The Price of Commodity Risk in Stock and Futures Markets*

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ABSTRACT

We find that commodity risk is priced in the cross-section of US stock returns. Following the financialization of commodities, investors hedge commodity price risk directly in the futures market, primarily via commodity index investments, whereas before they gained commodity exposure mainly via the stock market. As a result, we find that the annualized average returns of high-minus-low commodity beta stocks change from -8% pre-financialization to 11% post-financialization. As stock market investors increasingly participate in commodity futures markets, stock market risk is also priced in the cross-section of commodity futures returns.

JEL Classification Codes: G11, G12, G13

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Commodity prices are a risk factor that affects consumers, producers and investors alike. The recent increase in commodity futures market participation of financial institutions and retail investors, either directly or via commodity index related products, is known as the financialization of commodities and is usually dated around 2003-2004.[1] Before this financialization of commodities, (institutional) investors seeking commodity exposure mainly did so via (expensive) investments in physical commodities or via commodity-related equity investments (Lewis (2007)). This is no longer the case after the financialization, which is represented by a strong increase in institutional index investment in commodity futures markets from less than \$ 10 billion in 1998, to \$ 15 billion in 2003, and to \$ 250 billion in 2009 (Irwin and Sanders (2011)).

In this paper, we use this increase in "financial" flows from institutional index investment as a quasi-natural experiment that changes the risk-return trade-off in stock and commodity futures markets. In particular, we analyze the effect of commodity risk on expected stock returns, as well as the effect of increased commodity index investment on pricing in stock and commodity futures markets.

We develop a model in the spirit of Hirshleifer (1988, 1989) that establishes an important link between these markets. We model investors that are exposed to commodity price risk. First, commodity prices feed into inflation. Second, commodity prices are state variables that govern time-variation in consumption-investment opportunities, where previous research[2] shows a negative predictive relation, implying that Investors are negatively exposed to commodity prices (as with inflation). We model producers that maximize utility over income from these commodities, which they hedge in the futures market. When investors do not hedge their commodity price risk in the futures market, for example because of high participation costs, they can hedge this risk using stocks that are highly correlated

[1] See, e.g. Tang and Xiong (2012), Irwin and Sanders (2011), Stoll and Whaley (2009), Buyuksahin et al. (2010), Buyuksahin and Robe (2010), and Basak and Pavlova (2013).

[2] See, e.g., Driesprong et al. (2008), Hamilton (2008), and Jacobsen et al. (2013).

with commodities, and a hedge portfolio of high-minus-low commodity beta stocks will command a negative risk premium.

When investors do hedge directly with futures contracts, the hedging premium in the stock market goes to zero if the contract is used exclusively for hedging. When the futures contracts are attractive from an investment (or, speculative) point of view as well, our model indicates a reversal in the stock market price of commodity risk. Moreover, as a result of the participation of investors, stock market risk becomes a priced factor in the futures market. We find plausible conditions for a positive speculative investment in commodity futures to be optimal: the presence of sufficiently many producers relative to investors (speculators) and producers that are sufficiently more risk averse than investors.

Empirically, we find that commodity risk is priced in the cross-section of stock returns, but in opposite ways before and after the financialization of commodities (which we date at the end of 2003). 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.[3] Pre-financialization, high commodity beta stocks underperform by about -8% in average returns, which translates into -11.5% to -8.5% in risk-adjusted returns. Post-financialization, 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)), idiosyncratic volatility (Ang et al. (2006)) or betting against beta (Frazzini and Pedersen (2013)).

Likewise, stock market risk does not show up in the cross-section of commodity futures returns pre-financialization, but we do find evidence that stock market risk is a priced factor in this cross-section post-financialization, next to traditional hedging pressure. In a

[3] 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)). Although unreported, our conclusions are unchanged when adding the liquidity factor of Pastor and Stambaugh (2003).

double sort of the futures contracts on hedging pressure and stock market beta's, we find a total cross-spread in average returns of about 20%, of which 70% can be attributed to hedging pressure and the remaining 30% to stock market risk.

Our findings contribute to the literature on cross-sectional asset pricing and commodities. 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 also plays a role, following the financialization, 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 and, in addition, their speculative demand in commodity futures markets. Thus, our findings are also an important addition to papers that investigate the financialization of commodity futures markets (see, e.g., Tang and Xiong (2012), Irwin and Sanders (2011), Stoll and Whaley (2009), Buyuksahin et al. (2010), Buyuksahin and Robe (2010), Cheng et al. (2011), and Basak and Pavlova (2013)).

We find that the change in the stock market premium for commodity risk is driven by commodities from the Energy and (Precious) Metals sectors, consistent with the fact that the largest share of index investment is flowing into these sectors. Also, we 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 section, we derive a model that links stock and commodity (futures) markets. Section II describes the institutional background, the data and method. Section III presents results on the pricing of commodity risk in both the stock and futures markets. In Section IV we analyze sector and industry effects as well as the relation between inflation and commodity risk. Section V summarizes and concludes.

I Theoretical framework

We start out by developing a model that links the commodity futures market to 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: Producers, Speculators and Investors. There are N_{Pr} commodity Producers that can hedge their commodity risk in the futures market, and N_{Sp} specialized Speculators that only trade in the futures market, but not in the stock market, which is similar to the setup in Hirshleifer (1988). The markets are linked through N_{Inv} Investors that are exposed to commodity risk, but do not invest in commodity futures initially. Investors may refrain from trading in the futures market because of high participation costs. Hirshleifer (1988) motivates such participation costs with either explicit costs associated with entering the futures market, or the cost of becoming informed. Subsequently, we allow Investors to also trade in the futures market, which is tantamount to assuming a lowering of participation costs. This is likely facilitated by the availability of commodity index products (see, e.g. Idzorek (2007)). This is also in line with, for example, a small portion of open interest being submitted by institutional investors before 2003 (Irwin and Sanders (2011)) and the emergence of commodity index-based products that led to the financialization of commodity markets in recent years. The cross-hedging demands of these Investors in the stock market imply a commodity risk premium in the cross-section of stocks. Mimicking the recent influx of institutional investment in commodities, the purpose of our model is to analyze how changing participation in the futures market by these (institutional) Investors may impact both the stock and commodity futures markets.

B The stock market with and without Investors participating in the futures market

We first derive equilibrium demand and expected returns in the stock market. There are N_{Inv} Investors that are each endowed with one dollar that they can invest in the risk free asset, with return $R_{f,t}$, and K risky stocks, with excess return vector r_{t+1}. These Investors may also want to add the futures contract, with (pseudo-) return $R_{Fut,t+1}$, but may be prevented from doing so because of high (trading) costs associated with participating in the futures market. We model both cases where Investors do not and do participate in the futures market.

We write the portfolio return of the Investors exposed to commodity price risk as

$$y_{Inv,t+1} = R_{f,t} + w_r' r_{t+1} + w_{Fut} R_{Fut,t+1} + \varphi R_{S,t+1}. \tag{1}$$

Here, w_r is the K-dimensional vector of weights in stocks, w_{Fut} is the position in the futures contract and φ is the size of the exposure to spot commodity price risk $R_{S,t+1}$ per dollar invested. This exposure can be motivated in (at least) two ways. First, Investors are exposed to inflation risk and commodity prices represent a large and volatile component of inflation. Second, commodity prices are a state variable for many investment, production and consumption decisions.

Without futures market participation, Investors choose the optimal portfolio of stocks alone: w_r, whereas with participation they can add a futures position and maximize over $w = (w_r' \; w_{Fut})'$. Likewise, $\mu = (\mu_r' \; \mu_{Fut})'$ is a $K+1$ vector of expected excess stock returns and the expected futures return, Σ is their corresponding $(K+1) \times (K+1)$ covariance matrix, with sub-matrices Σ_{rr} $(K{\times}K)$, Σ_{rF} $(K \times 1)$ and σ_{FF} (1×1), representing the the (co)variances of the stocks, the stocks and the futures, and the futures contract only respectively; $\Sigma_S = (\Sigma_{rS}' \; \sigma_{FS})'$ is the corresponding $K+1$ vector of covariances with the spot commodity return. Assuming that relative risk aversion γ_{Inv} is identical for all Investors, they solve the following mean-variance utility problem in the two separate cases:

$$\begin{aligned} &\textbf{No participation: } \max_{w_r} \; R_{f,t} + w_r'\mu_r - \frac{\gamma_{Inv}}{2}\left\{w_r'\Sigma_{rr}w_r + 2w_r'\Sigma_{rS}\varphi + \varphi^2\sigma_{SS}\right\}, \quad (2) \\ &\textbf{Participation: } \max_{w} \; R_{f,t} + w'\mu - \frac{\gamma_{Inv}}{2}\left\{w'\Sigma w + 2w'\Sigma_S\varphi + \varphi^2\sigma_{SS}\right\}. \end{aligned}$$

In order to express the optimal portfolio weights, we assume the futures contract is perfectly correlated with the commodity return and for simplicity that the two returns have equal variances, i.e., $\sigma_{FF} = \sigma_{SS} = \sigma_{FS}$.[4] Using these assumptions, the partitioned inverse of Σ,

[4]We only need a perfect correlation for expositional purposes: the hedge demand will tilt towards the futures contract as long as it is a better hedge than the available stocks, such that the model's main implications go through. The assumption of equal variances is a matter of scaling only.

and the auxiliary regression of the futures return on the stocks

$$R_{Fut,t+1} = a + b' r_{t+1} + e_{t+1}, \text{ with} \tag{3}$$

$$\sigma_{ee} = Var(e_{t+1}), \tag{4}$$

Appendix A shows that the optimal portfolio in the two cases is

$$\textbf{No participation: } w_r = \gamma_{Inv}^{-1} \Sigma_{rr}^{-1} \mu_r - \varphi \Sigma_{rr}^{-1} \Sigma_{rS}, \tag{5}$$

$$\textbf{Participation: } w_r = \gamma_{Inv}^{-1} \Sigma_{rr}^{-1} \mu_r - w_{Fut,spec} \Sigma_{rr}^{-1} \Sigma_{rS} \tag{6}$$

$$w_{Fut} = w_{Fut,spec} - \varphi, \text{ with} \tag{7}$$

$$w_{Fut,spec} = \frac{1}{\gamma_{Inv}} \frac{a}{\sigma_{ee}}. \tag{8}$$

Without futures market participation, Investors only invest in the stock market (plus a risk free asset), and their optimal demand for stocks in Equation (5) combines a standard speculative demand (the tangency portfolio) with a minimum-variance hedge demand for commodity risk (similar to e.g., Merton (1973) and Anderson and Danthine (1981)). The hedge demand is defined over the coefficients from a regression of $R_{S,t+1}$ on r_{t+1}: $\Sigma_{rr}^{-1} \Sigma_{rS}$ and the exposure φ. If $\varphi < 0$ ($\varphi > 0$), Investors adjust upward their demand for high (low) commodity beta stocks in order to hedge.

With futures market participation, Investors invest in both stock and commodity futures markets and their optimal demands are given in Equations (6) and (7), respectively. The optimal futures demand in Equation (7) combines a speculative demand with a hedge demand. The hedge demand φ only affects the demand for futures contract, not for stocks, because $r_{Fut,t+1}$ is perfectly correlated with the commodity return $R_{S,t+1}$. Thus, hedging of commodity risk takes place entirely via the futures market and no longer via a hedge demand in the stock market. For instance, Investors go long (short) in the futures contract to hedge when $\varphi < 0$ ($\varphi > 0$). The speculative demand for futures $w_{Fut,spec} = \gamma_{Inv}^{-1}\sigma_{ee}^{-1}a$ is a standard speculative demand for the futures contract given that it is hedged with the stocks using Equation (3). Here, a is a (generalized) Jensen measure of the futures contracts versus the available stocks. A positive (negative) a, adjusted for residual risk σ_{ee}, implies diversification benefits from adding a long (short) position in the futures contract to the stock portfolio and therefore a speculative demand for futures contracts.

Finally, Equation (6) demonstrates that the optimal demand for stocks, w_r, adjusts the tangency portfolio with a minimum-variance hedge demand defined over the speculative demand for futures $w_{Fut,spec}$. Thus, if the agent seeks additional exposure to futures (beyond the hedge demand φ), he will hedge this additional exposure with the K risky stocks. Importantly, because of the perfect correlation between the futures and commodity return, the composition of this hedge portfolio is determined by $\Sigma_{rr}^{-1}\Sigma_{rS}$, as in the case without futures market participation.

Because only Investors participate in the stock market, w_r in Equation (5) and (6) is the market portfolio of stocks w_m. Using this, Appendix A shows

Proposition 1 *When Investors are exposed to commodity risk and may be prevented from participating in the futures market, expected excess stock returns depend on their covariance with the market portfolio ($r_{m,t+1}$) and the commodity return ($R_{S,t+1}$):*

$$\textbf{\textit{No participation:}}\; E(r_{k,t+1}) = \gamma_{Inv}\sigma_{km} + \gamma_{Inv}\varphi\sigma_{kS}, \tag{9}$$

$$\textbf{\textit{Participation:}}\; E(r_{k,t+1}) = \gamma_{Inv}\sigma_{km} + \gamma_{Inv}w_{Fut,spec}\sigma_{kS}. \tag{10}$$

Proposition 1 shows that expected stock returns depend on their covariance with the market portfolio as well as on their covariance with the commodity return, due to the hedge demand. The effect of commodity hedging on expected returns is different in the two cases though. When the Investor does not participate in the futures market, he uses stocks to hedge the exposure to commodity risk φ. As a result, commodity risk is priced in the stock market and the price per unit of covariance is $\gamma_{Inv}\varphi$. Thus, if $\varphi < 0$, the price of commodity risk is negative: Investors adjust upward the demand for stocks that move in-sync with the commodity, because these stocks are attractive as a hedge, which increases (decreases) their equilibrium price (expected excess return). Conversely, if $\varphi > 0$, the stock market price of commodity risk is positive.

When the Investors do participate in the futures market, Investors hedge their exposure to commodity risk directly using the futures contract. Consequently, φ no longer affects expected stock returns. However, if there is a speculative demand (long or short) for commodity futures when a is non-zero, Investors hedge this speculative demand in the stock market. Thus, commodity risk is again priced in the cross-section of stock returns. The difference in the size and sign of the commodity risk premium in the two cases depends on the size and sign of φ versus $w_{Fut,spec}$.

C The futures market

In this subsection, we derive the equilibrium demand and expected returns in the futures market. Without Investors, there are two classes of traders that participate in the futures market: Producers and Speculators. The N_{Pr} Producers are each 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 the same for each producer. Thus, total endowed wealth of the Producers is N_{Pr} and total (stochastic) output of the commodity is $Q_{t+1} = N_{Pr}q_{t+1}$. Consumers are characterized by the inverse demand function for the commodity: $Q^D_{t+1} = g\left(S_{t+1}\right)$, such that spot market equilibrium implies $Q_{t+1} = Q^D_{t+1}$. We normalize the Producer's problem similar to Investors, assuming again that the risk aversion is identical across Producers, such that he maximizes a mean-variance utility function over his portfolio return

$$\max_{h} E(q_{t+1}R_{S,t+1} + hR_{Fut,t+1}) - \frac{\gamma_{Pr}}{2}Var\left(q_{t+1}R_{S,t+1} + hR_{Fut,t+1}\right), \tag{11}$$

which combines the uncertain return from output $(q_{t+1}R_{S,t+1})$ with a hedge position in h futures contracts. Using the notation introduced before and the assumption that $\sigma_{FF} = \sigma_{SS} = \sigma_{FS}$, Appendix B shows that a Taylor series approximation of total output Q_{t+1} around its expected value $\overline{Q} = N_{Pr}\bar{q}$, results in the optimal futures position

$$h = \frac{1}{\gamma_{Pr}}\frac{\mu_{Fut}}{\sigma_{FF}} - (1+\eta), \tag{12}$$

where $\eta = g\left(\overline{Q}\right)/\overline{Q}g'\left(\overline{Q}\right)$ is a demand elasticity, as in Hirshleifer (1988). Equation (12) 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_{Sp} Speculators are likewise endowed with one dollar each, which they invest in the risk free asset and s futures contracts. Thus, Speculators maximize a mean-variance utility function over their portfolio return

$$\max_{s} R_{f,t} + s\mu_{Fut} - \frac{\gamma_{Sp}}{2}s^2\sigma_{FF}. \tag{13}$$

Assuming again that relative risk aversion is the same for all Speculators, the optimal futures position for each Speculator equals

$$s = \frac{1}{\gamma_{Sp}}\frac{\mu_{Fut}}{\sigma_{FF}}, \tag{14}$$

which is analogous to the speculative demand by Producers.

When Investors also participate, there are three classes of traders in the futures market: Producers, whose demand is given in Equation (12), Speculators, whose demand is given in Equation (14) and Investors, whose demand is given in Equation (7). Since futures contracts are in zero net supply, futures market equilibrium requires for the two cases

$$\begin{aligned} \textbf{No participation: } 0 &= N_{Pr}h + N_{Sp}s && (15) \\ \textbf{participation: } 0 &= N_{Pr}h + N_{Sp}s + N_{Inv}w_{Fut}. && (16) \end{aligned}$$

Using these market clearing conditions, Appendix C shows

Proposition 2 *In a futures market where (stock market) Investors may be prevented from participating in that futures market, the futures risk premium equals:*

$$\begin{aligned} \textbf{\textit{No participation: }} E(R_{Fut,t+1}) &= \frac{\lambda_{Pr}}{\lambda_{Pr}+\lambda_{Sp}}\gamma_{Pr}(1+\eta)\sigma_{FS} && (17) \\ \textbf{\textit{Participation: }} E(R_{Fut,t+1}) &= \frac{\lambda_{Pr}\gamma_{Pr}\left(1+\eta\right)+\lambda_{Inv}\gamma_{Inv}\varphi}{\lambda_{Pr}+\lambda_{Sp}+\tilde{\lambda}_{Inv}}\sigma_{FS} + \frac{\tilde{\lambda}_{Inv}\gamma_{Inv}}{\lambda_{Pr}+\lambda_{Sp}+\tilde{\lambda}_{Inv}}\sigma_{FT} && (18) \\ \lambda_i &= N_i/\gamma_i, i = Pr, Sp, Inv && (19) \\ \tilde{\lambda}_{Inv} &= \lambda_{Inv}\frac{\sigma_{FF}}{\sigma_{ee}}, && (20) \end{aligned}$$

where σ_{FT} denotes covariance with the tangency portfolio of stocks only, with weights $w_{Tan} = \gamma_{Inv}^{-1}\Sigma_{rr}^{-1}\mu_r$.

Thus, when only Producers and Speculators trade in the futures market, the futures risk premium depends on the covariance of the futures and the spot return σ_{FS},[5] the risk aversion of the Producers γ_{Pr}, and the risk aversion-adjusted market share of Producers in the futures market, $\lambda_{Pr}/\left(\lambda_{Pr}+\lambda_{Sp}\right)$. The term $\gamma_{Pr}\left(1+\eta\right)\sigma_{FS}$ reflects the hedge demand for futures contracts by Producers. This hedge demand is increasing in the covariance of

[5] We use here that $\sigma_{FS} = \sigma_{FF}$, as assumed earlier, and write Proposition 2 in terms of σ_{FS}, because it also holds when this assumption is relaxed.

the futures with the spot, adjusted for the demand elasticity, and in Producer risk aversion. With $\eta > -1$, the hedge demand will be a short position, and the futures risk premium will be positive. This finding is the familiar hedging pressure effect: a short hedge position has to be compensated by the speculative demand from 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: when there are more Speculators or their risk aversion is lower, there is a bigger speculative demand to absorb the hedge demand of Producers, thereby lowering the futures risk premium.

When Investors also participate in the futures market, the futures risk premium in Equation (18) contains a hedging pressure effect similar to Equation (17), except that now also Investors enter both the numerator and the denominator. Investors hedge commodity risk in the futures market, which adds to the hedging pressure effect by an amount $\lambda_{Inv}\gamma_{Inv}\varphi$. If $\varphi < 0$, the long hedge demand of Investors (partly) offsets the hedge demand by Producers, thus lowering 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 Equation (18) follows from the fact that Investors combine the futures contract with the stocks for speculative reasons. This makes stock market risk priced via the covariance of the futures return with the return on the tangency portfolio of stocks, w_{Tan}. Since only Investors invest in both stocks and futures, 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 λ_{Inv} is adjusted for this according to Equation (20).

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). In terms of our model, initially Investors did not hedge their commodity risk exposure in the futures market, but resorted to hedging in the stock market. Indeed, Lewis (2007) shows that the most common approach for institutional investors to gain commodity exposure has historically been via equity investments or via direct investment in physical commodities, which is expensive. Idzorek (2007) suggests the limited number of implementation vehicles as one of the reasons that commodities were excluded from investment portfolios until the early 2000s. With the financialization of commodities, institutional investments in commodity index products was facilitated by over-the-counter swap agreements, exchange-traded funds (ETF), exchange-traded notes (ETN), and mutual funds, benchmarked to well-diversified and transparent indices like the SP-GSCI and DJ-UBSCI.

As a result, commodity index investment by institutional investors, jumped from $ 15 billion in 2003 to $ 250 billion at the end of 2009. Figure 1 illustrates this surge in commodity investments. The figure plots total open interest in 33 commodities over time (200312 = 100) in US $ and the number of contracts outstanding. For both measures we see that open interest increases to record-high levels in each sector around 2003 without ever returning to historical levels. 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 10% in 2003 ($ 15 billion) to 40% in 2009 ($ 250 billion) (Irwin and Sanders (2011)). 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 (2012) 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-financialization" and the period thereafter as "post-financialization". 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.[6]

Table I about here.

We calculate futures returns using a roll-over strategy of first or second nearest-to-maturity contracts.[7] First, we focus on contracts that are relatively close to maturity, because these are 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.[8] For the Energy sector

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

[7] 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.

[8] By rolling over approximately one to two weeks before most commercial indices do, our index is not

we have contracts maturing in all months of the year; for most other commodities we have between four and eight delivery months per year. For all contracts except Sugar and Pork Bellies, the delivery months are never more than three months apart. Table I reports average returns, standard deviations (both in annualized percentages) and median total open interest (TOI) in US$ for each individual contract.[9] Historically, the Energy (Livestock and Meats) sector has contained the largest (smallest) commodities in open interest and trading volume. Throughout, we focus on an open interest-weighted total index (OIW) that aggregates all 33 commodities. Similar to value-weighted stock indices or production-weighted commercial commodity indices, OIW 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 as well as the SP-GSCI Excess Return Index and present additional evidence for OIW sector indexes.

C Estimating exposures in the stock market

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.[10]

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

$$R_{i,s} - R_{f,s} = \alpha_{i,t-1} + \beta_{i,t-1} R_{oiw,s} + \varepsilon_{i,s}, \text{ for } s = t-60, ..., t-1, \tag{21}$$

affected by their short-term market impact, which may partly cause this erratic behavior (Muo (2010)).

[9] 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.

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

where we require that at least three out of the last five years of returns are available. We apply Equation (21) 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, which we split into a period of 288 months pre-financialization and 84 months post-financialization. In a robustness check, we control for the benchmark factors of the CAPM (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) when estimating commodity beta.

First, we construct market value-weighted stock portfolios from both a one-dimensional sort in five commodity beta groups and an independent, two-dimensional sort in five commodity beta and five size groups. Second, we perform a one-dimensional between-industry sort, which constructs five industry-portfolios that equally weight nine or ten industries each. We apply the time-series regression approach of Black et al. (1972) to analyze average returns and risk-adjusted returns (relative to the CAPM, FF3M and FFCM) of the portfolios introduced above as well as the High minus Low commodity beta (HLCB) spreading portfolios constructed therefrom.

D Estimating exposures in the commodity futures markets

To assess if the stock market risk is a priced factor for the commodity futures returns we sort our 33 commodities with respect to the market and hedging pressure risks.[11]

In our model, stock market risk is defined as covariance with the tangency portfolio of stocks, which combines the market portfolio and the hedge portfolio for commodity risk

[11] This sorting requires a generalization of Proposition 2 from Section I to multiple commodity contracts which we present in the Internet Appendix, and which shows that the basic insights from Proposition 2 still hold with multiple commodity contracts.

(see Equation (5) and (6)). Accordingly, we sort commodity futures one-dimensionally at the quartiles of ranked covariance with each of the two portfolios.

The hedging pressure variable is defined as the difference between the number of short and long positions of commercial hedgers relative to their total position (e.g. de Roon et al. (2000), Hong and Yogo (2012)).[12] In addition, we smooth it by taking a 12-month moving average, similar to Hong and Yogo (2012) who used smoothed growth rate of open interest. Dictated by the availability of public CFTC data when sorting on hedging pressure we are restricted to a smaller cross-section (26 commodities) and time-series (1986 to 2010).

III The cross-section of stock and futures returns

We start out by documenting the main implications of the model, which are summarized in Propositions 1 and 2 of Section I. First, commodity risk is priced in the stock market and this price changes post-financialization. Second, stock market risk is priced in the futures market, but only post-financialization.

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 in the cross-section of stock returns and test if the risk premium varies over the two sub-periods. We present average returns and standard deviations for the period pre- and post-financialization in Panels A and B, respectively, whereas Panel C

[12] 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.

tests the differences in average returns between these two sub-periods.

Table II about here.

In average returns, stocks and industries with high commodity betas underperform consistently pre-financialization. Also, for all size quintiles except the smallest, average returns are decreasing monotonically in commodity beta. The High minus Low Commodity Beta (HLCB) spread is economically large and statistically significant at -8.11% for the one-dimensional sort of stocks and at -4.72% for industries.[13] On the contrary, high commodity beta stocks outperform consistently post-financialization. Average returns increase monotonically in commodity beta in all control groups, which adds up to a HLCB spread that is economically large and statistically significant at 12.08% for the one-dimensional sort of stocks and at 12.22% for industries. In both sub-periods, portfolio standard deviation increases almost monotonically in commodity beta, which is consistent with the idea that commodity beta captures an exposure to risk.

Finally, the results in Panel C demonstrate that the difference in average returns between the two sub-periods is highly significant around 20% for individual stocks and 17% for industry portfolio. Moreover, going from Low to High among the long-only portfolios, we see that the difference is increasing monotonically in commodity beta. Highlighting the importance of controlling for size, we find that the reversal is strongest among the bigger stocks in both sub-periods.

Table III about here.

Next, we see in Table III that the previously documented performance-beta relation and

[13] 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.

its reversal are robust when controlling for the usual risk factors. Table III is structured similarly to Table II except that we now present risk-adjusted returns (α's) for the two subperiods in Panels A and B, respectively. Pre-financialization, 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-financialization, only about 2% of the HLCB spread is captured by the MKT factor, leaving HLCB alphas that are over 10% for both stocks and industries. Again, in almost every case the alphas are monotonically decreasing pre-financialization and increasing post-financialization in 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% for stocks and 17% for industries.

The reversal from a negative to a positive commodity risk premium reported above is consistent with our model. Pre-financialization, when institutional investors hedge their commodity risk in the stock market, Equation (9) implies that the HLCB spread is negative when the fundamental exposure $\varphi < 0$. Post-financialization, when commodity futures represent a considerable fraction of many institutional investors' portfolios, Equation (10) implies that the spread is zero when these positions solely reflect a hedge demand, i.e., $w_{Fut,spec} = 0$, or positive when these positions also reflect a speculative demand, i.e, $w_{Fut,spec} > 0$.

A negative fundamental exposure is consistent with (i) investor's incentives to hedge inflation, which risk premium is also negative (see, e.g., Chen et al. (1986) and Ferson and Harvey (1991)) and (ii) the interpretation of commodity prices as a "recession state variables" along the lines of Cochrane (2005, Ch.9).[14]

Although a positive speculative demand for commodities is consistent with Greer (2000),

[14] See, for example Driesprong et al. (2008), Hamilton (2008), and Jacobsen et al. (2013) for evidence that energy and metal prices predict macroeconomic activity and stock market returns with a negative sign.

Gorton and Rouwenhorst (2006) and Erb and Harvey (2006), it is hard to justify it if index investment drives up prices too much. Results from Irwin and Sanders (2011), Stoll and Whaley (2009), and Buyuksahin and Robe (2010) question this price impact. Moreover, Appendix C derives the equilibrium conditions for $w_{Fut,spec} > 0$, which are sufficiently more Producers and sufficiently risk-averse Producers, such that their short hedging pressure still induces a positive futures risk premium.

These conditions are fairly mild and do not seem to be violated post-financialization. Using data from the CFTC Commitment of Traders Report from January 1986 to December 2010, Figure 2 shows that commercial hedger's (net) short positions are sufficient to cover non-commercial speculator's (net) long positions. 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. In fact, using more detailed daily data from the CFTC's private 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 investors' long positions over the last decade.

A.2 Commodity risk in the futures market

Table IV presents our tests of the model's implications for pricing in the commodity futures market. Proposition 2 predicts that stock market risk (defined as covariance with the tangency portfolio of stocks) is priced in the futures market post-financialization, whereas hedging pressure always affects the futures risk premium. Therefore, Panels A and B present average returns, pre- and post-financialization respectively, for portfolio sorts on covariance with the CRSP value-weighted market portfolio (MKT) as well as the stock-based High minus Low Commodity Beta portfolio (HLCB).[15]

For the post-financialization period, the last column also shows sorts on the average of the two covariances, which we treat as a proxy for covariance with the tangency portfolio. Although portfolios sorted on the average covariance cannot be ranked a priori, because the risk premium for exposure to MKT and HLCB may differ (see Equation (10)), we find that the post-ranking beta with respect to each of the two factors lines up monotonically from the High to Low exposure portfolio. Given that in the post-financialization period the risk premiums on both MKT and HLCB are positive (unlike in the pre-financialization period), the model implies that in this period average returns line up monotonically with the average covariance as well.

The predicted hedging pressure effect in futures markets is analyzed in Panel C. Since the hedging pressure effect is expected to be present in all periods, we show portfolio sorts on hedging pressure for both the pre- and post-financialization periods, as well as for the whole sample period. Finally, to ascertain that our results are not due to equal-weighting the futures returns, we also present results for the rank-based weighting scheme of Koijen et al. (2012).

Table IV about here.

Panel A demonstrates that stock market risk is not priced in the futures market pre-financialization, which is consistent with previous work. There is a strong, but inverse relation between MKT exposure and mean futures returns, and there is no relation between HLCB exposure and mean futures returns.

On the contrary, Panel B demonstrates that stock market risk is priced in the futures market post-financialization, as hypothesized. First, average futures returns increase

[15] HLCB is constructed from the one-dimensional sort of stocks on commodity beta (see Table II) and is long (short) an equal weighted portfolio of the top (bottom) two quintiles.

monotonically in MKT exposure, translating to an economically large and marginally significant High minus Low spread of 13.38%. The outperformance of High versus Low HLCB exposure futures is also large at 9.00%, but this spread is insignificant and the relation between HLCB exposure and returns is not entirely monotonic. Combining, the sort on the average of the two covariances presents a monotonic relation between stock market risk and mean futures returns. Both the High minus Low spread and the rank-weighted portfolio return are economically large and significant at 14.59% and 11.78%, respectively.

Panel C demonstrates that mean futures returns are increasing in hedging pressure when measured over the entire sample period, yielding an average return on the High minus Low hedging pressure portfolio of 9.4%, which is both economically and statistically significant. The effect is statistically marginally significant in both sub-periods, but larger economically in the recent period (going from 7.8% pre-financialization to 13.4% post-financialization).[16]

Although both the effect from stock market risk on mean futures returns in Panel B and the effect of hedging pressure in Panel C are economically large, these result from one-dimensional sorts only. Table V reports results from double sorting the futures on stock market risk on the one hand and hedging pressure on the other hand. Because of the limited number of futures contracts, we only categorize them into two groups on each dimension, resulting in a total of four portfolios again. As Table IV, and Proposition 2, indicate that stock market risk is only relevant for the commodity futures in the post-financialization period Table V reports the results only for this period.

Table V about here.

Table V shows three panels where the mean returns on the portfolios are sorted on hedging pressure versus i) MKT beta, ii) HLCB beta, and iii) the average of the MKT and

[16]These results do depend on smoothing the hedging pressure variable. In the Internet Appendix we present results without smoothing, which are largely consistent but weaker. This is consistent with previous literature where the effects of hedging pressure in sorted portfolios is somewhat mixed.

HLCB beta, as in Table IV. The results in the three panels all show a consistent pattern with the highest mean returns (between 14.4% and 18.1%) in the High-High portfolios and the lowest mean returns (between -1.1% and -6.6%) on the Low-Low portfolios. The resulting average spread on the High minus Low hedging pressure portfolios are between 13.5% and 14.2%, similar to the 13.4% on the single sort reported in Table IV. The resulting average spread on the High minus Low stock market beta portfolios is now between 4.9% and 6.9%, which is only half of what is found in the single sort in Table IV, and - unlike the one-dimensional spread - not significantly different from zero.

To sum up, we find that consistent with Proposition 2, hedging pressure shows up in the cross-section of futures returns both pre- and post-financialization, whereas stock market risk only shows up in the post-financialization period. In the double sorts, of the total spread in the four sorted portfolios, about 70% of the average return spread is due to hedging pressure, whereas the remaining 30% is due to stock market risk.

B Robustness checks

B.1 Exploring the structural break

Our analysis sofar sets the structural break at December 2003. To test the sensitivity of our results for the exact breakpoint, Table VI reports the HLCB reversal in the stock market (in average return and FFCM alpha) for different breakpoints from December 2000 until December 2005.

Table VI 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 are consistent with formal structural break tests that identify a break between 2002 and 2004 for the HLCB portfolios, giving further support to choosing December 2003 as in Domanski and Heath (2007) and Tang and Xiong (2012).

Table VII about here.

Table VII likewise shows the sensitivity of the results from the futures markets for the exact breakpoint. The table shows the High-minus-Low mean return from sorting on MKT beta, HLCB beta, the average over MKT and HLCB beta and sorting on hedging pressure. Unlike the results for the stock market, sorting futures contracts is more sensitive to the exact breakpoint. In particular, when the breakpoint is between 2000-2003, it is mainly the average of MKT and HLCB that induces a premium in the futures market, whereas after 2003, it is mainly MKT that induces a premium. Thus, in itself stock market risk is always important post-financialization, irrespective of the exact breakpoint, but the channel (MKT versus HLCB) appears to change. The sorts on hedging pressure, on the other hand, are rather insensitive to the exact breakpoint and are always present.

A related issue is whether the composition of the stock-based portfolios is stable around the breakpoint, given the change in sign of the stock market premium for commodity risk. To this end, Table VIII 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 sub-periods 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 sub-periods. Further, the unreported full Markov matrices show that stocks hardly ever move more than one portfolio at a time in any given sub-periods. Importantly, there is no substantial drop in this percentage in the sub-period 2001-2005. On the contrary, we observe a relatively high percentage of 89%, suggesting that the portfolios are stable.

Table VIII about here.

In short, the stability post-financialization indicates that the documented reversal is not driven by changing covariances. Rather, in line with our model, the reversal is driven by changing returns. To further substantiate this finding, we fix the portfolio composition to what it is in December 2003 and compare the performance of this strategy to the strategy that updates its weights every month in Panel B of Table VIII. First, we see that the returns of the two strategies are highly correlated post-financialization. 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 observe similar reversals for the two strategies.

B.2 Other robustness checks

We find that our results are robust in a number of other dimensions, which we report in the Internet Appendix. First, our results extend to alternative weighting schemes for the cross-section of commodities. Looking at the last columns in each panel of Tables II and III, we observe a significant reversal of around 14% when sorting on exposures to an EW commodity index, suggesting that our results are not solely driven by changing shares of open interest. Also, the Internet Appendix presents a significant reversal of over 16% for the (production-weighted) SP-GSCI commodity index.

Second, we find similar reversals in average and risk-adjusted returns when we control for the benchmark factors (MKT, SMB, HML and MOM) when estimating commodity betas. Third, our results extend when estimating risk premiums using OLS and GLS cross-sectional regressions with commodity beta-, size-, book-to-market- and industry-sorted portfolios as test assets. Thus, commodity exposures capture a risk factor that is separate from the traditional risk factors. Fourth, given that both commodity beta and size are persistent, transaction costs are unlikely to subsume the spreads. Indeed, we find similar results when rebalancing annually and when varying the length of the rolling window from two to ten years. Finally, our results are not driven by the recent financial crisis, as excluding it only strengthens the reversal.

IV Sectors, Industries and Inflation

This section presents a finer description of both the origin and the presence of the commodity risk premium in the stock market. In particular, we investigate (i) which commodity sectors drive our results, (ii) whether our stock market sorts mainly reflect industry effects, or whether they affect stock returns beyond the industry level, and (iii) whether our results are due to the change in the correlation between stock returns and inflation around the turn of the century, or indeed represent a change in the price of commodity risk.

A Commodity sectors

Table IX presents average post-ranking returns and FFCM alphas for portfolios sorted on Open Interest-weighted commodity sector indexes.[17] The evidence suggests that the reversal in the commodity risk premium is driven by the Energy and Metals and Fibers sectors. Pre-financialization, stocks with a high exposure to these sectors underperform by 3.82% and 6.13%, respectively. Post-financialization, these same stocks outperform by

[17] Similar results obtain for equal-weighted sector indexes.

13.57% and 5.84%, respectively. These returns are not a mirror image of the average return of the respective sector index post-financialization, which equals -2% for Energy and 16% for Metals and Fibers. In contrast, sorting on either the Agriculture or the Livestock and Meats index does not yield a consistent pattern in returns in either sub-period.

Table IX about here.

In the Internet Appendix, we present sorts on the five largest commodities per sector to further analyze these effects. First, we find that a (marginally) significant reversal of about 15% is common to all energy commodities, although for Natural Gas the reversal is only large and significant in FFCM alpha. For Metals and Fibers, we find a particularly large reversal for Precious Metals (Gold, Silver and Platinum) of about 10%. For the remaining Industrial Metals and Fibers as well as Agriculture and Livestock and Meats commodities, the reversal is positive, but small.

The fact that our results are driven by Energy and Precious Metals is unsurprising given that these are the largest commodities in terms of open interest. However, this result is also consistent with the model. First, a relatively large proportion of index investment is flowing into the Energy sector post-financialization, whereas energies are a relatively large and volatile component of inflation. Second, swings in both Energy and Precious Metals prices are likely most important for the macroeconomy. For instance, evidence in Hamilton (2008) suggests that Energy prices spike before recessions, whereas precious metals, and in particular Gold, are popular among investors as a safe haven and a hedge against inflation or currency risk. These views on Gold are challenged recently in Erb and Harvey (2013), however.

B 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 in the stock market 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 industry-months that contain fewer than ten stocks.

Table X presents average returns and FFCM alphas for the within-industry sort in a similar vein as Tables II and III.[18] 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 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 X about here.

Panel A demonstrates that low commodity beta stocks underperform high commodity beta stocks pre-financialization 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.

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

In Panel B we demonstrate that the post-financialization 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 a 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.

C 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 in the stock market 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 $\beta_{i,t-1}$

$$\begin{aligned} r_{i,s} &= a_{i,t-1} + c_{i,t-1} I_s + e_{i,s} \\ e_{i,s} &= \alpha_{i,t-1} + \beta_{i,t-1} R_{OIW,s} + \varepsilon_{i,s}, \text{ for } s = t-60, ..., t-1, \end{aligned} \tag{22}$$

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 are typically 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.[19] 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 XI 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. We test the difference in Panel C. Note, the left block of results orthogonalizes returns from non-traded unexpected inflation UI, the right block from the traded unexpected inflation factor UI1F.

Table XI about here.

When controlling for UI, we see that both mean and risk-adjusted returns remain economically large and significant in both sub-periods, 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,

[19] 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.

we find that commodity betas are by and large similar with and without UI. However, the right panel documents that the reversal in 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-financialization the HLCB spreads are very similar, adding up to a difference of over 14%, which is only slightly smaller than what we had before.

V Conclusion

Because many investment, production and consumption decisions are conditioned on commodity prices, one would expect them to be an important risk factor. In this paper, we use the surge in institutional index investment in commodity futures markets as a quasi-natural experiment and study how it affects pricing of commodity risk. We develop a model where investors are exposed to commodity price risk, but do not hedge their exposure in the futures markets initially, which is consistent with high participation costs, and only do so once those costs have declined, i.e. after the financialization of commodities. In this model, commodity risk is priced in the stock market with a different sign before and after the financialization. Conversely, stock market risk is priced in the commodity futures market, but only once investors start participating in the futures market, i.e., after the fincialization of commodities.

Indeed, we find a strong pattern in average stock returns existing along the cross-section of commodity exposures. Pre-financialization, High commodity beta stocks underperform by -8% per year in average and risk-adjusted returns, whereas post-financialization, these same stocks outperform by 11% per year. Furthermore, stock market risk only shows up in the cross-section of commodity futures returns post-financialization,where we find that about 70% of the cross-spread in average returns can be attributed to traditional hedging pressure and the remaining 30% to stock market risk.

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 important 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 hedged while holding industry exposures constant.

Appendix: Derivations

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

A Optimal portfolio for investors with and without futures market participation

The first order conditions for an Investor who does not participate in the futures market is

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

from which we get:

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

Similarly, for Investors who participate in the futures market, the first order conditions are

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

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 $\sigma_{ee} = Var(e_{t+1})$ 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

$$w = \begin{pmatrix} w_r \\ w_{Fut} \end{pmatrix} = \gamma_{Inv}^{-1} \begin{pmatrix} \Sigma_{rr}^{-1} \mu_r \\ \sigma_{ee}^{-1} a \end{pmatrix} - \begin{pmatrix} \gamma_{Inv}^{-1} \sigma_{ee}^{-1} a \Sigma_{rr}^{-1} \Sigma_{rS} \\ \varphi \end{pmatrix}.$$

Because only Investors participate in the stock market, the optimal demand for stocks w_r is the market portfolio w_m, both with and without futures market participation. Consequently, equilibrium expected excess stock returns are given by a two-factor asset pricing model in both cases. For each stock k we have

$$\begin{aligned} \text{No participation:} \quad & E(r_{k,t+1}) = \gamma_{Inv} \sigma_{km} + \gamma_{Inv} \varphi \sigma_{kS} \\ \text{Participation:} \quad & E(r_{k,t+1}) = \gamma_{Inv} \sigma_{km} + \gamma_{Inv} w_{Fut,spec} \sigma_{kS}, \end{aligned}$$

or in the more familiar form in terms of betas to and expected returns of the market portfolio ($r_{m,t+1}$) and a hedge portfolio for commodity price risk ($r_{h,t+1}$, with $w_m = \left(\iota_K' \Sigma_{rr}^{-1} \Sigma_{rS}\right)^{-1} \Sigma_{rr}^{-1} \Sigma_{rS}$)

$$E(r_{k,t+1}) = \beta_{km} E(r_{m,t+1}) + \beta_{ih} E(r_{h,t+1}).$$

B Optimal futures demand

Total output for each Producer equals $q_{t+1} = Q_{t+1}/N_{Pr}$, with expected value $\overline{q} = 1$, such that we can write $q_{t+1}R_{S,t+1} = \frac{Q_{t+1}}{N_{Pr}} g\left(Q_{t+1}\right)$. Using a Taylor series approximation of Q_{t+1} around its mean $\overline{Q}$, each Producer maximizes:

$$\max_h \frac{\overline{Q}}{N_{Pr}} g(\overline{Q}) + \frac{1}{N_{Pr}}(\overline{Q}g'(\overline{Q}) + g(\overline{Q}))(Q_{t+1} - \overline{Q}) + hr_{Fut,t+1}.$$

By Taylor approximation we also have $\sigma_{FS} = Cov(R_{Fut,t+1}, R_{S,t+1}) = g'(\overline{Q})Cov(Q_{t+1} - \overline{Q}, R_{Fut,t+1})$. Focusing on the components related to h alone, this allows us to write the maximization problem as

$$\max_h h\mu_{Fut} - \frac{\gamma_{\mathrm{Pr}}}{2}(h^2\sigma_{FF} + 2h(1+\eta)\sigma_{FS})$$

where $\eta = \frac{g(\overline{Q})}{\overline{Q}g'(\overline{Q}}$ is a demand elasticity. The optimal futures demand h follows immediately from the first order condition

$$\mu_{Fut} - \gamma_{\mathrm{Pr}} h\sigma_{FF} - \gamma_{\mathrm{Pr}}(1+\eta)\sigma_{FS} = 0.$$

C Futures risk premium

Using $\lambda_i = N_i/\gamma_i$ for $i = Pr, Sp, Inv$, the futures risk premium when Investors do not participate in the futures market follows directly from the market clearing condition and optimal futures demand of Producers and Speculators:

$$N_{Pr}\frac{\mu_{Fut}}{\gamma_{Pr}\sigma_{FF}} - N_{Pr}\left(1+\eta\right)\frac{\sigma_{FS}}{\sigma_{FF}} + N_{Sp}\frac{\mu_{Fut}}{\gamma_{Pr}\sigma_{FF}} = 0.$$

With Investors present, we combine the optimal futures demand of Producers, Speculators and Investors. Using the assumption $\sigma_{FF} = \sigma_{SS} = \sigma_{FS}$, rewriting from the auxiliary regression in Equation (3): $a = \mu_{Fut} - \Sigma'_{rF}\Sigma_{rr}^{-1}\mu_r = \mu_{Fut} - \gamma_{Inv}\sigma_{FT}$ with $w_{Tan} = \gamma_{Inv}^{-1}\Sigma_{rr}^{-1}\mu_r$, and finally imposing futures market clearing $N_{Pr}h + N_{Sp}s + N_{Inv}w_{Fut} = 0$, we have for the expected futures risk premium

$$\begin{aligned}
0 &= \lambda_{Pr}\frac{\mu_{Fut}}{\sigma_{FF}} - \lambda_{Pr}\gamma_{Pr}(1+\eta) + \lambda_{Sp}\frac{\mu_{Fut}}{\sigma_{FF}} + \lambda_{Inv}\left(\frac{\mu_{Fut} - \gamma_{Inv}\sigma_{FT}}{\sigma_{ee}}\right) - \lambda_{Inv}\gamma_{Inv}\varphi \text{ such that} \\
\mu_{Fut} &= \frac{\lambda_{Pr}\gamma_{Pr}(1+\eta) + \lambda_{Inv}\gamma_{Inv}\varphi}{(\lambda_{Pr} + \lambda_{Sp} + \lambda_{Inv}\sigma_{FF}/\sigma_{ee})}\sigma_{FF} + \frac{\lambda_{Inv}\sigma_{FF}/\sigma_{ee}\gamma_{Inv}}{(\lambda_{Pr} + \lambda_{Sp} + \lambda_{Inv}\sigma_{FF}/\sigma_{ee})}\sigma_{FT}.
\end{aligned}$$

Moreover, note that market clearing implies that in equilibrium we have for the speculative demand for the futures contract by Investors $w_{Fut,spec} = \gamma_{Inv}^{-1}\sigma_{ee}^{-1}a$:

$$\begin{aligned}
0 &= \lambda_{Pr}\frac{\mu_{Fut}}{\sigma_{FF}} - \lambda_{Pr}\gamma_{Pr}(1+\eta) + \lambda_{Sp}\frac{\mu_{Fut}}{\sigma_{FF}} + N_{Inv}w_{Fut,spec} - \lambda_{Inv}\gamma_{Inv}\varphi \text{ such that} \\
w_{Fut,spec} &= \left(\frac{N_{Pr}}{N_{Inv}}(1+\eta) + \varphi\right) - \frac{(\lambda_{Pr} + \lambda_{Sp})}{N_{Inv}}\frac{\mu_{Fut}}{\sigma_{FF}}.
\end{aligned}$$

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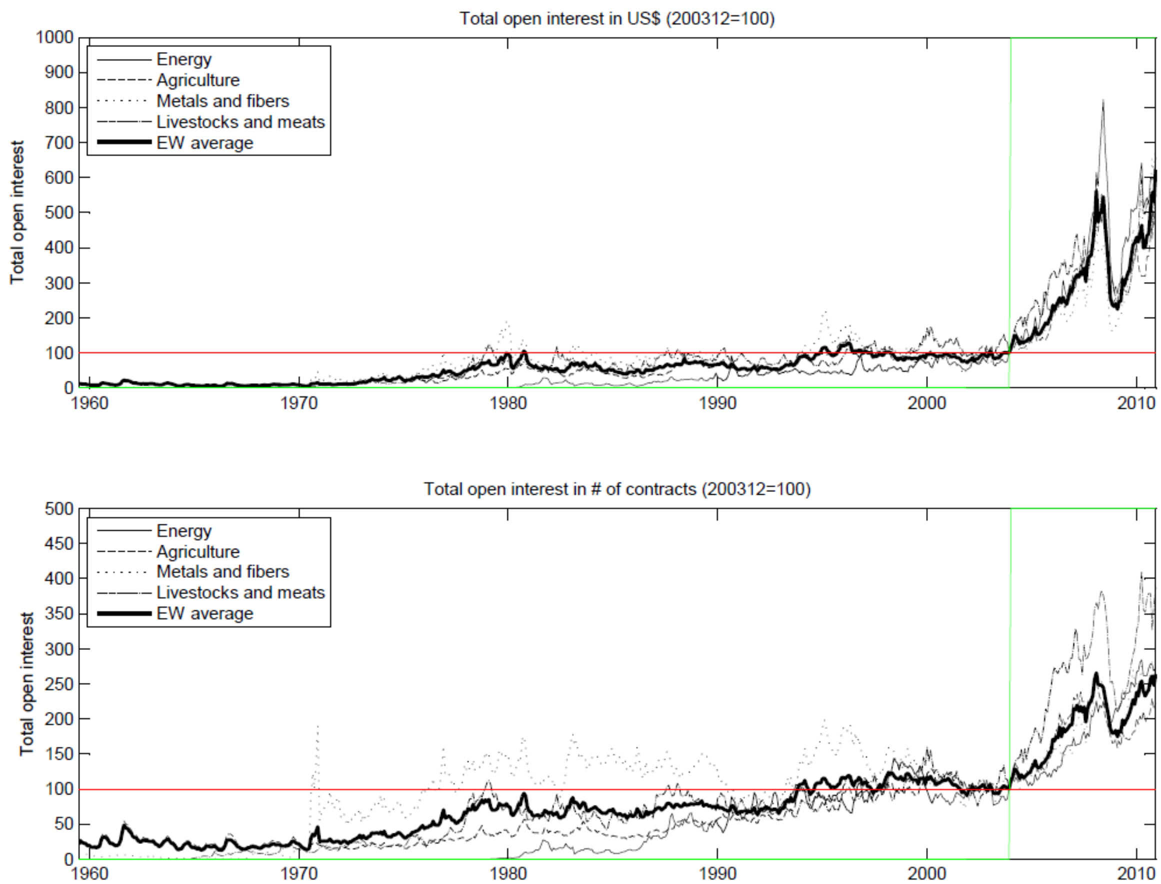

Figure 1: Total Open Interest in 33 commodities (1959 to 2010)
The top figure displays total open interest in 33 commodities in US$, which is calculated as the sum of the US$ open interest in each commodity (number of contracts outstanding times nearest-to-maturity futures price). The bottom figure displays total open interest in terms of the number of contracts outstanding. Both series are normalized to equal 100 in December 2003.

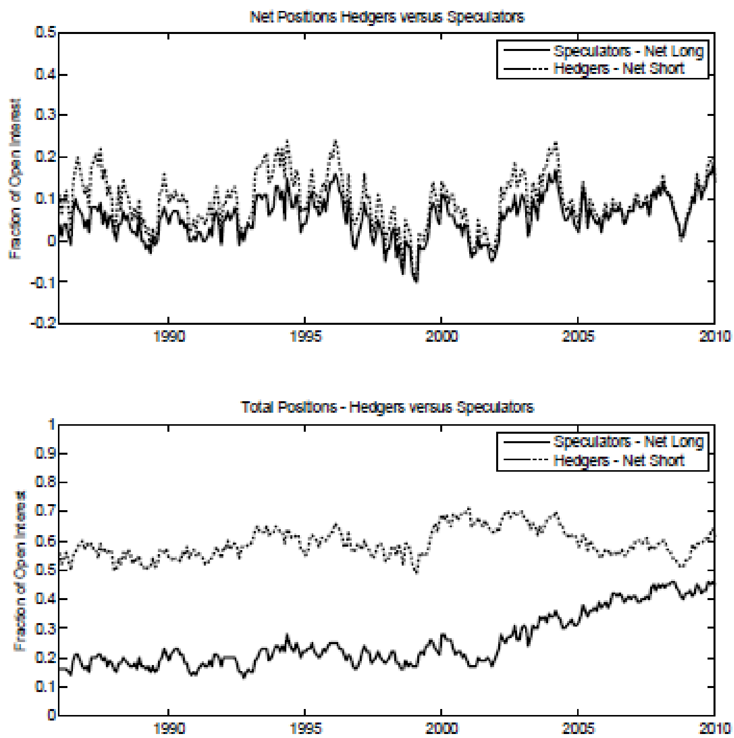

Figure 2: OIW Positions of Hedgers versus Speculators (1986-2010)
The top figure displays the Open Interest Weighted average over all commodities in the CFTC's historical Commitment of Traders (COT) reports of the net short position (short minus long) of commercial hedgers versus the net long position (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 1980 to 2003 (pre-financialization) and Panel B covers 2004 to 2010 (post-financialization). Panel C tests the difference between the two sub-periods. All t-statistics are based on White's heteroskedasticity-consistent standard errors.

	Panel A: Pre-financialization						Panel B: Post-financialization					
	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: Risk-adjusted returns over subsamples

This table presents risk-adjusted returns (alphas, 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 1980 to 2003 (pre-financialization) and Panel B covers 2004 to 2010 (post-financialization). Panel C tests the difference between the two sub-periods. All t-statistics are based on White's heteroskedasticity-consistent standard errors.

	Panel A:Pre-financialization						Panel B: Post-financialization					
	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: Sorting commodity futures on stock market risk and hedging pressure This table presents average returns (and White's heteroskedasticity consistent t-statistics in parentheses) for one-dimensional sorts of commodity futures on stock market risk (Panel A and B) and hedging pressure (Panel C). Consistent with the model of Section I, stock market risk is measured as covariance with the CRSP VW MKT portfolio (σ_{lM}) and the High minus Low Commodity Beta portfolio from a one-dimensional sort of stocks (σ_{lH}). In the last column, we present results for the average of the two (cross-sectionally standardized) covariances. The main portfolios of interest are the High minus Low spreading portfolio constructed from this sort and the rank-weighted portfolio of Koijen et al. (2013), where the weight on futures contract l, $w_{l,t}$, equals $q_t\left(rank_{l,t} - \frac{L_t}{2}\right)$ and q_t is a scalar that ensures the portfolio is long and short one unit. Panel A covers 1980 to 2003 (pre-financialization) and Panel B covers 2004 to 2010 (post-financialization). The hedging pressure sorts in Panel C cover the full sample as well as the sub-periods, but the sample runs from 1986 to 2010 dictated by data availability.

Sorting on	MKT exposure: σ_{lM}		HLCB exposure: σ_{lH}		Average exposure	
	Panel A: Stock market risk Pre-financialization					
High	-4.60	(-1.47)	3.72	(0.77)		
2	-1.26	(-0.42)	-2.07	(-0.74)		
3	2.52	(0.85)	-0.07	(-0.02)		
Low	5.64	(1.86)	0.66	(0.26)		
High - Low	-10.24	(-2.65)	3.06	(0.58)		
Rank-weighted	-7.62	(-2.27)	2.20	(0.49)		
	Panel B: Stock market risk Post-financialization					
High	13.35	(1.70)	8.02	(0.78)	15.45	(1.72)
2	7.95	(0.99)	14.74	(1.99)	6.99	(0.84)
3	6.59	(0.85)	6.54	(0.85)	4.29	(0.54)
Low	-0.02	(0.00)	-0.98	(-0.19)	0.87	(0.18)
High - Low	13.38	(1.80)	9.00	(0.93)	14.59	(1.85)
Rank-weighted	9.37	(1.49)	7.42	(0.94)	11.78	(1.83)
	Panel C: Hedging Pressure					
	Full sample		Pre-financialization		Post-financialization	
High	8.93	(2.67)	5.85	(1.73)	16.42	(2.06)
2	7.34	(2.22)	6.35	(1.96)	9.74	(1.19)
3	2.52	(0.74)	4.67	(1.40)	-2.72	(-0.33)
Low	-0.50	(-0.18)	-1.93	(-0.63)	2.98	(0.50)
High - Low	9.43	(2.59)	7.78	(1.92)	13.43	(1.75)
Rank-weighted	7.92	(2.61)	4.98	(1.47)	15.06	(2.37)

Table V: Double sorting commodity futures on stock market risk and hedging pressure

This table presents average returns in the post-financialization period (and White's heteroskedasticity consistent t-statistics in parentheses) for double sorts of commodity futures on hedging pressure and stock market risk. Stock market risk is measured as covariance with the CRSP VW MKT portfolio (σ_{lM}) in Panel A, as the covariance with the High minus Low Commodity Beta portfolio from a one-dimensional sort of stocks (σ_{lH}) in Panel B, and as the covariance with the average of the two (cross-sectionally standardized) covariances in Panel C.

		Mean returns				t-statistics			
					Panel A: HP versus σ_{lM}				
		H	L		Avg HP	H	L		Avg HP
HP	H	14.39	12.21		13.30	(1.68)	(1.59)		(1.76)
	L	5.10	-6.61		-0.75	(0.61)	(-0.99)		(-0.12)
				21.00	14.05			(2.66)	(2.85)
	Avg MKT	9.74	2.80	6.94		(1.23)	(0.44)	(1.15)	
					Panel B: HP versus σ_{lH}				
		H	L		Avg HP	H	L		Avg HP
HP	H	18.10	7.84		12.97	(2.19)	(1.00)		(1.78)
	L	-0.05	-1.01		-0.53	(-0.01)	(-0.18)		(-0.08)
				19.11	13.50			(3.04)	(2.39)
	Avg MKT	9.03	3.41	5.61		(1.12)	(0.58)	(0.90)	
					Panel C: HP versus average exposure				
		H	L		Avg HP	H	L		Avg HP
HP	H	17.98	9.62		13.80	(2.13	(1.21)		(1.82)
	L	0.32	-1.07		-0.38	(0.04	(-0.19)		(-0.06)
				19.04	14.17			(2.93)	(2.73)
	Avg MKT	9.15	4.28	4.87		(1.14)	(0.73	(0.94)	

Table VI: Exploring the structural break in the stock market
This table tests the difference between the two sub-periods for alternative breakpoints, i.e., December 2000, 2001, 2002, 2003, 2004 and 2005. We report average returns and FFCM alphas for the HLCB portfolios. All t-statistics are based on White's heteroskedasticity-consistent standard errors.

		Difference in alternative breakpoints											
		Alphas 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 VII: Exploring the structural break in the futures market
This table shows the High minus Low mean return from one-dimensional sorting of commodity futures on stock market risk and hedging pressure. Stock market risk is measured as covariance with the CRSP VW MKT portfolio (σ_{lM}), or the covariance with the High minus Low Commodity Beta portfolio from a one-dimensional sort of stocks (σ_{lH}), or as the covariance with the average of the two (cross-sectionally standardized) covariances. All t-statistics are based on White's heteroskedasticity-consistent standard errors.

	σ_{lM}		σ_{lH}		Average exposure		HP	
	Avg. Ret.	(t-stat)	Avg. Ret.	(t-stat)	Avg. Ret.	(t-stat)	Avg. Ret.	(t-stat)
Dec 2000	4.12	(0.91)	6.03	(1.28)	7.84	(1.81)	12.98	(2.96)
Dec 2001	5.96	(1.27)	8.87	(1.77)	9.81	(2.20)	12.80	(2.80)
Dec 2002	6.62	(1.28)	8.71	(1.64)	9.68	(2.06)	13.15	(2.76)
Dec 2003	7.47	(1.30)	8.80	(1.61)	8.58	(1.76)	12.69	(2.59)
Dec 2004	10.16	(1.70)	7.31	(1.24)	7.56	(1.36)	15.35	(2.96)
Dec 2005	13.11	(2.16)	3.44	(0.54)	4.41	(0.72)	16.29	(2.84)
Dec 2006	12.94	(1.90)	7.67	(1.18)	10.64	(1.66)	14.56	(2.25)

Table VIII: Stability of sort post-financialization

This table presents two results that demonstrate that our portfolios are stable in the post-financialization period. Panel A presents a summary of Markov switching matrices for the five one-dimensionally sorted stock portfolios (from H to L) for five-year sub-periods. Each column represents the diagonal of the switching matrix (averaged over all months in the sub-period), 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 alphas 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-financialization): $Corr(r_{free}, r_{fixed})$. 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 IX: Portfolios sorted on commodity sector indexes
This table presents means and FFCM alphas for stock portfolios sorted one-dimensionally in five groups on betas with respect to Open Interest-weighted commodity sector indexes, that is, an index of six energy commodities (Energy), an index of 15 agriculture commodities (Agriculture), an index of eight metals and fiber commodities (Metals & Fibers) and an index of four livestock and meat commodities (Livestock & Meats). For the spreading portfolios (HLCB), the table also presents corresponding t-statistics based on White's heteroskedasticity-consistent standard errors in parentheses.

		Energy	**Agriculture**	**Metals & Fibers**	**Livestock & Meats**
		Panel A: Pre-financialization			
Mean	H	4.71	8.34	4.59	6.79
	2	7.96	6.53	6.01	9.48
	3	9.09	9.13	7.64	7.65
	4	8.25	7.44	8.62	7.23
	L	8.54	7.43	10.72	5.93
	HLCB	-3.82	0.92	-6.13	0.86
	t-stat	(-0.86)	(0.29)	(-1.46)	(0.28)
FFCM α	H	-3.65	0.77	-0.92	-1.75
	2	-0.01	-0.04	-0.90	1.14
	3	1.50	1.75	1.26	-0.35
	4	1.32	0.73	1.88	1.14
	L	1.05	3.24	3.46	0.19
	HLCB	-4.69	-2.46	-4.38	-1.94
	t-stat	(-1.02)	(-0.80)	(-1.20)	(-0.58)
		Panel B: Post-financialization			
Mean	H	14.84	4.91	8.67	11.63
	2	6.40	6.59	5.76	5.21
	3	3.54	5.41	6.61	4.46
	4	3.81	8.17	4.95	4.19
	L	1.26	3.80	2.83	5.51
	HLCB	13.57	1.11	5.84	6.13
	t-stat	(2.22)	(0.19)	(0.89)	(1.17)
FFCM α	H	9.82	-1.03	2.66	4.96
	2	2.32	1.75	1.10	-0.05
	3	-1.13	1.72	2.69	0.35
	4	-0.01	4.00	1.03	1.08
	L	-2.99	-0.62	-1.15	1.38
	HLCB	12.81	-0.41	3.81	3.58
	t-stat	(2.19)	(-0.08)	(0.68)	(0.96)
		Panel C: Difference for HLCB portfolio			
Mean	HLCB	17.40	0.20	11.97	5.26
	t-stat	(2.30)	(0.03)	(1.54)	(0.87)
FFCM α	HLCB	17.50	2.05	8.18	5.52
	t-stat	(2.36)	(0.35)	(1.24)	(1.11)

Table X: 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 sub-period, Panel B for the second sub-period. In each panel we present average returns and FFCM α's (in annualized %'s). To conserve space, we present corresponding t-statistics (based on White's heteroskedasticity-consistent standard errors) 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: Pre-financialization						
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: Post-financialization						
			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 XI: 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 from a three-by-two sort on inflation beta and Size; presented in the right panel). Then, we regress the residuals from this regression on the OIW commodity index to estimate commodity betas, which we then use to sort. Panel A covers 1980 to 2003, Panel B covers 2004 to 2010 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 pre-financialization													
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 post-financialization													
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-financialization)-(Pre-financialization)													
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*