investing in commodity futures. In general, these and related papers find higher correlations among individual commodity futures returns as well as between commodity futures returns and more traditional asset returns, in particular equities. Given that the highly touted diversification benefits (see Gorton and Rouwenhorst, 2006; Buyuksahin et al., 2010; Conover et al., 2010; Jensen et al., 2000) from investing in commodity futures stem from their low (and even negative) correlation with the equity markets, these recent findings have largely called into question the benefits of commodity-related investment.

A few contemporary papers examine the diversification properties of commodities. Daskalaki and Skiadopoulos (2011) employ the DJ-UBS commodity index and a small series of individual futures contracts and explore whether an investor is made better off by including commodities in a portfolio of traditional assets. Using mean-variance and non-mean-variance spanning tests, they find that the out-of-sample diversification performance of commodity futures is non-beneficial to all types of investors. In a similar vein of research, Belousova and Dorfleitner (2012) implement spanning tests to investigate the diversification contribution of individual commodity futures to a portfolio of traditional assets from the perspective of a euro investor. They find that the diversification contribution of individual commodities varies greatly (among the different sectors), particularly during bull and bear markets, but that commodities, overall, are valuable diversification tools. These recent studies provide an interesting analysis of commodity futures as diversification tools; however, they do not explicitly examine how the diversification properties of commodities have evolved over the last decade and a half in the face of an era characterized by a substantial increase in investor participation in the commodity futures market. Additionally, no recent work (to the best of our knowledge) has contemporaneously evaluated the potential return benefits of commodities given the changing market landscape. Prior work has largely found the average annualized excess return of an individual commodity future to be roughly zero, but the annualized excess return of a tactical portfolio of commodity futures can be "equity-like" (see Gorton and Rouwenhorst, 2006; Erb and Harvey, 2006). Studies by Miffre and Rallis (2007) and Asness et al. (2013) document highly significant positive returns for different rank and holding periods of up to 12 months (i.e. momentum profits).[1] Moreover, DeGroot et al. (2014) and Fuertes et al. (2010) propose novel tactical strategies which incorporate term structure information (in addition to momentum strategies in some cases) to reap large returns.[2] Since tactical commodity investment seems to offer the greatest return potential, an analysis of the return performance of different types of commodity portfolios which appraises the return benefits, how they have changed over time, and how they subsequently perform as diversification tools in an investor's overall portfolio is of significant importance to practitioners and academicians alike.

In this paper, we fuse together an analysis of both the return performance and diversification properties of commodity futures to provide a broad examination of the highly popular asset class. We ask several specific questions: first, can we exploit new information regarding commodity futures contracts to obtain "equity-like" returns, and if so, what is the

[1] In particular, Asness et al. (2013) report returns of 0.7% for low return momentum portfolios and 13.1% for high return momentum portfolios. Miffre and Rallis (2007) identify 13 profitable momentum strategies in the commodity futures markets which generate an average return of 9.38% per year by tactically allocating wealth towards the best performing commodities and away from the worst performing ones.

[2] Fuertes et al. (2010) report annualized alphas of 10.14% and 12.66% for momentum and term structure strategies individually. However, a double-sort strategy which exploits both components generates a return of approximately 21.02%.

optimal investment strategy (i.e. what type of commodity portfolios perform best)? Furthermore, how have the returns of these new strategic portfolios and other commodity portfolios examined evolved over the last decade given the financialization of the commodities market? Second, given the demand for commodity futures not only as profitable return strategies but as overall portfolio diversifiers, how have the various commodity portfolios which we utilize performed as diversification tools for investors? Moreover, how have the diversification benefits of the commodity portfolios fared during the most recent US economic recession periods? Third, and finally, in what type of overall investor portfolio setting (i.e. buy-and-hold or actively managed) do commodity futures provide an adequate form of diversification?

In order to address the first question, we compare the annualized return performance and annualized risk-adjusted return performance of six traditional buy-and-hold portfolios and 27 tactical portfolios over the whole sample period (January 1986 to October 2013) and two sub-sample periods (January 1986 to December 2000 and January 2001 to October 2013).[3] The sub-sample analysis affords us the ability to more accurately evaluate the evolution of the diversification benefits of commodity futures given the financialization of the commodities market. To a lesser extent, the sub-samples allow us to observe any changes in potential return benefits from the various commodity portfolio strategies employed. Specifically, we utilize a sample of 29 commodity futures to construct five buy-and-hold sector-based portfolios (e.g. foods and fibers, grains and oilseeds, livestock, energy, and precious metals) as well as one equally-weighted portfolio which encompasses all of the aforementioned sectors. These buy-and-hold portfolios serve as a benchmark in which to compare our other strategies against. In an effort to dig deeper into the potential tactical opportunities of commodity futures we exploit

[3] The literature on commodity futures lacks a complete consensus on when the financialization period began; however, there is a general agreement that it occurred in the early 2000's. Given this, we analyze individual trading volumes of commodity futures and find January 2001 to be a reasonable estimate in which to split the full sample.

information based on basis, net speculation, and mathematical optimization to create nine commodity portfolios.

We follow prior empirical work which relates the concepts of basis and net speculation of commodity futures to their return properties and attempt to capitalize on this information content by analyzing portfolios formed on this information. The basis portfolios are utilized based on the findings of Gorton et al. (2013), who state that portfolios of commodity futures that take positions based on prior futures return, prior spot returns, and the futures basis with below average inventories are expected to earn higher risk premiums—consistent with the predictions of the Theory of Storage. Hence, basis portfolios contain a common source of risk which is orthogonal to variation in inventories and is compensated for in average returns. In a similar vein, the net speculation portfolios follow from the idea that producers and consumers of an underlying commodity transfer price fluctuation risk to speculators who are willing to bear the risk (see DeRoon et al., 2000; Bessembinder, 1992). If the short hedger supply is greater than the demand by long hedgers the futures price today has to be a downward-biased estimate of the futures price at maturity (i.e. normal backwardation). On the other hand, if hedgers are net long, the futures price today has to exceed the futures price at maturity in order to induce speculators to take short positions (i.e. contango). Hence, if commodity returns directly relate to the hedgers demand, net speculation should provide a meaningful tactical strategy. As argued in DeRoon et al. (2000), since hedging pressure is constructed from positions that by definition arise from hedging demand, it is reasonable to assume the variable will proxy for aggregate nonmarketable risks. Contrastingly, the mathematical portfolios follow from the purely theoretical strand of finance literature (see Konno and Yamazaki, 1991; Markowitz, 1952; Rockafellar and Uryasev, 2000) which utilizes mathematical techniques to maximize the risk-return tradeoff at periodic intervals. Specifically, we analyze three portfolios based on Markowitz's (1952) mean-variance frontier, conditional value at risk, and mean absolute deviation.

Rounding out the sample of tactical portfolios, we also create nine portfolios based on return momentum and nine portfolios based on term structure. The momentum strategies, as outlined in Miffre and Rallis (2007), are not merely compensation for risk as the momentum returns are found to be related to the propensity of commodity futures markets to be in backwardation or in contango, suggesting that the momentum strategies buy backwardated contracts and sell contangoed contracts. Hence, momentum profits can be linked to the Theory of Normal Backwardation. More importantly, however, Miffre and Rallis suggest that momentum returns have low correlations with the returns of more traditional asset classes, making them good candidates for inclusion in well-diversified portfolios. Our analysis allows us to directly evaluate the momentum return strategies over a more recent time period which reflects the financialization of the commodities market, as well as examine the supposition that such tactical strategies perform well as portfolio diversifiers. In a similar manner, the term structure portfolios offer valuable information such as lower volatility and heterogeneous risk-return differences based on contract maturities.[4] In order to exploit these unique features we create several portfolios based on different contract horizons and examine their return (and subsequent diversification) characteristics.

Looking towards both our second and third questions, we combine our various buy-and-hold and tactical commodity futures portfolios with four different kinds of investor portfolios (i.e. benchmark portfolios) and evaluate the diversification characteristics of the benchmark(s) from systematically adding the various commodity portfolios to it. We utilize the stochastic discount factor (SDF) and mean-variance asset pricing spanning tests to examine the

[4] See DeGroot et al. (2014) for additional discussion of momentum and term structure portfolios.

diversification properties of the benchmark and commodity portfolios. While prior work only utilizes mean-variance spanning tests, which assume a normal return pattern, we supplement this methodological approach with SDF-based asset pricing tests which do not assume any return pattern. In this sense, the SDF approach is a more robust method which captures whether commodities provide diversification opportunities. We utilize two US domestic portfolios to examine the diversification characteristics of commodity futures in the US markets. The first benchmark is a buy-and-hold portfolio consisting of CRSP value-weighted market index returns, comprised of all NYSE/AMEX/NASDAQ stocks, and the Barclays Capital US Aggregate Bond Index returns.[5] The second benchmark is an actively managed equity portfolio based on the Fama-French monthly size and momentum factors. The other two benchmark portfolios we employ examine the diversification characteristics of commodity futures in an international context. In the international setting, the first benchmark employed is a buy-and-hold portfolio of seven countries' equity index-level returns (e.g. Australia, Canada, France, Germany, Japan, the UK, and the US) and the Barclays Capital US Aggregate Bond Index returns. The second international benchmark is an actively managed equity portfolio comprised of 23 countries' index-level returns (e.g. Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Switzerland, Sweden the UK, and the US) based on the Fama-French monthly size and momentum factors. Similar to the examination of portfolio returns, we evaluate the diversification results over the full and sub-sample periods for both the US domestic and international benchmark portfolios.

[5] The Barclays Capital US Aggregate Bond Index is a commonly used benchmark by both passive and active investors to measure the portfolio performance of the US dollar-denominated investment grade fixed-rate taxable bond market.

The main results of this paper can be summarized as follows. First, over the full and sub-sample periods the annualized return performance of the “High” (or recent winner) momentum portfolios of commodity futures generally outperform the “Med” and “Low” (or recent loser) momentum portfolios.[6] The exceptions are the portfolios based on a one month look-back and one month holding period. In the first sub-sample period, the High portfolio outperforms the Low portfolio, as is common with all other look-back and holding periods, but in the latter sub-sample pattern is reversed. Consequently, the overall sample period average returns are very similar for both the High and Low portfolios of 12.70% and 12.92%, respectively. These results largely align with the recent work of Miffre and Rallis (2007) and Asness et al. (2013) which document higher return performance for the High momentum groups. Interestingly, we find that the difference in average returns between the High and Low momentum portfolios becomes notably smaller in the latter sub-sample period as compared to the first. The return results of the term structure portfolios are somewhat more varied. Over the full sample period and first sub-sample period the Low portfolio based on the difference between the nearby and next-nearby futures contracts (LowTS12) provide the highest returns of 15.81% and 15.22%, respectively. However, over the latter sub-sample period this pattern changes as the High portfolio based on the difference between the nearby and next-next nearby futures contracts (HighTS13) now provides the largest average return of 18.98%. The portfolio HighTS14 provides a similar mean return of 18.70% over the same period.

Focusing on the tactical portfolios created by exploiting information based on net speculation shows that the High speculative portfolio generates the largest annualized average

[6] Miffre and Rallis (2007) form portfolios based on quintiles. Our approach, similar to that of Asness et al. (2013), utilizes tertiles. The use of three portfolios as opposed to five is based on the rationale of enhanced risk diversification; however, it comes at the cost of a lower dispersion of returns between the best and worst performing futures, and hence the potential profitability of the strategies.

return (14.26%) over the full sample period. Similar results are obtained over the initial sub-sample period, but the trend is substantially changed over the latter sub-sample period as the Low speculative portfolio produces a mean return of 18.38%, compared to the High portfolio return of 14.14%. The portfolios formed on basis produce a consistent finding in which the High basis portfolio consistently outperforms the other two portfolios, over all sample periods. In fact, the High basis portfolio produces the largest average return over the whole sample period (17.92%) and latter sub-sample period (22.51%) compared to all other styles of commodity portfolios. Conversely, the mathematical portfolio constructs perform significantly worse. Following the theoretical literature which utilizes mean-variance and conditional value-at-risk techniques to systematically update the "optimal" portfolio weights proves to be the lowest return strategy by a significant margin, regardless of the period examined. In analyzing the risk-adjusted return performance of the various commodity portfolios we interestingly see that once risk is adjusted for there is a noticeable reduction in the statistical significance of the alpha estimates for many of the commodity portfolios when comparing the two sub-sample periods. Given the well-documented increase in equity-commodity return correlations since the 2000's, the risk-adjusted performance of the results over the latter sub-period is consistent with the notion that an increase in return comovement has also been associated with an increase in risk with those returns, hence rendering many of the returns (i.e. alpha estimates) statistically insignificant in the era characterized by financialization.

Second, when buy-and hold and tactical commodity portfolios are combined with a portfolio of buy-and-hold US domestic equities and US aggregate bond index returns, the majority of buy-and-hold and actively rebalanced commodity futures portfolios offer no significant diversification benefits over the latter sub-sample period. However, when the same portfolios are analyzed over the former sub-sample period we document the opposite conclusion—that is, the majority of commodity portfolios provide significant diversification benefits for investors. These findings support the argument that the financialization of the commodities market, beginning around the early 2000's, has otherwise eroded the diversification benefits of commodity futures for traditional buy-and-hold investment portfolios through the increased comovement of equity-commodity returns. In a similar vein, when the same buy-and hold and tactical commodity portfolios are combined with the same portfolio of buy-and-hold US domestic equities and US aggregate bond index returns and evaluated over the most recent recession periods which have occurred over the last two decades, only one of the commodity portfolios (Allmom) considered offers any diversification benefits to investors.

Third, when buy-and hold and tactical commodity portfolios are combined with a portfolio of actively managed US domestic equities, based on the monthly Fama-French size and momentum factors, the vast majority of commodity portfolios provide significantly more diversification opportunities over all sample periods considered, though the diversification benefits are slightly weaker in the latter sub-sample period. Thus, for investors who are willing to take on the additional risk inherent in a frequently (i.e. monthly) rebalanced equity-based portfolio (versus a traditional buy-and-hold approach), commodities can provide substantial diversification benefits. Fourth, and finally, the use of international buy-and-hold and actively managed equity-based reference (benchmark) portfolios provides somewhat similar results to those of the US domestic analysis. The main difference in findings is that the combination of the international buy-and-hold benchmark portfolio with the various commodity portfolios provides substantially more diversification benefits for an investor than in the US case. Overall, evidence suggests that the diversification properties of various portfolios of commodity futures have largely broken down for investors of traditional buy-and-hold benchmark portfolios, and to a lesser extent actively managed equity-based benchmark portfolios, since the early 2000's. This breakdown has been much less severe for the international buy-and-hold portfolios when compared to the US domestic buy-and-hold counterpart. We posit that these empirical findings are due to the financialization of the commodity markets. In general, the best way to utilize commodity futures as high return investment strategies and diversification tools is in conjunction with an actively managed equity-based benchmark portfolio, whether it be a US domestic or international portfolio.

The remainder of this paper is organized as follows. Section 2 discusses our dataset and the creation of the commodity futures return series. Section 3 explains the construction of the various buy-and-hold and tactical commodity futures portfolios, and provides an analysis of the various portfolio returns. Section 4 discusses the methodology used to evaluate if adding portfolios of commodity futures to an investor's overall portfolio, whether that be a US domestic or international portfolio, provides any diversification benefits, as well as summarizes the empirical findings. Section 5 offers concluding remarks.

2. Data and commodity futures return construction

The futures prices of the 29 commodity futures used in this study are all obtained from the Commodity Research Bureau (CRB). We extract price series information from January 1, 1986 to October 31, 2013.[7] The breakdown of the commodities by sector is as follows: six are from foods and fibers, nine are from grains and oilseeds, four are from livestock, five are from energy, and five are from precious metals. Table 1 provides a detailed list of the individual commodity futures, their respective sectors, exchange, and start date of the prices.

[7] The sample period is selected based on data availability. This particular time frame allows for the most commodity futures to be used which possess continuous return and net speculation data.

[Insert Table 1 Here]

In order to construct the futures return series we follow the procedure outlined by Miffre and Rallis (2007) whereby, for each particular commodity, we roll the daily futures prices of the nearby contract over to the next-nearby contract one month prior to the maturity of the nearby contract. This procedure is done for entire dataset of commodity futures to generate the continuous series of futures prices. We compute the daily return series, for each commodity future, by taking the log difference of the daily prices on two consecutive trading days. To facilitate our analysis we convert the daily returns into a monthly series. Specifically, following the work of Asness et al. (2013) and Moskowitz et al. (2012) we compound the daily returns into a cumulative index from which we compute returns at a monthly horizon. These return series are then used to create and evaluate the various types of commodity portfolios.

The equity return data used to construct the buy-and-hold US domestic reference portfolio is extracted from CRSP. The equity returns are based on a value-weighted index of all NYSE/AMEX/NASDAQ stocks. The bond index return data used in both the buy-and-hold US domestic reference portfolio and buy-and-hold international reference portfolio is obtained from Bloomberg. The bond index returns are those calculated by Barclays Capital. The equity return data used to compute the buy-and-hold international portfolio is also extracted from Bloomberg. The portfolio includes the index returns of seven developed countries: Australia, Canada, France, Germany, Japan, the UK, and the US. The return data for the actively managed US domestic equity and actively managed international equity portfolios, based on the Fama-French monthly size and momentum factors, are taken from Ken French's website.[8] The international portfolio includes the returns of 23 countries from four regions: Australia, Austria, Belgium, Canada,

[8] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Switzerland, Sweden, the UK and the US.

3. Commodity futures portfolio returns performance

3.1. Portfolio construction

Following the construction of the futures return series we create 33 different portfolios of commodity futures based on style and performance. Six of the portfolios consist of a buy-and-hold strategy. Five of those six portfolios are equally-weighted commodity sectors—foods and fibers, grains and oilseeds, livestock, energy, and precious metals—which represent the commodity futures specific to that group. The remaining portfolio is an equally-weighted composite of the five aforementioned commodity sectors. The sector-based portfolios help to unveil the heterogeneous nature of how commodity futures returns behave. What is more, the sector-based portfolios highlight the fact that each commodity underlying the futures contract, and each sector for that matter, have very unique characteristics in relation to diversification and risk management, which potentially makes some commodity futures groups better diversification tools than others and/or more profitable investment strategies than others. The remaining 27 portfolios are tactical portfolios which are actively rebalanced, 24 of these are rebalanced on a monthly basis, while the three net speculation portfolios are uniquely rebalanced on a weekly frequency and then compounded to a monthly horizon to facilitate further analysis.[9] The choice of monthly rebalancing (i.e. monthly holding periods) is dictated by the fact that both the momentum and term structure strategies are most profitable at this particular horizon.[10]

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[9] Speculation data is reported on a Tuesday-Tuesday basis to the US Commodity Futures Trading Commission (CFTC), and made publically available the following Friday on their website.
[10] Fuertes et al. (2010) document similar findings. We examine momentum and term structure portfolios with look-back periods of 1, 3, and 12 months and holding periods of 1, 3, and 12 months.

The nine momentum portfolios are formed as follows: at the end of (L) months (i.e. the look-back period) all commodities in the sample are ranked in descending order based on the past (L) month's average return. The commodity futures in the top 33% are assigned to a "High" return portfolio, the commodity futures in the middle 33% are assigned to a "Med" return portfolio, and those commodity futures in the bottom 33% are assigned to a "Low" return portfolio. The portfolios are then held for (H) months (i.e. the holding period). We analyze and report results for 1, 3, and 12 month look-back periods in combination with one month holding periods. Following the approach of Asness et al. (2013), Miffre and Rallis (2007), Shen et al. (2007), and Jegadeesh and Titman (1993, 2001), we evaluate the performance of the High, Med, and Low portfolios over the (H) subsequent months without a time period lag following the ranking (i.e. look-back) period. To reduce the effect of non-synchronous trading and the bid-ask bounce, Jegadeesh and Titman (1993) suggest measuring returns on the portfolios of futures two months after the initial ranking period (L). However, Asness et al. (2013) report that in case of commodity futures whether one lags the ranking period or not, it does not significantly alter the results. Therefore, following Asness et al. (2013) we do not measure portfolio returns with a lag following the ranking period. We derive a single time-series of monthly returns for each actively managed trading strategy in this manner.

The nine term structure portfolios follow an alternative formulation to that of DeGroot et al. (2014). These strategies, as originally motivated by Erb and Harvey (2006) and Gorton and Rouwenhorst (2006), seek to exploit the term structure of commodity futures prices. The term structure measures stem from the work of Samuelson (1965) who argues that the volatility of futures returns decreases as the maturity of contracts increases. Thus, the prices of the front contracts react most heavily to supply, demand, and news shocks, while prices further along the curve are influenced significantly less. Furthermore, as noted by DeGroot et al. (2014), even contracts on the same commodity with different maturities can exhibit large differences in returns and risks. Hence, non-front contracts which are further down the futures curve may behave differently and represent different investment opportunities. We calculate the term structure measures as follows:

$$TS_{i\_j} = F_{it} - F_{jt} \tag{1}$$

where F_{it} is the futures price of the nearby contract i at time t and F_{jt} is the futures price of the other nearby contract j at time t. The construction of the commodity portfolios based on the term structure is similar to the procedure for the return momentum portfolios. For each individual commodity we utilize equation (1), at various contract horizons, to obtain a daily difference series. Then to facilitate our analysis we average the daily series into a monthly one, whereby the series is then sorted in descending order and the commodity futures in the top 33% are assigned to a "High" term structure (TS) portfolio, the commodity futures in the middle 33% are assigned to a "Med" TS portfolio, and those commodity futures in the bottom 33% are assigned to a "Low" TS portfolio. The portfolios are then held for one (H) month and rebalanced. For each of the portfolios the returns for the month, t+1, are calculated using equal weights for all the futures contracts contained within their respective portfolio. This process is repeated to obtain a continuous time series of returns for the portfolios based on term structure.

The remaining nine portfolios are created from tactical strategies based on commodity futures basis, net speculation, and maximization of the Sharpe Ratios (i.e. the mathematical portfolios), respectively. Specifically, we analyze three portfolios sorted on the futures basis (spot price - futures price) of the commodities in the sample. We rank the commodity futures in descending order based on the past one month's basis, similar to the procedure for the momentum and term structure portfolios, and then form the portfolios. The commodity futures in the top 33% are assigned to a "High" basis portfolio, the commodity futures in the middle 33% are assigned to a "Med" basis portfolio, and those commodity futures in the bottom 33% are assigned to a "Low" basis portfolio. As with the previous portfolios the basis portfolios are also rebalanced monthly. More formally, the basis portfolios are constructed as follows: at the end of each month, t, we calculate the basis for each of the 29 commodity futures. Following Gorton et al. (2013), the basis for each commodity, i, is calculated as:

$$Basis_i = \left(\frac{F_{1t}}{F_{2t}} - 1\right) \times \frac{365}{D_{2t} - D_{1t}} \tag{2}$$

where $\mathrm{F_{1t}}$is the price of nearest futures contract, $\mathrm{F_{2t}}$ is the price of the next-nearby futures contract, and $\mathrm{D_{1t}}$ and $\mathrm{D_{2t}}$ are the number of days before the futures contracts $\mathrm{F_{1t}}$ and $\mathrm{F_{2t}}$ expire, respectively. For each of the portfolios the returns for the month, t+1, are calculated using equal weights for all the futures contracts contained within their respective portfolio. This process is repeated to obtain a continuous time series of returns for the portfolios based on basis.

In order to construct portfolios based on net speculators' positions we utilize the position of trader's data given in the US Commodity Futures Trading Commission's (CFTC's) weekly reports. For each commodity futures contract, i, we compute the variable $\mathrm{h_{i,t}}$, which is based on the aggregated weekly positions of non-commercial hedgers in all traded markets at time t, and is given as:

$$h_{i,t} = \frac{agg.\ short\ hedge\ positions - agg.\ long\ hedge\ positions}{total\ number\ of\ hedge\ positions} \tag{3}$$

Following our prior procedure, each week, t, we rank the commodity futures in descending order based on the past one month's net speculation positions ($h_{i,t}$) and again divide them into three groups. The commodity futures in the top 33% are assigned to a "High" net speculation portfolio, the commodity futures in the middle 33% are assigned to a "Med" net speculation portfolio, and those commodity futures in the bottom 33% are assigned to a "Low" net speculation portfolio. The portfolio returns for week, t+1, are calculated using equal weights for all the futures contracts contained within the respective portfolio. Since the CFTC hedging data is only available on a weekly occurrence, we first calculate the portfolio returns by rebalancing via a weekly frequency, and then convert these weekly returns into monthly returns by compounding them into a cumulative index.

Finally, the mathematical portfolios which utilize the concept of portfolio optimization include: Markowitz's (1952) mean variance portfolio, a conditional value at risk portfolio, and a mean absolute deviation portfolio. These portfolios are motivated by financial theory and utilize mathematical constructs to "optimize" an investor's risk-return tradeoff. The mean-variance portfolio of Markowitz (1952) uses the variance of portfolio returns as the risk proxy. We use the past 250 daily returns of the commodity futures and obtain weights, for each commodity in the sample, which maximize the Sharp Ratio. Formally, the maximization problem is defined as:

$$\max_{\omega} \mu^T \omega \qquad s.t. 1'\omega = 1 \text{ and } \omega^T \Sigma \, \omega \leq \sigma_{max}^2 \tag{4}$$

where, μ is the mean return of the commodity futures, Σ is the variance of the commodity returns, and ω are the portfolio weights. The weights obtained by maximizing the Sharpe Ratio using the past 250 daily returns are used to invest for the next one month period. The mean-variance portfolio is rebalanced monthly. The conditional value-at-risk (CVaR) portfolio measures risk under portfolio optimization as in Rockafellar and Uryasev (2000, 2002). In this approach, we use the conditional value-at-risk (CVaR) of the portfolio returns as the risk proxy instead of variance of the portfolio returns as in equation (4). The conditional value-at-risk for a portfolio is defined as:

$$CVaR_{\alpha}(x) = \frac{1}{(1-\alpha)} \int_{f(x,r) \geq VaR_{\alpha}(x)} f(x,r)p(r)dr \tag{5}$$

where, α is the probability level, $f(x, r)$ is the loss function for a portfolio x and asset returns r, p(r) is the probability density function for asset returns r, and VaR_{α} is the value-at-risk of portfolio x at probability level α. To construct the CVaR portfolio returns series, we compute the weights that maximize the ratio of the mean portfolio return to the CVaR using the past 250 daily returns of commodity futures, and then use these weights to invest for the next one month period. The CVaR portfolio is rebalanced monthly. Lastly, the mean-absolute-deviation (MAD) portfolio utilizes the optimization technique of Konno and Yamazaki (1991). The MAD portfolio optimization is similar to the mean-variance technique of Markowitz (1952). However, we utilize Konno and Yamazaki's (1991) redefined risk measure called MAD, which is given as:

$$\frac{1}{T} \sum_{t=1}^{T} \left| \sum_{i=1}^{n} (r_{it} - \bar{r}_i) \omega_i \right| \tag{6}$$

where, T is the length of time horizon, n is the total number of commodities, r_{it} is the return on the i^{th} commodity over the time horizon, t, where, $t = 1, 2, \ldots T$, $\bar{r}_i$ is the mean of i^{th} commodity return, and ω_i are the portfolio weights. In order to obtain the MAD portfolio return series, we replace the risk proxy in equation (4) by equation (6), and then solve equation (4) using the past 250 daily returns of commodity futures to obtain the appropriate weights. These weights are then used to allocate funds to invest for the next one month period. The MAD portfolio is similarly rebalanced on a monthly frequency.

3.2. Buy-and-hold and actively rebalanced commodity portfolio performance

Table 2 provides a snapshot of the average annualized futures returns performance of the buy-and-hold and tactical commodity portfolios. We report the results for both the full sample period and two sub-sample periods, along with the P-values, standard deviations, and Sharpe Ratios of each respective portfolio examined. Panel A summarizes the returns of the futures portfolios formed using traditional buy-and-hold strategies. Over the full sample period (January 1986 to October 2013) the energy sector has the highest annualized mean return of all five groups at 14.32%, this is followed by the precious metals sector with an average return of 8.63%. Upon examining the two sub-sample periods an interesting feature emerges, the average returns of the buy-and-hold portfolios, in general, tend to be higher in the second period (January 2001 to October 2013) when compared to the first period (January 1986 to December 2000). Furthermore, the average annualized return performance of most buy-and-hold portfolios over the first sub-sample sample period are not significantly different from zero at conventional significance levels of 10%, whereas in the second sub-sample period this trend is reversed. The overall results of the first sub-sample period are largely consistent with Erb and Harvey (2006) who find that the average annualized excess return of the average individual commodity future over the period 1982-2004 has been approximately zero. However, findings over the second sub-sample period seem to tell a much different story.

Panels B, C, and D display the performance of the tactical basis, speculation, and mathematical portfolios, respectively. Over the full sample period the High basis portfolio generates the largest annualized mean return of all portfolios at 17.92%. The sub-sample analysis shows that much of the large return over the full sample period is due to the tremendous performance of the portfolio in the second sub-sample period with a mean return of 22.51%. In general, the other two basis portfolios seem to earn a return commensurate with the more traditional buy-and-hold commodity portfolios. The average return of the High speculation portfolio over the full sample period (14.26%) also ranks it as one of the top performing portfolios. Interestingly, an examination of the sub-sample periods shows that the High speculation portfolio significantly outperforms the Low and Med portfolios by a wide margin in the first period, but in the second period the Low speculation portfolio average return surpasses that of the High by an average margin of about 4.00%. Finally, the mathematical portfolios, which are based on the financial theory of maximizing portfolio Sharpe Ratios using commodity weights, consistently yield the worst return performance of all commodity portfolios considered. In fact, all returns for the portfolios in Panel D are always statistically insignificant.

[Insert Table 2 Here]

Panel E presents the return performance of the tactical momentum portfolios where we consider three different look-back periods and a one month holding period. For instance, the first portfolio of panel E, LowL1H1, represents the annualized mean return of an equally-weighted portfolio holding the lowest return futures—the bottom 33% of commodity futures when sorted on past returns—based on a one month return look-back period (L) and one month holding period (H). All other momentum portfolios follow a similar interpretation. Over the whole sample period the annualized mean return of the HighL12H1 portfolio (14.66%) outperforms all other momentum portfolios examined. The next highest momentum portfolio return strategy is the HighL3H1 portfolio with a mean return of 13.84%. We find that the High momentum portfolios, in general, tend to outperform their similar Low momentum portfolio counterparts.

An analysis of the sub-sample periods yields similar conclusions. The HighL1H1 and Low1H1 portfolios present a minor exception to this finding with very similar returns of 12.70% and 12.92%, respectively. Prior work by Miffre and Rallis (2007) and Asness et al. (2013) similarly find higher return performance for the High (recent winner) momentum groups.

Panel F presents the return performance of the tactical term structure portfolios where we consider three different horizons. For instance, the first portfolio of Panel F, LowTS1_2, represents the annualized mean return of an equally-weighted portfolio holding the smallest differenced futures contracts—the bottom 33% of commodity futures when sorted on the difference between nearby and next-nearby contracts—based on a one month look-back period and one month holding period. All other term structure portfolios follow a similar interpretation. Over the whole sample period the annualized mean return of the LowTS1_2 portfolio (15.81%) outperforms all other term structure portfolios examined. The next highest term structure portfolio return strategy is the HighTS1_4 portfolio with a mean return of 14.41%. The results of the term structure portfolios are a bit more varied than those observed in the momentum section. The Low TS portfolios formed on the difference between the nearby contracts and the contracts at the shorter horizons (i.e. next-nearby and next-next-nearby) display the highest return performance amongst their Med and High counterparts. However, this finding is not true of the longer horizon difference contracts (TS1_4) where the High TS portfolio return performance is superior. Sub-sample analysis of the return performance yields consistent findings for the LowTS1_2 and HighTS1_4 portfolios. Contrastingly, the LowTS1_3 portfolio maintains the high return performance (12.73%) over the first sub-sample period, but the HighTS1_3 portfolio obtains the highest return performance over the second sub-period (18.98%). Overall, these findings are in line with the argument of DeGroot et al. (2014) that contracts on the same commodity with different maturities can exhibit large differences in returns and risks.

Focusing solely on buy-and-hold strategies, investment in the energy sector offers by far the greatest return potential. Energy sector investment is commensurate with many of the high performing tactical strategies based on speculation, momentum, and term structure over the full sample period. Regarding the tactical strategies, we see that the average annualized returns formed on basis tend to outpace all other tactical (and buy-and-hold) strategies over the full sample period. Looking at the latter sub-sample period, which is characterized by the financialization of the commodity market, the High basis portfolio again offers the highest return strategy, followed by the Low speculation portfolio, and strategies based on High momentum and High term structure.

3.3. Risk-adjusted commodity portfolio performance

The results in Table 2 provide a broad summary of the return performance of both buy-and-hold and various styles of tactical commodity portfolios. Moreover, it provides an analysis of how the returns of such strategies have evolved over time, with a particular emphasis on the last decade. This change is interesting given the prominent strand of literature which documents the financialization of the unique asset class over the last decade. Tang and Xiong (2012) highlight the impact of this change by recognizing the unique characteristics of the commodity futures market that precipitated the rapid growth of the commodity index investment. Prior to the early 2000's commodity prices largely provided a risk premium for idiosyncratic price risk (see Bessembinder, 1992; DeRoon et al., 2000) and had little or no correlation with more traditional asset markets. These features bear a sharp contrast to the price dynamics of typical financial assets which are well-known for solely carrying a premium for systematic risk and generally are highly correlated with each other. The fundamental process of financialization resulted in an increase of the correlations among the returns of the different types of futures and an increase in the correlations between more traditional assets, thus altering the pricing dynamics of the commodity futures. We posit that the changes in futures returns in the latter sub-sample period are a reflection of this process. In order to more comprehensively evaluate the impact of financialization on the futures returns in the commodities market we utilize risk-adjusted measures of performance. As such, we calculate risk-adjusted returns for the different portfolios of commodity futures using the autocorrelated regression model of the following form:

$$\left.\begin{array}{c} R_t = \alpha + X_t\beta + u_t \\ \mathrm{i} \\ u_t = \sum_{i=1}^{p} \rho_i u_{t-i} + v_t + \sum_{i=1}^{q} \delta_i v_{t-i} \\ \mathrm{i} \\ v_t \sim iid\ N(0, \sigma^2) \end{array}\right\} \qquad (7)$$

where, R_t is a vector of commodity portfolio return time series, X_t is a matrix of stock and bond market returns, and u_t is a vector of disturbance terms. The regression model is estimated using maximum likelihood. A characteristic advantage of regression models with time series error terms is that a shock at time t, as represented by v_t, has an immediate effect on R_t and continues to have effect at time $t+1, t+2$, etc. Moreover, regression models with time series errors are still able to preserve the sensitivity and interpretation of the regression coefficients. Therefore, the autocorrelated regression model helps us to correct for the simple multiple regression model which underestimates returns for some periods and overestimates returns for others. We regress the monthly returns of the various commodity portfolios on the CRSP value-weighted market index and the Barclays Capital U.S. Aggregate Bond index to obtain the risk-adjusted returns.[11] The risk-adjusted return results from the model in (7) are presented in Table 3.

[Insert Table 3 Here]

The most interesting feature of Table 3 is that after adjusting for risk, many of the alpha estimates of the commodity portfolios in the second sub-sample period become insignificant when compared to those in the first sub-sample period. Of particular interest, the alpha estimate of the buy-and-hold energy sector is no longer statistically significant after adjusting for risk. The High basis and Low speculation portfolios both maintain significant risk-adjusted returns in the second sub-sample period. Interestingly, only the alpha estimates of the Low return momentum portfolios are significant in the latter sub-ample period. Similarly, the Low TS portfolios have significant risk-adjusted returns in the second period. In some cases, the Med TS portfolios are significant but the returns are lower than those of the Low TS portfolios. Thus, for a relatively small subset of our overall commodity portfolios, a tactical strategy based on, High basis, Low speculation, Low momentum, and Low term structure can be a profitable return tactic in an era characterized by financialization.

Taken together, the results of Table 2 and 3 support the idea that the increase in equity-commodity comovement has subsequently changed the price dynamics of commodity futures. The contrast in returns and risk-adjusted alphas, as shown by the two sub-sample periods, lends credence to the argument that commodity markets were more segmented from outside financial markets prior to 2001. In the era characterized by the financialization of the commodity markets

[11] We utilize a time-series regression framework and calculate Newey-West HAC standard errors for each regression.

the ability of many types of buy-and-hold and tactical portfolios to earn higher returns (and risk-adjusted returns) has largely been diminished for many portfolios.

4. Diversification benefits of commodity futures

Tables 2 and 3 evaluate the return performance of both buy-and-hold and tactical commodity portfolios. However, one of the overriding reasons investors include commodity futures in their portfolio is for the diversification benefits as documented in prior literature. Yet, given the changing landscape of the commodity futures market via financialization, do commodity portfolios provide diversification benefits today? Furthermore, how have these diversification benefits performed over recent economic recession periods when they were desired most?

4.1. Testing methodology

To examine the diversification properties of our commodity futures portfolios, we exploit two strands of literature which develop spanning tests commonly used in the asset pricing literature. The first strand utilizes the stochastic discount factor (SDF) frontier introduced by Hansen and Jagannathan (1991), and later developed by DeSantis (1995), Bekaert and Urias (1996), and Maroney and Protopapadakis (2002). The second strand builds on the return mean-variance frontier literature originally proposed by Huberman and Kandel (1987), and later revised by DeRoon and Nijman (2001) and Khan and Zhou (2012). From each of these sects of literature we implement two different kinds of spanning tests. We consider both the SDF frontier and return mean-variance frontier based tests because the implications of spanning are different under each scenario. Penaranda and Sentana (2012) state that tests based on the return mean-variance frontier assess whether the exclusion of some assets reduce the risk-return trade-offs faced by investors, while the tests based on the SDF frontier help to determine whether additional assets impose tighter restrictions on the asset pricing models, irrespective of whether investors have mean-variance preferences. Furthermore, the mean-variance spanning tests assume a normal return pattern, whereas the SDF approach to asset pricing does not assume any return pattern. In this sense, the SDF approach provides a better way to capture whether commodities provide any diversification benefits. Despite the methodological choice, the goal of each test is the same: does a set of new assets improve the investment opportunity set relative to a benchmark asset? For each test, we construct a frontier of benchmark assets and ascertain whether that benchmark remains unchanged after increasing the number of assets in the portfolio. If the two frontiers coincide then there is spanning. In this case, there is no diversification benefit from adding new assets to the benchmark asset. However, if adding a new set of assets leads to a significant shift of the frontier, relative to the frontier of benchmark assets, then there is no spanning. In this case, the new set of assets provides diversification benefits.

Spanning tests in the SDF framework are implemented following DeSantis (1995), Bekaert and Urias (1996), and Maroney and Protopapadakis (2002). Formally, we let $\mathrm{R_t} = [\mathrm{R}'_{1t}, \mathrm{R}'_{2t}]^{t}$ represent returns on $\mathrm{n} = \mathrm{n}_1 + \mathrm{n}_2$ risky assets at time t, where R_{1t} and R_{2t} represent returns on n_1 benchmark assets and returns on the n_2 test assets, respectively. Further, we let $\mathrm{m_t}$ be the investor's marginal rate of substitution or discount factor. The main question we try to address here is how the region of the admissible discount factors changes when a group of test assets are added to the benchmark set of securities. Under the assumption that there are no transaction costs and the Law of One Price holds, the general unconditional asset pricing model can be written as:

$$E(R_t m_t) + E(m_t) = 1_n \tag{8}$$

Hansen and Jagannathan (1991) show that the linear projection of m_t onto the set of returns being priced has the minimum variance which satisfies equation (8), this means the lower bound of the discount factor that satisfies equation (8) is as follows:

$$m_{ct} = c + [R_t - E(R_t)]'\beta_c + \in \quad (9)$$

where, $\in$ is the error of the regression. Substituting the value of m_t from equation (9) into equation (8) we get the following:

$$E(R_t m_{ct}) + E(m_{ct}) - 1_n = 0 \quad (10)$$

Equation (10) can be used to examine whether or not a subset of the assets in R_{1t} price all of the assets in R_t. If we restrict the coefficients on the test assets in equation (10) to be zero under the null hypothesis, then we obtain the following system of orthogonality conditions under the null hypothesis:

$$E\left[R_t\left\{c + \left(R_{1t} - E(R_{1t})\right)'\beta_{c_1}\right\}\right] + c - 1_n = 0 \quad (11)$$

For a given value of c, there are n moment conditions, n_1 parameters to be estimated, and n_2 overidentifying restrictions. In order to implement the tests based on the SDF frontier, DeSantis (1995) proposes pre-specifying two values of risk-free rates, $c_1$and c_2. Then we can specify the following system of orthogonality conditions for the spanning test:

$$E\begin{bmatrix} R_t\left[c_1 + \left(R_t - E(R_t)\right)'\beta_{c_1}\right] + c_1 - 1_n \\ R_t\left[c_2 + \left(R_t - E(R_t)\right)'\beta_{c_2}\right] + c_2 - 1_n \end{bmatrix} = 0 \quad (12)$$

where, $\beta_{c_j} = \left[\beta'_{1c_j}, \beta'_{2c_j}\right]' \; \forall \; c_j, j = 1, 2$. In DeSantis (1995), the over-identifying restrictions are obtained by assuming that the $2 \times n_2$ coefficients in β_{2c_1} and β_{2c_2} are simultaneously equal to zero in system (12). Similarly, the spanning test of Bekaert and Urias (1996) can be implemented by estimating β_{2c_1} and β_{2c_2} and testing whether $\beta_{2c_1} = 0$ and $\beta_{2c_2} = 0$. The methodology developed by DeSantis (1995) uses a Likelihood ratio test whereas Bekaert and Urias (1996) use a Wald test.

Under the null hypothesis of spanning, the Hansen J-Statistic (Hansen, 1982; Hansen and Singleton, 1982) can be used to evaluate the over-identifying conditions implied by spanning. The DeSantis (1995) spanning test requires two stage GMM estimation. By contrast, the spanning test of Bekaert and Urias (1996) is computed in one stage. Both spanning tests have an asymptotic chi-square distribution with $2 \times n_2$ degree of freedom. The DeSantis (1995) spanning test is denoted "DeSantis" in the relevant tables. The spanning test of Bekaert and Urias (1996) is denoted "BU" in the relevant tables.

The return mean-variance frontier spanning tests are implemented following Huberman and Kandel (1987) and Kan and Zhou (2012), who define mean-variance spanning in a linear regression model. To test whether R_{1t} returns span the vector of returns R_t, we estimate the following model:

$$R_{2t} = \alpha + \beta R_{1t} + \varepsilon_t \tag{13}$$

where, $E[\varepsilon_t] = 0$. The null hypothesis of spanning is given as:

$$H_0: \alpha = 0_{n_2}, \qquad \delta = 1_{n_2} - \beta 1_{n_1} = 0_{n_2}$$

Kan and Zhou (2012) argue that the above null hypothesis is a joint test of α and δ which has very good power in testing assets that can reduce the variance of the global minimum variance portfolio. However, the test has little power against test assets that can only improve the tangency portfolio. Hence, they suggest a sequential (step-down) procedure to test the null spanning hypothesis. In their step-down procedure, you first test $\alpha = 0_{n_2}$ and then subsequently test $\delta = 0_{n_2}$ conditional on $\alpha = 0_{n_2}$. If the null hypothesis is rejected due to the first test, we know it is because the two tangency portfolios are very different. If the rejection is due to the second test, it is because the two global minimum variance portfolios are very different. Contrastingly, the traditional test of Huberman and Kandel (1987) is a joint test of $\alpha = 0_{n_2}$ and $\delta = 0_{n_2}$.

The test of Huberman and Kandel (1987) has χ^2 distribution with $22 \times n$ degrees of freedom. Kan and Zhou (2012) show that the first test in their step-down sequence has a central F-distribution with n_2 and $T - n_1 - n_2$ degrees of freedom, while the second test also has a central F-distribution with n_2, but with $T - n_1 - n_2 + 1$ degrees of freedom. The traditional spanning test of Huberman and Kandel (1987) is denoted as "Ftest" in the relevant tables. For the spanning tests of Kan and Zhou (2012), we denote the test of $\alpha = 0_{n_2}$ as "Ftest1" and the test of whether $\delta = 0_{n_2}$ given that $\alpha = 0_{n_2}$ as "Ftest2" in the relevant tables.

4.2. Spanning test results

The following sections report the results of the various spanning tests using the US domestic buy-and-hold, US actively managed, international buy-and-hold, and international actively managed portfolios as benchmark assets. The work of Bekaert and Urias (1996) show that the power of the spanning tests is extremely sensitive to the number of benchmark assets; therefore, we limit the number of assets in each case. We sequentially test whether adding portfolio(s) of commodity futures to the benchmark asset provide any diversification benefits. We utilize all buy-and-hold and tactical commodity portfolios examined in Tables 2 and 3. Furthermore, we supplement the aforementioned set of portfolios with five additional commodity futures portfolios which aggregate the High, Med, and Low portfolios of each respective tactical strategy. Specifically, these aggregated portfolios include: “Allbasis,” which is composed of all three portfolios sorted on basis, “Allspec” which is composed of all three portfolios sorted on speculation, “Allmath” which is composed of all three portfolios based on the mathematical constructs, “Allmom” which is composed of all nine momentum portfolios sorted on past returns from various look-back periods, and “AllTS” which is composed of all nine term structure portfolios sorted on the differenced futures contracts between various term structure horizons. These five supplemental portfolios provide the added benefit of analyzing the effects of numerous tactical portfolios together with a single benchmark asset.

4.2.1. US domestic buy-and-hold benchmark portfolio

Table 4 presents the spanning test results using a US domestic buy-and-hold portfolio, which consists of the CRSP value-weighted market index returns and the Barclays Capital US Aggregate Bond Index returns, as the benchmark asset. Each column provides the P-values of the respective spanning test from adding the portfolio of commodity futures to the benchmark portfolio across the different sample periods. Results for the whole sample period show that the null hypothesis of spanning is rejected at the (more stringent) significance level of 5% for almost all commodity portfolios.[12] This means that investors can improve their investment diversification opportunities by adding the respective portfolio(s) of commodities to the benchmark asset. Only for the buy-and-hold grains and oilseeds commodity portfolio do we fail

[12] Based on prior literature, we follow both Maroney and Protopapadakis (2002) and Errunza et al. (1999) who predominately use significance levels of 5% when evaluating spanning test results.

to reject the null hypothesis, implying that the portfolio provides no diversification benefits when combined with the benchmark asset. Similar results are observed over the first sub-sample period but with the exclusion of a few more diversifying commodity portfolios (i.e. Highspec, LowL1H1, HighL3H1, HighL12H1, HighTS1_3, and HighTS1_4). However, evaluating the spanning test results over the second half of the sample period reveals that the vast majority of commodity portfolios no longer provide any diversification benefits. This trend is common among all of the spanning tests employed. Specifically, out of all buy-and-hold portfolios considered, only the livestock sector portfolio provides any diversification benefit. If we turn our attention to the tactical commodity portfolios we find that only the Lowspec, Allspec, Allmath, LowL1H1, LowL12H1, Allmom, and LowTS1_2 portfolios continue to provide diversification benefits for the US domestic buy-and-hold benchmark. It is very interesting that just seven of the 38 commodity portfolios considered continue to provide any diversification benefits in the post-2000 era, whereas in the prior 14 years the opposite was true. Hence, in the decade notably marked by a dramatic increase in commodity market participants, resulting in increasing equity-commodity return correlations, we document that the salient diversification feature which characterized the commodity market has otherwise been eroded for both buy-and-hold and tactical portfolios of commodities when combined with a traditional buy-and-hold portfolio of US equities and bonds.

[Insert Table 4 Here]

Table 4 also summarizes the diversification properties of the commodity portfolios over the major economic crises periods which occurred during the overall sample period. As previously discussed, one of the primary reasons investors include commodities in their portfolios is for their theoretical properties of little comovement with traditional asset classes, which is particularly valuable during market downturns. Thus, we evaluate the diversification properties over the last three major economic recession (or crises) periods in the US based on the National Bureau of Economic Research (NBER) business cycle data.[13] The crisis time periods include: July 1990 to March 1991, March 2000 to November 2001, and December 2007 to June 2009. Results indicate that only the Allmom portfolio provides any diversification benefits when combined with a traditional US buy-and-hold portfolio during the economic crises periods. Taken together these findings call into question the perceived diversification benefits of investing in commodity futures when holding a traditional buy-and-hold portfolio composed of US equities and bonds.

4.2.2. US domestic actively managed benchmark portfolio

. Due to the lack of diversification benefits which commodities provide in the buy-and-hold benchmark setting we investigate the potential for diversification benefits using an actively managed equity-based portfolio as the benchmark asset. Table 5 presents the spanning test results using a US domestic actively managed portfolio, which consists of returns on six US equity portfolios formed on the Fama-French monthly size and momentum factors, as the benchmark asset. In all cases the various portfolios of commodity futures examined exhibit significantly greater diversification opportunities for investors than under the buy-and-hold scenario. The significance of the full sample period results are stronger than what we document over the same time period in Table 4. However, in contrast to that of Table 4, we find that over both sub-sample periods the significance of the results are much more strongly preserved. Only the buy-and-hold energy sector portfolio and a handful of tactical portfolios (i.e. Highspec, HighL1H1, HighL3H1, HighL12H1, HighTS1_2, HighTS1_3, HighTS1_4) in the latter half of

[13] http://www.nber.org/cycles.html

the sample period provide no additional diversification benefits when added to the actively managed benchmark asset. We postulate that this is likely due to the higher than average return correlations that the energy sector and the tactical portfolio composites have with the equity markets.

[Insert Table 5 Here]

The differing results of Tables 4 and 5 may be explained by the additional risk inherent in the frequently rebalanced equity portfolios based on size and momentum factors when compared to the traditional buy-and-hold portfolios. When the actively managed risky portfolio is augmented with different styles of commodity portfolios risk is subsequently reduced. Overall, the diversification findings observed over all sample periods are strongly consistent and show that if an investor is willing to take on the additional risk of an actively managed benchmark portfolio, the majority of commodity portfolios in both a buy-and-hold and tactical setting can provide substantial diversification benefits.

4.2.3. International buy-and-hold benchmark portfolio

The results of Tables 4 and 5 solely focus on the US domestic case as the benchmark asset. However, commodities are global products and investors who seek diversification opportunities generally hold securities from numerous different nations and not just the US, thus it seems rather intuitive to investigate the diversification properties of commodities on an international stage as well. Table 6 presents the spanning test results using an international buy-and-hold portfolio, which consists of returns on seven developed nation's equity indices and the Barclays Capital US Aggregate Bond Index returns, as the benchmark asset. The interpretation of results follows exactly from the prior sections. The full sample results of Table 6 show slightly stronger results when compared to the US domestic case. The notable difference between Tables 4 and 6 is that none of the mathematical portfolios provide any diversification opportunities in the international setting. However, all of the buy-and-hold and several of the previously non-beneficial tactical portfolios now become highly significant under the international benchmark portfolio. This result is of particular merit since it is the tactical portfolios which generally provide greater return potential.

[Insert Table 6 Here]

An examination of the two sub-sample periods shows a somewhat trend to what was observed in Table 4, but with much stronger diversification benefits preserved in the latter sub-sample period. Over the first half of the full sample period the vast majority of commodity portfolios provide exceptional diversification benefits when combined with a buy-and-hold international portfolio of equities and bonds, just as in the US domestic case. However, over the latter half of the sample period the spanning test results show that numerous commodity portfolios still provide some form of diversification. While it is readily apparent that several commodity portfolios have lost their power as diversification tools in moving from the first sub-sample period to the second, the overall findings bear a sharp contrast to what was observed in the US domestic analysis. The latter sub-sample results are somewhat mixed, particularly when compared to the US domestic case, but overall findings suggest international diversification opportunities in the post-2000 era using commodity portfolios have been diminished. Hence, while the diversification properties of commodity portfolios have been substantially reduced in the last decade for an international buy-and-hold portfolio of equities and bonds, just as in the buy-and-hold US domestic case, it seems to be to a much lesser degree. This is likely due to the increased heterogeneity of the equity securities held in the benchmark portfolio, which in turn have overall weaker correlations with the commodity futures. Nonetheless, this evidence points towards the financialization of the commodity market as weakening (to varying degrees) the diversification opportunities for all types of buy-and-hold investors.

4.2.4. International actively managed benchmark portfolio

Table 7 presents the spanning test results using an international actively managed portfolio, which consists of returns on six international equity portfolios formed on the Fama-French monthly size and momentum factors from 23 developed nation's equity indices, as the benchmark asset. Interestingly, the full sample results are markedly weaker when compared to the US domestic case in Table 5. Approximately nine commodity portfolios are insignificant whereas none were insignificant in the US analysis. However, in moving to the sub-sample analysis the results are strikingly similar to those of Table 5. Virtually all commodity portfolios provide substantial diversification benefits in the first period, but in the second period several of these portfolios (which are the same in Table 5) lose their significance. It seems that the addition of commodity portfolios to an actively managed benchmark asset, whether it be a US or international portfolio, offers the same diversification opportunities.

[Insert Table 7 Here]

Comparing the international actively managed benchmark results to the international buy-and-hold benchmark findings shows only marginal diversification gains for the actively managed reference portfolio. Specifically, only two more of the buy-and-hold commodity portfolios and the whole subset of mathematical portfolios become significant in Table 7 versus the results of Table 6. The tactical portfolio results remain largely unchanged in the two different contexts. This is particularly interesting given the strong contrast between the results of the US domestic buy-and-hold and actively managed reference portfolios. Thus, in the international portfolio setting the diversification gains from using an actively managed benchmark portfolio versus a traditional buy-and-hold approach provides only marginal diversification gains to the investor.

5. Concluding remarks

This paper examines the return performance and diversification benefits of both buy-and-hold and tactical portfolios of commodity futures. We fuse together both of these desired investment properties of the unique asset class to provide a thorough analysis of the futures market given the changes it has undergone over the last decade. Many recent studies which examine the effects of the financialization of the commodity futures market argue that the highly touted benefits, such as “equity-like” returns and diversification properties, may be eroding due to the increasing comovement between commodity futures and more traditional asset markets. Given these suppositions, we investigate two specific sub-sample periods in order to help evaluate the evolution of the return and diversification contributions from different styles of commodity portfolios over time.

We create both buy-and-hold and tactical commodity portfolios to observe and compare their return performance over time. In an attempt to dig deeper into the potential tactical opportunities of commodity futures we create commodity portfolios based on basis, net speculation, and mathematical optimization. Over the most recent time period, the High basis and Low speculation tactical portfolios outperform all other strategies examined. Additionally, the High momentum and Low term structure tactical portfolios generally exhibit high return performance as well. In order to further highlight the effects of the financialization of the commodity market we utilize risk-adjusted return measures to show that even though many commodity portfolios seemingly exhibit higher returns in the post-2000 era, many of these returns become statistically insignificant once risk is taken into account. Furthermore, we implement asset pricing spanning tests to show that since 2001 the vast majority of both buy-and-hold and tactical portfolios of commodity futures provide no additional diversification benefits when combined with a traditional buy-and-hold US domestic benchmark portfolio of equities and bonds. However, when we combine our buy-and-hold and tactical portfolios of commodity futures with an actively managed benchmark portfolio of US domestic equities the diversification benefits provided by adding the commodity portfolios improve substantially. We implement international buy-and-hold and actively managed benchmark portfolios as well and obtain somewhat similar results.

Overall, evidence suggests that the diversification properties of various portfolios of commodity futures have largely broken down for investors of traditional buy-and-hold benchmark portfolios, and to a lesser extent actively managed equity-based benchmark portfolios, since the early 2000's. This breakdown has been much less severe for the international buy-and-hold portfolios when compared to the US domestic buy-and-hold counterpart. Thus, in the international portfolio setting the diversification gains from using an actively managed benchmark portfolio versus a traditional buy-and-hold approach provides only marginal diversification gains to the investor.

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Table 1

Sample of Commodity Futures

Sector	Exchange Symbol	Commodity	Exchange	Futures Start Date
Foods & Fibers	CC	Cocoa	ICE	July, 1959
	KC	Coffee	ICE	August, 1972
	JO	Orange Juice	ICE	February, 1967
	SB	Sugar #11	ICE	January, 1961
	CT	Cotton	ICE	July, 1964
	LB	Lumber	CME	October, 1969
Grains & Oilseeds	WA	Barley	WCE	May, 1989
	WC	Canola	WCE	September, 1974
	C_	Corn #2	CBOT	July, 1959
	O_	Oats	CBOT	July, 1959
	RR	Rough Rice #2	CBOT	August, 1986
	S_	Soybeans	CBOT	July, 1959
	SM	Soybean Meal	CBOT	July, 1959
	BO	Soybean Oil	CBOT	July, 1959
	W_	Wheat	CBOT	July, 1959
Livestock	FC	Feeder Cattle	CME	November, 1971
	LC	Live Cattle	CME	November, 1964
	LH	Lean Hogs	CME	February, 1966
	PB	Pork Bellies	CME	September, 1961
Energy	CL	Crude Oil	NYMEX	March, 1983
	HO	Heating Oil #2	NYMEX	December, 1984
	HU	Unleaded Gas	NYMEX	November, 1978
	NG	Natural Gas	NYMEX	April,1990
	PN	Propane	NYMEX	August, 1987
Precious Metals	HG	Copper	NYMEX	July, 1959
	GC	Gold	NYMEX	December, 1974
	PA	Palladium	NYMEX	January, 1977
	PL	Platinum	NYMEX	March, 1968
	SI	Silver	NYMEX	June, 1963

This table provides the individual commodity futures examined, the respective sectors to which the commodity futures belong, as well as futures exchange information and start dates.

Table 2

Return Performance of Commodity Portfolios

	Period: 01/31/1986 to 10/31/2013				Period: 01/31/1986 to 12/31/2000				Period: 01/31/2001 to 10/31/2013			
Portfolios	Mean	P-val	SD	SR	Mean	P-val	SD	SR	Mean	P-val	SD	SR
Panel A: Buy-and-Hold												
Foods & Fibers	0.0649	**0.04**	0.57	0.11	0.0313	0.39	0.47	0.07	0.101	**0.06**	0.66	0.15
Grains & Oilseeds	0.0773	**0.04**	0.67	0.12	0.0503	0.25	0.57	0.09	0.107	**0.09**	0.77	0.14
Livestock	0.0609	**0.08**	0.62	0.10	0.0637	0.22	0.67	0.10	0.058	0.20	0.56	0.10
Energy	0.1432	**0.02**	1.05	0.14	0.1437	**0.07**	1.02	0.14	0.143	0.11	1.09	0.13
P. Metals	0.0863	**0.01**	0.63	0.14	0.0598	0.11	0.48	0.13	0.115	**0.06**	0.77	0.15
Ewport	0.0849	**0.00**	0.42	0.20	0.0657	**0.00**	0.30	0.22	0.106	**0.01**	0.52	0.20
Panel B: Basis												
Lowbasis	0.0783	**0.01**	0.50	0.16	0.0661	**0.04**	0.41	0.16	0.092	**0.05**	0.58	0.16
Medbasis	0.1061	**0.00**	0.47	0.22	0.0898	**0.00**	0.33	0.27	0.124	**0.01**	0.59	0.21
Highbasis	0.1792	**0.00**	0.89	0.20	0.1370	**0.01**	0.67	0.21	0.225	**0.01**	1.08	0.21
Panel C: Speculation												
Lowspec	0.1171	**0.00**	0.50	0.23	0.0559	**0.06**	0.38	0.15	0.184	**0.00**	0.60	0.31
Medspec	0.0902	**0.00**	0.56	0.16	0.0839	**0.03**	0.50	0.17	0.097	**0.05**	0.61	0.16
Highspec	0.1426	**0.01**	0.98	0.15	0.1436	**0.02**	0.77	0.19	0.141	0.14	1.18	0.12
Panel D: Mathematical												
Portmv	0.0197	0.50	0.53	0.04	-0.0089	0.79	0.43	-0.02	0.051	0.31	0.62	0.08
Portcvar	0.0011	0.97	0.51	0.00	-0.0123	0.69	0.41	-0.03	0.016	0.74	0.60	0.03
Portmad	0.0157	0.60	0.53	0.03	-0.0090	0.79	0.44	-0.02	0.043	0.39	0.62	0.07
Panel E: Momentum												
LowL1H1	0.1292	**0.00**	0.52	0.25	0.0995	**0.01**	0.46	0.21	0.162	**0.00**	0.58	0.28
MedL1H1	0.0749	**0.01**	0.50	0.15	0.0336	0.24	0.37	0.09	0.120	**0.02**	0.61	0.20
HighL1H1	0.1270	**0.01**	0.91	0.14	0.1023	**0.05**	0.66	0.15	0.154	**0.09**	1.12	0.14
LowL3H1	0.1188	**0.00**	0.51	0.23	0.0972	**0.00**	0.41	0.24	0.142	**0.00**	0.60	0.24
MedL3H1	0.0639	**0.02**	0.48	0.13	0.0279	0.31	0.35	0.08	0.103	**0.03**	0.58	0.18
HighL3H1	0.1384	**0.01**	0.91	0.15	0.1053	**0.05**	0.68	0.16	0.174	**0.05**	1.12	0.16
LowL12H1	0.1106	**0.00**	0.50	0.22	0.0692	**0.03**	0.41	0.17	0.156	0.00	0.58	0.27
MedL12H1	0.0859	**0.04**	0.74	0.12	0.0833	0.14	0.73	0.11	0.089	0.15	0.76	0.12
HighL12H1	0.1466	**0.01**	0.94	0.16	0.1344	**0.02**	0.72	0.19	0.160	**0.08**	1.13	0.14
Panel F: Term Structure												
LowTS1_2	0.1581	**0.00**	0.49	0.32	0.1522	**0.00**	0.42	0.36	0.165	**0.00**	0.56	0.29
MedTS1_2	0.0995	**0.00**	0.49	0.20	0.0889	**0.00**	0.37	0.24	0.111	**0.02**	0.59	0.19
HighTS1_2	0.0975	**0.06**	0.91	0.11	0.0488	0.35	0.67	0.07	0.151	**0.10**	1.11	0.14
LowTS1_3	0.1307	**0.00**	0.50	0.26	0.1273	**0.00**	0.45	0.28	0.134	**0.00**	0.56	0.24
MedTS1_3	0.0928	**0.00**	0.47	0.20	0.0772	**0.00**	0.33	0.23	0.110	**0.02**	0.59	0.19
HighTS1_3	0.1293	**0.01**	0.90	0.14	0.0739	0.15	0.65	0.11	0.190	**0.04**	1.11	0.17
LowTS1_4	0.1150	**0.00**	0.51	0.22	0.0863	**0.01**	0.45	0.19	0.146	**0.00**	0.57	0.26
MedTS1_4	0.0852	**0.00**	0.46	0.19	0.0884	**0.00**	0.35	0.25	0.082	**0.07**	0.55	0.15
HighTS1_4	0.1441	**0.00**	0.91	0.16	0.1047	**0.05**	0.69	0.15	0.187	**0.04**	1.10	0.17

This table provides the return performance of the various styles of commodity futures portfolios over the full sample period (January 31, 1986 to October 13, 2013) and two sub-sample periods (January 31, 1986 to December 31, 2000 and January 1, 2001 to October 31, 2013). "Mean" represents the average annualized return of the commodity portfolio, "P-val" is the P-value based on two-tailed significance tests for testing the hypothesis of whether the mean return is equal to zero, "SD" is the standard deviation of the portfolio, and "SR" is the Sharpe Ratio.

Table 3

Risk-Adjusted Return Performance of Commodity Portfolios

	Period: 01/31/1986 to 10/31/2013						Period: 01/31/1986 to 12/31/2000						Period: 01/31/2001 to 10/31/2013					
Portfolios	Alpha	P-val	Stock	P-val	Bond	P-val	Alpha	P-val	Stock	P-val	Bond	P-val	Alpha	P-val	Stock	P-val	Bond	P-val
Panel A: Buy-and-Hold																		
Foods & Fibers	0.0704	**0.01**	0.23	0.00	-0.42	0.97	0.0642	**0.04**	0.03	0.32	-0.46	0.96	0.0753	**0.07**	0.44	0.00	0.00	0.50
Grains & Oilseeds	0.0461	0.15	0.22	0.00	0.13	0.32	0.0442	0.20	0.05	0.29	0.00	0.50	0.0443	0.26	0.41	0.00	0.70	0.10
Livestock	0.0777	**0.01**	0.11	0.02	-0.39	0.94	0.0751	**0.08**	0.13	0.07	-0.38	0.85	0.0786	**0.05**	0.07	0.13	-0.43	0.90
Energy	0.1411	**0.03**	0.22	0.01	-0.20	0.67	0.1781	**0.07**	-0.11	0.71	-0.06	0.53	0.1060	0.15	0.53	0.00	0.12	0.42
P. Metals	0.0877	**0.01**	0.31	0.00	-0.48	0.98	0.1171	**0.00**	0.08	0.15	-0.80	1.00	0.0565	0.21	0.59	0.00	0.41	0.17
Ewport	0.0785	**0.00**	0.22	0.00	-0.22	0.91	0.0962	**0.00**	0.00	0.47	-0.35	0.99	0.0678	**0.08**	0.43	0.00	0.22	0.27
Panel B: Basis																		
Lowbasis	0.0636	**0.01**	0.24	0.00	-0.15	0.77	0.0824	**0.01**	0.05	0.26	-0.26	0.89	0.0453	**0.16**	0.45	0.00	0.36	0.17
Medbasis	0.1049	**0.00**	0.22	0.00	-0.28	0.93	0.1338	**0.00**	-0.02	0.67	-0.43	0.99	0.0802	**0.07**	0.47	0.00	0.30	0.19
Highbasis	0.1814	**0.00**	0.40	0.00	-0.48	0.90	0.2124	**0.00**	-0.02	0.60	-0.70	0.96	0.1580	**0.08**	0.82	0.00	0.42	0.28
Panel C: Speculation																		
Lowspec	0.1266	**0.00**	0.18	0.00	-0.33	0.96	0.0973	**0.00**	-0.03	0.73	-0.41	0.98	0.1503	**0.00**	0.42	0.00	0.30	0.19
Medspec	0.0759	**0.02**	0.21	0.00	-0.09	0.65	0.1062	**0.02**	-0.05	0.70	-0.13	0.65	0.0450	0.20	0.47	0.00	0.44	0.11
Highspec	0.1096	**0.05**	0.46	0.00	-0.18	0.68	0.1876	**0.01**	0.02	0.45	-0.41	0.82	0.0409	0.35	0.91	0.00	0.81	0.11
Panel D: Mathematical																		
Portmv	-0.0028	0.53	0.21	0.00	-0.01	0.51	0.0006	0.43	0.11	0.08	-0.41	0.94	-0.0181	0.63	0.37	0.00	0.85	0.02
Portcvar	-0.0078	0.59	0.19	0.00	-0.18	0.81	0.0010	0.39	0.08	0.19	-0.44	0.96	-0.0280	0.69	0.34	0.00	0.39	0.16
Portmad	-0.0088	0.60	0.21	0.00	0.02	0.47	0.0008	0.42	0.08	0.15	-0.39	0.92	-0.0328	0.73	0.41	0.00	0.93	0.01
Panel E: Momentum																		
LowL1H1	0.1542	**0.00**	0.23	0.00	-0.60	1.00	0.1432	**0.00**	0.09	0.07	-0.63	0.99	0.1683	**0.00**	0.36	0.00	-0.34	0.82
MedL1H1	0.0527	**0.05**	0.25	0.00	-0.07	0.63	0.0576	**0.05**	0.03	0.27	-0.35	0.93	0.0448	0.19	0.52	0.00	0.80	0.01
HighL1H1	0.0894	**0.07**	0.41	0.00	-0.06	0.56	0.1418	**0.01**	-0.06	0.77	-0.27	0.78	0.0401	0.35	0.91	0.00	1.03	0.08
LowL3H1	0.1190	**0.00**	0.25	0.00	-0.33	0.95	0.1346	**0.00**	0.08	0.11	-0.53	0.99	0.1068	**0.02**	0.44	0.00	0.23	0.26
MedL3H1	0.0600	**0.03**	0.21	0.00	-0.27	0.93	0.0472	**0.07**	0.05	0.11	-0.33	0.97	0.0731	0.11	0.41	0.00	0.09	0.39
HighL3H1	0.1277	**0.02**	0.38	0.00	-0.36	0.83	0.1560	**0.01**	-0.04	0.71	-0.43	0.86	0.1007	0.18	0.82	0.00	0.45	0.27
LowL12H1	0.1202	**0.00**	0.20	0.00	-0.37	0.98	0.1154	**0.00**	-0.02	0.65	-0.48	0.99	0.1290	**0.00**	0.41	0.00	0.13	0.34
MedL12H1	0.0944	**0.04**	0.22	0.00	-0.44	0.93	0.1141	**0.07**	0.02	0.41	-0.35	0.79	0.0703	0.17	0.43	0.00	-0.14	0.61
HighL12H1	0.1252	**0.02**	0.44	0.00	-0.30	0.77	0.1807	**0.01**	0.04	0.34	-0.50	0.88	0.0771	0.24	0.85	0.00	0.56	0.25
Panel F: Term Structure																		
LowTS1_2	0.1544	**0.00**	0.22	0.00	-0.15	0.79	0.1847	**0.00**	0.03	0.28	-0.30	0.93	0.1275	**0.00**	0.41	0.00	0.34	0.15
MedTS1_2	0.1022	**0.00**	0.22	0.00	-0.33	0.96	0.1253	**0.00**	0.00	0.48	-0.39	0.98	0.0827	**0.07**	0.42	0.00	0.08	0.42
HighTS1_2	0.0890	**0.07**	0.41	0.00	-0.49	0.90	0.1059	**0.05**	-0.01	0.53	-0.66	0.95	0.0766	0.23	0.84	0.00	0.40	0.30
LowTS1_3	0.1319	**0.00**	0.20	0.00	-0.23	0.88	0.1665	**0.00**	-0.01	0.55	-0.35	0.96	0.0979	**0.01**	0.40	0.00	0.30	0.20
MedTS1_3	0.0866	**0.00**	0.24	0.00	-0.25	0.89	0.1035	**0.00**	0.07	0.10	-0.40	0.98	0.0733	**0.10**	0.42	0.00	0.22	0.29
HighTS1_3	0.1130	**0.04**	0.43	0.00	-0.37	0.83	0.1203	**0.03**	0.03	0.34	-0.58	0.93	0.1134	0.16	0.84	0.00	0.48	0.26
LowTS1_4	0.1192	**0.00**	0.19	0.00	-0.28	0.92	0.1215	**0.00**	-0.02	0.65	-0.34	0.96	0.1138	**0.01**	0.40	0.00	0.24	0.26
MedTS1_4	0.0833	**0.00**	0.21	0.00	-0.27	0.91	0.1223	**0.00**	0.05	0.22	-0.44	0.98	0.0497	0.18	0.38	0.00	0.16	0.34
HighTS1_4	0.1217	**0.03**	0.45	0.00	-0.31	0.79	0.1489	**0.01**	0.06	0.25	-0.55	0.91	0.1050	0.17	0.86	0.00	0.55	0.22

This table provides the risk-adjusted return performance of the various styles of commodity futures portfolios over the full sample period (January 31, 1986 to October 13, 2013) and two sub-sample periods (January 31, 1986 to December 31, 2000 and January 1, 2001 to October 31, 2013). "Alpha" represents the average annualized risk-adjusted return of the commodity portfolio, "P-val" is the P-value based on two-tailed significance tests for testing the hypothesis of whether the mean return is equal to zero, "stock" is the CRSP value-weighted market index, and "bond" is the Barclays Capital U.S. Aggregate Bond index.

Table 4

Diversification Properties of Commodity Portfolios: US Domestic Buy-and-Hold Reference Portfolio

Portfolios	01/31/1986 to 10/31/2013					Crises Periods				
	BU	Desantis	Ftest	Ftest1	Ftest2	BU	Desantis	Ftest	Ftest1	Ftest2
Panel A: Buy-and-Hold										
Foods & Fibers	**0.00**	**0.00**	**0.00**	**0.05**	**0.00**	0.60	0.52	0.61	0.60	0.39
Grains & Oilseeds	0.13	0.12	0.06	0.28	**0.03**	0.55	0.56	0.64	0.94	0.34
Livestock	**0.00**	**0.00**	**0.00**	**0.05**	**0.00**	0.41	0.40	0.66	0.82	0.37
Energy	0.07	**0.05**	**0.02**	**0.03**	0.08	0.49	0.46	0.37	0.80	0.16
P. Metals	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	0.59	0.59	0.64	0.52	0.49
Ewport	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.76	0.75	0.81	1.00	0.52
Panel B: Basis										
Lowbasis	**0.00**	**0.00**	**0.00**	**0.04**	**0.00**	0.91	0.91	0.92	0.72	0.86
Medbasis	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.90	0.90	0.91	0.94	0.67
Highbasis	**0.04**	**0.02**	**0.00**	**0.00**	0.06	0.98	0.98	0.98	0.86	0.94
Allbasis	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	0.95	0.95	0.93	0.84	0.80
Panel C: Speculation										
Lowspec	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.55	0.51	0.48	0.53	0.30
Medspec	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	0.85	0.84	0.83	0.93	0.54
Highspec	0.22	0.20	0.12	0.08	0.26	0.99	0.99	0.99	0.92	0.96
Allspec	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.41	0.32	0.30	0.63	0.14
Panel D: Mathematical										
Portmv	**0.00**	**0.00**	**0.00**	0.95	**0.00**	0.89	0.90	0.89	0.73	0.74
Portcvar	**0.00**	**0.00**	**0.00**	0.82	**0.00**	0.91	0.90	0.92	0.86	0.70
Portmad	**0.00**	**0.00**	**0.00**	0.80	**0.00**	0.91	0.91	0.89	0.69	0.81
Allmath	**0.00**	**0.00**	**0.00**	0.75	**0.00**	0.25	**0.03**	0.21	0.38	0.15
Panel E: Momentum										
LowL1H1	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.09	0.07	0.14	0.99	**0.05**
MedL1H1	0.08	**0.05**	**0.00**	0.09	**0.00**	0.60	0.60	0.56	0.65	0.33
HighL1H1	0.41	0.38	0.13	0.11	0.21	0.56	0.57	0.72	0.99	0.42
LowL3H1	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.55	0.57	0.62	1.00	0.32
MedL3H1	**0.01**	**0.00**	**0.00**	**0.04**	**0.00**	0.88	0.89	0.85	0.66	0.72
HighL3H1	0.14	0.10	**0.01**	**0.03**	0.06	0.92	0.93	0.95	0.99	0.74
LowL12H1	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.47	0.36	0.31	0.17	0.51
MedL12H1	**0.01**	**0.00**	**0.00**	0.07	**0.00**	0.60	0.59	0.65	0.75	0.37
HighL12H1	0.15	0.13	**0.03**	**0.04**	0.13	0.82	0.82	0.82	0.54	0.89
Allmom	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	0.73	**0.00**
Panel F: Term Structure										
LowTS1_2	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	0.98	0.98	0.99	1.00	0.87
MedTS1_2	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.26	0.27	0.33	0.95	0.13
HighTS1_2	0.07	**0.05**	**0.01**	0.11	**0.01**	0.96	0.96	0.97	0.99	0.81
LowTS1_3	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	1.00	1.00	1.00	0.98	0.96
MedTS1_3	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.59	0.61	0.69	0.97	0.39
HighTS1_3	0.13	0.09	**0.01**	**0.04**	**0.04**	1.00	1.00	1.00	0.98	0.99
LowTS1_4	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.97	0.97	0.98	0.95	0.86
MedTS1_4	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.44	0.44	0.57	0.74	0.31
HighTS1_4	0.13	0.10	**0.02**	**0.03**	0.08	0.98	0.98	0.99	0.92	0.91
AllTS	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.10	**0.03**	0.13	1.00	**0.02**

Table 4 (cont.)

Diversification Properties of Commodity Portfolios: US Domestic Buy-and-Hold Reference Portfolio

	01/31/1986 to 12/31/2000					01/31/2001 to 10/31/2013				
Portfolios	BU	Desantis	Ftest	Ftest1	Ftest2	BU	Desantis	Ftest	Ftest1	Ftest2
Panel A: Buy-and-Hold										
Foods & Fibers	**0.00**	**0.00**	**0.00**	0.17	**0.00**	0.27	0.21	0.26	0.17	0.36
Grains & Oilseeds	0.14	0.09	**0.01**	0.41	**0.00**	0.70	0.70	0.70	0.50	0.60
Livestock	**0.00**	**0.00**	**0.00**	0.20	**0.00**	**0.02**	**0.00**	**0.00**	0.14	**0.00**
Energy	**0.02**	**0.01**	**0.04**	**0.05**	0.11	0.59	0.58	0.54	0.27	0.93
P. Metals	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	0.59	0.59	0.61	0.39	0.63
Ewport	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.39	0.36	0.26	0.11	0.68
Panel B: Basis										
Lowbasis	**0.00**	**0.00**	**0.00**	**0.05**	**0.00**	0.63	0.62	0.57	0.31	0.75
Medbasis	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.35	0.34	0.27	0.11	0.91
Highbasis	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.10	0.10	0.12	0.09	0.25
Allbasis	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.32	0.32	0.20	0.40	0.13
Panel C: Speculation										
Lowspec	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.03**	**0.03**	**0.02**	**0.00**	0.60
Medspec	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	0.64	0.64	0.66	0.36	0.95
Highspec	**0.02**	**0.01**	**0.01**	**0.02**	**0.04**	0.44	0.45	0.44	0.65	0.23
Allspec	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.01**	**0.01**	**0.00**	**0.01**	0.09
Panel D: Mathematical										
Portmv	**0.00**	**0.00**	**0.00**	0.82	**0.00**	0.86	0.87	0.83	0.71	0.63
Portcvar	**0.00**	**0.00**	**0.00**	0.72	**0.00**	0.58	0.58	0.58	0.54	0.40
Portmad	**0.00**	**0.00**	**0.00**	0.77	**0.00**	0.68	0.71	0.63	0.51	0.49
Allmath	**0.00**	**0.00**	**0.00**	0.97	**0.00**	**0.01**	**0.00**	**0.01**	0.32	**0.00**
Panel E: Momentum										
LowL1H1	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.17
MedL1H1	**0.00**	**0.00**	**0.00**	0.10	**0.00**	0.12	0.11	0.24	0.36	0.16
HighL1H1	**0.01**	**0.01**	**0.00**	**0.03**	**0.00**	0.13	0.13	0.19	0.67	0.08
LowL3H1	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.14	0.12	0.11	**0.04**	0.97
MedL3H1	**0.00**	**0.00**	**0.00**	0.16	**0.00**	0.59	0.56	0.29	0.15	0.51
HighL3H1	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	0.29	0.28	0.36	0.30	0.33
LowL12H1	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	0.07	**0.05**	**0.04**	**0.01**	0.86
MedL12H1	**0.01**	**0.00**	**0.01**	0.11	**0.01**	0.47	0.41	0.40	0.33	0.36
HighL12H1	**0.01**	**0.01**	**0.00**	**0.01**	**0.01**	0.31	0.31	0.41	0.42	0.29
Allmom	**0.00**	**0.00**	**0.00**	0.07	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.01**
Panel F: Term Structure										
LowTS1_2	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**	**0.03**	**0.03**	**0.01**	0.74
MedTS1_2	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.32	0.28	0.23	0.11	0.53
HighTS1_2	**0.00**	**0.00**	**0.00**	0.11	**0.00**	0.46	0.46	0.52	0.41	0.42
LowTS1_3	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.14	0.12	0.12	**0.04**	0.89
MedTS1_3	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.46	0.44	0.35	0.16	0.78
HighTS1_3	**0.00**	**0.00**	**0.00**	0.06	**0.00**	0.20	0.20	0.25	0.24	0.24
LowTS1_4	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.09	0.07	0.06	**0.02**	0.85
MedTS1_4	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.33	0.31	0.37	0.29	0.35
HighTS1_4	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	0.19	0.19	0.25	0.25	0.22
AllTS	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**	0.80	0.82	**0.00**	0.07	**0.00**

This table presents the spanning test results using a US domestic buy-and-hold portfolio, which consists of the CRSP value-weighted market index returns and the Barclays Capital U.S. Aggregate Bond Index returns, as the benchmark asset. Results are calculated over the full sample period (January 31, 1986 to October 13, 2013) and two sub-sample periods (January 31, 1986 to December 31, 2000 and January 1, 2001 to October 31, 2013). The null hypothesis of all tests is spanning; that is, adding a portfolio of commodity futures to the benchmark assets provides no diversification benefits. The DeSantis (1995) spanning test is denoted "DeSantis," the spanning test of Bekaert and Urias (1996) is denoted "BU," the traditional spanning test of Huberman and Kandel (1987) is denoted as "Ftest,"and for the spanning test of Kan and Zhou (2012), we denote the test of $\alpha = 0_{n_2}$ as "Ftest1" and the test of whether $\delta = 0_{n_2}$ given that $\alpha = 0_{n_2}$ as "Ftest2." Each column provides the P-values of the respective spanning test from adding the portfolio of commodity futures, in the respective row, to the benchmark portfolio.

Table 5

Diversification Properties of Commodity Portfolios: US Domestic Actively Managed Reference Portfolio

	01/31/1986 to 10/31/2013					01/31/1986 to 12/31/2000					01/31/2001 to 10/31/2013				
Portfolios	BU	Desantis	Ftest	Ftest1	Ftest2	BU	Desantis	Ftest	Ftest1	Ftest2	BU	Desantis	Ftest	Ftest1	Ftest2
Panel A: Buy-and-Hold															
Foods & Fibers	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.06	0.00
Grains & Oilseeds	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.47	0.00	0.01	0.00	0.00	0.07	0.00
Livestock	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.28	0.00
Energy	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.04	0.00	0.18	0.12	0.07	0.12	0.10
P. Metals	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.05	0.00	0.01	0.00	0.00	0.06	0.00
Ewport	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Panel B: Basis															
Lowbasis	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.03	0.00
Medbasis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Highbasis	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.05	0.03	0.01	0.63
Allbasis	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Panel C: Speculation															
Lowspec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Medspec	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.07	0.00
Highspec	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.03	0.00	0.17	0.17	0.20	0.12	0.39
Allspec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Panel D: Mathematical															
Portmv	0.00	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.42	0.00
Portcvar	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.98	0.00
Portmad	0.00	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.57	0.00
Allmath	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.14	0.00
Panel E: Momentum															
LowL1H1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
MedL1H1	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.07	0.00	0.20	0.06	0.00	0.02	0.00
HighL1H1	0.01	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.01	0.00	0.27	0.27	0.20	0.08	0.69
LowL3H1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
MedL3H1	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.06	0.00	0.05	0.00	0.00	0.05	0.00
HighL3H1	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.01	0.00	0.20	0.19	0.13	0.05	0.61
LowL12H1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
MedL12H1	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.30	0.00	0.01	0.00	0.00	0.20	0.00
HighL12H1	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.02	0.00	0.19	0.18	0.12	0.05	0.62
Allmom	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.02	0.00
Panel F: Term Structure															
LowTS1_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MedTS1_2	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
HighTS1_2	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.14	0.00	0.29	0.28	0.22	0.09	0.63
LowTS1_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MedTS1_3	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00
HighTS1_3	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.09	0.00	0.14	0.13	0.07	0.03	0.59
LowTS1_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
MedTS1_4	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00
HighTS1_4	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.05	0.00	0.14	0.13	0.10	0.03	0.70
AllTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

This table presents the spanning test results using a US domestic actively managed portfolio, which consists of returns on six US equity portfolios formed on the Fama-French monthly size and momentum factors, as the benchmark asset. Results are calculated over the full sample period (January 31, 1986 to October 13, 2013) and two sub-sample periods (January 31, 1986 to December 31, 2000 and January 1, 2001 to October 31, 2013). The null hypothesis of all tests is spanning; that is, adding a portfolio of commodity futures to the benchmark assets provides no diversification benefits. The DeSantis (1995) spanning test is denoted "DeSantis," the spanning test of Bekaert and Urias (1996) is denoted "BU," the traditional spanning test of Huberman and Kandel (1987) is denoted as "Ftest,"and for the spanning test of Kan and Zhou (2012), we denote the test of $\alpha = 0_{n_2}$ as "Ftest1" and the test of whether $\delta = 0_{n_2}$ given that $\alpha = 0_{n_2}$ as "Ftest2." Each column provides the P-values of the respective spanning test from adding the portfolio of commodity futures, in the respective row, to the benchmark portfolio.

Table 6

Diversification Properties of Commodity Portfolios: International Buy-and-Hold Reference Portfolio

	01/31/1986 to 10/31/2013					01/31/1986 to 12/31/2000					01/31/2001 to 10/31/2013				
Portfolios	BU	Desantis	Ftest	Ftest1	Ftest2	BU	Desantis	Ftest	Ftest1	Ftest2	BU	Desantis	Ftest	Ftest1	Ftest2
Panel A: Buy-and-Hold															
Foods & Fibers	0.05	0.06	0.02	0.08	0.03	0.00	0.00	0.00	0.28	0.00	0.26	0.26	0.28	0.12	0.80
Grains & Oilseeds	0.01	0.02	0.00	0.16	0.00	0.00	0.00	0.00	0.18	0.00	0.40	0.37	0.38	0.30	0.35
Livestock	0.00	0.00	0.00	0.08	0.00	0.01	0.02	0.03	0.15	0.03	0.01	0.01	0.01	0.22	0.01
Energy	0.04	0.04	0.04	0.02	0.28	0.05	0.05	0.10	0.05	0.37	0.01	0.01	0.01	0.07	0.02
P. Metals	0.05	0.05	0.04	0.02	0.25	0.03	0.03	0.04	0.01	0.60	0.24	0.23	0.18	0.20	0.19
Ewport	0.01	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.07	0.02	0.81
Panel B: Basis															
Lowbasis	0.01	0.01	0.00	0.05	0.00	0.00	0.00	0.00	0.05	0.00	0.33	0.31	0.33	0.18	0.51
Medbasis	0.01	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04
Highbasis	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.01	0.02
Allbasis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.07	0.01
Panel C: Speculation															
Lowspec	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.89
Medspec	0.02	0.02	0.01	0.01	0.28	0.00	0.00	0.00	0.01	0.03	0.20	0.19	0.25	0.14	0.46
Highspec	0.04	0.04	0.05	0.03	0.25	0.01	0.01	0.01	0.01	0.26	0.04	0.04	0.02	0.33	0.01
Allspec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Panel D: Mathematical															
Portmv	0.38	0.41	0.34	0.67	0.16	0.00	0.01	0.01	0.77	0.00	0.85	0.85	0.85	0.62	0.79
Portcvar	0.13	0.17	0.14	0.85	0.05	0.00	0.01	0.00	0.82	0.00	0.97	0.97	0.96	0.83	0.88
Portmad	0.36	0.40	0.31	0.80	0.13	0.01	0.02	0.02	0.73	0.01	0.98	0.98	0.98	0.86	1.00
Allmath	0.16	0.21	0.21	0.38	0.16	0.02	0.09	0.07	0.98	0.01	0.34	0.30	0.19	0.14	0.38
Panel E: Momentum															
LowL1H1	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.05	0.01	0.01	0.01	0.00	0.58
MedL1H1	0.14	0.14	0.03	0.02	0.29	0.00	0.00	0.00	0.10	0.00	0.02	0.02	0.04	0.02	0.26
HighL1H1	0.06	0.06	0.07	0.03	0.41	0.01	0.01	0.00	0.01	0.06	0.02	0.02	0.04	0.17	0.03
LowL3H1	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.05	0.02	0.44
MedL3H1	0.14	0.15	0.01	0.05	0.02	0.00	0.00	0.00	0.12	0.00	0.25	0.25	0.17	0.06	0.82
HighL3H1	0.02	0.02	0.02	0.01	0.17	0.03	0.02	0.01	0.00	0.30	0.00	0.00	0.02	0.07	0.03
LowL12H1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.43
MedL12H1	0.03	0.04	0.01	0.11	0.01	0.05	0.05	0.02	0.22	0.01	0.40	0.39	0.37	0.45	0.23
HighL12H1	0.01	0.00	0.01	0.01	0.04	0.01	0.01	0.01	0.00	0.97	0.01	0.01	0.02	0.14	0.02
Allmom	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.03	0.00
Panel F: Term Structure															
LowTS1_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.53
MedTS1_2	0.02	0.01	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.03	0.03	0.12
HighTS1_2	0.04	0.03	0.03	0.09	0.04	0.14	0.14	0.19	0.07	0.80	0.02	0.02	0.03	0.15	0.03
LowTS1_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.03	0.01	0.39
MedTS1_3	0.03	0.03	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.05	0.04	0.19
HighTS1_3	0.01	0.00	0.01	0.02	0.03	0.05	0.05	0.08	0.02	0.99	0.01	0.01	0.01	0.05	0.02
LowTS1_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.02	0.00	0.65
MedTS1_4	0.02	0.02	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.49	0.49	0.48	0.23	0.89
HighTS1_4	0.01	0.01	0.01	0.01	0.04	0.03	0.03	0.04	0.01	0.85	0.02	0.02	0.03	0.07	0.05
AllTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.00	0.01	0.03

This table presents the spanning test results using an international buy-and-hold portfolio, which consists of returns on seven developed nation's equity indices and the Barclays Capital U.S. Aggregate Bond Index returns, as the benchmark asset. These nations include: Australia, Canada, France, Germany, Japan, the UK, and the US. Results are calculated over the full sample period (January 31, 1986 to October 13, 2013) and two sub-sample periods (January 31, 1986 to December 31, 2000 and January 1, 2001 to October 31, 2013). The null hypothesis of all tests is spanning; that is, adding a portfolio of commodity futures to the benchmark assets provides no diversification benefits. The DeSantis (1995) spanning test is denoted "DeSantis," the spanning test of Bekaert and Urias (1996) is denoted "BU," the traditional spanning test of Huberman and Kandel (1987) is denoted as "Ftest,"and for the spanning test of Kan and Zhou (2012), we denote the test of $\alpha = 0_{n_2}$ as "Ftest1" and the test of whether $\delta = 0_{n_2}$ given that $\alpha = 0_{n_2}$ as "Ftest2." Each column provides the P-values of the respective spanning test from adding the portfolio of commodity futures, in the respective row, to the benchmark portfolio.

Table 7

Diversification Properties of Commodity Portfolios: International Actively Managed Reference Portfolio

Portfolios	01/31/1986 to 10/31/2013					01/31/1986 to 12/31/2000					01/31/2001 to 10/31/2013				
	BU	Desantis	Ftest	Ftest1	Ftest2	BU	Desantis	Ftest	Ftest1	Ftest2	BU	Desantis	Ftest	Ftest1	Ftest2
Panel A: Buy-and-Hold															
Foods & Fibers	**0.00**	**0.00**	**0.00**	0.24	**0.00**	**0.00**	**0.00**	**0.00**	0.32	**0.00**	**0.00**	**0.00**	**0.00**	0.37	**0.00**
Grains & Oilseeds	**0.00**	**0.00**	**0.00**	0.54	**0.00**	**0.00**	**0.00**	**0.00**	0.65	**0.00**	**0.01**	**0.00**	**0.01**	0.29	**0.00**
Livestock	**0.00**	**0.00**	**0.00**	0.16	**0.00**	**0.00**	**0.00**	**0.00**	0.52	**0.00**	**0.00**	**0.00**	**0.00**	0.21	**0.00**
Energy	0.20	0.15	0.13	0.67	**0.05**	**0.05**	**0.04**	0.16	0.56	0.07	0.62	0.57	0.50	0.48	0.34
P. Metals	**0.00**	**0.00**	**0.00**	0.29	**0.00**	**0.00**	**0.00**	**0.00**	0.16	**0.00**	**0.01**	**0.00**	**0.00**	0.48	**0.00**
Ewport	**0.00**	**0.00**	**0.00**	0.16	**0.00**	**0.00**	**0.00**	**0.00**	0.12	**0.00**	**0.00**	**0.00**	**0.00**	0.14	**0.00**
Panel B: Basis															
Lowbasis	**0.00**	**0.00**	**0.00**	0.09	**0.00**	**0.00**	**0.00**	**0.00**	0.14	**0.00**	**0.00**	**0.00**	**0.00**	0.12	**0.00**
Medbasis	**0.00**	**0.00**	**0.00**	0.17	**0.00**	**0.00**	**0.00**	**0.00**	0.07	**0.00**	**0.02**	**0.00**	**0.00**	0.19	**0.00**
Highbasis	0.61	0.60	0.46	0.27	0.56	**0.01**	**0.00**	**0.00**	0.22	**0.00**	0.44	0.44	0.44	0.21	0.81
Allbasis	**0.00**	**0.00**	**0.00**	0.34	**0.00**	**0.00**	**0.00**	**0.00**	0.22	**0.00**	**0.00**	**0.00**	**0.00**	0.45	**0.00**
Panel C: Speculation															
Lowspec	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	0.15	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Medspec	**0.00**	**0.00**	**0.00**	0.20	**0.00**	**0.00**	**0.00**	**0.00**	0.33	**0.00**	**0.00**	**0.00**	**0.00**	0.13	**0.00**
Highspec	0.25	0.23	0.11	0.39	**0.05**	**0.00**	**0.00**	**0.00**	0.19	**0.00**	0.65	0.65	0.64	0.36	0.82
Allspec	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**	0.34	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**
Panel D: Mathematical															
Portmv	**0.00**	**0.00**	**0.00**	0.63	**0.00**	**0.00**	**0.00**	**0.00**	0.78	**0.00**	**0.00**	**0.00**	**0.00**	0.80	**0.00**
Portcvar	**0.00**	**0.00**	**0.00**	0.47	**0.00**	**0.00**	**0.00**	**0.00**	0.93	**0.00**	**0.00**	**0.00**	**0.00**	0.48	**0.00**
Portmad	**0.00**	**0.00**	**0.00**	0.51	**0.00**	**0.00**	**0.00**	**0.00**	0.76	**0.00**	**0.00**	**0.00**	**0.00**	0.66	**0.00**
Allmath	**0.00**	**0.00**	**0.00**	0.63	**0.00**	**0.00**	**0.00**	**0.00**	0.77	**0.00**	**0.01**	**0.00**	**0.00**	0.49	**0.00**
Panel E: Momentum															
LowL1H1	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.07	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**
MedL1H1	**0.01**	**0.00**	**0.00**	0.29	**0.00**	**0.00**	**0.00**	**0.00**	0.25	**0.00**	0.29	0.14	**0.01**	0.22	**0.00**
HighL1H1	0.64	0.61	0.36	0.79	0.16	**0.00**	**0.00**	**0.00**	0.33	**0.00**	0.85	0.85	0.86	0.61	0.87
LowL3H1	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	0.04	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**
MedL3H1	**0.00**	**0.00**	**0.00**	0.69	**0.00**	**0.00**	**0.00**	**0.00**	0.81	**0.00**	**0.03**	**0.00**	**0.00**	0.34	**0.00**
HighL3H1	0.87	0.86	0.72	0.69	0.48	**0.00**	**0.00**	**0.00**	0.44	**0.00**	0.73	0.73	0.76	0.48	0.81
LowL12H1	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	0.26	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**
MedL12H1	**0.00**	**0.00**	**0.00**	0.78	**0.00**	**0.00**	**0.00**	**0.00**	0.62	**0.00**	**0.01**	**0.00**	**0.00**	0.49	**0.00**
HighL12H1	0.75	0.74	0.57	0.52	0.39	**0.00**	**0.00**	**0.00**	0.14	**0.00**	0.83	0.82	0.78	0.50	0.87
Allmom	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	0.33	**0.00**	**0.00**	**0.00**	**0.00**	0.06	**0.00**
Panel F: Term Structure															
LowTS1_2	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
MedTS1_2	**0.00**	**0.00**	**0.00**	0.12	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	0.16	**0.00**
HighTS1_2	0.67	0.66	0.58	0.82	0.30	**0.00**	**0.00**	**0.00**	0.95	**0.00**	0.88	0.88	0.89	0.68	0.80
LowTS1_3	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**
MedTS1_3	**0.00**	**0.00**	**0.00**	0.28	**0.00**	**0.00**	**0.00**	**0.00**	0.24	**0.00**	**0.00**	**0.00**	**0.00**	0.23	**0.00**
HighTS1_3	0.91	0.91	0.83	0.87	0.56	**0.00**	**0.00**	**0.00**	0.85	**0.00**	0.67	0.67	0.69	0.44	0.71
LowTS1_4	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.04**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**
MedTS1_4	**0.00**	**0.00**	**0.00**	0.42	**0.00**	**0.00**	**0.00**	**0.00**	0.13	**0.00**	**0.00**	**0.00**	**0.00**	0.57	**0.00**
HighTS1_4	0.95	0.95	0.90	0.79	0.69	**0.02**	**0.01**	**0.01**	0.66	**0.00**	0.67	0.67	0.70	0.46	0.67
AllTS	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**

This table presents the spanning test results using an international actively managed portfolio, which consists of returns on six international equity portfolios formed on the Fama-French monthly size and momentum factors from 23 developed nation's equity indices, as the benchmark asset. The nations include: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Switzerland, Sweden, the UK, and the US. Results are calculated over the full sample period (January 31, 1986 to October 13, 2013) and two sub-sample periods (January 31, 1986 to December 31, 2000 and January 1, 2001 to October 31, 2013). The null hypothesis of all tests is spanning; that is, adding a portfolio of commodity futures to the benchmark assets provides no diversification benefits. The DeSantis (1995) spanning test is denoted "DeSantis," the spanning test of Bekaert and Urias (1996) is denoted "BU," the traditional spanning test of Huberman and Kandel (1987) is denoted as "Ftest,"and for the spanning test of Kan and Zhou (2012), we denote the test of $\alpha = 0_{n_2}$ as "Ftest1" and the test of whether $\delta = 0_{n_2}$ given that $\alpha = 0_{n_2}$ as "Ftest2." Each column provides the P-values of the respective spanning test from adding the portfolio of commodity futures, in the respective row, to the benchmark portfolio.