The Stock Market Price of Commodity Risk*

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Abstract

We find that commodity risk is priced in the cross section of US stock returns. Following the Commodity Futures Modernization Act (CFMA) in 2000, investors can hedge commodity price risk directly in the futures market, primarily via commodity index investments, whereas before the CFMA they could gain commodity exposure mainly via the stock market. As a result, we find that the mean returns on high-minus-low commodity beta stocks changes from -8 per year pre-CFMA to 11% per year post-CFMA. In addition, as stock market investors increasingly participate in commodity future markets post-CFMA, we find that stock market risk also affects mean commodity futures returns.

JEL Classification Codes: G11, G12, G13

Keywords: Asset pricing, Commodity futures market, Commodity index investment, Commodity risk premium, Hedging

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Commodity prices are a risk factor that affects consumers, producers and investors alike. Before the passage of the Commodity Futures Modernization Act (CFMA) in December, 2000, (institutional) investors seeking commodity exposure mainly had to do so via (expensive) investments in physical commodities or via commodity-related equity investments. Until then, most investors faced position limits set by the Commodity Futures Trading Commission (CFTC) on traded futures contracts as well as swaps and other over-the-counter derivatives related to commodity futures. This is no longer the case after the CFMA, leading to a strong increase in institutional index investment in commodity futures markets from less than \$ 10 billion in 1998, to around \$ 15 billion in 2003, and to over \$ 210 billion at the end of 2009 (CFTC (2009)). The introduction of the CFMA therefore serves like a quasi-natural experiment that changes the behavior of investors.

This paper analyzes the effect of commodity risk on stock returns, as well as the effect of increased commodity index investment following the CFMA on the stock and the commodity futures market.

We develop a model in the spirit of Hirshleifer (1988, 1989) that establishes an important link between stock and commodity futures markets. We model investors that are exposed to commodity price risk, for instance because of the link with inflation, and producers that maximize utility over income from these commodities, which they hedge in the futures market. When investors cannot hedge their commodity price risk in the futures market, but need to do so in the stock market, the hedge portfolio implies a negative hedging premium. When investors are able to hedge directly with a futures contract, the hedging premium in the stock market goes to zero if the contract is used exclusively for hedging. When the futures contract is attractive from an investment (or, speculative) point of view as well, our model indicates a reversal in the stock market premium and an increasing role of the stock market risk in explaining the cross-section of commodity futures returns. We find plausible conditions for such a positive speculative investment to be optimal: the presence of sufficiently many producers relative to investors (speculators) in the futures market and producers that are sufficiently more risk averse than investors (as in Hirshleifer (1988, 1989)).

Empirically, we find that commodity risk is priced in the cross section of stock returns, in opposite ways before and after the CFMA. Sorting stocks according to their beta with respect to a broad index of 33 commodity futures, we find a cross-section of expected returns that cannot be explained by the traditional portfolio return-based asset pricing models.[1] Pre-CFMA, high commodity beta stocks underperform by about -8% in average returns, which translates into -11.5% to -8.5% in risk-adjusted returns. Post-CFMA, this performance reverses to around 11% in both average and risk-adjusted returns. The magnitude of these returns is similar to other sorts reported in the literature, such as momentum (Jegadeesh and Titman (1993)).

Likewise, stock market risk does not show up in the cross-section of commodity futures returns pre-CFMA, but we do find evidence that stock market risk is relevant in explaining commodity futures returns post-CFMA.

As discussed in Lewis (2007), the most common approach for institutional investors to gain commodity exposure has historically been via equity investments. However, with the emergence of commodity index-based products, these products have become the most popular route. Figure 1 illustrates this surge in commodity investments. The figure plots total open interest in 33 commodities over time (200312 = 100) in US$ (top) and the number of contracts outstanding (bottom). For both measures we see that open interest increases to record-high levels in each sector around 2003 without ever returning to historical levels. Indeed, according to Stoll and Whaley (2009), the total trading volume of US exchange-traded commodity futures has grown six fold from 0.6 to 3.5

[1] These are the CAPM (Sharpe (1964), Lintner (1965) and Mossin (1966)), the Fama-French three-factor model (Fama and French (1993)), and the Fama-French-Carhart model (Carhart (1997)).

billion contracts during the period from 1998 to 2008. Even more important for our analysis, the share of total open interest in the futures market that is attributable to institutional index investment has grown from around 6% in 1998 to around 40% in 2009, representing dollar values of $ 10 billion to $ 210 billion respectively. In line with the conditions mentioned above we show that these index investments are well-accommodated by traditional hedgers in futures markets (see, among others, Stoll and Whaley (2009), Irwin and Sanders (2010) and Cheng et al. (2011)).

Our findings contribute to the literature on cross-sectional asset pricing and commodities. Similar to Chen et al. (2010), our results suggest that real factors matter in asset pricing. Our first contribution is to establish an important link between stock markets and commodity (futures) markets. These markets were previously thought to be segmented, given that the traditional portfolio return-based stock market factors play a weak role, if any, in explaining the cross-section of commodity futures returns (see, e.g., Dusak (1973), Bessembinder (1992), Bessembinder and Chan (1992) and Erb and Harvey (2006)). We show that, conversely, commodity risk does play a role in explaining the cross section of stock returns and that stock market risk plays a role, post-CFMA, in explaining the cross-section of futures returns. Our results imply that the two markets are linked due to investor's need to hedge commodity risk pre-CFMA and, in addition, their speculative demand in commodity futures markets post-CFMA. Thus, our findings are also an important addition to papers that investigate the financialization of commodity futures markets (see, e.g., Tang and Xiong (2009), Irwin and Sanders (2010), Stoll and Whaley (2009), Buyuksahin et al. (2010), Buyuksahin and Robe (2010), Cheng et al. (2011), and Basak and Pavlova (2013)).

We also show that the commodity premium in the stock market, and its reversal, show up using only the between-industry or only the within-industry variation in commodity betas. This finding indicates that within-industry variation, due to, for instance, corporate hedging practices, market power, or the place of a firm in the supply chain, is priced in addition to the pricing of between-industry variation due to differences in fundamental exposures to certain commodities. In fact, our regression-based measure of commodity risk essentially controls for the fact that some firms hedge (or unhedge) their exposures and therefore provides for a more natural measure of commodity risk than looking at SIC codes alone, as in Gorton and Rouwenhorst (2006).

In the next two sections we introduce our model that links commodity, stock, and futures markets and describe the change in institutional background around the introduction of the CFMA. Section II elaborates on the data and method. Section III presents returns along the cross-section of commodity exposures. In Section IV we analyze industry effects and the relation between inflation and commodity risk premium. Section V summarizes and concludes.

I Theoretical framework

We start out by developing a model that links commodity spot and futures markets to the stock market. Here, changing participation in the futures market implies a reversal in the commodity risk premium in the stock market. Our model uses a standard two-date mean-variance framework in the spirit of Hirshleifer (1988, 1989) and Bessembinder and Lemmon (2002). An important difference with these papers is that we do not model the stock market as one security, rather we model it as consisting of multiple stocks, thereby allowing for a price of commodity risk in the cross-section of stock returns.

A Economic setting

There are three types of agents: N_P commodity Producers that can hedge their commodity risk in the futures market, N_S specialized Speculators that only trade in the futures market, and N_I Investors that initially only trade in the stock market. Producers and Speculators only trade in the futures market and not in the stock market, either because of (fixed) trading or participation costs or because of wealth restrictions. Investors initially do not trade in the futures market because of position limits (set by the CFTC) that prevents them from doing so. The purpose of our model is to analyze the effects on both the futures and the stock market when these position limits are lifted.

B The futures market with Producers and Speculators only

There are N_P Producers that each are endowed with one dollar with which they (each) produce q_{t+1} units of a commodity. The amount produced is stochastic and has expectation one, but is assumed to be same for each producer. Thus, total endowed wealth of the Producers is also N_P and total (stochastic) output of the commodity is $Q_{t+1} = N_P q_{t+1}$. Consumers are characterized by the inverse demand function for the commodity: $Q_{t+1}^D = g\left(S_{t+1}\right)$, where spot market equilibrium implies $Q_{t+1} = Q_{t+1}^D$. Producers maximize a mean-variance utility function over income from output $\left(q_{t+1}S_{t+1}\right)$ which they can hedge by investing in h futures contracts on the commodity with a futures price F_t. The optimal futures position h then follows from:

$$
\begin{aligned}
max_h E\left[Y_{t+1}\right] - \frac{\gamma_P}{2} Var\left[Y_{t+1}\right], & \\
Y_{t+1} &= q_{t+1}S_{t+1} + h\left(S_{t+1} - F_t\right).
\end{aligned}
$$

Here γ_P is the risk aversion, which is assumed to be the same for all Producers. It is slightly more convenient to express this problem in relative terms:

$$
max_h E\left[y_{t+1}\right] - \frac{\gamma_P}{2} Var\left[y_{t+1}\right], \tag{1}
$$

$$
y_{t+1} = \frac{Y_{t+1}}{S_t} = q_{t+1}R_{S,t+1} + hR_{Fut,t+1}, \tag{2}
$$

with $R_{S,t+1}$ the relative change in the spot price, and $R_{Fut,t+1}$ the (pseudo) return on the futures contract. We denote expected returns by μ_i and (co)variances by σ_{ij}. Following Hirshleifer (1988), Appendix A.1 shows that a Taylor series approximation of S_{t+1} around its expected value $\bar{S}$ when the expected output $\bar{q} = 1$, results in the optimal futures position

$$h = \frac{1}{\gamma_P}\frac{\mu_{Fut}}{\sigma_{FF}} - (1+\eta)\frac{\sigma_{FS}}{\sigma_{FF}}. \tag{3}$$

Here η is the demand elasticity, $\eta = g\left(\bar{S}\right)\bar{Q}/\bar{S}g'\left(\bar{S}\right)$. Equation (3) is a well-known result that separates the optimal futures position in a speculative demand and a pure hedge demand. The pure hedge demand reflects both price and quantity risk by adjusting the futures position according to the demand elasticity.

The N_S Speculators are likewise endowed with one dollar each, which they invest in a riskfree deposit with return $R_{f,t}$ to which they add s futures contracts. Thus, Speculators maximize a mean-variance utility function

$$max_s R_{f,t} + \mu_{Fut} - \frac{\gamma_S}{2}\sigma_{FF},$$

where γ_S is the risk aversion that is again assumed to be equal for all Speculators. The optimal futures demand by Speculators equals

$$s = \frac{1}{\gamma_S}\frac{\mu_{Fut}}{\sigma_{FF}}, \tag{4}$$

similar to the speculative demand by Producers. Since futures contracts are in zero net supply, futures market equilibrium requires $N_P h + N_S s = 0$. Combining this with the optimal positions in (3) and (4), leads to:

Proposition 1: *In a futures market with only Producers and Speculators the futures* *risk premium equals*

$$E\left[R_{Fut,t+1}\right] = \frac{\lambda_P}{\lambda_P+\lambda_S}\gamma_P\sigma_{FS}\left(1+\eta\right), \tag{5}$$
$$\lambda_i = N_i/\gamma_i, i=P,S. \tag{6}$$

Proposition 1 shows a well-known result that the futures risk premium, or the price of commodity risk in the futures market, depends on the covariance of the futures and the spot return σ_{FS}, the risk aversion of the Producers γ_P, and the risk aversion-adjusted market share of Producers in the futures market, $\lambda_P/\left(\lambda_P+\lambda_S\right)$. The term $\gamma_P\sigma_{FS}\left(1+\eta\right)$ reflects the hedge demand for futures contracts by Producers. Producers have a higher demand for futures the bigger the covariance of the futures with the spot risk, adjusted for the demand elasticity, and the higher their risk aversion. Assuming that $\sigma_{FS}>0$ and $\eta>-1$, the hedge demand will be a short position, and the futures risk premium will be positive. This is the familiar hedging pressure effect: a short hedge position has to be compensated by the speculative demand from both Speculators and Producers themselves. This speculative demand can only be a long position if the futures risk premium is positive. The risk adjusted market share of the Producers versus Speculators reflects the strength of the hedging pressure effect: if there are more Speculators and if the risk aversion of Speculators is lower, then there is a bigger speculative demand to absorb the hedge demand of Producers, thereby lowering the futures risk premium.

C The stock market with Investors facing position limits in the futures market

There are N_I Investors that are each endowed with one dollar that they can invest in the risk free asset and K risky stocks. The stocks have excess returns given by the K-vector r_{t+1}, with expectation μ_r and covariance matrix Σ_{rr}. These Investors may also want to add futures contracts, but may be prevented from doing so because of position limits (for instance following from the CFTC). We will first consider the case where the position limits are such that Investors cannot take a position in the futures market and then compare this to the case where there are no position limits and they can choose an optimal position in the futures market.

Investors are exposed to commodity price risk, where the size of the exposure is φ per dollar invested. This exposure may arise because Investors are exposed to inflation risk and commodity prices represent large and volatile component of inflation, or because commodities are a state variable that predict consumption-investment opportunities (e.g., Merton (1973), Long (1974), and Fama (1996)).

In the presence of position limits, investors choose their optimal portfolio w_r over stocks only, with w_r a K-dimensional vector. In the absence of position limits they can add a futures positions, and they choose their portfolio $w = \begin{pmatrix} w_r' & w_{Fut} \end{pmatrix}'$, with w a $K+1$ vector. We likewise denote μ as the $K+1$ vector of expected excess stock returns plus the expected futures return, $\mu = \begin{pmatrix} \mu_r' & \mu_{Fut} \end{pmatrix}'$, Σ the $(K+1) \times (K+1)$covariance matrix of the K stock returns and the futures returns, and Σ_S the $K+1$ vector of covariances between the stock and futures returns on the one hand and the commodity return on the other hand, $\Sigma_S = \begin{pmatrix} \Sigma_{rS}' & \sigma_{FS} \end{pmatrix}$'. Investors choose their optimal investment portfolio by maximizing the following mean-variance utility function, in the presence respectively absence of position limits:

$$\begin{aligned} \text{with limits } (w_{Fut} = 0)\text{:} \qquad & max_{w_r} R_{f,t} + w_r'\mu_r - \frac{\gamma_I}{2} \left\{ w_r'\Sigma_{rr}w_r + 2w_r'\Sigma_{rS}\varphi + \varphi^2\sigma_{SS} \right\}, \\ \text{without limits:} \qquad & max_w R_{f,t} + w'\mu - \frac{\gamma_I}{2} \left\{ w'\Sigma w + 2w'\Sigma_S\varphi + \varphi^2\sigma_{SS} \right\}. \end{aligned}$$

Here γ_I is the risk aversion of Investors, which is assumed to be equal for all Investors. In order to express the optimal portfolio weights, it is useful to consider a regression of the futures returns on the K stock returns:

$$R_{Fut,t+1} = a + b' r_{t+1} + e_{t+1}, \text{ with} \tag{7}$$

$$\sigma_{ee} = Var\left[e_{t+1}\right]. \tag{8}$$

Using this, Appendix A.2 shows that the optimal portfolios with and without position limits can be expressed as:

$$\text{with limits: } w_r = \frac{1}{\gamma_I}\Sigma_{rr}^{-1}\mu_r - \varphi\Sigma_{rr}^{-1}\Sigma_{rS}, \tag{9}$$

$$\text{without limits: } w_r = \frac{1}{\gamma_I}\Sigma_{rr}^{-1}\mu_r - w_{Fut,spec}\Sigma_{rr}^{-1}\Sigma_{rF} \tag{10}$$

$$w_{Fut} = w_{Fut,spec} - \varphi\frac{\sigma_{FS}}{\sigma_{FF}}, \text{ with} \tag{11}$$

$$w_{Fut,spec} = \frac{1}{\gamma_I}\frac{a}{\sigma_{ee}}. \tag{12}$$

In the presence of position limits, Investors only invest in the stock market (plus a risk free asset), and their optimal demand for stocks in (9) consists of the standard Markowitz portfolio plus a hedge portfolio that hedges against commodity price risk. The hedge portfolio $\Sigma_{rr}^{-1}\Sigma_{rS}$ are the regression coefficients of a regression of commodity returns $R_{S,t+1}$ on the K stock returns r_{t+1}. If $\varphi < 0$, which would be the case if Investors want to hedge against inflation, or if commodity prices negatively predict investment opportunities, the optimal portfolio takes bigger (smaller) positions in stocks that have a high (low) correlation with commodity returns.

If there are no position limits for the futures contract, the optimal futures position is given in Equation (11). As with the Producers, the optimal futures demand consists of a speculative part $w_{Fut,spec}$ and a hedge demand for commodity risk. Since the futures and the commodity return are perfectly correlated, the hedging of the commodity risk takes place entirely via the futures market and no longer via the stock market as in (9): the exposure φ only affects the demand for futures, not for stocks. The speculative demand for futures depends on the intercept a and residual variance σ_{ee} from the regression in (7). The intercept is basically the (generalized) Jensen measure of the futures contracts versus the available stocks. A positive (negative) a therefore allows for diversification possibilities relative to the stock portfolio by going long (short) in the commodity futures. As follows from Equation (10), if there is such a speculative demand for the futures contract, the demand for stocks is adjusted according to the regression coefficients b in (7), which are the mimicking portfolio of the stocks for the futures contract. This adjustment in the stock positions can also be interpreted as a hedge demand for stocks, to hedge against the speculative position in the futures contract. Notice that, because of the perfect correlation between the futures and commodity return, the hedge portfolio in (10) is proportional to the one in (9), i.e., $\Sigma_{rr}^{-1}\Sigma_{rF} = \frac{\sigma_{SS}}{\sigma_{FF}}\Sigma_{rr}^{-1}\Sigma_{rS}$.

When all Investors have the same risk aversion, w_r in (9) and (11) must also equal the market portfolio of stocks. Using this, Appendix A.2 shows:

Proposition 2: *When Investors are exposed to commodity price risk and face possible position limits in the futures market, the expected excess returns on stocks depend on their covariance with the market and the covariance with commodity returns:*

$$\begin{aligned} \textit{with limits: } E\left[r_{i,t+1}\right] &= \gamma_I \sigma_{im} + \gamma_I \varphi \sigma_{iS}, && (13) \\ \textit{without limits: } E\left[r_{i,t+1}\right] &= \gamma_I \sigma_{im} + \frac{a}{\sigma_{ee}} \frac{\sigma_{SS}}{\sigma_{FF}} \sigma_{iS}. && (14) \end{aligned}$$

Proposition 2 shows that expected stock returns depend on their covariance with the market as well as on their covariance with the commodity return, due to the hedge demand. The effect of commodity hedging on the expected stock returns is different in case there are position limits in the futures market versus the case where there are no limits though. When there are limits on the futures position, the stocks are used to hedge the commodity risk and the expected stock returns depend on their covariance with the commodity returns and φ. If $\varphi < 0$, investers have a bigger demand for stocks that have a high correlation with commodity returns, leading to lower expected returns on those stocks. The reverse holds when $\varphi > 0$. In both cases commodity risk is priced in the cross-section of stock returns.

When there are no position limits in the futures market, Investors can hedge commodity risk using futures contract and the exposure to commodity risk φ no longer affects expected stock returns. However, if there is a speculative demand (long or short) for commodity futures due to a/σ_{ee} being non-zero, there is a hedge demand in the stock portfolio resulting from this. Because the commodity and the futures returns are perfectly correlated, commodity risk is again priced in the cross-section of stock returns. The size and sign of the effect of commodity risk in the two scenarios depends on the size and sign of $\gamma_I \varphi$ versus $\frac{a}{\sigma_{ee}} \frac{\sigma_{SS}}{\sigma_{FF}}$.

D The futures market with Producers, Speculators and Investors

When there are no position limits in the futures markets for Investors, they will also take positions in the futures market, according to (11) and (12). Thus, there are three groups of traders in the futures markets: Producers, whose demand is given in (3), Speculators, whose demand is given in (4) and Investors, whose demand is given in (11) and (12). Futures market equilibrium again requires that total demand for futures contracts adds up to zero, i.e., $N_P h + N_S s + N_I w_{Fut} = 0$. Using that in (7) and (11) $a = \mu_{Fut} - b' \mu_r$, we can solve for the equilibrium expected return on the futures contract. Appendix A.3 shows:

Proposition 3: *In a futures market with Producers, Speculators, and Investors, where Investors are exposed to commodity risk and do not face position limits in the* *futures market, the futures risk premium equals*

$$
\begin{aligned}
E\left[R_{Fut,t+1}\right] &= \frac{\lambda_P\left(1+\eta\right)\gamma_P+\lambda_I\varphi\gamma_I}{\lambda_P+\lambda_S+\tilde{\lambda}_I}\sigma_{FS}+\frac{\tilde{\lambda}_I\gamma_I}{\lambda_P+\lambda_S+\tilde{\lambda}_I}\sigma_{Fut,tan}, && (15)\\
\textit{with } \lambda_i &= N_i/\gamma_i, i=P,S,I && (16)\\
\tilde{\lambda}_I &= \lambda_I\frac{\sigma_{FF}}{\sigma_{ee}}, && (17)\\
\sigma_{Fut,tan} &= Cov\left[R_{Fut,t+1}, r_{t+1}^{tan}\right]. && (18)
\end{aligned}
$$

Here r_{t+1}^{tan} *is the return on the tangency portfolio of stocks only.*

The first term of the expected futures return in (15) is similar to Proposition 1, except that now also the Investors enter both the numerator and the denominator. Since Investors also want to hedge their commodity risk in the futures market, they add to the hedging pressure via $\lambda_I\varphi\gamma_I$. If $\varphi<0$ the hedging demand of the Investors (partly) offsets the hedging demand by Producers, thus lowering the hedging pressure and the futures risk premium. If $\varphi>0$ the hedging demand of Investors increases total hedging pressure and therefore the futures risk premium. Even if Investors do not have an exposure to commodity risk, i.e., $\varphi=0$, they enter the first term via the denominator, thereby lowering the futures risk premium. This effect is similar to the presence of Speculators.

The second term in (15) follows from the fact that Investors combine the futures contract with the stock market investments for speculative reasons. This makes stock market risk priced via the covariance of the futures returns with the return on the tangency portfolio of stocks, w_r^{tan}. Since only the Investors invest in both stocks and futures, whereas Producers and Speculators do not invest in the stock market, the weight assigned to this stock market risk is the risk aversion weighted market share of Investors in the futures market. Because Investors care about the residual risk of the futures σ_{ee} rather than total risk σ_{FF}, their market share $\tilde{\lambda}_I$ is adjusted for this according to (17).

II Empirical framework

A Institutional setting

The model outlined above relies on an assumption that a structural break must have occurred in the investment practices of a large group of agents (Investors). We argue that this break occurred following the passage of the Commodity Futures Modernization Act (CFMA) on December 21, 2000. The act allowed institutional investors (insurance companies, pension funds, foundations and hedge funds e.g.) and wealthy individuals to take large positions in commodity futures and other commodity derivatives, whereas before 2000 most of them faced narrow position limits imposed by the Commodity Futures Trading Commission (CFTC) to prevent "excessive speculation".

In terms of our model, this means that Investors could not hedge their commodity risk exposure in the futures market historically, but had to resort to hedging in the stock market or to directly investing in physical commodities, which is expensive (Lewis (2007)). After the CFMA, Investors can get the desired commodity exposure via the futures market and other commodity derivatives markets. As a result, commodity index investment by such investors in over-the-counter swap agreements, exchange-traded funds (ETF), exchange-traded notes (ETN), and managed funds, benchmarked to well-diversified and transparent indices like the SP-GSCI and DJ-UBSCI, jumped from \$ 15 billion in 2003 to over \$ 210 billion at the end of 2009 (CFTC (2009) and Muo (2010)). These numbers underestimate the true investments in commodities, because the exchange-traded market still represents less than 10% of the total market for commodity derivatives (Etula (2010)).

In line with, among others, Domanski and Heath (2007) and Tang and Xiong (2009), we use the observable change in total open interest seen in Figure 1 to motivate splitting our sample at December 31, 2003. We refer to the period before December 31, 2003 as "pre-CFMA" and the period thereafter as "post-CFMA". Below we show that our results are not sensitive to the exact breakpoint chosen.

B Commodity futures data

We construct an index of commodity futures to represent the futures contract modeled in Section I. We collect data on prices and open interest of 33 exchange-traded, liquid commodities from the Commodity Research Bureau (CRB), supplemented with data from the Futures Industry Institute (FII). A detailed overview of the sample is given in Table I. The commodities are divided into four broad sectors: Energy, Agriculture, Metals and Fibers, and Livestock and Meats.[2]

Table I about here.

We calculate futures returns by using a roll-over strategy of first and second nearest-to-maturity contracts.[3] First, we focus on contracts that are relatively close to maturity because these are typically the most liquid. Second, this strategy is similar to the construction of commercial indexes, like the SP-GSCI and the DJ-UBSCI. We roll out of the first nearest contract and into the second nearest contract at the end of the month before the month prior to maturity. In this way, we guard against the possible confounding impact of erratic price and volume behavior commonly observed close to maturity.[4] For Energy commodities we have contracts maturing in all months of the year; for most other commodities we have between four and eight delivery months available. For all contracts except Sugar and Pork Bellies, the delivery months are never more than three months

[2]For instance, Hong and Yogo (2012) use a similar partitioning.

[3]To be precise, we calculate uncollateralized futures returns in month t, as $R_t = \frac{F_{t,T}}{F_{t-1,T}} - 1$, where $F_{t,T}$ is the futures price at the end of month t of the nearest contract whose expiration date T is after the end of month $t+1$. These uncollateralized futures returns are comparable with excess returns on stocks and are made up of both the spot return and the roll return.

[4]This erratic behavior might be partly caused by the commonality in index investors' roll-over strategies. By rolling over approximately one to two weeks before most commercial indices do, our index is not affected by their short-term market impact (see, e.g., Muo (2010)).

apart.

Table I reports average returns, standard deviations (both in annualized percentages) and median total open interest (TOI) in US$ for each individual contract.[5] Historically, the Energy sector has contained the largest commodities and the Livestock and Meats sector the smallest in open interest and trading volume. Throughout, we focus on an open interest-weighted total index (OIW) that aggregates all 33 commodities, and which, similar to value-weighted stock indices or production-weighted commercial commodity indices, weights month t commodity returns according to TOI at the end of month $t-1$. We show that the main results are robust for an equal weighted total index (EW) and present additional robustness checks for OIW sector indexes and the SP-GSCI Excess Return Index in the Internet Appendix.

C Estimating commodity exposures

To find out whether commodity prices are a relevant risk factor in the stock market, we apply the Fama and French (1992, 1993, 1996) portfolio approach. We sort both individual stocks (that is, all ordinary common shares traded on NYSE, AMEX and NASDAQ excluding financial firms) and 48 industry portfolios on their beta with respect to the OIW commodity index.[6]

At the end of each month $t-1$, we re-estimate the commodity beta for stock (or industry) i, $\beta_{i,t-1}$, over a 60-month rolling window using

$$R_{i,s} - R_{f,s} = \alpha_{i,t-1} + \beta_{i,t-1} R_{oiw,s} + \varepsilon_{i,s}, \text{ for } s = t-60, ..., t-1, \tag{19}$$

where we require that at least three out of the last five years of returns are available.

[5]TOI is defined as the sum of the open interest of all outstanding contracts (i.e., contracts with different maturities) for a specific commodity, multiplied by the first-nearest futures price.

[6]The 48 industry portfolios are sourced from Kenneth French's Web site.

We apply equation (19) from January 1975 onwards to ensure that the OIW total index consists of at least 20 commodities, such that it can be reasonably expected to mimic the important macroeconomic impact that commodities have.As a result, the sample of post-ranking portfolio returns spans from January 1980 to December 2010. To allow for the hypothesized reversal, we split the sample at December 2003, which adds up to 288 months in the pre-CFMA period and 84 months in the post-CFMA period.

First, we construct 25 market value-weighted stock portfolios based from an independent sort in five commodity beta groups and five size groups. We also consider results for a one-dimensional sort on commodity beta in five value-weighted stock portfolios. Second, a one-dimensional between-industry sort constructs five industry portfolios from the 48 industries, equally weighting nine or ten industries in each portfolio.

We apply the time-series regression approach of Black et al. (1972) to analyze average and risk-adjusted post-ranking returns of the portfolios introduced above as well as the High minus Low commodity beta (HLCB) spreading portfolios constructed therefrom. To this end, we use the Fama-French-Carhart factors (MKT, SMB, HML and MOM, available from Kenneth French's Web site) to benchmark against the CAPM of Sharpe (1964), Lintner (1965) and Mossin (1966), the three-factor model of Fama and French (1993, denoted as FF3M), and the four-factor model of Carhart (1997, denoted as FFCM).

III The cross-section of stock and futures returns

We start out by documenting the main implications of the model outlined in Section I, that is the pricing of commodity risk in the stock market and a change in this price post-CFMA, and the price of stock market risk in the futures markets, post-CFMA.

A Basic sorting results

A.1 Commodity risk in the stock market

Our first main results are presented in Table II. Here, we analyze whether a commodity risk premium is present when conditioning on the pre- and post-CFMA periods, in line with the hypothesized reversal. We present average returns and standard deviations for the two sub-periods of interest in Panel A and Panel B, respectively. Panel C tests the differences in returns between the pre- and post-CFMA periods.

Table II about here.

In average returns, stocks and industries with high commodity betas underperform consistently pre-CFMA. Also, for all size quintiles except the smallest, the average returns are decreasing monotonically in the commodity beta. The HLCB spread is economically large and statistically significant at -8.11% for the one-dimensional sort of stocks and at -4.72% for industries.[7] On the contrary, post-CFMA high commodity beta stocks outperform consistently. Again, the HLCB spread is economically large and statistically significant at 12.08% for the one-dimensional sort of stocks and at 12.22% for industries. Also, in almost all cases the average returns now increase monotonically with their commodity beta. In both subperiods we observe also a monotonic relation between portfolio standard deviations and commodity beta, which may suggest that commodity beta captures an exposure to risk. The results in Panel C show that the pre- and post-CFMA difference in the HLCB returns of around 20% for individual stocks and 17% for industries is highly significant, whereas the difference in returns over the two-subperiods increases monotonically with commodity beta.

[7] We find Construction, Steel Works (etc.), Petroleum and Natural Gas, Precious Metals, Mining, Coal and Machinery among the industries with consistently high commodity betas and Retail, Insurance and Consumer Goods among the industries with consistently low commodity betas.

Table III about here.

Next, we see in Table III that the previously documented performance-beta relation and its reversal survive when controlling for the usual risk factors. Table III is structured similarly to Table II except that we now present risk-adjusted returns ($\alpha's$) for the two sub-periods in Panels A and B, respectively. Pre-CFMA, the HLCB spread actually widens to large and significant CAPM, FF3M and FFCM alphas of between -8% and -10% for the one-dimensional sort of stocks and around -6% for industries. Post-CFMA, only about 2% of the HLCB spread is captured by the MKT factor, leaving HLCB α's that are over 10% for both stocks and industries. Again, in almost every case the alphas are decreasing or increasing monotonically with the commodity beta. Panel C summarizes this evidence and shows that the difference in the two commodity risk premiums adds up to an economically large and highly significant difference of about 20% (17%) for stocks (industries). Highlighting the importance of controlling for size, we find that the performance-beta relation is strongest, adding up to the largest performance differential, among the bigger stocks in both subperiods.

We can interpret this reversal in risk premium in the context of our model. Pre-CFMA when institutional investors hedge their commodity risk in the stock market, equation (13) implies that HLCB spread will be negative if $\varphi < 0$. Post-CFMA when commodity futures represent a considerable fraction of many, large institutional investors' portfolios, our model implies that the spread can either be zero, if these positions solely reflect a hedge demand $w_{Fut,spec} = 0$, or positive, if these positions also reflect speculative demand $w_{Fut,spec} > 0$. Thus, given that $\varphi < 0$ if Investors are interested in hedge against inflation, or if commodity prices negatively predict the investment opportunity set, and if the speculative demand for commodity futures is positive, as documented in the literature,[8] the reversal in the commodity risk premium reported above is consistent with our model.

Although, a positive speculative demand makes historical sense, it is hard to justify a positive speculative investment if the influx of index investor capital drives up prices too much. Results from Irwin and Sanders (2010), Stoll and Whaley (2009), and Buyuksahin and Robe (2010) question this price impact. Moreover, the conditions for $w_{Fut,spec} > 0$ (i.e., sufficiently more Producers and sufficiently risk-averse Producers) are fairly mild and do not seem to be violated post-CFMA. Essentially, from Equation (15) we need that the hedging pressure from Producers is sufficiently large so that the resulting expected futures returns still induce a positive speculative demand for Investors.

To illustrate this, Figure 2 shows that commercial hedger's (net) short positions are sufficient to cover non-commercial speculator's (net) long positions, using data from the CFTC Commitment of Traders Report from January 1986 to December 2010. To be precise, Panel A demonstrates that the OIW average net short position of hedgers has historically been larger than the OIW average net long position of speculators, whereas the difference is decreasing steadily since 1986. Further, Panel B demonstrates that the total short position of hedgers has always been larger than the total long position of speculators, although this difference is decreasing since 2000.

We recognize that these results are perhaps biased, as the CFTC's historical classification rules are outdated. However, using more detailed daily data from the CFTC's Large Trader Reporting System, Cheng et al. (2011) arrive at a similar conclusion. For the average commodity, traditional hedgers' short positions increase in lockstep with index

[8]Following the CFMA, the demand for diversified commodity investments increased sharply, when the equity market collapse and the widely publicized findings of Greer (2000), Gorton and Rouwenhorst (2006), and Erb and Harvey (2006) suggested that commodity futures are an attractive asset class for the prudent investor. First, historical returns on broad commodity indexes are similar to stocks in risk and return. Second, correlations between commodities and traditional asset classes are small and sometimes negative, largely due to different behavior over the business cycle. Third, commodities are useful as a hedge against inflation, unexpected inflation and changes in expected inflation (see, e.g., Bodie (1983), Gorton and Rouwenhorst (2006) and Bekaert and Wang (2010)).

investors' long positions over the last decade.

A.2 Stock market risk in the commodity futures market

Comparing Equations (5) and (15), one of the implications of the model in Section I is that in the absence of (futures) position limits for stock market Investors the expected futures returns also depend on the covariance of the futures returns with the stock market's tangency portfolio. Thus, both pre-CFMA and post-CFMA the futures risk premia are driven by hedging pressure in the futures market, whereas only post-CFMA we may expect stock market risk to be relevant for the futures risk premia as well.

In Table IV we sort the commodity futures in our dataset into four portfolios based on hedging pressure and based on their beta with respect to stock market portfolios.[9] Following the literature (e.g., de Roon et al. (2000)) we construct for each futures contract a hedging pressure variable as the difference between the number of short and the number of long hedge positions by large traders relative to the total number of hedge positions of large traders:

$$\frac{\#\text{short hedge positions - \# long hedge positions}}{\text{total \# hedge positions}}.$$

Unlike the model in Section I this allows Producers (hedgers) to take both long and short positions in futures contracts, but we show in the Internet Appendix that the model is easily extended by allowing Producers to have either long or short exposures.

Table IV about here.

The first two columns of Table IV show that the mean returns of the four sorted portfolios increase monotonically with hedging pressure, as implied by the model. This

[9] We observe hedging pressure data for 25 out of our 33 commodities.

holds both pre-CFMA (Panel A) and post-CFMA (Panel B). The resulting spread in mean returns for the high versus low hedging pressure portfolios are 7.57% and 11.92% in the two subperiods respectively, which are economically meaningful and statistically marginally significant. This positive relation between hedging pressure and mean futures returns, also post-CFMA, is in line with a positive speculative demand for commodity futures from Investors.

The next columns sort the same commodity futures on their beta with respect the stock market portfolio and with respect to the HLCB portfolio (from the stock market) respectively. In our model, the tangency portfolio in equation (15) is a combination of the market portfolio and the HLCB portfolio, which is why we use both to sort on. Panel A shows that pre-CFMA, if anything, sorting on the stock market beta yields an inverse relation with mean returns, whereas there is no relationship between the mean returns on the commodity futures and their beta with respect to the HLCB portfolio. For the post-CFMA period in Panel B, the mean returns on the commodity futures portfolios do increase monotonically with their stock-market beta, although the resulting spread between the high beta and low beta commodities is not significant. Sorting on the HLCB beta does not give a strong pattern in mean futures returns. The positive relation between the stock market beta and the mean futures returns is consistent with the increased participation of Investors in the futures market post-CFMA though.

Since our model implies that both the (stock) market portfolio and the HLCB portfolio may be relevant in explaining the cross-section of futures returns post-CFMA, Panels A and B also report mean returns for double sorts on the market and the HLCB portfolio. Due to the limited number of futures contracts, we again sort in only four portfolios. This results in a 2×2 matrix of mean returns, where the model in Equation (15) implies that futures in the low-low portfolio (i.e., with the lowest market and lowest HLCB betas) have the lowest mean return, whereas the futures in the high-high portfolio (highest market and highest HLCB beta) have the highest mean return. The mean returns on the low-high and the high-low portfolios should be in between these lowest and highest means, but a priori these two cannot be ranked.

The results in Panel A show that pre-CFMA the difference between the two extreme portfolios is statistically and economically insignificant, whereas post-CFMA we do observe a significant spread. These results are again in line with our model that implies that stock market risk affects the expected futures returns via the market and HLCB portfolio. The resulting spread between the high-high and low-low portfolios of 11.4% is both economically and statistically significant. Thus, as suggested by the model in Section I, the cross-section of futures returns are related to hedging pressure in both the pre-CFMA and the post-CFMA periods, and to stock market risk only in the post-CFMA period.

B Robustness checks

B.1 Exploring the structural break

Our analysis sofar sets the structural break for the pre- and post-CFMA period at December 2003. To test the sensitivity of our results for the exact breakpoint, Table V reports the HLCB reversal for different breakpoints from December 2000 until December 2005. A breakpoint at December 2000 would imply the effects of the CFMA to be effective immediately after its passage, whereas the subsequent breakpoints allow the effects to materialize more gradually over time. Table V reports both average returns and FFCM alphas.

Table V about here.

For all breakpoints, the one-dimensional sort for stocks and industries results in a reversal between 13% and 23% in average and risk-adjusted returns, which is always statistically significant. Thus, our results are not sensitive to the exact dating of the breakpoint. Moving from 2000 to 2005, we see an inverted U-shape. For individual stocks, the largest difference in average returns is obtained when we split the sample in December 2002 (20.69%), whereas the largest difference in FFCM α is obtained when we split in December 2004 (23.00%). For industries, both spreads are largest when we split in December 2002. These results suggest that the structural break occurs between December 2002 and 2004, giving support to choosing December 2003 as the breakpoint, as in Domanski and Heath (2007) and Tang and Xiong (2009).

A related issue is whether the composition of these portfolios is stable following the CFMA. To this end, Table VI presents the time-series average of the diagonal elements of Markov switching matrices for the five stock portfolios sorted one-dimensionally on commodity beta for each of the five-year subperiods in our sample. For instance, in the first column, we see that on a month-to-month basis, 95% (93%) of the stocks in the High (Low) beta portfolio do not switch. The different columns demonstrate that the average percentage of stocks that do not switch portfolios varies between 82% and 89% in the different subperiods. Further, the unreported full Markov matrices show that stocks hardly ever move more than one portfolio at a time in any given subperiods. Importantly, there is no substantial drop in this percentage in the subperiod 2001-2005, when the effects of the CFMA should be most apparent. On the contrary, we observe a relatively high percentage of 89%, suggesting that the portfolios are stable.

Table VI about here.

In short, the stability post-CFMA indicates that the documented reversal is not driven by changing covariances. Rather, in line with our model, the reversal is driven by changing average returns. To further substantiate this finding, we fix the portfolio composition to what it is in December 2003 and compare the resulting HLCB portfolio to the HLCB portfolio that updates its weights every month in Panel B of Table VI. First, we see that the returns of the two strategies are highly correlated post-CFMA. For the one-dimensional sort of stocks (for the industry sort), the correlation between the two HLCB portfolios equals 90% (92%) from January 2004 until the onset of the crisis in June 2007, and 0.66 (0.57) until December 2010. Second, we also observe a similar reversal in the risk premiums.

B.2 Other robustness checks

We find that our results are robust in a number of dimensions. First, looking at the last columns in each panel of Tables II and III we see that our conclusions extend for the one-dimensional sort on the EW commodity index. This shows that the documented reversal in risk premium is not driven by changing shares of open interest of the commodities within our index.

In the Internet Appendix, we obtain similar spreads for the (production-weighted) SP-GSCI commodity index. Moreover, we observe economically meaningful reversals for sorts on an Energy and a Metals and Fibers index, consistent with the relatively large proportion of index investment flowing into these sectors post-CFMA. High Energy beta stocks outperform by about 13.5%, while sorting on exposures to a Metals and Fibers index gives HLCB spreads of 6% post-CFMA. Note, however, these returns are not a mirror image of the returns on the sector indexes themselves, which are -2% for Energy and 16% for Metals and Fibers post-CFMA.

We also find similar reversals in average and risk-adjusted returns when sorting the stocks based on commodity betas estimated controlling for the benchmark factors in each rolling window. Our results also extend to using Fama and MacBeth (1973) cross-sectional regressions to estimate risk premiums. Thus, commodity exposures capture a risk factor that is separate from the traditional risk factors.

Finally, given that both commodity beta and size are persistent, transaction costs are unlikely to subsume the spreads. Indeed, we find similar results when rebalancing only once a year and when varying the length of the rolling window from two to ten years. Also, our results are not driven by the recent financial crisis, as excluding it only strengthens our result.

IV Industry effects and inflation

As additional robustness checks, this section investigates whether i) our sorting results mainly reflect industry effects, or are a pure stock-commodity play and ii) our results are due to the change in the correlation between stock returns and inflation, or indeed represent a change in commodity price risk.

A Within-industry effects

The robustness of our main results for a one-dimensional sort of industries suggests that the reversal in the commodity risk premium can be captured using only between-industry variation in commodity betas. This subsection demonstrates that the reversal can also be captured using only within-industry variation. To this end we construct five market value-weighted stock portfolios within each industry by splitting at the quintiles of ranked commodity betas within that industry. Here, we exclude four financial industries and in each month $t-1$ industries that contain fewer than ten stocks.

Table VII presents average returns and FFCM alphas for the within-industry sort in a similar vein as Tables II and III.[10] In each block, the first five rows and columns present results for portfolios that equally weight the within-industry portfolios (i.e., within-industry group High, 2, 3, 4 or Low, where High consists of stocks whose beta is high relative to

[10] CAPM and FF3M alphas are similar but not presented to conserve space.

other stocks in the industry) of typically seven or eight industries that fall into the relevant group of the between-industry sort (i.e., between-industry group High, 2, 3, 4 or Low). The sixth column presents the average within-industry effect, which is a portfolio that equal-weights five between-industry groups. The sixth row presents the HLCB within-industry portfolios.

Table VII about here.

Panel A demonstrates that low commodity beta stocks underperform high commodity beta stocks pre-CFMA across the full spectrum of industry betas. In average returns, the underperformance within industries ranges from -6% to -3% per year, which adds up to a strictly monotonic commodity beta-return relation for the average within-industry portfolio and a significant HLCB spread of -4.35%. These conclusions are even stronger in risk-adjusted returns.

In Panel B we demonstrate that the post-CFMA reversal is present across the full spectrum of industry betas, as well. The outperformance of high commodity beta stocks within each industry is monotonic and adds up to significant 11.69% for the average within-industry portfolio and again extends to risk adjusted returns. Further, in Panel C we show that this reversal is economically large and significant in four out of five between-industry groups.

In summary, these within-industry effects suggest that variation in commodity beta within industries, perhaps due to differences in corporate hedging practices, market power or the place of a firm in the supply chain, is priced in a manner consistent with our hypothesis. This indicates that our findings are not merely picking up the fundamental commodity exposure of a given industry. Rather, there are important differences in firm exposures to commodity risk within industry, even when the industry at large is not exposed.

B Inflation

One natural question is whether sorting on commodity returns is tantamount to sorting on (unexpected) inflation and therefore whether the results are driven by the reversal in the correlation between inflation and the stock market after the turn of the century (see e.g., Bekaert and Wang (2010) and Campbell et al. (2011)). To verify that the commodity effect we document is separate, we consider sorts wherein we first orthogonalize stock returns from inflation effects. Thus, in each rolling window, we run two regressions to find $\beta_{i,t-1}$

$$\begin{aligned} R_{i,s} - R_{f,s} &= a_{i,t-1} + c_{i,t-1} I_s + e_{i,s} \\ e_{i,s} &= \alpha_{i,t-1} + \beta_{i,t-1} R_{oiw,s} + \varepsilon_{i,s}, \text{ for } s = t-60, ..., t-1, \end{aligned} \tag{20}$$

where I_s is either unexpected inflation (UI) or a mimicking portfolio of unexpected inflation (UIF), which addresses the concern that stock's exposures to non-traded factors typically economically small and hard to estimate. For the non-traded measure of inflation UI, we follow e.g., Erb and Harvey (2006) and Hong and Yogo (2012) and use the month t change in the annual inflation rate, i.e., $UI_t = \frac{CPI_t}{CPI_{t-12}} - \frac{CPI_{t-1}}{CPI_{t-13}}$, which assumes annual inflation is integrated of order one.[11] The inflation factor UIF is constructed using a three-by-two sort on betas with respect to UI and size, similar to Fama and French (1993).

In Table VIII we present means and FFCM alphas for the usual one- and two-dimensional sorts on these inflation-controlled commodity betas for both sub-periods of interest in Panels A and B, and test the difference in Panel C. Note, the left block of results orthogonalizes returns from non-traded unexpected inflation UI, the right block

[11] Our results extend using three alternative measures of (unexpected) inflation used by others in the past: (i) the difference between the monthly inflation rate and the short-term t-bill rate; (ii) an ARIMA(0,1,1)-innovation extracted from the monthly inflation series; and, (iii) monthly inflation itself.

from the traded unexpected inflation factor UI1F.

Table VIII about here.

When controlling for UI, we see that both mean and risk-adjusted returns remain economically large and significant in both subperiods, adding up to a HLCB spread in average returns of -7.36% (-5.14%) for the one-dimensional sort on stocks (industries) in the first sub-period and 9.74% (10.12%) in the second sub-period. The performance differentials add up to a difference of around 15% for both stocks and industries in case of both the OIW and the EW index, which is very similar to what we found in Table II. Again, these performance differentials are typically significant, strengthen in risk-adjusted returns and are strongest among the biggest stocks.

This result may not come as a surprise, given that one may not expect the commodity beta to change much when stocks' exposures to non-traded inflation are small. Indeed, we find that commodity betas are by and large similar with and without UI. However, the right panel documents that the commodity risk premium easily extends when controlling for UIF as well. Although in the first sub-period the HLCB spreads are slightly smaller, we see that they remain economically large and significant in risk-adjusted returns. Post-CFMA the HLCB spreads are very similar, adding up to a difference of over 14%, which is only slightly smaller than what we had before. Again, the commodity beta-return relation is typically quite monotonic and stronger among big stocks.

V Conclusion

Because many investment, production and consumption decisions are conditioned on commodity prices, one would expect them to be a common risk factor in the economy. In this paper we utilize the information about the increased commodity index investment following the passage of the CFMA to study the effect of commodity risk in the economy. We study this risk premium in a model where investors are exposed to commodity price risk, for example because of the link with inflation, but are initially restricted from hedging their exposure in the futures markets, in line with the position limits present before the introduction of CFMA. In such economy commodity risk does play a role in explaining the cross-section of stock returns and stock market risk plays a role, post-CFMA, in explaining the cross-section of commodity futures returns.

Indeed, we find a strong pattern in expected stock returns existing along the cross-section of commodity exposures. Pre-CFMA, stocks with high commodity betas underperform those with low commodity betas by -8% per year in average returns, while post-CFMA, stocks with high commodity betas outperform by 11% per year. This reversal is consistent with the structural change in the behavior of investors who were seeking commodity exposure in the stock market pre-CFMA and subsequently in the commodity futures markets. This is also consistent with the fact that stock market risk only shows up in the cross-section of commodity futures returns post-CFMA.

Our findings are particularly relevant for stocks that are strongly exposed to commodity price risk and suggest that commodity betas can be used in devising strategies that use stocks to hedge or speculate on commodity prices. This finding is particularly interesting for those institutions that might still be prevented or restricted, in any way, from directly investing in commodity markets. Interestingly, the performance differentials we document extend to strategies that use only between-industry variation in commodity betas and to strategies that use only within-industry variation, which implies that commodity risk can be (and is in practice) hedged while holding industry exposures constant.

Appendix A Derivations

This appendix presents detailed derivations for the model outlined in Section I.

A.1 Optimal futures demand

Total supply equals $N_P q_{t+1} = Q_{t+1}$, with $\bar{q} = 1$. Using a Taylor series approximation of S_{t+1} around its mean $\bar{S}$, and defining $\bar{Q} = N_P \bar{q}$, we have for $Q_{t+1}S_{t+1} = g\left(S_{t+1}\right) S_{t+1}$:

$$
\begin{aligned}
g\left(S_{t+1}\right) S_{t+1} &\approx g\left(\bar{S}\right)\bar{S} + \left\{g\left(\bar{S}\right) + \bar{S}g'\left(\bar{S}\right)\right\}\left(S_{t+1} - \bar{S}\right) \\
&= g\left(\bar{S}\right)\bar{S} + N_P\left(1+\eta\right)\left(S_{t+1} - \bar{S}\right),
\end{aligned}
$$

from which we have

$$
q_{t+1}S_{t+1} = \frac{1}{N_P} Q_{t+1}S_{t+1} \approx g\left(\bar{S}\right)\bar{S} + \left(1+\eta\right)\left(S_{t+1} - \bar{S}\right).
$$

Combining this with the optimization problem of the Producer, the first order condition is

$$
\mu_{Fut} - \gamma_P\left\{\sigma_{FF}h + \sigma_{FS}\left(1+\eta\right)\right\} = 0,
$$

from which the optimal futures demand demand follows immediately.

A.2 Optimal portfolio for investors with and without position limits

The first order conditions for the mean-variance Investor that faces position limits in the futures market are:

$$
\mu_r - \gamma_I\left\{\Sigma_{rr}w_r + \Sigma_{rS}\varphi\right\} = 0,
$$

from which we get:

$$w_r = \gamma_I^{-1}\Sigma_{rr}^{-1}\mu_r - \varphi\Sigma_{rr}^{-1}\Sigma_{rS}.$$

Similarly, without position limits, the first order conditions are

$$\begin{pmatrix} \mu_r \\ \mu_{Fut} \end{pmatrix} - \gamma_I \left\{ \begin{pmatrix} \Sigma_{rr} & \Sigma_{rF} \\ \Sigma_{Fr} & \sigma_{FF} \end{pmatrix} \begin{pmatrix} w_r \\ w_{Fut} \end{pmatrix} + \begin{pmatrix} \Sigma_{rS} \\ \sigma_{FS} \end{pmatrix} \varphi \right\} = 0.$$

Using that the partitioned inverse of Σ can be written as

$$\Sigma^{-1} = \begin{pmatrix} \Sigma_{rr}^{-1} + \sigma_{ee}^{-1}bb' & -\sigma_{ee}^{-1}b \\ -\sigma_{ee}^{-1}b' & \sigma_{ee}^{-1} \end{pmatrix},$$

where b and $\sigma_{ee} = Var\left[e_{t+1}\right]$ follow from the regression

$$R_{Fut,t+1} = a + b'r_{t+1} + e_{t+1},$$

the first order conditions can be solved for w as

$$w = \begin{pmatrix} w_r \\ w_{Fut} \end{pmatrix} = \gamma_I^{-1} \begin{pmatrix} \Sigma_{rr}^{-1}\mu_r \\ \sigma_{ee}^{-1}a \end{pmatrix} - \begin{pmatrix} \gamma_I^{-1}\sigma_{ee}^{-1}a\Sigma_{rr}^{-1}\Sigma_{rF} \\ \varphi\sigma_{FF}^{-1}\sigma_{FS} \end{pmatrix}.$$

In both cases, with and without position limits, all stock market Investors choose the same optimal portfolio, implying that the optimal portfolio of stocks equals the market portfolio of stocks, $w_r = w_m$. Using this in the first order conditions, Proposition 2 follows immediately.

A.3 Futures risk premium

Combining the optimal futures demand of Producers, Speculators and Investors, and imposing futures market clearing $N_P h + N_S s + N_I w_{Fut} = 0$ we have

$$\lambda_P \frac{\mu_{Fut}}{\sigma_{FF}} - \lambda_P \gamma_P (1+\eta) \frac{\sigma_{FS}}{\sigma_{SS}} + \lambda_S \frac{\mu_{Fut}}{\sigma_{FF}} + \lambda_I \frac{\mu_{Fut} - b' \mu_r}{\sigma_{ee}} - \lambda_I \gamma_I \varphi \frac{\sigma_{FS}}{\sigma_{FF}}.$$

Using that $b = \Sigma_{rr}^{-1} \Sigma_{rF}$, and that $\gamma_I^{-1} \Sigma_{rr}^{-1} \mu_r$ is the tangency portfolio for the stock market, we can solve for μ_{Fut} and write

$$\mu_{Fut} = E\left[R_{Fut,t+1}\right] = \frac{\lambda_P (1+\eta) \gamma_P + \lambda_I \varphi \gamma_I}{\lambda_P + \lambda_S + \lambda_I \sigma_{FF}/\sigma_{ee}} + \frac{\lambda_I \gamma_I \sigma_{FF}/\sigma_{ee}}{\lambda_P + \lambda_S + \lambda_I \sigma_{FF}/\sigma_{ee}} \sigma_{Fut,tan}.$$

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Figure 1: Total Open Interest in 33 commodities (1959 to 2010)

The top figure displays total open interest in 33 commodities in US$, which is calculated as the sum of the US$ open interest in each commodity (number of contracts outstanding times nearest-to-maturity futures price). The bottom figure displays total open interest in terms of the number of contracts outstanding. Both series are normalized to equal 100 in December 2003.

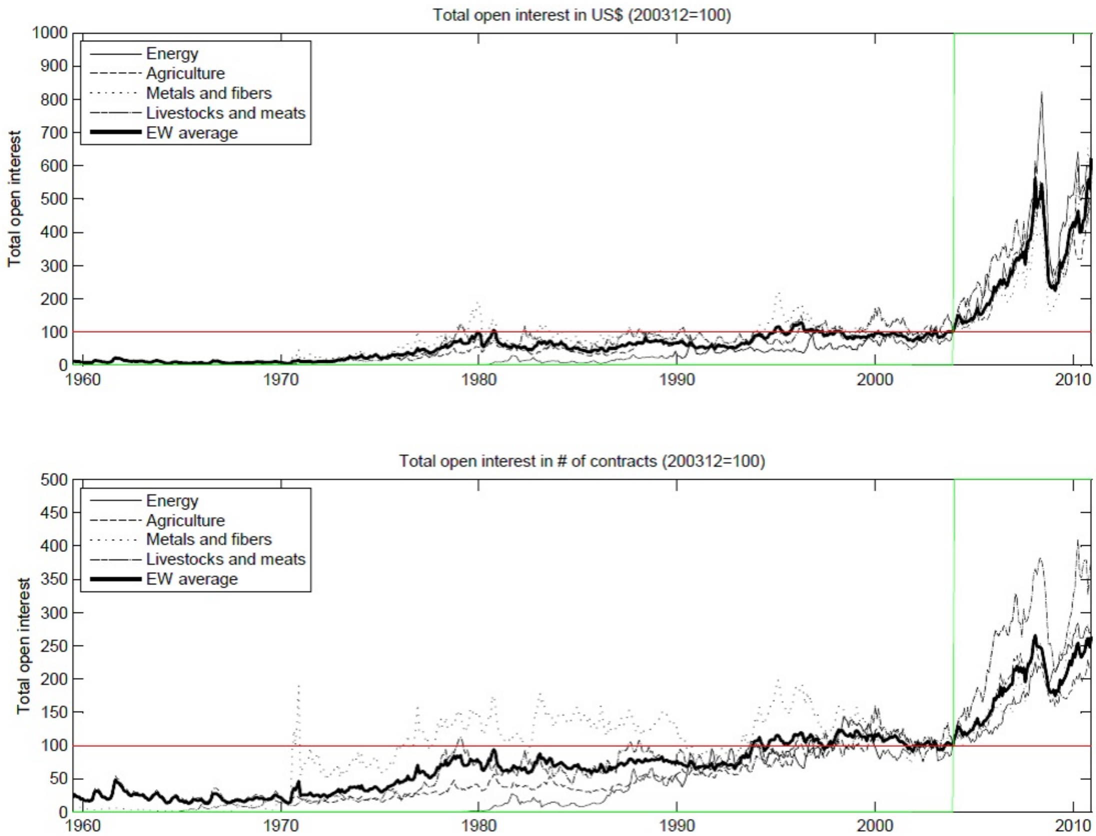
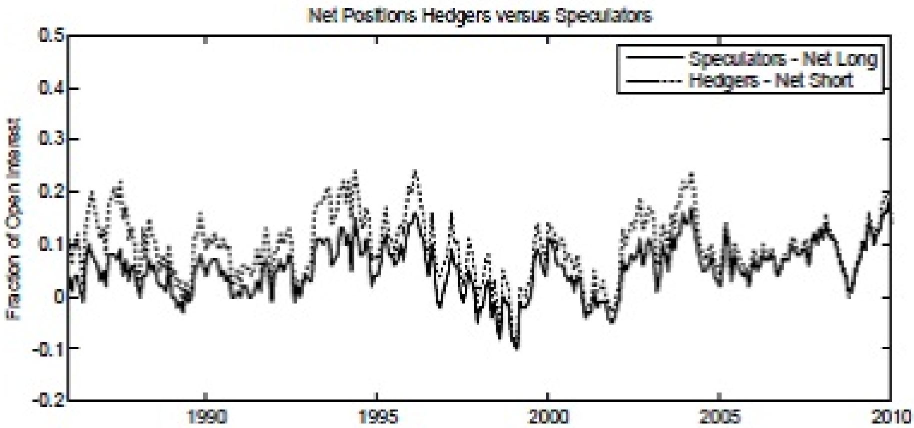


Figure 2: OIW Positions of Hedgers versus Speculators (1986-2010)

The top figure displays the Open Interest Weighted average over all commodities in the CFTC's historical Commitment of Traders (COT) reports of the net short position (short minus long) of commercial hedgers versus the net long position (long minus short) of non-commercial speculators. The bottom figure displays the Open Interest Weighted average of the short position of commercial hedgers versus the long position (long plus spreading) of non-commercial speculators. All series are presented as a fraction of Open Interest. Traders are classified as in the COT reports, which are available from 1986 onward.



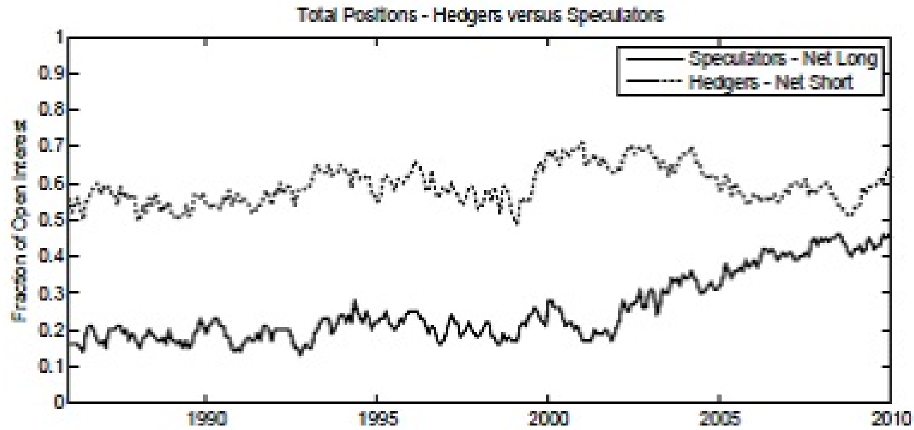


Table I: Overview of commodity futures
This table presents detailed characteristics of 33 commodity futures, divided over four sectors: Energy (E), Agriculture (A), Metals and Fibers (M) and Livestock and Meats (L). The table lists: (i) a commodities' sector (sec.) and symbol (sym.; as it appears in the CRB data); (ii) the exchange on which it is traded [(1)]; (iii) the delivery months considered; (iv) the first month in which both a return and total open interest (TOI) are observed (the end date, December 2010, is common to all contracts except propane and flaxseed, for which TOI approaches zero in 2007 and 2003, respectively); (v) annualized average return and standard deviation (in US$, * indicates significance at the 10%-level); and finally, (vi) the median TOI (in US$ MM).

(Sec.) Comm. (Sym.)	Exchange	Delivery Months	First Obs.	Avg. Ret.	St. Dev.	TOI
(E) Crude Oil (CL)	NYMEX	All	198304	12.75*	33.71	7793
(E) Gasoline (HU/RB) [(2)]	NYMEX	All	198501	18.35*	35.80	2353
(E) Heating Oil (HO)	NYMEX	All	197904	9.92*	31.95	2925
(E) Natural Gas (NG)	NYMEX	All	199005	-3.74	51.79	11233
(E) Gas-Oil-Petroleum (LF)	ICE	All	198910	13.59*	32.12	2491
(E) Propane (PN)	NYMEX	All	198709	27.13*	47.05	21
(A) Coffee (KC)	ICE	3,5,7,9,12	197209	8.21	37.84	1234
(A) Rough Rice (RR)	CBOT	1,3,5,7,9,11	198701	-2.82	28.90	76
(A) Orange Juice (JO)	ICE	1,3,5,7,9,11	196703	5.50	32.75	217
(A) Sugar (SB)	ICE	3,5,7,10	196102	7.73	43.73	941
(A) Cocoa (CC)	ICE	3,5,7,9,12	195908	3.60	31.05	463
(A) Milk (DE)	CME	2,4,6,9,12	199602	2.57	24.42	531
(A) Soybean Oil (BO)	CBOT	1,3,5,7,8,9,10,12	195908	7.88*	29.85	822
(A) Soybean Meal (SM)	CBOT	1,3,5,7,8,9,10,12	195908	9.13*	29.06	1005
(A) Soybeans (S-)	CBOT	1,3,5,7,8,9,11	196501	5.69	26.98	3514
(A) Corn (C-)	CBOT	3,5,7,9,12	195908	-1.38	23.43	2083
(A) Oats (O-)	CBOT	3,5,7,9,12	195908	-0.46	29.16	51
(A) Wheat (W-)	CBOT	3,5,7,9,12	195908	0.17	24.48	833
(A) Canola (WC)	WCE	3,5,6,7,9,11	197702	0.38	22.18	196
(A) Barley (WA)	WCE	3,5,7,10,12	198906	-2.59	22.15	18
(A) Flaxseed (WF)	WCE	3,5,7,10,11,12	198501	1.27	20.26	21
(M) Cotton (CT)	ICE	3,5,7,10,12	195908	3.20	23.30	1086
(M) Gold (GC)	NYMEX	2,4,6,8,10,12	197501	1.70	19.47	6224
(M) Silver (SI)	NYMEX	3,5,7,9,12	197202	6.48	32.50	2790
(M) Copper (HG)	NYMEX	1,3,5,7,9,12	197210	10.77*	27.77	1250
(M) Lumber (LB)	CME	1,3,5,7,9,11	196911	-3.15	27.62	121
(M) Palladium (PA)	NYMEX	3,6,9,12	197702	13.26*	36.01	94
(M) Platinum (PL)	NYMEX	1,4,7,10	197208	7.69*	27.79	324
(M) Rubber (YR)	TOCOM	All	199204	9.46	32.58	565
(L) Feeder Cattle (FC)	CME	1,3,4,5,8,9,10,11	197112	3.90	16.40	516
(L) Live Cattle (LC)	CME	2,4,6,8,10,12	196412	5.46*	16.49	1925
(L) Lean Hogs (LH)	CME	2,4,6,7,8,10,12	196603	4.52	25.51	692
(L) Pork Bellies (PB)	CME	2,3,5,7,8	196402	2.03	33.72	191

[(1)] CBOT = Chicago Board of Trade; CME = Chicago Mercantile Ex.; ICE = ICE Futures US; NYMEX = New York Mercantile Ex.; TOCOM = Tokyo Commodity Ex.; WCE = Winnipeg Commodity Ex.
[(2)] Until June 2006 returns are based on the Unleaded Gasoline (HU) contract, from July 2006 on the Reformulated Gasoline Blendstock (RB) contract

Table II: Average stock returns over subsamples

This table presents average returns and standard deviations, in annualized %'s) for the commodity-beta sorted portfolios of interest. Panel A covers 198001 to 200312 (Pre-CFMA) and Panel B covers 200401 to 201012 (Post-CFMA). Panel C tests the difference over the two sample periods. All t-statistics are based on White's heteroskedasticity-consistent standard errors.

	Panel A - 198001-200312						Panel B: 2004-2010					
	OIW	OIW	OIW	OIW	OIW	EW	OIW	OIW	OIW	OIW	OIW	EW
	Size quintile				One-way		Size quintile				One-way	
	S	3	B	Stocks	48 Ind.	Stocks	S	3	B	Stocks	48 Ind.	Stocks
						Mean returns						
H	5.88	3.55	2.33	1.91	5.00	4.45	12.13	15.29	15.10	14.85	14.57	11.93
4	8.88	6.90	7.04	6.58	8.23	5.77	12.02	9.97	4.78	5.64	5.97	7.33
3	10.56	9.44	6.32	7.04	7.84	8.25	11.07	8.58	2.08	3.58	6.62	5.16
2	10.55	11.32	9.24	9.53	10.07	8.81	9.25	7.91	3.08	3.87	6.47	5.07
L	8.93	13.03	10.01	10.02	9.72	9.33	1.88	1.98	3.25	2.77	2.35	3.24
HLCB	-3.04	-9.47	-7.68	-8.11	-4.72	-4.88	10.25	13.31	11.85	12.08	12.22	8.69
t(HLCB)	(-1.17)	(-2.36)	(-1.77)	(-2.02)	(-1.70)	(-1.16)	(1.98)	(2.00)	(1.88)	(1.95)	(1.92)	(1.34)
						Standard deviations						
H	27.11	26.75	24.52	24.33	19.13	25.90	31.07	28.47	21.48	22.73	24.65	24.46
4	21.75	19.19	19.17	18.35	17.67	21.06	27.42	22.27	15.62	16.82	22.46	19.58
3	19.20	17.47	17.25	16.72	17.68	16.19	25.71	20.48	15.81	16.51	19.71	15.48
2	19.41	17.91	16.51	16.16	16.26	15.01	23.03	19.07	14.17	14.69	17.65	14.25
L	23.60	21.66	17.76	17.86	15.72	15.68	23.82	19.66	14.44	14.90	15.39	13.75
						Panel C: Difference						
			Returns						t-statistics			
H	6.25	11.74	12.78	12.94	9.57	7.48	(0.48)	(0.97)	(1.34)	(1.30)	(0.95)	(0.70)
4	3.14	3.06	-2.26	-0.93	-2.26	1.56	(0.28)	(0.33)	(-0.32)	(-0.13)	(-0.24)	(0.18)
3	0.51	-0.85	-4.24	-3.46	-1.22	-3.09	(0.05)	(-0.10)	(-0.61)	(-0.49)	(-0.15)	(-0.46)
2	-1.30	-3.41	-6.16	-5.66	-3.60	-3.74	(-0.14)	(-0.42)	(-0.97)	(-0.88)	(-0.48)	(-0.60)
L	-7.04	-11.04	-6.75	-7.25	-7.37	-6.09	(-0.69)	(-1.28)	(-1.03)	(-1.08)	(-1.11)	(-1.00)
HLCB	13.29	22.78	19.53	20.19	16.95	13.58	(2.29)	(2.93)	(2.55)	(2.73)	(2.44)	(1.75)

Table III: Average risk-adjusted stock returns over subsamples

This table presents risk-adjusted returns (α's, in annualized %'s) for the commodity-beta sorted portfolios of interest. We use the CAPM, FF3M and FFCM as benchmark asset pricing models. Panel A covers 198001 to 200312 (Pre-CFMA) and Panel B covers 200401 to 201012 (Post-CFMA). Panel C tests the difference over the two sample periods. All t-statistics are based on White's heteroskedasticity-consistent standard errors.

	Panel A - 198001-200312						Panel B: 2004-2010					
	OIW	OIW	OIW	OIW	OIW	EW	OIW	OIW	OIW	OIW	OIW	EW
	Size quintile				One-way		Size quintile				One-way	
	S	3	B	Stocks	48 Ind.	Stocks	S	3	B	Stocks	48 Ind.	Stocks
						α_{CAPM}						
H	-3.59	-6.71	-6.95	-7.73	-2.67	-5.86	4.40	8.32	10.30	9.45	8.61	6.07
4	0.92	-1.19	-0.72	-1.30	0.72	-3.29	5.18	4.32	0.93	1.24	0.17	2.23
3	3.49	2.13	-1.25	-0.52	0.38	0.98	4.76	3.30	-2.01	-0.77	1.46	1.07
2	3.55	3.99	2.16	2.44	3.22	2.36	3.49	3.13	-0.54	0.06	1.88	1.37
L	0.60	4.59	3.21	2.82	3.18	2.91	-3.99	-2.93	-0.08	-0.92	-1.65	-0.25
HLCB	-4.18	-11.30	-10.16	-10.54	-5.85	-8.77	8.38	11.25	10.38	10.37	10.26	6.31
t(HLCB)	(-1.63)	(-2.82)	(-2.41)	(-2.72)	(-2.11)	(-2.30)	(1.91)	(1.89)	(1.71)	(1.77)	(1.70)	(1.10)
						α_{FF3M}						
H	-3.99	-6.34	-4.36	-6.19	-4.68	-3.78	1.47	6.71	11.42	9.91	8.65	6.33
4	-1.36	-3.02	1.22	-0.11	-1.40	-0.87	2.20	2.41	1.74	1.37	-0.92	1.72
3	0.27	-0.36	0.15	0.27	-2.57	1.15	1.43	1.57	-1.88	-0.99	1.01	1.16
2	-0.21	1.25	2.42	2.18	1.45	1.54	0.68	1.51	-0.48	-0.20	1.16	1.14
L	-1.86	2.18	3.70	2.42	1.05	2.08	-6.71	-4.65	0.42	-1.02	-2.03	-0.04
HLCB	-2.13	-8.53	-8.06	-8.61	-5.73	-5.86	8.17	11.36	11.00	10.93	10.68	6.37
t(HLCB)	(-0.83)	(-2.09)	(-1.92)	(-2.25)	(-2.06)	(-1.69)	(1.96)	(1.97)	(1.84)	(1.91)	(1.89)	(1.13)
						α_{FFCM}						
H	-1.73	-6.12	-5.52	-6.67	-4.75	-3.52	1.65	6.81	11.30	9.82	8.60	6.23
4	0.69	-3.23	-0.97	-1.73	-0.92	0.40	2.40	2.46	1.67	1.33	-0.82	1.76
3	2.41	0.43	-0.61	-0.13	-1.99	0.76	1.60	1.66	-1.83	-0.93	1.08	1.16
2	2.82	3.48	3.22	3.33	2.13	1.08	0.77	1.53	-0.47	-0.19	1.23	1.18
L	2.75	5.59	5.88	4.99	2.12	2.77	-6.66	-4.67	0.36	-1.08	-2.01	-0.09
HLCB	-4.48	-11.71	-11.39	-11.66	-6.87	-6.30	8.31	11.48	10.94	10.90	10.60	6.32
t(HLCB)	(-1.91)	(-2.85)	(-2.75)	(-3.10)	(-2.44)	(-1.80)	(2.02)	(1.98)	(1.82)	(1.90)	(1.90)	(1.12)
						Panel C: Difference						
	Alphas						t-statistics					
HLCB	12.57	22.55	20.54	20.92	16.11	15.09	(2.47)	(3.14)	(2.78)	(2.98)	(2.43)	(2.18)
HLCB	10.31	19.89	19.05	19.54	16.41	12.23	(2.10)	(2.82)	(2.60)	(2.84)	(2.60)	(1.85)
HLCB	12.79	23.19	22.33	22.56	17.47	12.61	(2.70)	(3.27)	(3.06)	(3.28)	(2.79)	(1.90)

Table IV: Average commodity futures returns over subsamples

This table presents average returns and standard deviations, in annualized %'s) for the commodity futures sorted portfolios based on hedging pressure, market and HLCB beta. Panel A covers 198001 to 200312 (Pre-CFMA) and Panel B covers 200401 to 201012 (Post-CFMA). All t-statistics are based on White's heteroskedasticity-consistent standard errors.

Panel A: Commodity-based sorted portfolios for 198001 to 200312

	Single sorts					
	Hedging Pressure		Market β		HLCB β	
	Mean	St. dev	Mean	St. dev	Mean	St. dev
L	-0.04	11.69	6.89	13.51	2.12	16.31
2	0.25	11.58	5.13	14.36	0.64	14.22
3	1.99	13.10	0.53	13.09	2.11	12.67
H	7.53	11.79	0.62	12.53	8.93	19.27
HL	7.57	14.73	-6.27	16.96	6.82	25.03
t(HL)	(1.85)		(-1.61)		(1.19)	

	Double sorts			
	HLCB β			
	mean		St. dev	
Market β	L	H	L	H
L	1.36	7.43	14.68	15.21
H	-2.25	3.83	13.08	16.12
HH-LL	2.48		19.50	
t(HH-LL)	(0.55)			

Panel B: Commodity -based sorted portfolios for 200401 to 201012

	Single sorts					
	Hedging Pressure		Market β		HLCB β	
	Mean	St. dev	Mean	St. dev	Mean	St. dev
L	3.17	17.53	0.04	17.87	-1.78	12.19
2	9.43	20.39	7.29	21.21	8.58	19.32
3	6.28	22.11	9.74	20.25	12.48	19.70
H	15.09	20.52	10.90	20.92	6.76	27.37
HL	11.92	19.36	10.86	19.14	8.54	26.15
t(HL)	(1.63)		(1.50)		(0.86)	

	Double sorts			
	HLCB β			
	mean		St. dev	
Market β	L	H	L	H
L	-2.23	8.09	14.56	24.87
H	9.06	9.16	19.66	21.00
HH-LL	11.38		16.98	
t(HH-LL)	(1.77)			

Table V: Exploring the structural break

This table tests the difference over two sample periods for alternative breakpoints after the introduction of the Commodity Futures Modernization Act, i.e., December 2000, 2001, 2002, 2003, 2004 and 2005. We report average returns and FFCM α's for the HLCB portfolios. All t-statistics are based on White's heteroskedasticity-consistent standard errors.

		Difference in alternative breakpoints after CFMA											
		$\alpha's$ in ann.%'s						t-statistics					
							Dec. 2000						
Means	HLCB	9.18	12.63	14.49	15.72	15.38	9.44	(1.84)	(1.73)	(2.01)	(2.33)	(2.63)	(1.27)
FFCM	HLCB	8.93	15.18	17.92	18.31	15.59	9.79	(2.06)	(2.17)	(2.47)	(2.76)	(2.80)	(1.58)
							Dec. 2001						
Means	HLCB	8.65	14.81	19.77	19.00	15.29	10.30	(1.68)	(2.02)	(2.76)	(2.81)	(2.50)	(1.42)
FFCM	HLCB	8.92	17.79	21.60	20.75	15.18	8.22	(2.04)	(2.49)	(3.03)	(3.15)	(2.69)	(1.32)
							Dec. 2002						
Means	HLCB	13.38	18.60	21.31	20.69	18.89	15.76	(2.51)	(2.53)	(2.89)	(2.95)	(2.92)	(2.17)
FFCM	HLCB	11.90	18.65	23.40	22.21	18.03	12.32	(2.70)	(2.75)	(3.31)	(3.38)	(3.06)	(1.97)
							Dec. 2003						
Means	HLCB	13.29	22.78	19.53	20.19	16.95	13.58	(2.29)	(2.93)	(2.55)	(2.73)	(2.44)	(1.75)
FFCM	HLCB	12.79	23.19	22.33	22.56	17.47	12.61	(2.70)	(3.27)	(3.06)	(3.28)	(2.79)	(1.90)
							Dec. 2004						
Means	HLCB	12.56	22.19	20.13	20.48	17.15	15.85	(1.94)	(2.59)	(2.42)	(2.52)	(2.20)	(1.90)
FFCM	HLCB	12.24	22.63	23.17	23.00	18.14	15.83	(2.36)	(2.95)	(2.93)	(3.06)	(2.61)	(2.20)
							Dec. 2005						
Means	HLCB	10.91	22.19	15.11	16.97	13.60	13.40	(1.47)	(2.29)	(1.68)	(1.89)	(1.55)	(1.43)
FFCM	HLCB	9.51	21.29	18.32	19.37	14.15	13.34	(1.65)	(2.52)	(2.17)	(2.36)	(1.84)	(1.64)

Table VI: Stability of sort post-CFMA

This table presents two results that demonstrate that our portfolios are stable after the introduction of the CFMA. Panel A presents a summary of Markov switching matrices for the five one-dimensional stock portfolios (from H to L) for five-year subperiods. Each column represents the diagonal of the switching matrix (averaged over all months in the subperiod), which represents the fraction of stocks that does not switch out of that respective portfolio. Panel B presents means and FFCM alphas for stock and industry portfolios sorted one-dimensionally in five commodity beta groups, where we fix the ranking on its December 2003 value. Note, the stock portfolios contain only those stocks that are in the December 2003 sample. We present average returns and FFCM α's for the long-only portfolios and for the high minus low commodity beta (HLCB) portfolios we also present the corresponding t-statistics based on White's heteroskedasticity-consistent standard errors. Also, we present two correlations of these portfolios with the original portfolios (that allow the composition to change freely post-CFMA): $Corr(r_{free}, r_{fixed})$. This correlation is presented for the period until June 2007, just before the financial crisis, and until December 2010.

Panel A: Diagonal of Markov switching matrices

	1980-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010
H	0.95	0.93	0.95	0.92	0.94	0.94
4	0.87	0.83	0.87	0.79	0.86	0.83
3	0.84	0.79	0.84	0.75	0.84	0.79
2	0.85	0.82	0.87	0.77	0.87	0.81
L	0.93	0.92	0.94	0.89	0.95	0.92
Average	0.89	0.86	0.89	0.82	0.89	0.86

Panel B: Returns when portfolio composition is fixed at December 2003

	Stocks		48 Ind.	
	Means	FFCM	Means	FFCM
H	9.98	5.71	12.20	7.61
4	4.74	1.43	8.78	3.34
3	3.13	-0.74	1.76	-3.79
2	5.93	0.87	7.67	1.79
L	2.88	-2.20	4.87	-1.45
HLCB	7.10	7.91	7.33	9.06
t-stat	1.55	1.67	1.41	1.97
	June 2007	December 2010	June 2007	December 2010
$Corr(r_{free}, r_{fixed})$	0.90	0.66	0.92	0.57

Table VII: Within-industry sorted commodity beta portfolios
This table demonstrates the results from the within-industry sort as explained in Section II.C. First, we sort all stocks within each industry into five commodity beta bins (presented row-wise). Then, using the aggregate industry portfolios, we sort the industries into five bins (presented column-wise). Combining, in each 5-by-5 block, a cell presents the equal weighted average of the respective (H,2,3,4 and L) within-industry portfolios among the respective (H,2,3,4 and L) beta industries. The sixth column presents the equal weighted average over rows, that is, an average within-industry portfolio. The sixth row presents the HLCB within-industry portfolio. Panel A presents the results for the first subperiod, Panel B for the second subperiod. In each panel we present average returns and FFCM α's (in annualized %'s, left). To conserve space, we present corresponding t-statistics (based on White's heteroskedasticity-consistent standard errors, right) only for the average within-industry portfolio and the HLCB within-industry portfolios.

			Between-industry group						
			H	4	3	2	L	Avg	t-stat
Panel A: Returns from 1980-2003 (Pre-CFMA)									
Mean	Within-	H	3.39	4.06	4.53	7.87	7.72	5.52	(1.30)
	industry	4	5.51	4.84	6.84	12.93	9.81	7.99	(2.22)
	group	3	4.25	7.58	7.66	10.59	11.02	8.22	(2.47)
		2	5.98	8.60	10.97	13.42	8.53	9.50	(2.84)
		L	6.78	10.19	8.71	11.21	12.44	9.86	(2.71)
		HLCB	-3.39	-6.13	-4.17	-3.34	-4.72	-4.35	(-2.13)
		t-stat	(-1.02)	(-1.96)	(-1.54)	(-1.14)	(-1.62)	(-2.13)	
FFCM α	Within-	H	-8.27	-6.09	-5.75	-2.46	-2.23	-4.96	(-3.62)
	industry	4	-3.97	-4.64	-3.35	4.22	0.80	-1.39	(-1.24)
	group	3	-5.71	-1.76	-2.09	2.64	3.57	-0.67	(-0.55)
		2	-2.81	0.54	2.05	5.12	1.58	1.30	(1.09)
		L	-1.36	1.49	-1.38	2.40	6.78	1.58	(1.09)
		HLCB	-6.92	-7.58	-4.37	-4.86	-9.01	-6.55	(-3.40)
		t-stat	(-1.84)	(-2.62)	(-1.56)	(-1.68)	(-3.19)	(-3.40)	
Panel B: Returns from 2004-2010 (Post-CFMA)									
			H	4	3	2	L	Avg	t-stat
Mean	Within-	H	18.91	15.32	13.10	18.52	9.95	15.16	(1.41)
	industry	4	17.54	6.05	8.95	7.12	11.31	10.20	(1.20)
	group	3	15.16	9.80	7.57	4.50	6.92	8.79	(1.26)
		2	10.40	7.47	4.14	4.36	4.90	6.25	(0.94)
		L	5.27	4.31	7.72	-0.53	0.58	3.47	(0.50)
		HLCB	13.64	11.01	5.38	19.05	9.37	11.69	(1.98)
		t-stat	(1.67)	(1.68)	(0.70)	(2.24)	(1.29)	(1.98)	
FFCM α	Within-	H	12.60	6.54	3.90	7.64	1.59	6.45	(1.99)
	industry	4	10.22	-1.71	2.52	-0.95	3.98	2.81	(1.70)
	group	3	8.31	3.68	2.27	-1.25	2.21	3.04	(2.12)
		2	4.39	1.29	-1.27	-1.01	0.20	0.72	(0.54)
		L	-1.33	-3.22	1.73	-6.95	-3.90	-2.73	(-1.48)
		HLCB	13.92	9.76	2.17	14.58	5.48	9.18	(2.14)
		t-stat	(1.83)	(1.60)	(0.40)	(2.54)	(1.08)	(2.14)	
Panel C: Difference for HLCB within-industry portfolios									
Mean		HLCB	17.03	17.14	9.55	22.39	14.08	16.04	
		t-stat	(1.94)	(2.36)	(1.18)	(2.49)	(1.80)	(2.57)	
FFCM α		HLCB	20.84	17.34	6.53	19.44	14.49	15.73	
		t-stat	(2.45)	(2.57)	(1.06)	(3.02)	(2.50)	(3.35)	

Table VIII: Commodity beta sorts orthogonal to (unexpected) inflation

This table presents average and risk-adjusted returns (FFCM α's) for sorts where inflation effects are netted out. In each 60-month rolling window, we first orthogonalize returns from a measure of unexpected inflation (UI, the monthly change in annual inflation; presented in the left panel) or an unexpected inflation factor (UIF, constructed in the same way as the commodity factor COM; presented in the right panel). Then, we regress the residuals from this regression on the commodity index to estimate betas. Panel A covers 198001 to 200312, Panel B covers 200401 to 201012 and Panel C tests the differences for the HLCB portfolios. * indicates significance at the 10%-level, using White standard errors.

		Returns orthogonalized from unexpected inflation						Returns orthogonalized from unexpected inflation factor					
		OIW	OIW	OIW	OIW	OIW	EW	OIW	OIW	OIW	OIW	OIW	EW
		Size quintile				One-way		Size quintile				One-way	
		S	3	B	Stocks	48 Ind.	Stocks	S	3	B	Stocks	48 Ind.	Stocks
Panel A: Risk-adjusted returns 1980-2003 (Pre-CFMA)													
Means	H	6.20	3.90	1.99	2.31	4.67	4.28	6.79	4.73	3.87	3.38	6.05	5.88
	4	9.30*	7.12*	7.82*	7.09*	8.40*	6.42	8.76*	7.27*	6.78*	6.75*	8.17*	7.12
	3	10.17*	8.79*	6.07*	6.81*	8.65*	7.59*	10.43*	9.91*	6.26*	7.05*	7.97*	6.75*
	2	10.28*	11.95*	8.61*	8.98*	9.38*	8.82*	11.01*	10.94*	8.66*	8.91*	9.44*	8.34*
	L	9.02*	12.72*	9.77*	9.67*	9.81*	9.19*	7.88*	12.17*	8.18*	8.72*	9.35*	9.07*
	HLCB	-2.83	-8.82*	-7.78*	-7.36*	-5.14*	-4.92	-1.09	-7.44*	-4.31	-5.34	-3.30	-3.18
FFCM	H	-1.91	-5.89*	-5.88*	-6.36*	-5.19*	-3.65	-1.23	-4.46*	-4.49	-5.39*	-3.81*	-2.18
	4	1.00	-3.18*	-0.50	-1.64	-1.27	0.63	0.44	-3.26*	-1.43	-2.05*	-1.30	1.34
	3	2.23	-0.02	-0.64	-0.18	-1.00	-0.15	2.50	0.48	-0.41	0.02	-0.55	-0.58
	2	2.44	4.27*	2.90*	3.08*	1.69	1.19	3.35*	2.63*	2.31*	2.36*	0.38	0.44
	L	3.36	5.52*	5.64*	4.77*	2.41	2.93*	2.15	6.07*	3.81*	3.89*	2.11	2.55*
	HLCB	-5.27*	-11.41*	-11.53*	-11.13*	-7.61*	-6.59*	-3.38*	-10.54*	-8.30*	-9.28*	-5.92*	-4.73
Panel B: Risk-adjusted returns 2004-2010 (Post-CFMA)													
Means	H	12.49	12.46	13.11	12.68	12.77	11.20	13.36	14.69	13.65*	13.87	14.31	13.68
	4	10.15	9.65	3.12	4.97	6.73	7.80	11.89	9.93	5.41	6.55	3.09	6.43
	3	9.22	10.16	3.25	4.62	6.62	5.51	7.48	8.61	2.17	3.33	10.62	4.60
	2	8.66	6.16	2.07	2.78	7.03	4.99	9.25	6.26	2.06	2.86	5.06	5.06
	L	5.03	4.12	2.45	2.94	2.65	2.68	3.44	4.00	3.61	3.22	3.28	1.13
	HLCB	7.47	8.34	10.65*	9.74	10.12	8.52	9.92*	10.69	10.04*	10.65*	11.03*	12.54*
FFCM	H	2.02	4.21	9.46*	7.85*	6.46	5.32	2.81	6.53	9.89*	8.82*	7.91*	7.95*
	4	0.56	2.19	-0.15	0.59	0.05	2.62	2.20	2.48	1.99	2.02	-2.99	1.00
	3	0.03	3.22*	-0.74	0.04	1.11	1.31	-1.20	1.91	-1.32	-0.78	5.06*	0.48
	2	-0.05	-0.32	-1.35	-1.17	1.94	1.36	0.61	-0.57	-1.33	-1.06	-0.52	1.44
	L	-3.54	-2.60	-0.33	-0.81	-1.70	-0.65	-5.35*	-2.80	-0.05	-1.57	-1.05	-3.02
	HLCB	5.56	6.81	9.79*	8.66	8.16	5.97	8.16*	9.33	9.94*	10.39*	8.96	10.98*
Panel C: Difference (Post-CFMA)-(Pre-CFMA)													
Means	HLCB	10.29*	17.16*	18.44*	17.10*	15.26*	13.44*	11.01*	18.13*	14.34*	15.99*	14.33*	15.73*
FFCM	HLCB	10.83*	18.22*	21.32*	19.79*	15.77*	12.55*	11.54*	19.87*	18.24*	19.67*	14.88*	15.70*