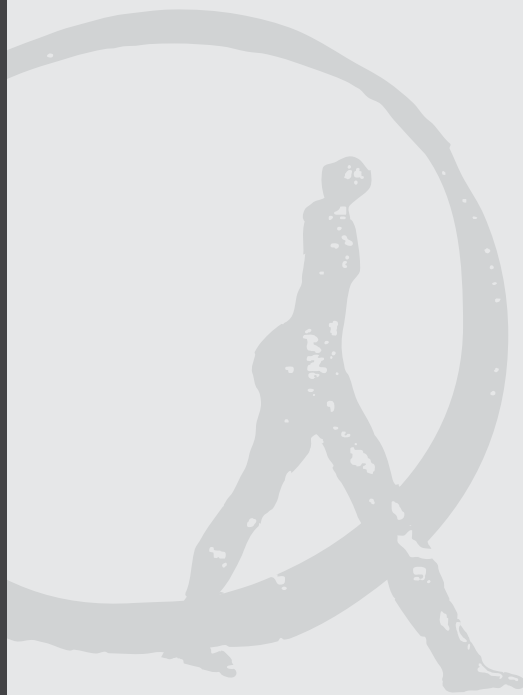


# Capturing the Risk Premium of Commodity Futures: The Role of Hedging Pressure

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## Abstract

We construct factor-mimicking portfolios that capture the hedging-pressure-based risk premium of commodity futures. We consider single sorts based on the open interests of either hedgers or speculators, as well as double sorts based on both positions. We find strong evidence for a risk premium arising from the combination of the two positions. Further tests show that the hedging-pressure-based risk premium rises with the lagged volatility of commodity markets and that the cross-sectional price of commodity risk is positive. Our risk premium is also found to explain part of the performance of active portfolios based on momentum and/or term structure.

Keywords: Commodity, Risk premium, Hedging pressure, Hedgers, Speculators

JEL classification: G13, G14

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EDHEC pursues an active research policy in the field of finance. EDHEC-Risk Institute carries out numerous research programmes in the areas of asset allocation and risk management in both the traditional and alternative investment universes.

While commodity futures have moved into the investment mainstream only over the last decade,<sup>1</sup> the academic debate over the existence and source of a commodity futures risk premium has been intense ever since the 1930s. The first hypothesis for the source of a commodity futures risk premium was the risk transfer or hedging pressure hypothesis of Keynes (1930) and Hicks (1939), where the risk premium accrued to speculators as a reward for accepting the price risk which hedgers sought to transfer. This theory was extended by several authors culminating in the equilibrium-based generalized hedging pressure hypothesis of Hirshleifer (1989), (1990), where due to non-participation effects<sup>2</sup> hedging pressure influences the risk premium of commodity futures. The theories of Working (1949) and Brennan (1958) relate the variation in futures prices to issues of storage and inventories rather than issues of risk transfer. More recently, Routledge, Seppi and Spatt (2000) show that time-varying convenience yields can arise in the presence of risk-neutral agents from the presence of an embedded timing option,<sup>3</sup> while Gorton, Hayashi and Rouwenhorst (2008) model the risk premium present in commodity futures markets as a function of inventory levels.

The early empirical tests of the hedging pressure hypothesis focused on the role of own commodity hedging pressure<sup>4</sup> as a determinant of either futures prices (Houthakker (1957), Cootner (1960), Chang (1985), Bessembinder (1992)) or the CAPM risk premium (Dusak (1973), Carter, Rausser and Schmitz (1983)). More recently, studies have begun to focus on the role of hedging pressure as a systematic factor. De Roon, Nijman and Veld (2000) find cross-commodity hedging pressure effects for individual commodity futures risk premiums, as suggested in Anderson and Danthine (1981). Acharya, Lochstoer and Ramadorai (2010) show that systematic hedging pressure effects can arise in the context of limits on the risk-taking capacity of speculators.<sup>5</sup>

In this paper we construct factor-mimicking portfolios in order to examine the systematic effects of hedging pressure on the risk premium of commodity futures. We sort our cross section of up to 28 commodity futures on the contract's hedging pressure and go long the backwarddated commodities and short the contangoed commodities. To assign a commodity to either the backwarddated or contangoed portfolio, we use one of the following three sorts: the first sort is based *solely* on commercial (or hedgers') hedging pressure,<sup>6</sup> the second sort is based *solely* on non-commercial (or speculators') hedging pressure<sup>7</sup> and the third sort is based on *both* commercial and non-commercial hedging pressures. The motivation for the two single-sorts comes from the fact that the hedging pressure hypothesis implies two separate sub-hypotheses (Chang (1985)): the first one relates to naïve speculators who earn a risk premium by simply taking positions that are opposite to those of hedgers and the second one relates to informed speculators who earn a risk premium as a compensation for accurately pricing risk and forecasting returns.<sup>8</sup> Evidence that the hedger-based risk premium and the speculator-based risk premiums are positive will support Chang (1985) sub-hypotheses. The double sort tests whether combining commercial hedging pressure and non-commercial hedging pressure does a better job capturing the risk premium than taking the positions of either hedgers or speculators in isolation.

As the hedging pressure hypothesis does not specify investment horizon, we consider different ranking and holding periods for our hedging pressure-based portfolios ranging from 4 weeks to 52 weeks. These permutations lead to 32 single-sort and 32 double-sort risk premiums. All in all, the conclusions provide support for Hirshleifer's (1989) and Chang's (1985) hypotheses. If we follow the positions of hedgers, the commodity risk premium averages out to 7.8% a year. By contrast, and over the same period, a long-only equally-weighted portfolio of commodity futures earns only 0.24% a year. These results provide support for the first sub-hypothesis in

1 - Institutional investing in commodity futures increased from \$18 billion in 2003 to \$250 billion in 2010 according to a recent survey of over 250 institutional investors by Barclays Capital.

2 - The non-participation effects arise from the inability (due to high set-up costs) of small investors to respond to the risk transfer demands of hedgers. This leads to persistence of downward or upward biases in futures prices.

3 - Starting with Cootner (1967), there have been several attempts to connect the theory of storage to the hedging pressure hypothesis. More recently, Dinceler, Khokher and Titman (2003) try to link commodity futures risk premiums to storage, while Khan, Khokher and Simin (2008) study how commodity futures risk premiums vary with scarcity.

4 - Defined as the percentage of market participants (either hedgers or speculators) who are net long.

5 - In addition, two recent papers (Hong and Yogo (2010), Tang and Xiong (2010)) suggest the presence of systematic factors in the cross section of commodity futures prices driven by the arrival of financial investors in these markets.

6 - Commercial hedging pressure is calculated as the percentage of large commercial hedgers (as defined by the CFTC) who are net long at any point in time.

7 - Non-commercial hedging pressure is calculated as the percentage of large non-commercial traders or large speculators (as defined by the CFTC) who are net long at any point in time.

8 - This sub-hypothesis is also consistent with the analysis of Working (1958), in which speculators play a more prominent role by identifying profit opportunities and initiating trades with hedgers.

that a naïve speculator meeting hedging demand earns a positive mean return over the period 1992-2010. If instead we follow the positions of speculators, the commodity risk premium averages out to 10.2% a year. Thus the evidence for a speculator-based risk premium is somewhat stronger, consistent with the theoretical analysis of Working (1958) and the empirical findings of Houthakker (1957) and Chang (1985). This indicates that speculators are capable of capturing sources of risk other than hedger-based price risk.<sup>9</sup>

Finally, using a variant of Fama and French (1993) methodology, we combine the positions of hedgers and speculators in a double-sort. We find that sorting on, first, hedgers' and, second, speculators' positions yield the best results with an average risk premium at 10.6%. The portfolio with the highest risk premium earns 16.1% a year (with an associated *t*-statistic at 2.92) and is obtained when the ranking period is set to 26 weeks and the holding period to 4 weeks. Thus combining commercial and non-commercial hedging pressure appears to provide the best method of capturing the risk premium. It is interesting to note that, regardless of the sorting method used and of the ranking and holding periods, the hedging-pressure-based risk premiums are higher than the mean return of a long-only equally weighted portfolio of commodity futures. The average outperformance stands at 8.74% a year with a range from 2.98% to 15.83%.

Further to this main contribution, we also report a set of four results. First, we find a positive relationship between our hedging-pressure-based risk premiums and the lagged conditional volatility of an equally weighted portfolio of commodities. This result is consistent with the hedging pressure hypothesis, as speculators are deemed to demand, and hedgers should be willing to pay, a higher risk premium when the risk of commodity futures markets rises. Second, the cross-sectional price of commodity risk associated with the hedging-pressure-based risk premium is found to be positive and often significant, while the price of risk of a long-only equally-weighted portfolio of commodities is zero, both statistically and economically. Third, the time-varying risk premiums based on hedging pressure are found to be better suited for risk diversification than long-only positions in commodities. However, the incremental mean returns and the added diversification benefits of the hedging-pressure-based benchmarks come at the cost of losing the inflation hedge that is naturally provided by commodities (Bodie and Rosansky (1980), Bodie (1983)). Fourth, our hedging-pressure-based risk premiums are found to be better suited than long-only portfolios to explaining the outperformance of active strategies in commodity futures markets.

To summarize, our results suggest that it is essential to use the information contained in the positions of hedgers and speculators if we are to properly model the time-series and cross-sectional properties of the risk premiums present in commodity futures markets. A failure to account for hedging pressure results in the misleading conclusion that there is no risk premium or risk transfer in commodity futures markets and in the mistaken impression that active commodity strategies perform remarkably well. For these reasons we suggest that our hedging-pressure-based benchmark be used as a building block for strategic asset allocation. It could also become a useful tool to appraise the performance of tactical asset allocation strategies in commodity futures markets.

The rest of the paper is organized as follows: Section I presents the data. Section II highlights the methodology used to capture the hedging pressure-based risk premium and looks at its time-series properties. Section III studies the cross-sectional pricing of the risk premium and Section IV its role for strategic asset allocation (namely, its diversification properties and role as an inflation hedge). Section V tests the ability of the hedging-pressure-based time-varying risk premium to explain the performance of active strategies commonly implemented in commodity markets and Section VI concludes.

## I. Data

We use the Friday settlement prices of 28 commodity futures as obtained from Datastream. The cross section is chosen based on the availability of hedgers' and speculators' positions in the CFTC Commitment of Traders Report. It includes 12 agricultural commodities (cocoa, coffee C, corn, cotton n°2, oats, frozen concentrated orange juice, rough rice, soybean meal, soybean oil, soybeans, sugar n°11, wheat), 5 energy commodities (electricity, heating oil n°2, light sweet crude oil, natural gas, unleaded gasoline), 4 livestock commodities (feeder cattle, frozen pork bellies, lean hogs, live cattle), 5 metal commodities (copper, gold, palladium, platinum, silver), milk and random length lumber. The positions of hedgers and speculators are collected every Tuesday and made available to the public the following Friday. The hedging pressure data are available at a weekly frequency as of September 30, 1992, which marks the beginning of our dataset. The dataset ends January 8, 2010.

Futures returns are calculated as follows. We collect the futures prices on all nearest and second nearest contracts. We hold the nearest contract up to one month before maturity. At the end of that month, we roll our position over to the second nearest contract and hold that contract up to one month prior to maturity. The procedure is then rolled forward to the next set of nearest and second nearest contracts when a new sequence of futures returns is compiled. Futures returns are then measured as the difference in the logarithms of the prices.

The CFTC classifies traders based on the size of their positions into reportable and non-reportable traders. Reportable traders constitute 70 to 90% of the open interest in any given futures markets<sup>10</sup> and are further classified as commercial or non-commercial traders. A trader's reported futures position is determined to be commercial if the position is deemed to be used for hedging purposes as defined by CFTC regulations. According to CFTC Form 40, this requires that the trader be "engaged in business activities hedged by the use of the futures and option markets." A reportable trader's futures position is otherwise determined to be non-commercial.

Hedging pressure for a category (say, speculators) is defined as the number of long contracts in that category divided by the total number of contracts in the category. For example, hedging pressure of 0.3 for hedgers means that over the previous week 30% of hedgers were long and thus 70% were short, a sign of a backwardated market. Conversely, hedging pressure of 0.3 for speculators means that over the previous week 30% of speculators were long and 70% were short, a sign of a market in contango.

## II. Time-Series Properties of the Commodity Futures Risk Premium

### II A. Methodology

Backwardation occurs when commodity producers are more prone to hedge than commodity consumers and processors. The then net short positions of hedgers lead to the intervention of net long speculators and thus to the rising price pattern typically associated with backwardation. Contango arises when consumers and processors of a commodity outnumber producers. The then net long positions of hedgers lead to the intervention of net short speculators and to the falling price pattern typically linked to contango.

The method we use attempts to capture the risk premium predicted by the hedging pressure theory of Cootner (1960) and Hirshleifer (1990). As the theory assumes that risk premiums are present in both backwardated and contangoed markets, the approach does not consist only of buying commodity futures when hedgers were previously net short or/and speculators were previously net long (backwardated markets). It also shorts commodity futures when hedgers were previously net long or/and speculators were previously net short (contangoed markets).

10 - The remaining percentages cover the positions of non-reportable traders; they are not considered in this study since they cannot be identified as hedgers or speculators.

Using as many commodities as possible, we first sort commodities based on the average hedging pressure of hedgers and speculators over a ranking period of  $R$  weeks.<sup>11</sup> For the hedger-based portfolio, we go long the 15% of the cross section with the lowest hedgers' hedging pressure, as this sort corresponds to backwardation, and short the 15% of the cross section with the highest hedgers' hedging pressure, as this sort corresponds to contango. The resulting long-short portfolio is labeled  $L_{Hedg} - H_{Hedg}$ , where  $L_{Hedg}$  and  $H_{Hedg}$  refer to the portfolios with low and high hedgers' hedging pressure respectively. Vice-versa, the speculator-based portfolio goes long the 15% of the cross section with the highest speculators' hedging pressure (backwardation) and shorts the 15% of the cross section with the lowest speculators' hedging pressure (contango). Similarly, the resulting long-short portfolio is labeled  $H_{Spec} - L_{Spec}$ . The constituents of the long-short portfolios are equally weighted and held over a period of  $H$  weeks. At the end of the  $H$ -week period, the iterative procedure is implemented again to form two new  $L_{Hedg} - H_{Hedg}$  and  $H_{Spec} - L_{Spec}$  portfolios. This recursive approach yields a time series of 897 weekly observations that measure the time-varying price of risk present in commodity futures markets.

While these single-sort portfolios give *prime facie* evidence of the possible existence of a risk premium, there might be some benefit from using the positions of hedgers and speculators jointly, as opposed to separately. With this in mind, we employ a methodology to construct mimicking portfolios for hedging pressure that is an extension of that proposed in Fama and French (1993) to form size and book-to-market-value sorted portfolios. The double-sort methodology is as follows. We first use the 50% breakpoint to split the universe of commodity futures into two portfolios based on the average hedging pressure of hedgers over a ranking period of  $R$  weeks. As before, the resulting portfolios with the highest and lowest hedgers' hedging pressure are labeled  $H_{Hedg}$  and  $L_{Hedg}$ . We also split the universe of commodity futures into three portfolios based on the average hedging pressure of speculators over the same previous  $R$  weeks. The following breakpoints are used: 30% for the portfolio with the lowest speculators' hedging pressure ( $L_{Spec}$ ), 40% for the portfolio with medium speculators' hedging pressure ( $M_{Spec}$ ) and 30% for the portfolio with the highest speculators' hedging pressure ( $H_{Spec}$ ).

We then form two portfolios ( $L_{Hedg}H_{Spec}$  and  $H_{Hedg}L_{Spec}$ ) from the intersection of the two hedger-based and three speculator-based portfolios. For example,  $L_{Hedg}H_{Spec}$  contains, out of the 50% of commodity futures with the lowest hedgers' hedging pressure, the 30% of contracts with the highest speculators' hedging pressure. Clearly,  $L_{Hedg}H_{Spec}$  is made of backwardated contracts and should earn a positive mean return if the normal backwardation theory of Keynes (1930) is valid. Similarly,  $H_{Hedg}L_{Spec}$  contains, out of the 50% of commodity futures with the highest hedgers' hedging pressure, the 30% of contracts with the lowest speculators' hedging pressure. Clearly,  $H_{Hedg}L_{Spec}$  is made of contangoed contracts and should earn a negative mean return if the contango theory of Cootner (1960) is valid. As before for the single-sort portfolios, the constituents of the double-sort portfolios are equally weighted. The return of the hedging-pressure-mimicking portfolio in each of the subsequent  $H$  weeks is defined as the difference in returns between  $L_{Hedg}H_{Spec}$  and  $H_{Hedg}L_{Spec}$ . At the end of the  $H$ -week period, the iterative procedure is implemented again to generate new returns for  $L_{Hedg}H_{Spec}$ ,  $H_{Hedg}L_{Spec}$  and  $L_{Hedg}H_{Spec} - H_{Hedg}L_{Spec}$ . Since it was arbitrary to sort, first, on hedgers' hedging pressure and, second, on speculators' hedging pressure, we reverse the sorting order and also generate a commodity futures risk premium that goes long  $H_{Spec}L_{Hedg}$  and short  $L_{Spec}H_{Hedg}$ .

Two things are important. First, when it comes to setting  $R$  and  $H$ , the backwardation and contango theories do not help us, so we analyze any combination of ranking and holding periods of 4, 13, 26 and 52 weeks.<sup>12</sup> These permutations result in a total of 16 risk premiums in commodity futures markets for each of the single-sort and each of the double-sort portfolios. Second, in line with Fama and French (1993), the single- and double-sort portfolios contain 30% of the cross section available at the time of portfolio formation, taking long positions in the 15% most

11 - Because of our limited cross section (of up to 28 commodities), we do not limit ourselves to the commodities with exactly  $R$  observations in the ranking period. We include all the commodities with up to  $R$  weeks of observations. This is to ensure that our portfolios are sufficiently diversified.

12 - The choice of holding periods that exceed the standard one-month horizon is further motivated by recent research on long-term equity pricing (Bandi, Garcia, Lioui and Perron (2009)).

backwardated commodities and short positions in the 15% most contangoed commodities.<sup>13</sup> By contrast, Standard and Poor's Goldman Sachs Commodity Index (S&P-GSCI), like all first-generation indices, takes long positions on the whole of the cross section.

## II. B. Empirical Results

Tables I and II present summary statistics for the returns of the backwardated, contangoed and long-short portfolios. More specifically, Table I summarizes the results when either the hedging pressure of hedgers (in Panel A) or the hedging pressure of speculators (in Panel B) is used as sorting criterion for asset allocation. Table II reports the same information for the double-sort portfolios which combine the two signals. The risk premiums measured from the positions of hedgers in Table I, Panel A, are positive with a mean at 7.82% a year and a range from 3.22% (R=52, H=26) to 13.33% (R=4, H=26). 18.75% (31.25%) of the 16 hedger-based risk premiums are significant at the 5% (10%) level. The risk premiums measured from the positions of speculators in Table I, Panel B, are also positive with a mean at 10.23% a year and a range from 4.66% (R=26, H=52) to 14.44% (R=26, H=4). 43.75% (68.75%) of the 16 speculator-based risk premiums are significant at the 5% (10%) level. In both tables, the backwardated portfolios earn positive (albeit insignificant) mean returns (with an average mean return at 5.18% in Panel A and 4.59% in Panel B) and the contangoed portfolios earn negative (albeit insignificant) mean returns (with an average mean return at -2.64% in Panel A and -5.64% in Panel B).

Table I: Single-Sort Risk Premium Based on either the Positions of Hedgers or the Positions of Speculators

The table presents summary statistics for the backwardated, contangoed and long-short risk premium based on either the positions of hedgers (Panel A) or the positions of speculators (Panel B). R (H) is the number of weeks in the ranking (holding) period. The means and standard deviations (SD) are annualized. Sharpe is the ratio of the annualized mean to the annualized standard deviation. Significant at x% counts the percentage of mean returns that are significant at the x% level.

	Backwardation				Contango				Risk premium			
	Mean	t-stat	SD	Sharpe	Mean	t-stat	SD	Sharpe	Mean	t-stat	SD	Sharpe
<b>Panel A: Risk premium based on hedgers' positions</b>												
R = 4, H = 4	0.0406	0.86	0.1957	0.2077	-0.0443	-1.16	0.1583	-0.2797	0.0849	1.55	0.2271	0.3739
R = 4, H = 13	0.0567	1.25	0.1890	0.2999	-0.0346	-0.87	0.1646	-0.2102	0.0913	1.71	0.2224	0.4105
R = 4, H = 26	0.0843	1.82	0.1929	0.4369	-0.0490	-1.24	0.1636	-0.2994	0.1333	2.45	0.2263	0.5888
R = 4, H = 52	0.0671	1.43	0.1955	0.3433	0.0048	0.12	0.1679	0.0288	0.0623	1.13	0.2295	0.2713
R = 13, H = 4	0.0520	1.13	0.1904	0.2731	-0.0584	-1.47	0.1648	-0.3544	0.1104	2.03	0.2249	0.4909
R = 13, H = 13	0.0718	1.55	0.1917	0.3744	-0.0371	-0.93	0.1643	-0.2261	0.1089	1.96	0.2293	0.4749
R = 13, H = 26	0.0464	0.99	0.1932	0.2402	-0.0325	-0.82	0.1633	-0.1990	0.0789	1.41	0.2314	0.3410
R = 13, H = 52	0.0572	1.23	0.1925	0.2971	-0.0132	-0.33	0.1637	-0.0806	0.0704	1.26	0.2311	0.3045
R = 26, H = 4	0.0574	1.22	0.1926	0.2979	-0.0460	-1.14	0.1656	-0.2780	0.1034	1.83	0.2314	0.4469
R = 26, H = 13	0.0482	1.03	0.1917	0.2513	-0.0441	-1.10	0.1651	-0.2672	0.0923	1.63	0.2320	0.3977
R = 26, H = 26	0.0468	1.01	0.1892	0.2472	-0.0279	-0.70	0.1624	-0.1715	0.0744	1.34	0.2274	0.3270
R = 26, H = 52	0.0473	1.01	0.1916	0.2469	-0.0176	-0.49	0.1462	-0.1204	0.0647	1.23	0.2157	0.2999
R = 52, H = 4	0.0509	1.07	0.1931	0.2635	-0.0119	-0.30	0.1619	-0.0733	0.0628	1.10	0.2312	0.2714
R = 52, H = 13	0.0413	0.88	0.1901	0.2171	0.0024	0.06	0.1600	0.0151	0.0388	0.69	0.2282	0.1702
R = 52, H = 26	0.0329	0.70	0.1905	0.1728	0.0006	0.01	0.1645	0.0035	0.0322	0.58	0.2268	0.1421
R = 52, H = 52	0.0280	0.61	0.1844	0.1518	-0.0136	-0.33	0.1664	-0.0815	0.0416	0.75	0.2248	0.1848
Average	0.0518		0.1915	0.2701	-0.0264		0.1627	-0.1621	0.0782		0.2275	0.3435
Significant at 5%		0%				0%				18.75%		
Significant at 10%		6.25%				0%				31.25%		
<b>Panel B: Risk premium based on speculators' positions</b>												
R = 4, H = 4	0.0619	1.38	0.1867	0.3316	-0.0488	-1.10	0.1852	-0.2636	0.1107	1.99	0.2313	0.4786
R = 4, H = 13	0.0442	1.00	0.1836	0.2408	-0.0497	-1.09	0.1888	-0.2629	0.0939	1.66	0.2349	0.3996
R = 4, H = 26	0.0637	1.39	0.1910	0.3333	-0.0666	-1.45	0.1914	-0.3481	0.1303	2.31	0.2341	0.5564
R = 4, H = 52	0.0510	1.18	0.1798	0.2837	-0.0377	-0.84	0.1864	-0.2021	0.0887	1.63	0.2264	0.3917
R = 13, H = 4	0.0419	0.96	0.1816	0.2310	-0.0654	-1.41	0.1916	-0.3413	0.1073	1.89	0.2350	0.4567
R = 13, H = 13	0.0436	0.98	0.1829	0.2382	-0.0698	-1.52	0.1902	-0.3670	0.1134	1.99	0.2351	0.4821
R = 13, H = 26	0.0710	1.61	0.1829	0.3882	-0.0536	-1.22	0.1817	-0.2952	0.1246	2.18	0.2369	0.5261
R = 13, H = 52	0.0202	0.47	0.1765	0.1146	-0.0643	-1.34	0.1978	-0.3249	0.0845	1.47	0.2383	0.3546
R = 26, H = 4	0.0736	1.68	0.1795	0.4098	-0.0708	-1.51	0.1926	-0.3677	0.1444	2.58	0.2301	0.6274
R = 26, H = 13	0.0388	0.87	0.1820	0.2131	-0.0822	-1.78	0.1892	-0.4346	0.1210	2.12	0.2341	0.5170
R = 26, H = 26	0.0519	1.18	0.1809	0.2869	-0.0805	-1.77	0.1867	-0.4311	0.1319	2.41	0.2248	0.5870
R = 26, H = 52	0.0387	0.94	0.1693	0.2288	-0.0081	-0.16	0.2017	-0.0400	0.0466	0.85	0.2253	0.2071
R = 52, H = 4	0.0387	0.85	0.1839	0.2104	-0.0557	-1.18	0.1907	-0.2919	0.0944	1.68	0.2278	0.4143
R = 52, H = 13	0.0370	0.81	0.1844	0.2006	-0.0551	-1.12	0.1992	-0.2764	0.0921	1.59	0.2346	0.3924
R = 52, H = 26	0.0198	0.42	0.1892	0.1046	-0.0414	-0.84	0.2004	-0.2067	0.0610	1.04	0.2367	0.2577
R = 52, H = 52	0.0387	0.90	0.1735	0.2234	-0.0535	-1.10	0.1960	-0.2731	0.0923	1.67	0.2235	0.4127
Average	0.0459		0.1817	0.2524	-0.0564		0.1918	-0.2954	0.1023		0.2318	0.4413
Significant at 5%		0%				0%				43.75%		
Significant at 10%		6.25%				12.50%				68.75%		

13 - We also form portfolios with 40% (50%) of the cross section available at the time of portfolio formation, taking long positions in the 20% (25%) backwardated commodities and short positions in the 20% (25%) contangoed commodities. The conclusions of the paper remain unchanged and the results are available upon request.

On the whole, the evidence presented in Table I indicates that the single-sort strategy goes some way towards capturing the risk premium present in commodity futures markets. The possibility remains that combining the information conveyed by the positions of both hedgers and speculators might do an even better job at capturing this risk premium. With this in mind, Table II presents summary statistics for the double-sort backwardated, contangoed and long-short portfolios.

Table II: Double-Sort Risk Premium Based on the Positions of Both Hedgers and Speculators

The table presents summary statistics for the backwardated, contangoed and long-short risk premium based on the positions of both hedgers and speculators. In Panel A, the sorting is implemented on, first, the positions of hedgers and, second, the positions of speculators. The sorting order is reversed in Panel B. R (H) is the number of weeks in the ranking (holding) period. The means and standard deviations (SD) are annualized. Sharpe is the ratio of the annualized mean to the annualized standard deviation. Significant at x% counts the percentage of mean returns that are significant at the x% level.

	Backwardation				Contango				Risk premium			
	Mean	t-stat	SD	Sharpe	Mean	t-stat	SD	Sharpe	Mean	t-stat	SD	Sharpe
<b>Panel A: Risk premium based on the positions of first hedgers and second speculators</b>												
R = 4, H = 4	0.0476	1.06	0.1873	0.2543	-0.0576	-1.30	0.1846	-0.3117	0.1052	1.89	0.2311	0.4551
R = 4, H = 13	0.0448	1.01	0.1852	0.2419	-0.0447	-1.00	0.1867	-0.2395	0.0895	1.59	0.2340	0.3826
R = 4, H = 26	0.0492	1.06	0.1933	0.2546	-0.0630	-1.40	0.1870	-0.3366	0.1122	2.00	0.2332	0.4810
R = 4, H = 52	0.0428	0.97	0.1836	0.2332	-0.0309	-0.70	0.1845	-0.1674	0.0737	1.38	0.2215	0.3326
R = 13, H = 4	0.0325	0.74	0.1808	0.1796	-0.0782	-1.71	0.1893	-0.4129	0.1106	1.99	0.2301	0.4809
R = 13, H = 13	0.0388	0.89	0.1802	0.2152	-0.0858	-1.87	0.1895	-0.4530	0.1246	2.22	0.2321	0.5370
R = 13, H = 26	0.0532	1.22	0.1801	0.2956	-0.0747	-1.74	0.1772	-0.4217	0.1280	2.31	0.2289	0.5590
R = 13, H = 52	0.0084	0.20	0.1751	0.0480	-0.0696	-1.49	0.1929	-0.3607	0.0780	1.39	0.2312	0.3373
R = 26, H = 4	0.0879	2.05	0.1761	0.4994	-0.0727	-1.57	0.1900	-0.3828	0.1607	2.92	0.2260	0.7109
R = 26, H = 13	0.0293	0.66	0.1818	0.1610	-0.0960	-2.13	0.1853	-0.5180	0.1252	2.24	0.2300	0.5446
R = 26, H = 26	0.0449	1.02	0.1805	0.2485	-0.0953	-2.11	0.1849	-0.5153	0.1397	2.56	0.2240	0.6236
R = 26, H = 52	0.0315	0.76	0.1694	0.1859	-0.0136	-0.28	0.2006	-0.0679	0.0450	0.83	0.2216	0.2028
R = 52, H = 4	0.0750	1.63	0.1862	0.4030	-0.0704	-1.54	0.1850	-0.3807	0.1455	2.58	0.2279	0.6382
R = 52, H = 13	0.0434	0.95	0.1844	0.2356	-0.0617	-1.34	0.1866	-0.3309	0.1052	1.87	0.2269	0.4636
R = 52, H = 26	0.0208	0.45	0.1878	0.1109	-0.0443	-0.90	0.1985	-0.2232	0.0649	1.12	0.2344	0.2769
R = 52, H = 52	0.0558	1.28	0.1759	0.3174	-0.0388	-0.79	0.1982	-0.1959	0.0946	1.71	0.2239	0.4228
Average	0.0441		0.1817	0.2427	-0.0623		0.1888	-0.3324	0.1064		0.2286	0.4655
Significant at 5%		6.25%				12.50%				50%		
Significant at 10%		6.25%				31.25%				68.75%		
<b>Panel B: Risk premium based on speculators' positions</b>												
R = 4, H = 4	0.0619	1.38	0.1867	0.3316	-0.0488	-1.10	0.1852	-0.2636	0.1107	1.99	0.2313	0.4786
R = 4, H = 13	0.0442	1.00	0.1836	0.2408	-0.0497	-1.09	0.1888	-0.2629	0.0939	1.66	0.2349	0.3996
R = 4, H = 26	0.0637	1.39	0.1910	0.3333	-0.0666	-1.45	0.1914	-0.3481	0.1303	2.31	0.2341	0.5564
R = 4, H = 52	0.0510	1.18	0.1798	0.2837	-0.0377	-0.84	0.1864	-0.2021	0.0887	1.63	0.2264	0.3917
R = 13, H = 4	0.0419	0.96	0.1816	0.2310	-0.0654	-1.41	0.1916	-0.3413	0.1073	1.89	0.2350	0.4567
R = 13, H = 13	0.0436	0.98	0.1829	0.2382	-0.0698	-1.52	0.1902	-0.3670	0.1134	1.99	0.2351	0.4821
R = 13, H = 26	0.0710	1.61	0.1829	0.3882	-0.0536	-1.22	0.1817	-0.2952	0.1246	2.18	0.2369	0.5261
R = 13, H = 52	0.0202	0.47	0.1765	0.1146	-0.0643	-1.34	0.1978	-0.3249	0.0845	1.47	0.2383	0.3546
R = 26, H = 4	0.0736	1.68	0.1795	0.4098	-0.0708	-1.51	0.1926	-0.3677	0.1444	2.58	0.2301	0.6274
R = 26, H = 13	0.0388	0.87	0.1820	0.2131	-0.0822	-1.78	0.1892	-0.4346	0.1210	2.12	0.2341	0.5170
R = 26, H = 26	0.0519	1.18	0.1809	0.2869	-0.0805	-1.77	0.1867	-0.4311	0.1319	2.41	0.2248	0.5870
R = 26, H = 52	0.0387	0.94	0.1693	0.2288	-0.0081	-0.16	0.2017	-0.0400	0.0466	0.85	0.2253	0.2071
R = 52, H = 4	0.0387	0.85	0.1839	0.2104	-0.0557	-1.18	0.1907	-0.2919	0.0944	1.68	0.2278	0.4143
R = 52, H = 13	0.0370	0.81	0.1844	0.2006	-0.0551	-1.12	0.1992	-0.2764	0.0921	1.59	0.2346	0.3924
R = 52, H = 26	0.0198	0.42	0.1892	0.1046	-0.0414	-0.84	0.2004	-0.2067	0.0610	1.04	0.2367	0.2577
R = 52, H = 52	0.0387	0.90	0.1735	0.2234	-0.0535	-1.10	0.1960	-0.2731	0.0923	1.67	0.2235	0.4127
Average	0.0459		0.1817	0.2524	-0.0564		0.1918	-0.2954	0.1023		0.2318	0.4413
Significant at 5%		0%				0%				43.75%		
Significant at 10%		6.25%				12.50%				68.75%		

As predicted by the normal backwardation theory, the backwardated portfolios tend to earn positive mean returns. Consistently buying backwardated contracts earns positive, albeit insignificant, mean returns of 4.41% on average in Table II, Panel A, and of 4.38% on average in Table II, Panel B, depending on the sorting order used. As predicted by the contango theory, the annualized mean returns earned from consistently holding a long position in contangoed markets one negative, albeit often insignificant, with an average at -6.23% a year in Table II, Panel A, and at -2.75% a year in Table II, Panel B. Depending on whether we sort first on hedgers' or on speculators' net positions, the portfolios that are long backwardation and short contango earn on average annual mean returns of 10.64% (in Panel A) and 7.09% (in Panel B). These risk premiums range from 4.50% (R=26, H=52) to 16.07% (R=26, H=4) a year in Panel A and from 3.36% (R=52, H=26) to 12.45% (R=4, H=26) in Panel B. 68.75% of the 16 risk premiums are positive and significant at the 10% level or better in Panel A (when we sort first on hedgers' and second on speculators' positions), while only 12.5% of the 16 risk premiums are positive and

significant at the 10% level or better in Panel B (when we sort first on speculators' and second hedgers' positions). These results clearly show that sorting first on hedgers' hedging pressure and second on speculators' hedging pressure gives us the best criterion for asset allocation.

The best performance is achieved in Table II, Panel A, when the ranking and holding periods are set to 26 and 4 weeks, respectively, and when the sorting is based first on the hedging pressure of hedgers and second on the hedging pressure of speculators. Then the mean return equal 16.07% a year and is significant at the 1% level ( $t$ -statistic of 2.92). By contrast, a long-only equally weighted portfolio made of the same 28 commodity futures as those used to capture the time-varying risk premiums generates an out-of-sample annualized mean return of only 0.24% ( $t$ -statistics of 0.09). Similarly, the S&P-GSCI earns a mere 3.70% a year ( $t$ -statistic of 0.70) over the same period.

On a risk-adjusted basis, the reward-to-risk ratios of the single-sort long-short portfolios range from 0.14 to 0.59 with a mean at 0.34 in Table I, Panel A (based on hedgers' positions), and range from 0.21 to 0.63 with a mean at 0.44 in Table I, Panel B (based on speculators' positions). If instead the asset allocation is based on a double-sort, the reward-to-risk ratios range from 0.20 to 0.71 with a mean of 0.47 in Table II, Panel A (when the sorting is done first on hedgers' and second on speculators' positions), and from 0.15 to 0.54 with a mean at 0.31 in Table II, Panel B (when the sorting is reversed). The reward-to-risk ratios of the long-short risk premiums compare favorably to those of long-only benchmarks that stand at 0.02 for the equally weighted portfolio and 0.17 for the S&P-GSCI. Our results are interesting given the conclusions of DeMiguel, Garlappi and Uppal (2009), that show that equal weighting of an equity portfolio offers a better Sharpe ratio than mean-variance optimization out-of-sample.

Clearly, allowing for short, as well as long, positions is important when it comes to capturing the risk premium present in commodity futures markets. Clearly also, dynamic trading is required to capture this risk premium. These two points highlight the limits of long-only passive benchmarks (such as the S&P-GSCI or a long-only equally-weighted portfolio) that are traditionally used in an attempt to capture the price of commodity risk or to assess the performance of active portfolios. Not only do these benchmarks fail to recognize the long-short nature of the commodity futures risk premium, but also fail to account for the need to dynamically trade commodity futures (beyond mere rebalancing) if one is to capture their risk premium accurately.

### II. C. The Relationship between Risk Premium and Volatility

We next examine the relationship between our hedging pressure-based risk premium and the volatility of commodity futures markets. Several studies (Litzenberger and Rabinowitz (1995), Pindyck (2004)) suggest that changes in volatility could affect commodity price levels. Bearing this in mind, it seems fair to hypothesize that the higher the volatility of commodity markets, the higher the propensity of commodity producers and consumers to hedge and thus the higher the premium that they are likely to pay to get rid of price risk. Likewise, in periods of high volatility in commodity futures markets speculators are likely to demand a higher risk premium as compensation for the incremental risk taken.

To test this hypothesis empirically, we model the volatility of an equally weighted portfolio of commodities as an asymmetric GARCH(1,1) process (Glosten, Jagannathan and Runkle (1993), Rabemananjara and Zakoian (1993)) using the first 52 observations of our sample. Therefore, we obtain

$$\begin{aligned} r_{p_t} &= \mu + \varepsilon_{p_t} \\ h_{p_t} &= \omega + \gamma \varepsilon_{p_{t-1}}^2 + \eta I_{t-1} \varepsilon_{p_{t-1}}^2 + \theta h_{p_{t-1}} \end{aligned} \quad (1)$$

where  $r_{p_t}$  is an equally weighted portfolio, rebalanced weekly, that includes the 28 futures contracts used to capture the commodity risk premium,  $\varepsilon_{p_t} \sim N(0, h_{p_t})$ ,  $h_{p_t}$  is the conditional variance of

returns,  $\mu$ ,  $\omega$ ,  $\gamma$ ,  $\eta$  and  $\theta$  are parameters to estimate and  $I_{t-1} = 1$  if  $\varepsilon_{Pt-1} < 0$  (bad news) and  $I_{t-1} = 0$  otherwise. It follows that the conditional variance of the equally weighted portfolio returns depends on 1. the square of past return shocks (past idiosyncratic risk), 2. past realisations of the conditional variance itself (past total risk) and 3. any asymmetric response of volatility to good and bad news.

We then regress the hedging-pressure based risk premium on a constant and lagged conditional variance using a 2SLS estimator to address issues of endogeneity.<sup>14</sup>

$$RP_t = \alpha + \beta h_{Pt-1} + u_t \quad (2)$$

where  $RP_t$  is the time-varying risk premium based on the positions of hedgers and/or speculators as modelled in Section II.A,  $\alpha$  and  $\beta$  are parameters to estimate. The sample is then rolled over to the next weekly observation. Regressions (1) and (2) are re-estimated to produce a new estimate of  $\beta$ .  $t$ -tests, with a Newey and West (1987) correction of the standard errors, are then performed on the resulting vector of  $\beta$  to determine whether speculators demand higher risk premiums in periods of increased volatility. This rolling window approach is chosen to ensure that the relationship between the conditional risk premium and conditional volatility does not suffer from a look-ahead bias.

Table III reports the averages of the  $\beta$  coefficients from (2) for each of the time-varying risk premiums modeled in Section II. A. It is clear from the table that, irrespective of the criterion used to allocate commodities to portfolios, higher conditional volatility leads to higher risk premium. On average, a 1% rise in weekly conditional volatility leads to a 1.60% rise in weekly risk premium across the various single and double sorts. This is consistent with the idea that in periods of high volatility in commodity markets hedgers are willing to pay a higher cost for their insurance. Likewise, speculators in commodity futures markets demand a risk premium that is proportionate to the price risk they take on. If in place of the long-short hedging pressure-based risk premium we use the returns on long-only benchmarks as dependent variables in (2), the results go against the fundamental notion that risk and return go hand-in-hand. Indeed, the average  $\beta$  coefficient relative to a long-only portfolio of commodities (the S&P-GSCI) stands at -0.44 (-1.49) with an associated  $t$ -statistic at -1.61 (-2.78).

Table III: The Relationship between the Hedging Pressure-Based Time-Varying Risk Premium and the Conditional Volatility of Commodity Markets  
The table presents slope coefficients of regressions of the time-varying commodity risk premium on the lagged conditional volatility of commodity markets, where the latter is measured by applying a GARCH(1,1)-GJR process to the returns of an equally-weighted weekly-rebalanced portfolio of commodities. The numbers in parentheses are the associated  $t$ -statistics with a Newey and West (1987) correction of the standard errors. R (H) is the number of weeks in the ranking (holding) period. Positive and significant at x% counts the percentage of coefficients on lagged volatility that are positive and significant at the x% level.

Risk premium based on	Hedgers's positions	Speculators's positions	First hedgers' and then speculators' positions	First speculators' and then hedgers' positions
R = 4, H = 4	1.5721 (3.25)	0.6345 (1.30)	0.3907 (0.71)	0.5987 (1.13)
R = 4, H = 13	1.4896 (2.70)	2.0073 (3.40)	2.4537 (4.38)	0.5550 (1.13)
R = 4, H = 26	2.1319 (3.60)	2.5235 (3.95)	2.9147 (4.70)	2.8755 (4.50)
R = 4, H = 52	2.0923 (3.06)	0.7757 (1.00)	1.1926 (1.53)	2.2104 (3.12)
R = 13, H = 4	1.4419 (2.53)	0.9341 (1.48)	1.2054 (2.34)	1.1159 (1.89)
R = 13, H = 13	2.4138 (3.37)	2.1117 (3.03)	2.2688 (3.35)	1.8037 (2.17)
R = 13, H = 26	2.0961 (2.90)	0.7628 (1.33)	0.6507 (1.22)	1.5932 (2.20)
R = 13, H = 52	2.3174 (3.66)	1.6006 (2.38)	1.2345 (1.73)	2.1790 (3.38)
R = 26, H = 4	2.5516 (3.73)	1.1902 (2.07)	1.8742 (3.29)	2.4660 (3.36)
R = 26, H = 13	2.4996 (3.95)	0.9109 (1.44)	0.8137 (1.34)	1.8177 (2.46)
R = 26, H = 26	1.8001 (2.95)	0.2517 (0.50)	0.3259 (0.68)	1.4643 (2.09)
R = 26, H = 52	2.0036 (3.63)	2.1030 (4.19)	2.2597 (4.45)	2.1093 (3.67)
R = 52, H = 4	2.0124 (3.03)	1.1238 (2.20)	0.7572 (1.74)	2.1423 (2.98)
R = 52, H = 13	1.7575 (3.12)	1.4506 (2.64)	1.1067 (2.07)	1.2085 (1.88)
R = 52, H = 26	1.6321 (3.05)	1.5991 (2.61)	1.6985 (2.99)	1.5295 (2.79)
R = 52, H = 52	0.9182 (1.63)	1.8137 (3.70)	1.9211 (4.05)	0.8583 (1.48)
Average	1.9206	1.3621	1.4418	1.6580
Positive and significant at 5%	93.75%	62.50%	56.25%	68.75%
Positive and significant at 10%	93.75%	62.50%	68.75%	81.25%

14 - We use as instruments a constant term and lagged values of 1. the dividend yield on the S&P-500 index, 2. default spread, 3. the slope of the term structure of interest rate and 4. the one-month Treasury-bill rate.

15 - Because of the absence of initial investment in futures markets, investors do not receive any compensation for differed consumption (Dusak (1973)). The intercept term  $\lambda_0$  traditionally included in (4) as a proxy for the risk-free rate of return is therefore omitted.

### III. Cross-Sectional Pricing of Commodity Futures Returns

While the evidence presented thus far center around the time-series properties of the commodity risk premiums, this section focuses on its cross-sectional properties. We assume that commodity futures returns are driven by the linear multifactor model

$$R_t = E(R) + BF_t + \iota_t \quad (3)$$

where  $R_t$  is a  $N$ -vector of commodity futures returns,  $E(\cdot)$  is the expectation operator,  $B$  is the  $N \times K$ -matrix of sensitivities of the returns to the  $K$ -vector of factors  $F_t$  (where  $K \geq 1$ ),  $\iota_t$  is a  $N$ -vector of error terms. In the case of a single index model,  $F_t$  corresponds to the hedging pressure-based time-varying risk premium modeled in Section II. Given a set of simplifying assumptions and under the no-arbitrage condition (Ross (1976)), the following risk-return relationship holds

$$E(R) = B\lambda \quad (4)$$

where  $\lambda$  is a  $K$ -vector of systematic risk premiums.<sup>15</sup> Combining (3) and (4) yields

$$R_t = B\lambda + BF_t + \varepsilon_t \quad (5)$$

We use NLSUR (non-linear seemingly unrelated regression) developed by McElroy, Burmeister and Wall (1985) to estimate both the quantities of risk,  $B$ , and the price of risk,  $\lambda$ , in (5). This approach has two major advantages relative to the traditional Fama and MacBeth (1973) approach traditionally employed in the asset pricing literature (e.g., Bessembinder (1992)). First, NLSUR simultaneously estimates  $B$  and  $\lambda$  and consequently eliminates the errors-in-variables (EIV) problem present in the two-step methodology of Fama and MacBeth (1973). This is critical as the construction of arbitrary portfolios to solve the EIV problem is impossible given our limited cross section of commodities.<sup>16</sup> Second, NLSUR allows for the residuals variance-covariance matrix to be non-diagonal; i.e., allows for some weak cross-sectional co-variations in idiosyncratic commodity returns. This feature too is important in our setting as modeling the impact of idiosyncratic shocks on commodity returns is likely to matter for commodities that belong to the same family or have the same style (e.g., soy complex, energy, precious metals).

Table IV presents the prices of risk associated with the hedging pressure-based time-varying risk premium for each of the two single-sort and each of the two double-sort portfolios. In total, since we have 16 combinations of ranking and holding periods, we end up with 16 estimates of the price of commodity risk for each of the single or double sorts; or 64 estimates. The price of commodity risk is always positive and often significant at the 5% level or better. Although the conclusion holds irrespective of whether the sorting is based on the positions of hedgers and/or the positions of speculators, the price of commodity risk is more significant when the sorting is based on either the positions of speculators on their own (as in Table I, Panel B), or the combination of, first, the positions of hedgers and, second, the positions of speculators (as in Table II, Panel A). Interestingly, the price of commodity risk  $\lambda$  in (5) is positive, suggesting that when the risk premium  $F_t$  in (5) rises (and thus commodity futures markets become more backwardated and/or more contangoed), expected returns rise for commodities with positive  $B$  and fall for commodities with negative  $B$ .

A commodity futures contract offers a significant expected return if both the price of risk,  $\lambda$ , and the associated measure of risk,  $B$ , in (4) are simultaneously significant. A careful look at the vector  $B$ , not reported here to conserve space, suggests that, when  $\lambda$  is significant at the 5% level,  $B$  tends to be positive and significant for cocoa, coffee, copper, corn, crude oil, gold, orange, palladium, platinum, silver, sugar and unleaded gas. These 12 futures therefore offer positive expected returns in (4) and are thus more often than not in backwardation. By contrast,

16 - In the case of commodity futures, the choice of a criterion to sort contracts into portfolios is not obvious. NLSUR solves this problem as the methodology can be directly applied to individual assets instead of portfolios of assets (as in Fama and Mac-Beth (1973)).

the  $B$  of cotton, electricity, feeder cattle, frozen pork bellies, lean hogs, live cattle and natural gas tend to be negative and significant, suggesting that these 7 futures contracts offer negative expected returns in (4) and are thus more often than not in contango. The mean return of an equally-weighted weekly-rebalanced portfolio of the 12 backwardated futures equals 3.72% a year ( $t$ -statistic of 1.11) and that of an equally-weighted weekly-rebalanced portfolio of the 7 contangoed futures equals -4.36% a year ( $t$ -statistic of -1.07), with a long backwardation, short contango portfolio earning 8.06% ( $t$ -statistic of 1.76). At 0.41 the Sharpe ratio of this long-short portfolio compares favorably to that of the long-only equally-weighted portfolio (0.02). This result gives credence to our decision (based on the sign and significance level of  $B$ ) to sort commodities into backwardated or contangoed portfolios.

Table IV: Cross-Sectional Pricing of the Commodity Risk Premium

The table reports the prices of commodity risk associated with the time-varying risk premium. The numbers in parentheses are the associated  $t$ -statistics. The system is estimated with NLSUR.  $R$  ( $H$ ) is the number of weeks in the ranking (holding) period. Positive and significant at  $x\%$  counts the percentage of prices of risk that are positive and significant at the  $x\%$  level.

Risk premium based on	Hedgers' positions	Speculators' positions	First hedgers' and then speculators' positions	First speculators' and then hedgers' positions
R = 4, H = 4	0.0030 (2.20)	0.0110 (4.04)	0.0106 (4.18)	0.0040 (2.76)
R = 4, H = 13	0.0025 (1.93)	0.0102 (4.20)	0.0106 (4.63)	0.0030 (2.33)
R = 4, H = 26	0.0004 (0.34)	0.0114 (4.18)	0.0123 (4.44)	0.0012 (0.95)
R = 4, H = 52	0.0023 (2.01)	0.0119 (3.29)	0.0112 (3.66)	0.0014 (1.33)
R = 13, H = 4	0.0026 (2.21)	0.0106 (4.71)	0.0106 (4.66)	0.0028 (2.40)
R = 13, H = 13	0.0012 (1.06)	0.0089 (3.37)	0.0093 (3.51)	0.0011 (1.00)
R = 13, H = 26	0.0021 (2.19)	0.0074 (2.47)	0.0070 (2.67)	0.0023 (2.39)
R = 13, H = 52	0.0015 (1.76)	0.0079 (2.61)	0.0079 (2.61)	0.0015 (1.76)
R = 26, H = 4	0.0022 (2.11)	0.0105 (4.16)	0.0094 (3.88)	0.0024 (2.01)
R = 26, H = 13	0.0013 (1.17)	0.0109 (4.59)	0.0106 (4.83)	0.0022 (1.72)
R = 26, H = 26	0.0009 (0.99)	0.0077 (3.39)	0.0069 (3.10)	0.0020 (2.12)
R = 26, H = 52	0.0015 (1.63)	0.0032 (1.66)	0.0032 (1.66)	0.0015 (1.63)
R = 52, H = 4	0.0019 (1.75)	0.0051 (2.68)	0.0033 (2.01)	0.0016 (1.28)
R = 52, H = 13	0.0011 (1.05)	0.0031 (1.88)	0.0024 (1.55)	0.0012 (1.02)
R = 52, H = 26	0.0014 (1.25)	0.0023 (1.28)	0.0041 (2.26)	0.0018 (1.51)
R = 52, H = 52	0.0008 (0.62)	0.0018 (0.88)	0.0036 (1.64)	0.0008 (0.50)
Average	0.0017	0.0077	0.0077	0.0019
Positive and significant at 5%	31.25%	75%	81.25%	37.50%
Positive and significant at 10%	50%	87.50%	87.50%	50%

When a long-only weekly-rebalanced portfolio of commodity futures is used as  $F_t$  in place of the hedging-pressure-based risk premiums in (5), the weekly price of commodity risk is zero both in economic and statistical terms (-0.00 with a  $t$ -statistic of 0.12). This result highlights the need to take both long and short positions (based on hedging pressure) to accurately capture the commodity risk premium. A failure to take the positions of hedgers and speculators into account results in the misleading conclusion that there is no risk premium in commodity futures markets.

The possibility remains that commodity risk is not priced once other risk factors are taken into account. Along with the commodity risk premium based on hedgers' and then speculators' positions, we allow for the excess return of the equity market, shocks to the exchange rates and shocks to the slope of the term structure of interest rates to jointly enter the pricing relationship.<sup>17</sup> Table V presents coefficient estimates for the resulting prices of risk  $\lambda$  along with the associated  $t$ -statistics. It appears that the inclusion of the 3 aforementioned systematic risk factors does not alter our former conclusion on the pricing of commodity price risk. As in Table IV, the price of commodity risk is positive and significant at the 5% level 62.5% of the time (versus 81.25% in Table IV for the risk premium based on, first, hedgers' and, second, speculators' positions) with a cross-sectional average at 0.0078 a week (versus 0.0077 in Table IV).

17 - We use the percentage change in the USD versus major currencies index and the spread between the yield on 10-year US Treasury bonds with constant maturity and the 3-month Treasury bill rate. Shocks to these factors are modeled as the difference between the factors themselves and their 52-week moving average. The excess return of the equity market is estimated as the value-weighted return on all NYSE, AMEX, and NASDAQ stocks minus the one-month Treasury bill rate (as provided by Kenneth French).

Table V: Cross-Sectional Pricing of the Commodity Risk Premium and of Traditional Risk Factors

The table reports the prices of risk  $\lambda$  associated with 1. The time-varying risk premiums based on the positions of, first, hedgers and, second, speculators (Comm), 2. the equity market excess returns (ERM), 3. FX shocks (UFX) and 4. shocks to the slope of the term structure of interest rates (UTS). Shocks in a variable are measured as the spread between the variable itself and its 52-week moving average.  $t(\lambda)$  are the associated  $t$ -statistics. The system is estimated with NLSUR. R (H) is the number of weeks in the ranking (holding) period. Significant at  $x\%$  counts the percentage of prices of risk that are significant at the  $x\%$  level.

	Commodity risk premium		Equity risk premium		FX shocks		Term spread shocks	
	$\lambda_{Comm}$	$t(\lambda_{Comm})$	$\lambda_{ERM}$	$t(\lambda_{ERM})$	$\lambda_{UFX}$	$t(\lambda_{UFX})$	$\lambda_{UTS}$	$t(\lambda_{UTS})$
R = 4, H = 4	0.0124	3.57	0.0034	0.96	0.0048	2.47	0.0071	7.61
R = 4, H = 13	0.0113	3.83	0.0015	0.45	0.0043	2.32	0.0076	8.04
R = 4, H = 26	0.0141	3.76	0.0022	0.63	0.0047	2.44	0.0071	7.66
R = 4, H = 52	0.0115	2.56	0.0067	1.63	0.0054	2.47	0.0068	6.72
R = 13, H = 4	0.0102	3.67	0.0025	0.74	0.0042	2.32	0.0070	7.80
R = 13, H = 13	0.0105	2.90	0.0030	0.82	0.0052	2.51	0.0073	7.50
R = 13, H = 26	0.0082	2.17	0.0057	1.39	0.0056	2.50	0.0073	7.06
R = 13, H = 52	0.0094	2.12	0.0060	1.50	0.0051	2.41	0.0070	6.98
R = 26, H = 4	0.0096	3.08	0.0028	0.79	0.0044	2.31	0.0076	7.93
R = 26, H = 13	0.0112	3.78	0.0041	1.10	0.0049	2.40	0.0076	7.62
R = 26, H = 26	0.0039	1.24	0.0045	1.20	0.0047	2.31	0.0079	7.70
R = 26, H = 52	0.0011	0.40	0.0046	1.18	0.0050	2.37	0.0079	7.51
R = 52, H = 4	0.0028	1.27	0.0038	1.05	0.0049	2.45	0.0074	7.73
R = 52, H = 13	0.0021	0.98	0.0040	1.08	0.0050	2.47	0.0076	7.70
R = 52, H = 26	0.0035	1.41	0.0043	1.15	0.0047	2.31	0.0080	7.72
R = 52, H = 52	0.0038	1.34	0.0024	0.71	0.0039	2.16	0.0078	8.25
Average	0.0078		0.0038		0.0048		0.0074	
Significant at 5%		62.50%		0%		100%		100%
Significant at 10%		62.50%		0%		100%		100%

#### IV. Strategic Role of the Hedging-Pressure-Enhanced Risk Premium

The strategic decision to invest into commodities depends on the risk-return trade-off that commodities offer—as captured by our hedging pressure-based time-varying risk premium. It also breaks down to the risk diversification and inflation hedging properties of commodities (Bodie and Rosansky (1980), Bodie (1983), Erb and Harvey (2006), Gorton and Rouwenhorst (2006)). This section tests whether the hedging pressure risk premiums serve as better tools for risk diversification and inflation hedging as long-only positions in an equally-weighted portfolio of commodities. With this in mind, we collect weekly observations from *Datastream* on 13 traditional asset classes (as proxied by 6 J.P.Morgan fixed income indices with different durations or countries of issuance and 7 international equity indices with different styles) and quarterly observations on inflation.

Table VI reports pairwise return correlations between 1. the commodity risk premiums based on the positions of, first, hedgers and, second, speculators and 2. the 13 traditional asset classes mentioned above. The correlations with a long-only equally weighted portfolio of all commodities are also reported. Finally, the table presents (in parentheses)  $t$ -statistics for the null hypothesis that the correlation obtained with the long-only index is equal to that obtained with the long-short benchmark. The average correlation with the J.P.Morgan fixed income indices, across the various indices and the various holding and ranking periods, stands at 0.02 for the hedging pressure-enhanced risk premium and at 0.05 for the long-only index. The average correlation relative to the equity indices stands at -0.02 for the enhanced benchmarks and at 0.28 for the long-only benchmark. Interestingly 77% of the time we reject the null hypothesis that the correlations obtained with the hedging-pressure-based benchmarks are equal to those obtained with the long-only benchmark in favor of the alternative that the former are actually smaller than the latter. These results suggest that the time-varying risk premiums based on hedging pressure are better suited for risk diversification than long-only positions in commodity futures.

When it comes to inflation hedging, the conclusions are less supportive of our long-short benchmarks. Indeed, the correlations between the hedging pressure-based risk premiums and unexpected inflation<sup>18</sup> on the right-hand side of Table VI average out at -0.15, while the correlation between the long-only benchmark and unexpected inflation is positive at the 1% level. Similarly, the slope coefficients of regressions of the commodity benchmarks on unexpected inflation ( $\beta_{Uj}$ ) show that a shock to inflation of 1% leads to an average drop in the returns of the long-short benchmarks by 2.50% and to an average rise in the returns of the long-only benchmark by 4.12%. The incremental mean returns and the added diversification benefits of the long-short benchmarks come at the cost of losing the inflation hedge that is naturally provided by commodities (Bodie and Rosansky (1980), Bodie (1983)). This result corroborates the evidence in Miffre and Rallis (2007), who also show that commodity-based momentum portfolios do not offer a hedge against unexpected inflation.

Table VI: Diversification and Inflation Hedging

The table reports correlation coefficients between the time-varying risk premiums based on the positions of first hedgers and second speculators and 13 traditional asset classes. The correlations relative to a long-only portfolio are also reported. The numbers in parentheses are *t*-statistics for the null hypothesis that the correlation obtained relative to the long-short commodity benchmark equals that obtained relative to the long-only portfolio of commodities.  $\beta_{Uj}$  is the slope coefficient of a regression of the commodity risk premium on unexpected inflation.  $t(\beta_{Uj})$  and  $R^2$  are the associated *t*-statistic and goodness-of-fit statistic, respectively. R (H) is the number of weeks in the ranking (holding) period.

	Correlation with JPM fixed income indices										Correlation with equity indices										Quarterly unexpected inflation		
	US Govt	US 3-month	US 12-month	Global Asia	Global Africa	Global Europe	Global	Average	S&P500	Russell 2000	Russell 1000 Value	Russell 1000 Growth	MSCI Europe	MSCI Asia-Pacific	MSCI Latin America	MSCI Average	Correlation	$\beta_{Uj}$	$t(\beta_{Uj})$	$R^2$			
Long-only	-0.1278	-0.0316	-0.0219	0.2324	0.1249	0.1439	0.0533	0.2243	0.2463	0.2476	0.2069	0.3696	0.3245	0.3635	0.2831	0.4663	4.1243	4.35	22%				
R=4, H=4	-0.0346	0.0271	0.0214	0.0214	-0.0158	-0.0040	0.0026	-0.0656	-0.0131	-0.0631	-0.0588	0.0161	0.0688	0.0270	-0.0129	-0.1015	-1.6667	-0.84	1%				
R=4, H=13	0.0555	0.0153	0.0370	0.0370	0.0097	0.0162	0.0284	(-6.22)	(-5.57)	(-6.68)	(-5.69)	(-7.72)	(-5.61)	(-7.37)		(-12.76)							
R=4, H=26	(3.90)	(0.99)	(1.24)	(-4.05)	(-2.36)	(-2.62)		(-5.52)	(-5.30)	(-5.96)	(-5.10)	(-8.11)	(-6.62)	(-7.16)		(-14.14)							
R=4, H=52	0.0752	0.0156	0.0510	0.0510	0.0166	0.0321	0.0402	(-0.0318)	0.0168	(-0.0266)	(-0.0251)	0.0022	0.0983	0.0961	0.0043	(-13.22)							
R=13, H=4	(4.32)	(1.00)	(1.54)	(-3.76)	(-2.22)	(-2.30)	0.0061	(-5.49)	(-4.93)	(-5.89)	(-4.96)	(-8.03)	(-5.79)	(-7.17)		(-11.90)							
R=13, H=13	0.0168	0.0234	0.0179	0.0179	-0.0263	-0.0133	0.0061	(-0.0251)	0.0010	(-0.0395)	(-0.0058)	(-0.0027)	0.0413	0.0082	-0.0032	(-13.22)							
R=13, H=26	(3.07)	(1.16)	(0.84)	(-4.44)	(-3.10)	(-3.23)	0.0302	(-5.34)	(-5.27)	(-6.17)	(-4.55)	(-8.14)	(-6.16)	(-7.78)		(-25.71)							
R=13, H=52	0.0377	0.0303	0.0630	0.0630	-0.0055	-0.0070	0.0302	(-0.0400)	(-0.0009)	(-0.0463)	(-0.0270)	(-0.0296)	0.0007	0.0148	-0.0183	(-16.54)							
R=26, H=4	(3.52)	(1.31)	(1.80)	(-3.51)	(-2.67)	(-3.10)	0.0223	(-5.66)	(-5.31)	(-6.32)	(-5.00)	(-8.73)	(-7.04)	(-7.63)		(-15.08)							
R=26, H=13	0.0289	0.0091	0.0497	0.0497	-0.0064	0.0031	0.0223	(-4.74)	(-4.37)	(-5.35)	(-4.07)	(-7.61)	(-5.76)	(-6.72)		(-11.11)							
R=26, H=26	(3.33)	(0.86)	(1.51)	(-3.78)	(-2.69)	(-2.89)	0.0129	(-5.60)	(-5.19)	(-6.45)	(-4.71)	(-8.75)	(-6.49)	(-7.79)		(-0.283)							
R=26, H=52	0.0247	-0.0217	0.0177	0.0177	0.0098	0.0292	0.0129	(-0.0311)	0.0428	(-0.0013)	0.0167	0.0215	0.0596	0.0569	0.0285	(-11.11)							
R=52, H=4	(3.24)	(0.21)	(0.84)	(-4.44)	(-2.36)	(-2.35)	0.0019	(-4.74)	(-4.37)	(-5.35)	(-4.07)	(-7.61)	(-5.76)	(-6.72)		(-16.39)							
R=52, H=13	0.0164	0.0000	0.0166	0.0166	-0.0134	-0.0247	0.0019	(-0.0445)	(-0.0169)	(-0.0578)	(-0.0219)	(-0.0623)	(-0.0031)	(-0.0309)	-0.0325	(-14.25)							
R=52, H=26	(3.06)	(0.67)	(0.81)	(-4.47)	(-2.84)	(-3.46)	0.0191	(-5.76)	(-5.65)	(-6.57)	(-4.89)	(-9.23)	(-7.12)	(-8.64)		(-14.73)							
R=52, H=52	0.0579	0.0148	0.0435	0.0435	-0.0250	-0.0033	0.0191	(-0.0509)	(-0.0135)	(-0.0505)	(-0.0408)	(-0.0461)	(-0.0019)	(-0.0110)	-0.0307	(-13.86)							
R=26, H=4	(3.95)	(0.98)	(1.38)	(-3.91)	(-3.07)	(-3.37)	0.0121	(-5.90)	(-5.58)	(-6.41)	(-5.30)	(-9.09)	(-7.09)	(-8.20)		(-0.787)							
R=26, H=13	0.0331	-0.0124	0.0272	0.0272	-0.0057	0.0033	0.0121	(-0.0423)	(-0.0025)	(-0.0526)	(-0.0261)	(-0.0384)	0.0110	(-0.0029)	-0.0220	(-12.26)							
R=26, H=26	(3.42)	(0.40)	(1.04)	(-4.25)	(-2.68)	(-2.89)	0.0153	(-5.71)	(-5.34)	(-6.45)	(-4.98)	(-8.92)	(-6.81)	(-8.02)		(-12.25)							
R=26, H=52	0.0223	0.0257	0.0427	0.0427	-0.0191	-0.0224	0.0153	(-0.0531)	(-0.0136)	(-0.0605)	(-0.0398)	(-0.0506)	(-0.0002)	(-0.0038)	-0.0316	(-13.28)							
R=52, H=4	(3.19)	(1.21)	(1.37)	(-3.93)	(-2.95)	(-3.41)	0.0354	(-5.95)	(-5.58)	(-6.63)	(-5.28)	(-9.19)	(-7.06)	(-8.04)		(-13.28)							
R=52, H=13	0.0316	0.0715	0.0653	0.0653	-0.0046	-0.0165	0.0354	(-0.0396)	(-0.0325)	(-0.0516)	(-0.0126)	(-0.0514)	0.0106	(-0.0067)	-0.0254	(-15.70)							
R=52, H=26	(3.39)	(2.18)	(1.85)	(-3.46)	(-2.66)	(-3.29)	0.0063	(-5.53)	(-5.99)	(-6.43)	(-4.70)	(-9.21)	(-6.82)	(-8.10)		(-13.97)							
R=52, H=52	0.0386	0.0087	0.0263	0.0263	-0.0382	-0.0298	0.0063	(-0.1052)	(-0.0638)	(-0.1123)	(-0.0887)	(-0.0665)	(-0.0123)	(-0.0221)	-0.0701	(-14.98)							
R=52, H=4	(3.53)	(0.85)	(1.02)	(-4.27)	(-3.35)	(-3.57)	0.0323	(-7.08)	(-6.67)	(-7.76)	(-6.33)	(-9.99)	(-7.32)	(-8.44)		(-13.97)							
R=52, H=13	0.0669	0.0337	0.0617	0.0617	-0.0207	-0.0093	0.0323	(-0.0909)	(-0.0561)	(-0.0974)	(-0.0770)	(-0.0664)	0.0081	(-0.0196)	-0.0570	(-15.70)							
R=52, H=26	(4.14)	(1.38)	(1.77)	(-3.54)	(-2.99)	(-3.15)	0.0279	(-6.77)	(-6.50)	(-7.43)	(-6.08)	(-9.54)	(-6.88)	(-8.39)		(-14.98)							
R=52, H=52	0.0511	0.0447	0.0501	0.0501	-0.0156	-0.0129	0.0279	(-0.0664)	(-0.0346)	(-0.0828)	(-0.0463)	(-0.0657)	0.0001	(-0.0128)	-0.0441	(-15.13)							
R=52, H=4	(3.80)	(1.61)	(1.52)	(-3.78)	(-2.88)	(-3.22)	0.0036	(-6.34)	(-6.04)	(-7.11)	(-5.42)	(-9.53)	(-7.05)	(-8.24)		(-15.13)							
R=52, H=13	0.0392	0.0342	0.0349	0.0349	-0.0628	-0.0569	0.0036	(-0.0570)	(-0.0413)	(-0.0894)	(-0.0198)	(-0.0414)	0.0109	(-0.0284)	-0.0380	(-16.27)							
R=52, H=26	(3.55)	(1.35)	(1.20)	(-4.09)	(-3.85)	(-4.12)	0.0036	(-6.03)	(-6.18)	(-7.26)	(-4.85)	(-8.99)	(-6.82)	(-8.58)		(-16.27)							
R=52, H=52	(3.55)	(1.35)	(1.20)	(-4.09)	(-3.85)	(-4.12)	0.0036	(-6.03)	(-6.18)	(-7.26)	(-4.85)	(-8.99)	(-6.82)	(-8.58)		(-16.27)							

## V. Revisiting the

18 - Unexpected inflation is measured quarterly as the spread between the percentage change in the consumer price index (CPI) and the one-year moving average of the percentage CPI change.

The profitability of momentum strategies in commodity futures markets is now well documented (Erb and Harvey (2006), Miffre and Rallis (2007)). Gorton, Hayashi and Rouwenhorst (2008) argue that the returns of these strategies may be compensation for bearing inventory risk. It is thus natural to analyze whether our hedging pressure-based risk premiums are able to explain these returns too, particularly as Miffre and Rallis (2007) report that momentum portfolios tend to go long backwarddated commodities and short contangoed ones. Along the same line, we test whether our hedging pressure-based risk premiums explain part of the performance of two other active strategies that have been shown to work well in commodity futures markets: 1. the term structure strategy of Erb and Harvey (2006) and Gorton and Rouwenhorst (2006) and 2. the double-sort strategy based on momentum and term structure of Fuertes, Miffre and Rallis (2010). Section V starts with a brief description of the methodologies employed to form these active portfolios.

#### V. A. Methodology

The single-sort momentum portfolios consist of long positions in the commodity futures with the best mean returns over the previous  $R$  weeks (winners) and short positions in the commodity futures with the worst mean returns over the previous  $R$  weeks (losers). As with the hedging pressure-based risk premiums, 15% of the cross section available at the time of portfolio formation is included in the winner and loser portfolios. The positions are held over the next  $H$  weeks, when a new set of winner, loser and momentum portfolios is formed.

The single-sort term structure portfolios as in Erb and Harvey (2006) and Gorton and Rouwenhorst (2006) consist of long positions in the commodity futures with the highest average roll-returns over the previous  $R$  weeks and short positions in the commodity futures with the lowest average roll-returns over the previous  $R$  weeks. Roll-returns are measured as the difference in the log of the prices of the nearest and second nearest contracts. The positions are held over the next  $H$  weeks, when a new set of long, short and term structure portfolios is formed. As previously, 15% of the cross section available at the time of portfolio formation is included in the long and short portfolios.

The double-sort strategy that combines the momentum and term structure signals follows from Fuertes, Miffre and Rallis (2010). The available cross section is first split into winner and loser portfolios based on mean returns over the previous  $R$  weeks using the 50% breakpoint. We then form two portfolios; the first one, called *Winner-High*, contains the 30% of the constituents of the winner portfolio with the highest roll-returns over the ranking period and the second one, called *Loser-Low*, containing the 30% of the constituents of the loser portfolio with the lowest roll-returns over the ranking period. The double-sort portfolio simply buys *Winner-High*, shorts *Loser-Low* and holds the position over the next  $H$  weeks. Since it was arbitrary to sort on, first, momentum and, second, roll-returns, we reverse the sorting order, buying the *High-Winner* portfolio and shorting the *Low-Loser* portfolio.

For the sake of consistency with the hedging pressure-based risk premiums modeled in Section II, all the active portfolios studied in Section V present the following four characteristics. First, past performance and average roll-returns are modeled over ranking periods of 4, 13, 26 or 52 weeks. As the long-short positions are held over holding periods of 4, 13, 26 and 52 weeks, we end up with 16 momentum portfolios, 16 term structure portfolios and 32 active double-sort portfolios arising from the permutations of these 4 ranking and these 4 holding periods. Second, to minimize transaction costs, the active strategies are non-overlapping. Third, the constituents of the active portfolios are equally-weighted. Fourth, the active portfolios contain 30% of the cross section available at the time of portfolio formation, taking long positions in the 15% whose prices are expected to appreciate and short positions in the 15% whose prices are expected to decline.

## V. B. Preliminary Results

Table VII presents summary statistics on the performance of the active portfolios. As previously reported (e.g., Fuertes, Miffre and Rallis, 2010), the momentum and term structure strategies convey useful signals on which to tactically allocate wealth. On average, the momentum strategy earns 6.69% a year, the term structure strategy 6.48% and the double-sort strategy 11.15%. 25% of the momentum portfolios, 25% of the term structure portfolios and 56.25% of the double-sort portfolios offer positive mean returns that are significant at the 5% level or better. On a risk-adjusted basis, the strategies that combine the momentum and term structure signals appear to be the most profitable, with Sharpe ratios at 0.48 on average (compared to 0.27 for the strategies that use either one of the two signals in isolation).

Table VII: Summary Statistics for Active Portfolios

The table presents summary statistics for four active strategies in commodity futures markets, based on a momentum signal, the slope of the commodity price curve or a combination of the two signals. R (H) is the number of weeks in the ranking (holding) period. The means are annualized. Sharpe is the ratio of the annualized mean to the annualized standard deviation. Positive at x% counts the percentage of active mean returns that are positive and significant at the x% level.

	Momentum strategy			Term structure (TS) strategy			Double-sort strategy based on first momentum and then TS			Double-sort strategy based on first TS and then momentum		
	Mean	t-stat	Sharpe	Mean	t-stat	Sharpe	Mean	t-stat	Sharpe	Mean	t-stat	Sharpe
R = 4, H = 4	-0.0628	-0.89	-0.2153	0.0504	0.94	0.2265	0.0908	1.64	0.3937	0.0547	0.89	0.2141
R = 4, H = 13	0.0291	0.46	0.1112	0.0949	1.76	0.4235	0.1556	3.06	0.7371	0.1401	2.48	0.5968
R = 4, H = 26	-0.0045	-0.07	-0.0180	0.0995	1.88	0.4522	0.1246	2.52	0.6056	0.0720	1.33	0.3202
R = 4, H = 52	0.0284	0.44	0.1049	0.0845	1.48	0.3558	0.1062	2.14	0.5150	0.0359	0.63	0.1509
R = 13, H = 4	0.1548	2.33	0.5640	0.1343	2.53	0.6130	0.1883	3.51	0.8487	0.1845	2.90	0.7010
R = 13, H = 13	0.1513	2.28	0.5529	0.1247	2.40	0.5805	0.1499	2.95	0.7136	0.2104	3.44	0.8330
R = 13, H = 26	0.0699	1.14	0.2760	0.1078	2.09	0.5062	0.1049	2.03	0.4911	0.1354	2.32	0.5612
R = 13, H = 52	0.0186	0.30	0.0725	0.0782	1.45	0.3499	0.0822	1.56	0.3767	0.0892	1.54	0.3716
R = 26, H = 4	0.1506	2.20	0.5374	0.1050	1.98	0.4816	0.1157	2.11	0.5146	0.1497	2.36	0.5747
R = 26, H = 13	0.1197	1.78	0.4347	0.0480	0.88	0.2138	0.0746	1.38	0.3355	0.1248	1.97	0.4800
R = 26, H = 26	0.0720	1.08	0.2621	0.0276	0.49	0.1197	0.0544	1.00	0.2430	0.0921	1.50	0.3661
R = 26, H = 52	0.0820	1.31	0.3200	0.0070	0.12	0.0293	0.0866	1.48	0.3604	0.1208	2.05	0.4996
R = 52, H = 4	0.1848	2.61	0.6462	0.0471	0.86	0.2132	0.1529	2.83	0.7000	0.1757	2.69	0.6661
R = 52, H = 13	0.0897	1.33	0.3283	0.0406	0.74	0.1837	0.1202	2.21	0.5477	0.1029	1.66	0.4112
R = 52, H = 26	0.0248	0.37	0.0926	-0.0110	-0.21	-0.0509	0.0859	1.62	0.3998	0.0721	1.18	0.2920
R = 52, H = 52	-0.0387	-0.61	-0.1509	-0.0027	-0.05	-0.0134	0.1051	2.02	0.5009	0.0107	0.18	0.0436
Average	0.0669		0.2449	0.0648		0.2928	0.1124		0.5177	0.1107		0.4426
Positive at 5%		25%			25%			62.50%			50%	
Positive at 10%		31.25%			37.50%			62.50%			56.25%	

Table VIII, Panel A, presents the average hedgers' hedging pressure of the long and short active portfolios, where these hedging pressures are measured over the holding periods of the active strategy considered. Table VIII, Panel B, presents the same information for the speculators' hedging pressure. For the hedging pressure-based benchmarks to explain the performance of the active strategies, the long active portfolios should have over the holding periods low hedgers' hedging pressure and high speculators' hedging pressure, as these are characteristics of backwardated assets. Conversely, the short active portfolios should have high hedgers' hedging pressure and low speculators' hedging pressure, as these are characteristics of contangoed assets.

The evidence presented in Table VIII supports these hypotheses for the single-sort momentum strategy and for the two double-sort strategies. For example, the hedgers' hedging pressure of the long momentum portfolios at 0.43 on average in Panel A is less than that of the short momentum portfolios at 0.47, with the difference that is negative and significant for 87.50% of the 16 momentum strategies studied. Similarly, the speculators' hedging pressure of the long momentum portfolios in Panel B exceeds that of the short momentum portfolios by an average of 0.12, a difference that is positive and significant for 93.75% of the momentum portfolios considered. This indicates that the hedging-pressure-based benchmarks are good candidates for capturing part of the performance of momentum portfolios. The same conclusion applies to the two double-sort strategies based on momentum and term structure but does not extend to the single-sort term structure strategy for which the hedgers' hedging pressure of the long portfolios (at 0.47 on average in Panel A) exceeds that of the short portfolios (at 0.45 on average), with the difference

in hedgers' hedging pressures that is positive and significant for 87.50% of the term structure strategies considered. These results hint toward the conclusion that the hedging-pressure-based risk premiums are likely to explain the returns of the momentum and double-sort portfolios better than those of the term structure portfolios. We now turn our attention to this specific point.

Table VIII: Average Hedging Pressure of Active Long and Short Portfolios

Panel A presents the average over the holding periods of the hedgers' hedging pressure of the long (L) and short (S) active portfolios. Panel B presents the average over the holding periods of the speculators' hedging pressure of the long and short active portfolios. R (H) is the number of weeks in the ranking (holding) period of the active strategies. The column labeled  $H_0: L=S$  presents  $t$ -statistics for the null hypothesis that the hedging pressure of the long portfolio equals that of the short portfolio. Positive (Negative) at 5% counts the percentage of active strategies for which the difference in the hedging pressure of the long and short portfolios is positive (negative) and significant at the 5% level.

	Momentum strategy			Term structure (TS) strategy			Double-sort strategy based first on momentum and then on TS			Double-sort strategy based first on TS and then on momentum		
	Long (L)	Short (S)	$H_0: L=S$	Long (L)	Short (S)	$H_0: L=S$	Long (L)	Short (S)	$H_0: L=S$	Long (L)	Short (S)	$H_0: L=S$
<b>Panel A: Hedgers' Hedging Pressure</b>												
R = 4, H = 4	0.4000	0.4769	-22.49	0.4541	0.4562	-0.72	0.4264	0.4693	-14.77	0.4038	0.4700	-19.89
R = 4, H = 13	0.4151	0.4729	-17.31	0.4658	0.4547	3.80	0.4340	0.4622	-9.41	0.4109	0.4622	-15.95
R = 4, H = 26	0.4314	0.4563	-7.23	0.4537	0.4530	0.27	0.4421	0.4627	-7.30	0.4181	0.4601	-12.10
R = 4, H = 52	0.4322	0.4631	-9.65	0.4659	0.4504	5.42	0.4511	0.4545	-1.39	0.4180	0.4524	-10.36
R = 13, H = 4	0.4020	0.4898	-28.51	0.4655	0.4546	3.83	0.4209	0.4705	-17.95	0.4064	0.4802	-23.93
R = 13, H = 13	0.4200	0.4732	-16.59	0.4653	0.4502	5.78	0.4241	0.4613	-13.49	0.4269	0.4599	-9.23
R = 13, H = 26	0.4374	0.4601	-7.10	0.4611	0.4450	6.08	0.4246	0.4500	-8.85	0.4313	0.4539	-5.95
R = 13, H = 52	0.4405	0.4569	-5.03	0.4785	0.4467	10.98	0.4368	0.4479	-3.75	0.4333	0.4468	-3.70
R = 26, H = 4	0.4166	0.4875	-24.17	0.4687	0.4484	7.31	0.4308	0.4657	-12.84	0.4201	0.4756	-18.89
R = 26, H = 13	0.4303	0.4697	-12.51	0.4701	0.4497	7.26	0.4411	0.4581	-6.29	0.4298	0.4646	-11.24
R = 26, H = 26	0.4428	0.4608	-5.61	0.4716	0.4466	9.45	0.4485	0.4531	-1.80	0.4385	0.4575	-6.13
R = 26, H = 52	0.4321	0.4676	-11.01	0.4671	0.4564	4.17	0.4430	0.4546	-4.26	0.4248	0.4533	-7.46
R = 52, H = 4	0.4293	0.4718	-14.55	0.4656	0.4494	6.80	0.4415	0.4610	-7.21	0.4295	0.4669	-12.59
R = 52, H = 13	0.4392	0.4593	-6.71	0.4691	0.4460	9.47	0.4442	0.4557	-4.18	0.4384	0.4568	-6.16
R = 52, H = 26	0.4440	0.4456	-0.52	0.4763	0.4471	11.99	0.4525	0.4509	0.56	0.4409	0.4461	-1.71
R = 52, H = 52	0.4495	0.4450	1.59	0.4737	0.4494	9.86	0.4543	0.4511	1.07	0.4506	0.4453	1.85
Average	0.4289	0.4660		0.4670	0.4502		0.4385	0.4580		0.4263	0.4595	
Negative at 5%			87.50%			0%			75%			87.50%
Positive at 5%			0%			87.50%			0%			0%
<b>Panel B: Speculators' Hedging Pressure</b>												
R = 4, H = 4	0.7034	0.4970	38.05	0.6345	0.5715	12.55	0.6777	0.5298	29.98	0.7022	0.4993	39.31
R = 4, H = 13	0.6647	0.5268	26.97	0.6186	0.5739	9.31	0.6594	0.5441	24.47	0.6762	0.5183	32.04
R = 4, H = 26	0.6345	0.5533	15.09	0.6221	0.5763	9.48	0.6340	0.5546	16.43	0.6484	0.5374	20.77
R = 4, H = 52	0.6015	0.5441	10.89	0.5918	0.5912	0.12	0.6144	0.5771	7.69	0.6302	0.5676	11.26
R = 13, H = 4	0.7096	0.4616	47.53	0.6153	0.5703	9.18	0.6845	0.5239	35.34	0.7044	0.4697	47.11
R = 13, H = 13	0.6765	0.5018	32.76	0.6120	0.5774	7.29	0.6636	0.5416	25.89	0.6655	0.5006	30.12
R = 13, H = 26	0.6429	0.5381	18.63	0.6093	0.5974	2.60	0.6520	0.5618	18.39	0.6471	0.5349	19.28
R = 13, H = 52	0.6166	0.5699	7.70	0.5801	0.6016	-4.54	0.6173	0.5780	7.91	0.6317	0.5790	8.54
R = 26, H = 4	0.6836	0.4652	46.14	0.6028	0.5757	5.30	0.6564	0.5439	24.46	0.6832	0.4812	43.64
R = 26, H = 13	0.6577	0.4972	29.51	0.5934	0.5828	2.00	0.6304	0.5618	14.78	0.6573	0.5108	29.14
R = 26, H = 26	0.6264	0.5232	18.62	0.5845	0.5971	-2.39	0.6139	0.5754	7.68	0.6376	0.5306	21.67
R = 26, H = 52	0.6100	0.5351	13.71	0.5639	0.6049	-7.88	0.5903	0.5871	0.60	0.6146	0.5477	11.77
R = 52, H = 4	0.6608	0.4876	37.66	0.5874	0.5891	-0.33	0.6283	0.5605	14.44	0.6615	0.5013	34.30
R = 52, H = 13	0.6254	0.5151	22.04	0.5759	0.5954	-3.85	0.6103	0.5650	8.93	0.6332	0.5254	21.12
R = 52, H = 26	0.6019	0.5435	10.89	0.5634	0.6021	-8.12	0.5947	0.5775	3.49	0.6122	0.5494	12.13
R = 52, H = 52	0.5830	0.5742	1.66	0.5601	0.5999	-7.77	0.5960	0.5932	0.56	0.5912	0.5713	3.42
Average	0.6436	0.5208		0.5947	0.5879		0.6327	0.5610		0.6498	0.5265	
Negative at 5%			0%			37.50%			0%			0%
Positive at 5%			93.75%			50%			87.50%			100%

### V. C. Performance of Active Commodity Strategies

Table IX compares the performance of the active portfolios to that of 5 benchmarks. The two first benchmarks are long-only: these are a long-only equally-weighted portfolio of all commodities and the S&P-GSCI. The latter three benchmarks are long-short: these are 1. the time-varying risk premiums based on first the positions of hedgers and second on those of speculators with the same ranking and holding periods as the active strategy under review (HS-benchmark with corresponding R and H), 2. the time-varying risk premiums based first on the positions of speculators and second on those of hedgers with the same ranking and holding periods as the active strategy under review (SH-benchmark with corresponding R and H) and 3. the best performing risk premium in Table II, Panel A (HS-risk premium with R=26 and H=4). The comparison is based on annualized mean returns in Panel A, on Sharpe ratios in Panel B and on alpha from regressions of the active returns on either one of the selected benchmarks in Panel C. For example, the first entries in Panel A mean

that the average momentum portfolio earns an annualized mean return that is 6.7% higher than that of the long-only equally weighted benchmark with 25% (0%) of these differences that are positive (negative) at the 5% level. Similarly, the first entry in Panel B, 0.22, stands for the average difference in Sharpe ratios between the active momentum-based portfolios and the long-only equally weighted benchmark with 81.25% of the active portfolios offering reward-to-risk ratios that exceed that of the long-only equally weighted benchmark. Finally, the first entry in Panel C, measures the average alpha (6.7%) of the momentum portfolio relative to the long-only equally weighted benchmark with 25% (0%) of these alphas that are positive (negative) and significant at the 5% level.

Table IX: Performance of Active Strategies Relative to a Set of Selected Benchmarks

Panel A reports the difference in mean returns between the active portfolios and 5 selected benchmarks. Panel B reports the average difference in Sharpe ratios between the active portfolios and the same 5 benchmarks. Panel C reports the average annualized alphas of regressions of the active portfolios on either one of the 5 benchmarks. Positive stands for the percentage of active portfolios that outperform the benchmark (at the 5% level if in italics), Negative stands for the percentage of active portfolios that underperform the benchmark (at the 5% level if in italics). R (H) is the r

	Momentum strategy		Term structure (TS) strategy		Double-sort strategy based on first momentum and then TS		Double-sort strategy based on first TS and then momentum		All active strategies	
	Average	Positive Negative	Average	Positive Negative	Average	Positive Negative	Average	Positive Negative	Average	Positive Negative
<b>Panel A: Difference in mean returns between the active portfolios and the benchmarks</b>										
Long-only equally-weighted portfolio	0.0667	25% 0%	0.0646	12.50% 0%	0.1122	43.75% 0%	0.1105	37.50% 0%	0.0885	29.69% 0%
S&P-GSCI	0.0292	0% 0%	0.0271	0% 0%	0.0747	6.25% 0%	0.0730	6.25% 0%	0.0510	3.13% 0%
HS-benchmark with corresponding R and H	-0.0405	0% 6.25%	-0.0426	0% 0%	0.0050	0% 0%	0.0033	0% 0%	-0.0187	0% 1.56%
SH-benchmark with corresponding R and H	-0.0045	0% 0%	-0.0066	0% 0%	0.0410	0% 0%	0.0393	0% 0%	0.0173	0% 0%
HS-benchmark with R=26 and H=4	-0.0951	0% 18.75%	-0.0989	0% 12.50%	-0.0472	0% 0%	-0.0489	0% 0%	-0.0725	0% 7.81%
<b>Panel B: Difference in Sharpe ratios between the active portfolios and the benchmarks</b>										
Long-only equally-weighted portfolio	0.2242	81.25% 18.75%	0.2721	87.50% 12.50%	0.4970	1 0	0.4219	1 0	0.3538	92.19% 7.81%
S&P-GSCI	0.0752	56.25% 43.75%	0.1231	75% 25%	0.3480	1 0	0.2729	87.50% 12.50%	0.2048	79.69% 20.31%
HS-benchmark with corresponding R and H	-0.2212	25% 75%	-0.1733	31.25% 68.75%	0.0516	68.75% 31.25%	-0.0234	50.00% 50.00%	-0.0916	43.75% 56.25%
SH-benchmark with corresponding R and H	-0.0642	43.75% 56.25%	-0.0164	43.75% 56.25%	0.2086	93.75% 6.25%	0.1335	75.00% 25.00%	0.0654	64.06% 35.94%
HS-benchmark with R=26 and H=4	-0.4660	0 1	-0.4181	0 1	-0.1932	18.75% 81.25%	-0.2662	6.25% 93.75%	-0.3364	6.25% 93.75%
<b>Panel C: Alphas relative to selected benchmarks</b>										
Long-only equally-weighted portfolio	0.0669	25% 0%	0.0648	25% 0%	0.1124	62.50% 0%	0.1107	50% 0%	0.0887	40.63% 0%
S&P-GSCI	0.0601	25% 0%	0.0582	18.75% 0%	0.1040	50% 0%	0.1040	43.75% 0%	0.0816	34.38% 0%
HS-benchmark with corresponding R and H	0.0302	0% 0%	0.0516	12.50% 0%	0.0881	31.25% 0%	0.0747	18.75% 0%	0.0612	15.63% 0%
SH-benchmark with corresponding R and H	0.0498	18.75% 0%	0.0583	12.50% 0%	0.1006	37.50% 0%	0.0938	37.50% 0%	0.0756	26.56% 0%
HS-benchmark with R=26 and H=4	0.0144	0% 0%	0.0422	0% 0%	0.0805	25% 0%	0.0618	12.50% 0%	0.0497	9.38% 0%

Regardless of the panel considered, the conclusion from Table IX is as follows: while it is quite easy to beat a long-only benchmark through active trading, it is rather difficult to outperform an efficient benchmark that takes into account the propensity of futures markets to be either in backwardation or in contango. Take, for example, the difference in mean returns between the active portfolios and the benchmarks as reported on the right-hand side of Panel A. The active portfolios earn on average 8.85% more than the long-only equally-weighted benchmark and 5.10% more than the S&P-GSCI. On the other hand, the active strategies earn on average 2.46% less a year than the three sets of hedging-pressure-based benchmarks considered. The difference between the returns of the active portfolios and those of the hedging-pressure-based benchmarks is even at times negative and significant at the 5% level, with, for example, 18.75% of the momentum portfolios earning less than the best performing long-short benchmark (HS-benchmark with R=26 and H=4) at the 5% level.

The same conclusion applies when we look at risk-adjusted performance in Panel B (Sharpe ratios) and in Panel C (alphas). The Sharpe ratios of the active portfolios exceed that of the long-only equally-weighted benchmark 92.19% of the time, with an average difference in Sharpe ratios at 0.35.<sup>19</sup> Based on this previously reported result, one may be tempted to conclude that active trading is a source of outperformance in commodity futures markets. In fact, the active strategies do not look nearly as profitable relative to long-short benchmarks that take backwardation and contango into account. Then the Sharpe ratios of the active portfolios are higher than those of the long-short benchmarks only 38% of the time, with an average difference in Sharpe ratios that is negative at -0.12. Most remarkably, only 6.25% of the active portfolios offer Sharpe ratios higher than 0.71, the Sharpe ratio of the best performing benchmark (in Table II, Panel A).

Similarly the alphas calculated relative to the hedging-pressure-based benchmarks tend to be smaller (at 6.22% a year on average) than those calculated relative to the long-only benchmarks (8.51%). The percentage of alphas that are positive and significant at the 5% level drops from 37.5% (for the long-only benchmarks) to 17.19% (for the hedging pressure-based benchmarks) when we allow for long as well as short positions in commodity futures. This clearly suggests that our long-short dynamic risk premiums are better suited than long-only benchmarks to explaining the performance of active strategies in commodity futures markets.

On the whole, the evidence presented in Table IX suggests that part of the performance of the active portfolios relates to systematic time-varying exposure to the risks present in commodity futures markets. Our time-varying hedging-pressure-based risk premiums seem particularly useful at capturing the outperformance of the momentum portfolios, for which the average alpha (at 3.15% a year) is 53% less than the mean returns reported in Table VII (6.69% a year). This suggests that 53% of the average mean return identified in Table VII directly relates to time-variation in the commodity futures risk premiums. By contrast, the long-only benchmarks explain a mere 5% of the observed mean returns. The hedging-pressure based risk premiums explain 22% of the mean returns of the term structure portfolios reported in Table VII and 25% of the mean returns of the double-sort active portfolios. Again, these results compare favorably to those found for the long-only benchmarks (the long-only benchmarks indeed explain solely 5% of the mean returns of the term structure strategies and 3.35% of the mean returns of the strategies that jointly exploits momentum and term structure signals). Finally, it is interesting to note that, as expected from Table VIII, the hedging pressure-based risk premiums explain the mean returns of the momentum and double-sort portfolios better than the mean returns of the term structure portfolios.

19 - These results confirm that, as previously reported (Fuertes, Miffre and Rallis (2010)), actively trading commodity futures is a source of risk-adjusted performance relative to a long-only passive benchmark. Fuertes, Miffre and Rallis (2010) also report that the returns of the active strategies cannot be explained by a lack of liquidity, data mining, time-varying risk or transaction costs.

## VI. Conclusions

We construct factor-mimicking portfolios to capture the effect of systematic hedging pressure on the risk premium of commodity futures. These long-short portfolios buy backwarddated commodities and sell contangoed commodities, where the decision to allocate a commodity to either portfolio is based on the positions of hedgers, the positions of speculators or a double-sort that combines both positions. These long-short portfolios outperform a long-only equally-weighted portfolio by an average of 8.74% a year. The speculator-based portfolios earn on average 10.23% a year and outperform the hedger-based portfolios by 2.42%. This shows that, while there is a sizable risk transfer-based premium (equal to 7.82% a year), speculators demand a risk premium beyond that earned for merely taking on price risk, where this additional 2.42% return may reflect their own skills at modeling risk premium or their own ability to forecast futures returns (Chang (1985)). The largest risk premiums are obtained from a double-sort strategy based first on the positions of hedgers and second on those of speculators. When the ranking period is set to 26 weeks and the holding period is set to 4 weeks, that risk premium equals 16.07% a year and is significant at the 1% level. All these results suggest that systematic hedging pressure is a significant determinant of commodity futures risk premium.

Further results can be summarized as follows. First, in line with the notion that higher risk should be rewarded by higher returns, we find a positive relationship between our hedging pressure-based risk premiums and the lagged conditional volatility of commodity futures markets. Second, our cross-sectional results show that the price of commodity risk based on hedging pressure is positive and often significant, while the price of risk of a long-only equally-weighted portfolio of commodities is zero, both statistically and economically. Third, since investors traditionally use commodities for risk diversification and inflation hedging, it is important to test whether the return enhancement comes at the cost of losing the risk diversification and inflation hedge that are naturally provided by commodities. We find increased benefits in terms of risk diversification, but an absence of inflation hedge, for our hedging pressure-based benchmarks. Fourth, our dynamic long-short portfolios are found to be better suited at explaining the outperformance of active strategies commonly implemented in commodity futures markets, than long-only benchmarks.

Bringing all these results together it appears essential to use the information contained in the positions of hedgers and speculators to properly model the time-series and cross-sectional properties of the risk premiums present in commodity futures markets. A failure to account for hedging pressure results in the misleading conclusion that there is no risk premium or risk transfer and to the mistaken impression that active strategies perform remarkably well. For these reasons we suggest that our hedging-pressure-based benchmarks be used as building blocks for strategic asset allocation or to appraise the performance of tactical asset allocation strategies in commodity futures markets.

Overall, our paper contributes to the recent literature (Gorton, Hayashi and Rouwenhorst (2008), Acharya, Lochstoer and Ramadorai (2010), Hong and Yogo (2010), Tang and Xiong (2010)) that examines the role of systematic factors which influence the cross section of commodity prices. It would be interesting to analyze the relationship between our hedging pressure-based dynamic long-short portfolios and those based on inventory considerations, in order to further study the link between hedging pressure-based and storage-based theories. Our dynamic long-short portfolios could also provide useful benchmarks for analyzing the performance of commodity trading advisers and, more generally, any hedge fund with commodity exposure. We see these issues as interesting avenues for future research.

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