PSL Quarterly Review, vol. 65 n. 260 (2012), 79-109

Do financial investors affect the price of wheat?

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Following a dramatic surge in financial investment in commodity derivatives markets by institutional investors, hedge funds and large investment banks, agricultural commodity prices started to fluctuate together in an unprecedented fashion. In June 2008 all main agricultural prices peaked at their highest level in 30 years, and then fell sharply in the next six months. In 2010 there was a new steep rise, with prices peaking in early 2011 at levels higher than those reached in 2008. A worldwide debate has erupted over the role of financial speculation in driving these price dynamics.

The hypothesis put forward by several observers goes as follows: during the last decade financial investors significantly increased their investments in commodity futures markets, influencing the formation of futures prices, which are the benchmark for spot prices. In particular, financial actors had been buying large amounts of futures contracts between 2004 and 2008, putting a huge upwards pressure on prices. Then they temporarily exited those markets between late 2008 and early 2009, selling the contracts they held and causing the fall in prices. They started being bullish again from mid-2009, triggering the new price peak of 2010-2011. If this hypothesis holds true, then the policy implication is that new regulatory measures are needed in order to curb excessive speculation on commodity derivatives markets.

Although this theory seems convincing, the underlying evidence is still not clear-cut. Some empirical results have been presented (for example by Gilbert, 2009; Tang and Xiong, 2010; Buyuksahin and Robe, 2010) which suggest that financial speculation affected recent agricultural commodity price dynamics, but conclusive evidence is still to be found. In my view this is due to a lack of information about commodity derivatives markets (fairly

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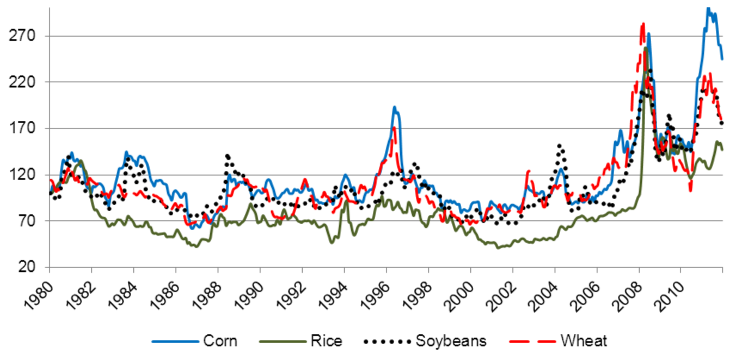
reliable data about trading volumes and net positions of each category of traders are only available for U.S. centralized exchanges and only for the 2006-2011 period) and to the fact that time-series are still relatively short, due to the novelty of the phenomenon. This article aims to contribute to the debate by presenting some reflections on the financialization of agricultural commodities (section 2) and new empirical evidence (section 4) to support the hypothesis that financial investors, and in particular index traders, have affected wheat price dynamics in recent years.

1. Recent agricultural commodity price dynamics

The long phase of stability and moderation of agricultural commodity prices, which started in the eighties, ended abruptly in the second half of the last decade. The sharp price increases in 2007-2008 and 2010-2011, and the even quicker fall in prices that took place between the two spikes, were surprisingly rapid and deep.

Figure 1 – *Agricultural commodity prices on the international market (January 1980=100)*



Source: Elaboration on IMF data (Primary Commodity Prices Database).

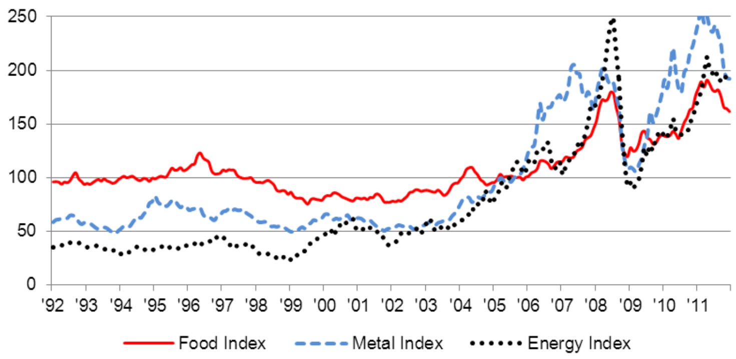
In one and a half years – between January 2007 and June 2008 – all main agricultural prices rose sharply, reaching their highest levels in thirty years. The wheat price increased by 78%, corn by 75%, rice by 166% and soybeans by 116%. During the following six months, from July until December 2008, prices fell sharply: wheat declined by 37%, corn by 45%, rice by 34%, and soybeans by 42%. A new surge has been observed since spring 2010, with prices peaking in early 2011 at levels similar to those reached in 2008. Since mid-2011, prices appear to have been declining again.

These price swings were shared not only by all agricultural commodities – a fact not completely surprising, given the strong substitution effects which exist between some of them – but even by energy and metal commodities (see figure 2). The key feature of these price trends is that they do not appear to be fundamental-driven, since offer and demand dynamics were not (and probably cannot be) so volatile in the short term. Even if during the 2000s an overall cereal production deficit was observed in six years out of ten, if we stick to the data made available by the FAO and the USDA, physical market fundamentals do not appear to justify the steep price increases of 2007-2008 and 2010-2011. In these years there was no particular consumption peak, nor a significant fall in production. Indeed, main exporters' stocks did not show a clear downwards trend (see figure 3). Cereals' stocks declined between 2006 and 2008, but not so steeply to fully justify the dramatic rise in prices; indeed, in 2008 cereals' stocks were broadly at the same level as in 2003.

2. The boom cycle of commodity derivatives markets

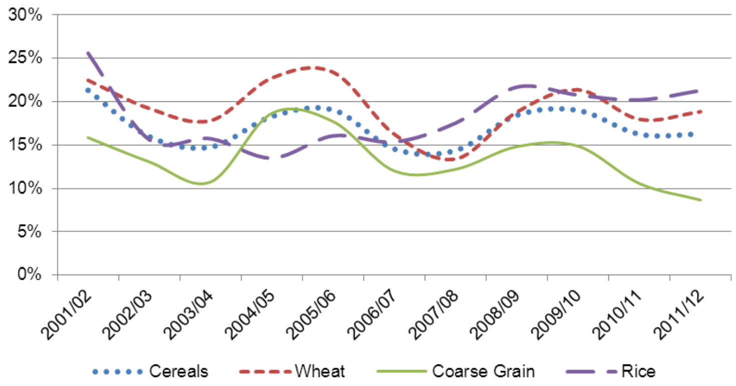
It is widely debated whether recent commodity price dynamics were affected by financial speculation. The hypothesis goes as follows: during the last decade financial investors significantly increased their investments in commodity futures markets, influencing the formation of futures prices, which are the benchmark for spot prices. In particular, financial actors were buying large amounts of futures contracts between 2004 and 2008, placing a huge upwards pressure on prices. They then temporarily exited those markets between late 2008 and early 2009, selling the contracts they held and causing the rapid fall of prices.

Figure 2 – *Agricultural, energy and metal commodity prices on international markets (2005 = 100)*



Source: Elaboration on IMF data (Primary Commodity Prices Database).

Figure 3 – *Major exporters' stock-to-disappearance ratio*[1]



Source: Elaboration on FAO estimates (FAO, 2011).

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[1] Disappearance is defined by the FAO as domestic utilization plus exports for any given season.

They started being bullish again from mid 2009, triggering the new price peak of 2010-2011. The remainder of this section will delve into this hypothesis, while section 4 presents some new empirical evidence in support of it.

2.1. A "wall of money" flowing into commodities

As a matter of fact, during the 2000s financial investors flooded commodity futures markets with what many observers called a "wall of money". This was part of a larger shift in portfolio strategy that drove financial institutions away from traditional equity markets and towards commodity and real estate derivatives (Basu and Gavin, 2011). The rise of financial investment in commodity derivatives started in the aftermath of the 2000-2002 financial crisis, triggered by the burst of the dotcom bubble. 2007 saw a further huge acceleration of commodity derivatives growth as financial capitals were distancing themselves from the collapsing US housing market. Between 2004 and 2008, the notional amount[2] of commodity derivatives traded OTC grew by an impressive 900% and the number of contracts traded in organized exchanges increased by a no less remarkable 214%. In late 2008 there was a fall in commodity derivatives trading, both OTC and centralized, as financial institutions were selling their assets in an attempt to get liquid and cover losses during the financial crises. The slump was reversed in late 2009 when a new surge of financial investments in commodities began. The number of futures contracts traded in commodity exchanges fell by 20% between March and December 2008. The number then started rising again and by summer 2010 it had reached a new high, 71 percentage points higher than the previous peak of spring 2008. According to the most recent available data, published in December 2011 by the Bank for International Settlements (BIS), a new declining trend seems to have started in late 2011. Notional amounts of over-the-counter transactions reached their peak in spring 2008 and then fell by 67% during the

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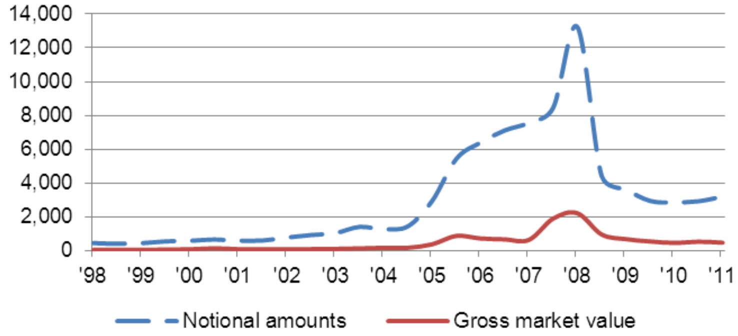
[2] According to the BIS, **"**[n]ominal or notional amounts outstanding are defined as the gross nominal or notional value of all deals concluded and not yet settled on the reporting date" (Bank for International Settlements, 2011).

following six months. The declining trend has reversed since the second half of 2010 but notional amounts remained well below the 2008 peak; it is probable that the new increase was driven by the spike in commodity prices rather than by a new increase in the number of transactions (notional amounts are determined both by the number of contracts traded and by the price of the underlying commodity – see notes 2 and 3).

In conclusion, we can distinguish an initial commodity derivatives boom cycle (2007-2008) and a second cycle (2010-2011). The first cycle was characterized by an increase in OTC transactions higher than that in contracts traded in centralized exchanges, while in the second cycle it was the growth of exchange-traded derivatives that was more relevant.[3] In both cases the boom in commodity derivatives trading coincided with a peak in international commodity prices.

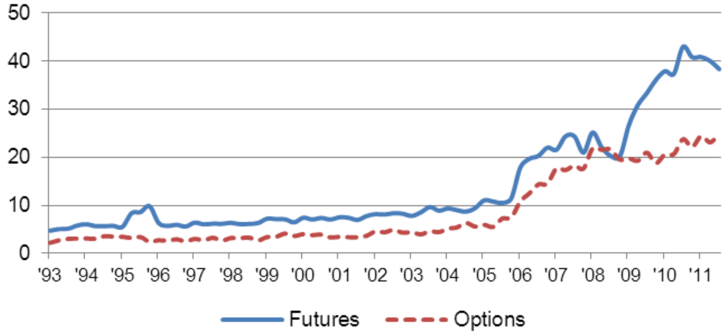
Figure 4 – *Amounts outstanding of over-the-counter commodity derivatives (billions of US dollars, half-yearly observations, last observation June 2011)*



Source: Elaboration on BIS data (BIS, 2011).

[3] We can infer this distinction from BIS data (see figures 4 and 5) even though the data are not completely comparable, because the notional amounts of contracts traded OTC is influenced not only by the number of contracts traded but also by the price fluctuations of the underlying commodity.

Figure 5 – *Commodities' derivative financial instruments traded on organized exchanges (millions of contracts, quarterly observations, last observation September 2011)*



Source: Own elaboration on BIS data (BIS, 2011).

2.2. The actors in commodity futures markets

We can distinguish three main types of actors in commodity derivatives markets, depending on the aims and strategies they exhibit. Commercial operators trade commodity derivatives in order to hedge their transactions on the spot market, while financial investors are motivated by the search for yields and/or by portfolio diversification strategies. Financial investors operating in commodity markets can be divided into two categories, which we call commodity index traders and money managers. Commodity index traders are passive agents whose aim is to gain exposure to commodities as an asset class. They do so by tracking a commodity index, which is a weighted average of different commodity prices, with fixed weights (mainly) dependent on world production and updated once a year. To invest in commodity indices, investors buy financial instruments whose value is proportional to the value of the indices. These instruments – swap agreements, ETFs and ETNs – are typically offered by large financial institutions. These institutions buy commodity futures contracts in order to hedge their commitment with their clients. By contrast, we term "money managers" any financial investors who do not track a commodity index, but instead actively buy and sell futures contracts in an attempt to anticipate price changes.

These categories are to be seen as dynamic rather than static. In real futures markets, there is no clear-cut distinction between hedging and speculation. Rather, there is a continuum between pure hedging and speculation. Often big commercial operators carry out speculative operations; at the same time, complex speculative strategies followed by financial institutions can sometimes bring the latter to trade on physical markets. Furthermore, there are cases in which the same trader runs multiple lines of business, blurring the distinction between index traders and money managers.

2.3. Structural change in agricultural futures markets' composition and the rise of index trading

During the last decade, the remarkable influx of financial speculative investment has drastically changed the composition of commodity futures markets. Fairly reliable data about trading volumes and net positions of each category of traders are only available for U.S. centralized exchanges and only for the 2006-2011 period.[4] However, the growth in commodity derivatives trading was so steep that only speculative investments could have triggered it, because physical production did not grow at similar rates; so the huge new demand for futures contracts cannot have come from commercial operators trying to hedge their physical markets' operations. Better Markets, a nonprofit organization, roughly calculated that in the period 2005-2008 commodity index funds alone pumped as much as 300 billion dollars into US commodity futures markets, and that the market share of financial speculators in the Chicago Board Of Trade wheat futures market rose from 12% of the market in 1996 to 65% in 2008, with the hedging of producers and purchasers dropping to 35%.

The composition of the futures market is important because it determines the relative importance of the different factors that affect

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[4] This information is made available by the CFTC. For years prior to 2006, the CFTC's data is such that a considerable part of index traders are classified as commercial hedgers.

futures prices. Money managers' demand for commodity futures contracts is a function of their own expectations about the future fluctuations of prices and of the present and future returns of the other financial markets in which they operate, while commercial hedgers' demand is a function of physical production and consumption of the commodity. Index traders' demand depends on their own expectations about the future returns of the commodity index they are tracking, and on the present and future fluctuations of the other financial markets in which they operate. That is why a futures market dominated by financial speculators can disconnect prices from physical market fundamentals, linking them instead to financial investors' expectations about their own collective behavior (the "beauty contest" described by Keynes, 1936) and to other financial markets' dynamics.

According to the data made available by the US market authority (CFTC), in the period 2006-2011 financial speculators held on average a market share of more than 50% in all main US agricultural exchanges (see figure 6). The large majority of this financial investment came from commodity index funds. At first glance this could seem counter-intuitive, given that agricultural commodities are present in commodity indices with only small weightings. Indeed, it is energy commodities and in particular crude oil that lead the indices and consequently attract the greatest part of the financial inflow. But we have to consider that (1) commodity index funds' total investment has been so huge that even a small fraction of it corresponds to a great amount of capital; (2) agricultural futures markets are less liquid than energy futures markets, so they are less able to absorb capital inflows; (3) commodity index traders follow a strategy of buying futures contracts and then holding them for a long time, substituting each near-maturity contract with the next; this means that they take almost only long positions, in such a way that their net position on the market is always positive, and almost as high as their trading volume (while money managers' net position is significantly lower than their trading volume, because opposite bets offset each other).

The fact that commodity index traders' net position tends to be high compared to that of other types of traders implies that these financial actors tend to exert a huge impact on futures prices. Indeed, if we accept the fact that the overall net position of a group of traders is a proxy for its price impact, it follows that commodity index traders were the category that exerted the greatest impact on agricultural futures prices in the period 2006-2011 (see figure 6).

2.4. The relation between spot and futures prices

The strong connection between spot prices and futures prices means that the impact of index traders' investment was felt not only by commercial hedgers operating on commodity futures markets, but also by food consumers around the world. Spot and futures prices are linked by arbitrage links, by the price discovery function and by the hedging activity of producers and purchasers. No-arbitrage implies that the futures price equals the spot price augmented by the cost of carry[5] and diminished by the convenience yield.[6] But we do not necessarily need to assume no-arbitrage to state that there is a strong link between spot and futures prices. Futures markets were created in order to let commercial traders hedge their physical transactions (the "hedging function") and to discover a price to be used as a benchmark for spot prices (the "price discovery function"). The "hedging function" implies that for commercial operators the futures price is the price that they will actually receive (or pay) for their physical transactions, as long as they hedged those transactions on the futures market. The "price discovery function" implies that futures prices are used as a benchmark for spot prices. This is confirmed by empirical analysis. In particular, Hernandez and Torero (2010) showed that futures and spot prices of main agricultural commodities are highly correlated, and that changes in futures prices tend to lead changes in spot prices.

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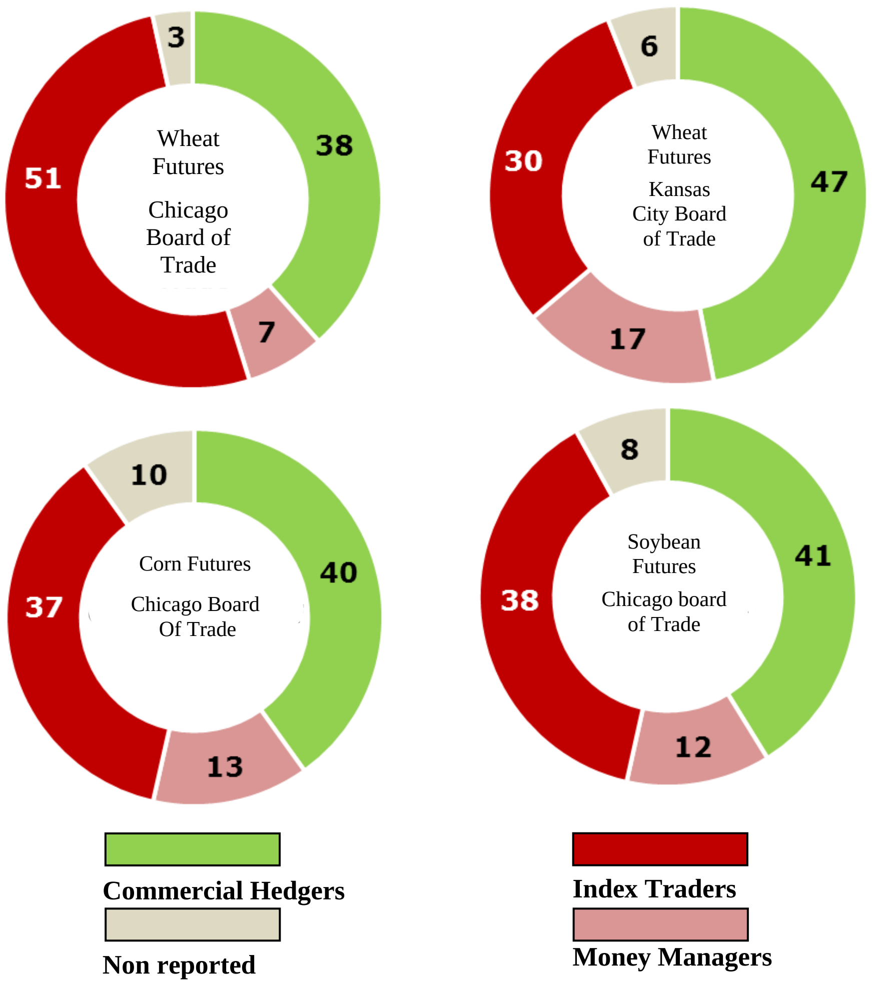
[5] Which in the case of agricultural commodities is equal to the opportunity cost (i.e. the riskless interest rate) plus the cost of storage.

[6] The convenience yield is the major utility resulting from holding the physical commodity instead of a futures contract for the same amount, given that physical inventories offer insurance against sudden supply disruptions.

Table 1 – *Commodity futures markets, actors and instruments*

	COMMERCIAL HEDGERS	SPECULATORS	
		MONEY MANAGERS	**COMMODITY INDEX TRADERS**
Who they are	Physical market operators (big producers, elevators, large scale purchasers)	Individual investors or investment funds (e.g. hedge funds).	Big investment banks which sell Commodity Index Funds to their clients
Aims	Minimize risks linked to price variations, to which they are exposed because of their commercial operations on the physical markets.	Profit from future price changes	To hedge their commitment with their clients, to whom they pay a cash flow linked to the returns of the commodity index.
Net aggregate position on the futures market	Their aggregate net position is traditionally negative, because they are mainly big producers and elevators (even some big purchasers trade futures contracts, albeit on a minor scale).	Usually not so ample compared to their trading volume. Its sign change depends on expectations about future price changes.	Necessarily positive and almost equal to their trading volume. In other words, they tend to take only long positions.
Demand function	Their demand for futures contracts is a function of physical market fundamentals (demand and supply of the physical commodity).	Their demand for futures contracts is a function of their expectations about the future price movements and the returns of the other financial markets in which they invest.	Inelastic to the price of each single commodity in which they invest, their demand is sensitive to the returns of the tracked commodity index and to the returns of other financial markets.

Figure 6 – *Futures market composition (net positions %), 2006-2011*[7]



Source: Elaboration on CFTC data (Commitments of Traders supplemental report).

[7] Computed as the ratio of the absolute value of the net position of each category to the sum of the absolute values of the net positions of all categories.

3. Previous empirical studies

Several studies have attempted to assess the impact of financial investments on agricultural commodity prices. Gilbert (2009) tested several commodities' price dynamics in order to find evidence of speculative bubbles caused by feedback trading or by index trading. Only in a few commodity markets – in particular soybean and copper – did his models point to a speculative bubble caused by extrapolative expectations, while in many he finds evidence of a bubble caused by index traders. Other studies investigate the issue using Granger causality tests. In particular, Hernandez and Torero (2010) show that futures prices lead spot prices more often than the reverse, while Irwin *et al*. (2009) find that index funds' positions across futures markets have no impact on relative price changes across those markets. More closely related to our article are the works of Tang and Xiong (2010) and Buyuksahin and Robe (2010). The latter uses non-public data from the US Market Authority (CFTC) to show that the correlations between the returns of investable commodities and equity indices increase amid greater participation by hedge funds. Tang and Xiong, on the other hand, find that since the early 2000s futures prices of non-energy commodities in the US became increasingly correlated with oil, and that this trend is systematically more pronounced for commodities included in the two most popular commodity indices, which suggests that index traders may have played an important role in affecting commodity prices.

4. Empirical evidence

In this section new empirical evidence is presented in support of the hypothesis that index traders' investments have affected wheat price dynamics in recent years. In particular, I focus on Hard Red Winter Wheat, the most traded wheat in international spot markets. According to the FAO, Hard Red Winter (HRW) is the benchmark for international wheat prices.

4.1. The time-series og futures price

I have used historical data from the Kansas City Board of Trade (KCBT) to construct a weekly weighted average futures price for HRW wheat, with weights proportional to the transaction volume of each contract (see Appendix 1). A preliminary analysis of this futures price time-series revealed the following relevant characteristics: (1) the variable in levels is not stationary, while its first difference logarithmic transformation is stationary; (2) there is a first-order positive serial correlation; (3) there is autoregressive conditional heteroskedasticity;[8] (4) The error distribution carries more weight in the tails than a normal distribution, so it is better approximated by a Student-*t*. These aspects were highlighted by formal tests (described in Appendix 2).

4.2. The correlation between wheat prices, US stock market returns and crude oil prices

The analysis presented here is based on the evolving correlations between wheat price fluctuations, US stock market returns and oil prices. I test the hypothesis that index traders' investment influenced HRW wheat price dynamics, linking them to US stock market returns and to oil price fluctuations. If this hypothesis holds, we should find that in recent years wheat price dynamics have become increasingly correlated to oil price movements and stock market returns, and that these correlations have been caused by a correlation between these two variables and the index tracked by commodity index funds. I use returns on the S&P 500 index as a proxy for US stock market returns, and Brent crude oil price changes as an indicator of oil price movements.

Beginning in 2007[9] wheat futures price dynamics are positively related to the returns of the equity index S&P500. This correlation is still

[8] A time-series presents conditional heteroskedasticity, or volatility clusters, if there is an alternation between periods of higher and lower volatility.

[9] I chose 2007 as the breakpoint date on the basis of a QLR test for parameter instability and structural change with unknown change point (based on Andrews, 2003). The QLR test (figure 7) for regression n. 1 estimated on the whole sample (1986-2011) indicated 2008 as the most probable breakpoint date, but it suggested that the correlation between

significant if we include in the equation, as control variables, the US Dollar exchange rate[10] (measured by the Trade Weighted Exchange Index calculated by the Federal Reserve) and a dummy accounting for the global recession of 2008-2009 (regression n. 3 in table 2), but it fades away when we control for the returns of the commodity index S&P-GSCI, the most tracked by commodity index funds (regression n. 5). In other words, the linkage between wheat price movements and stock market returns is spurious, and it is determined by the commodity index S&P-GSCI, the most tracked by commodity index traders.

An analogous result holds for the correlation between wheat price and oil price. Since 2007 this correlation becomes highly significant, and this result is robust to the inclusion of control variables such as the US Dollar exchange rate index, the dummy accounting for global recession, and gasoline price (regression n. 4). In this case, gasoline price is used as a further control variable, in order to account for the effect of biofuel production in linking wheat price to oil price (it is gasoline price, and not crude oil price, which determines the profitability of biofuels). Even in this case, the correlation fades away if we include in the regression the S&P-GSCI commodity index (regression n. 6), suggesting that even the correlation between wheat price and oil price is spurious, with the most tracked commodity index as the confounding variable.

The estimates in table 2 were obtained from a Generalized Autoregressive Conditional Heteroskedasticity (Garch 1,1) with Student-*t* error distribution. I chose this model in order to take account of the presence of conditional heteroskedasticity and of the non-normal distribution of wheat price returns.

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wheat price and stock market returns has gradually developed during the second half of the last decade. An analogous result was found for the correlation between wheat price and oil price dynamics (figure 8).

[10] I control for the USD exchange rate because it is related to both US stock market dynamics and international commodity prices. This control may be excessive, for financial investors consider investing in commodities as an insurance against USD exchange rate fluctuations, and/or as a bet on the appreciation/depreciation of the dollar. Furthermore, most hedge funds and index traders are probably active in both commodities and currencies trading.

Table 2 – *Correlation between HRW wheat futures price, US equity index S&P500 and Brent oil price, GARCH(1,1)-t model*

	Dependent variable: HRW wheat futures price					
	1991-2006		2007-2011			
(Regression No.)	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.0007	0.0007	0.002	0.004	0.001	0.004
	(0.39)	(0.45)	(0.44)	(0.15)	(0.72)	(0.23)
AR(1)	**0.18*** **	**0.18*** **	**0.13** **	**0.11* **	**0.15** **	**0.15** **
	(0.0000)	**(0.0000)**	**(0.048)**	**(0.08)**	**(0.02)**	**(0.02)**
US EQUITY INDEX	-0.04	-	**0.26* **	-	0.07	-
	(0.45)		**(0.055)**		(0.61)	
BRENT OIL PRICE	-	0.02	-	**0.13** **	-	0.01
		(0.37)		**(0.02)**		(0.85)
US DOLLAR	-0.16	**-0.20* **	**-0.96*** **	**-1.1*** **	**-0.80*** **	**-0.88*** **
	(0.14)	**(0.10)**	**(0.0002)**	**(0.0001)**	**(0.0007)**	**(0.001)**
DUMMY	-	-	-0.006	**-0.01* **	-0.003	-0.009
			(0.33)	**(0.06)**	(0.59)	(0.12)
GASOLINE PRICE	-	-0.02	-	**-0.19** **	-	**-0.19** **
		(0.67)		**(0.04)**		**(0.03)**
S&P-GSCI COMMODITY INDEX	-	-	-	-	**0.28*** **	**0.29*** **
					(0.0002)	**(0.0002)**
Regression Statistics						
N	840	836	227	227	227	227
Adjusted R^2	0.03 (0.03)	0.04 (0.03)	0.17 (0.14)	0.19 (0.17)	0.22 (0.19)	0.24 (0.22)
F-stat	5.3	7.89	5.5	10.1	6.8	11.35
	(0.00000)	(0.000003)	(0.000002)	(0.000000)	(0,000000)	(0.000000)

Note: p-values in parentheses. The coefficients for the conditional variance are not reported for reasons of parsimony. Coefficients estimates are noted as significant at the 1%(***), 5%(**) and 10%(*) levels. For 2011 the data only cover the first four months. Coefficients that are significantly different from 0 at the 10% level are noted in bold print. All variables are expressed in first differences of the natural logarithm. Data sources are listed in Appendix 1.

Figure 7 – *QLR test statistic for the US EQUITY INDEX coefficient*

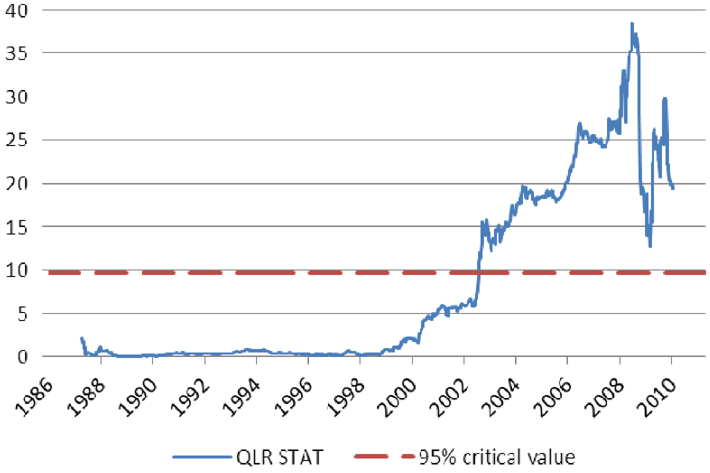
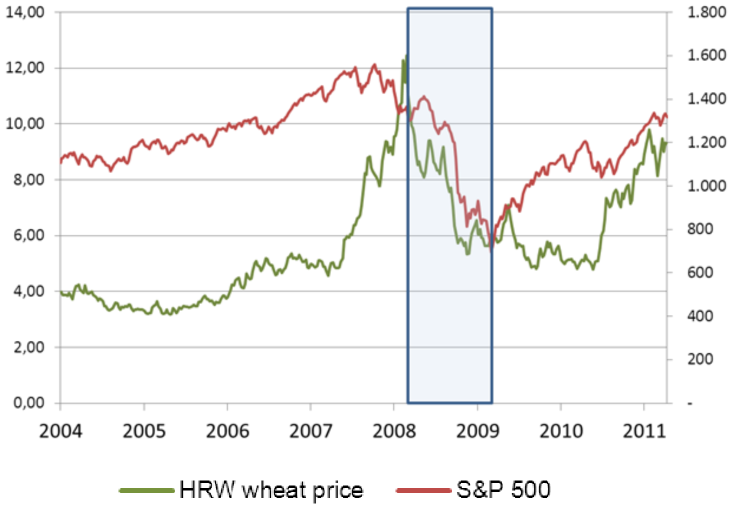


Figure 8 – *QLR test statistic for the BRENT OIL PRICE coefficient*

Figure 9 – *The dummy variable accounting for the global recession*



Note: $DUMMY_t = 1$ if week *t* is in the period shaded in blue; $DUMMY_t = 0$ otherwise.

The estimates in table 2 were obtained from a Generalized Autoregressive Conditional Heteroskedasticity (Garch 1,1) with Student-*t* error distribution. I chose this model in order to take account of the presence of conditional heteroskedasticity and of the non-normal distribution of wheat price returns.

These results suggest that commodity index traders have affected wheat price dynamics, linking them to stock market dynamics and to the price of oil, which is the main component of all commodity indices. The evolution of the coefficient of the US dollar exchange rate is also notable. While in the period 1991-2006 it is -0.20 and barely significant, in 2007-2011 it is unitary and highly significant. Since 2007, in other words, for every percentage decrease in the US dollar exchange rate index, the price of HRW wheat has tended to increase by a percentage point. Controlling for the commodity index this negative elasticity decreases but still remains high (-0.80), suggesting that this relation is only partly determined by index traders.

4.3. Interpretation of results

The empirical analysis presented suggests that commodity index traders have played a significant role in affecting wheat price fluctuations in recent years. In particular they seem to have linked wheat price dynamics to US equity market returns and to oil price movements. As shown in table 2, the commodity index (S&P-GSCI) tracked by most commodity index funds is the confounding variable that determines the linkages between wheat price dynamics and stock market returns, as well as between wheat price dynamics and oil price movements.

Indeed, the fact that the correlation between wheat price dynamics and stock market returns appears to be mediated by the returns of the S&P-GSCI commodity index is consistent with the hypothesis that index traders determine these correlations. As stated in section 2, index traders' demand for futures contracts depends on their own expectations about the future returns of the commodity index they are tracking, and on the present and future fluctuations of the other financial markets in which they operate (this makes sense if one thinks that index traders are active at the same time in equity, agricultural commodity and energy commodity markets; it is difficult to believe that their strategies in the different markets in which they operate can be independent from each other). Thus, the correlation between wheat price dynamics and stock market returns is not a direct one, but a spurious one: the returns of the S&P-GSCI commodity index are correlated with stock market returns, and in turn wheat price fluctuations are correlated to the S&P-GSCI index returns.

In interpreting the positive sign of the correlation between wheat price and US stock market returns, I argue that when stocks' market value increases, diversification incentives induce investors to move some money into commodities (Tang and Xiong, 2010). The positive sign of the relation between oil price and wheat price is probably due to the way commodity index funds work. When the oil price increases, they automatically increase their investments in all the other commodities included in the index, in order not to alter the fixed weights.

The US dollar exchange rate appears to have had a huge impact on recent wheat price dynamics. This relationship was present even in the previous period, and its sign is negative. This is consistent with the fact that commodities are priced in dollars, so we expect exporters to raise prices when the dollar depreciates, especially in oligopolistic markets, in order to keep (*ceteris paribus*) real prices fixed. However, the impact of the US dollar exchange rate became remarkably stronger after 2007, so new factors must have stepped in. We can suppose that financial investors played a role, because they see commodities as a hedge against US dollar depreciation. The estimates presented in table 2 show that only a minor part of this influence can be attributed to index traders. We can suppose that money managers were more influential in this regard, because they are more reactive to macroeconomic signals, but there may even have been other factors behind the relationship, which leaves room for further research.

5. Concluding remarks

By highlighting the influence of index traders on wheat price dynamics this work aims to contribute to the debate on the role of financial markets in recent food price swings, and on the need for better regulated commodity futures markets. The empirical analysis presented suggests that financial investors played an important role in affecting wheat price fluctuations in recent years, by linking them to US equity market returns and to oil price movements.

In my view the data, facts and empirical findings presented here and in many other studies (see for example UNCTAD, 2011; Tang and Xiong, 2010; Buyuksahin and Robe, 2010; IATP, 2011; Gilbert, 2009; Masters and White, 2008) make a strong case for a new wave of regulation on commodity derivatives markets. The economic and human costs of recent commodity price fluctuations have been dramatically high, with a strong negative worldwide impact on poverty and food security. I agree with Jayati Ghosh (2011) when she advocates the application of the precautionary principle on this matter. In the presence of significant, if not conclusive, evidence that the growth of financial speculative transactions contributed to recent agricultural price fluctuations, it is the responsibility of regulators to act to reverse the process of deregulation of commodity derivatives markets that allowed the financialization to happen. Position limits should be increased again, and commodity index traders should not be exempted from them (as they have been since 1991). The jurisdiction of market authorities should be extended to OTC transactions, and to markets which are now almost completely unregulated (such as the ones in London). The Dodd-Frank act, recently approved in the US, is a step in this direction in that it provides for the centralization and regulation of OTC transactions. It remains to be seen how it will be implemented by the US Market Authority (the CFTC). Moreover, coordination between market authorities, coupled with the imposition of analogous rules in all the main commodity exchanges, would be necessary to impede investors bypassing rules and limits simply by trading the same commodity on exchanges elsewhere.

Commodity derivatives were created to stabilize commodity price dynamics. As a result of their uncontrolled expansion, they now appear to be a factor of destabilization. In the end, what is being called for by many academics, institutions and NGOs is simply the application of the Commodity Exchange Act, a US law approved in 1936, which states that it is the task of regulators to "diminish, eliminate or prevent excessive speculation causing sudden or unreasonable fluctuations in the price of a commodity".

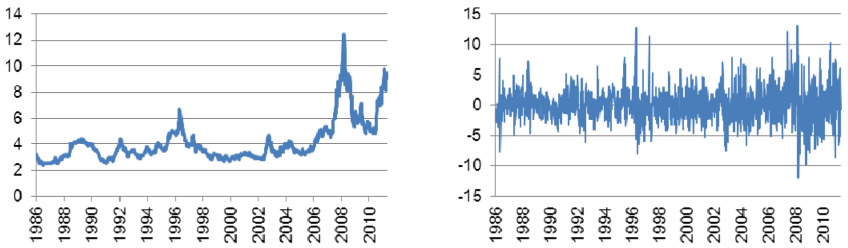
Appendix 1 - Data and sources

The average weekly futures price was calculated as a weighted average of the prices of the different contracts traded in each week, with weights proportional to the trading volumes of each contract. Formally:

$$Pwheat_t = \frac{\sum_{i=1}^{N} p_i Vol_i}{\sum_{i=1}^{N} Vol_i} \qquad (1)$$

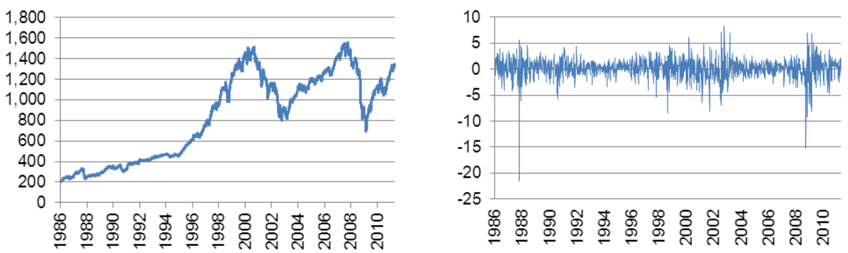
where $Pwheat_t$ is average weekly futures price of week t; P_i is price of contract i in week t; Vol_i is trading volume for contract i in week t; N is overall trading volume in week i.

Figure A1 – *HRW average weekly futures prices and percentage changes*



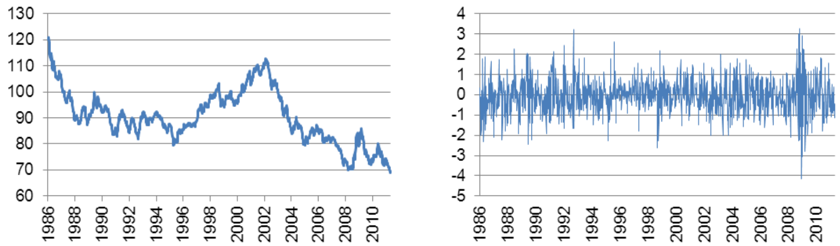
Source: Elaboration on KCBT data. Hard Red Winter wheat futures prices were downloaded from the Kansas City Board of Trade website at the URL http://www.kcbt.com/historical_data.asp.

Figure A2 – *S&P500 index in levels and in percentage changes*



Source: Elaboration on S&P data. Available online at the URL: http://www.cboe.com/SPX.
Note: The S&P 500 index, used by countless empirical works as a proxy for the US equity market performance, is available from the Standard & Poor's website. We chose it among other indices because it is representative of the whole market.

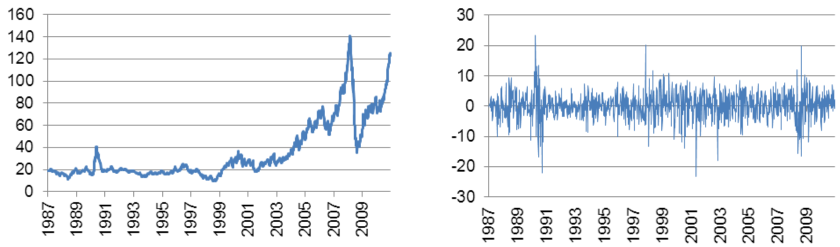
Figure A3 – *US dollar Trade Weighted Exchange Index in levels and in percentage changes*



Note: Weighted average of the exchange rate of the US dollar with the currencies of the main commercial partners of the US.

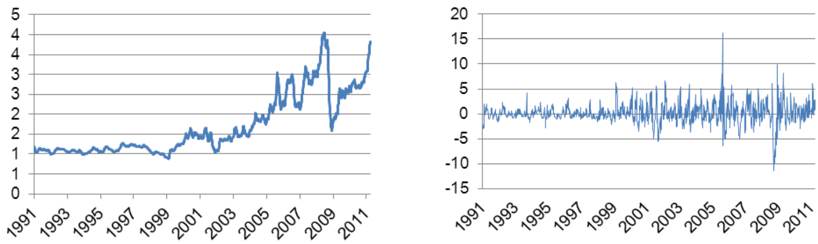
Source: Elaboration on US Federal Reserve data. US Dollar exchange rate dynamics are measured by the Trade Weighted Exchange Index calculated by the Federal Reserve. Available online at the URL: http://research.stlouisfed.org/fred2/series/TWEXM.

Figure A4 – *Brent crude oil price in levels and in percent changes*



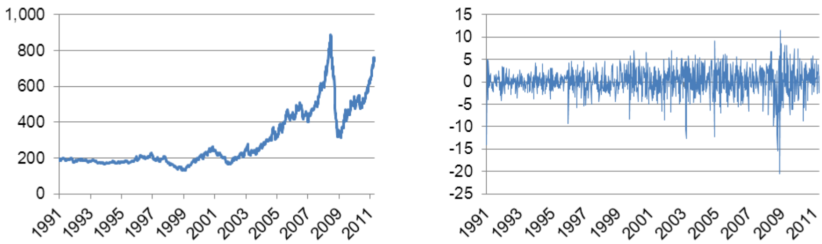
Source: Elaboration on US Energy Information Administration data. Available online at the URL http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RBRTE&f=W

Figure A5 – *Gasoline price in the US in levels and in percentage changes*



Source: Elaboration on US Energy Information Administration data. Available online at the URL:http://www.eia.gov/oil_gas/petroleum/data_publications/wrgp/mogas_history.html

Figure A6 – *S&P-GSCI index in levels and in percentage changes*

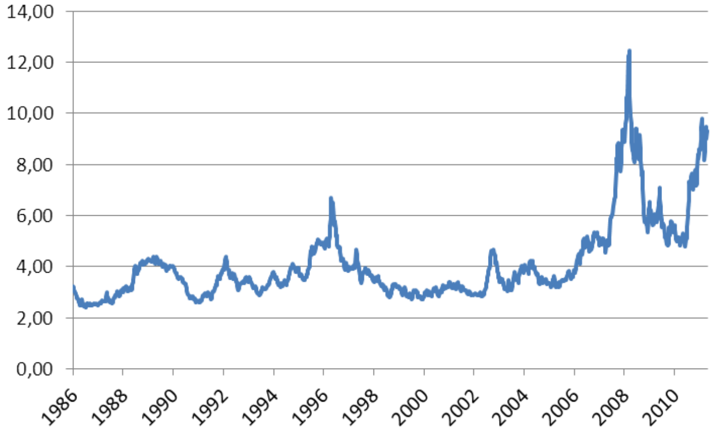


Source: Own elaboration on Goldman Sachs data. S&P-GSCI commodity index returns comes from Goldman Sachs and were downloaded from the website "Wikiposit", at the URL: http://wikiposit.org /w?action=dl&dltypes=comma%20separated&sp=weekly&uid=WP204FB.

Appendix 2 - Time-series of the weekly average futures price

Visual inspection (figure A7) suggests that the time-series of the average weekly futures price of Hard Red Winter wheat is non-stationary, i.e. the probability distribution for the empirical observations does not seem to be constant over time. Mean, standard deviation and autocorrelation parameters seem to change with time. In particular, "eyeballing" the data suggests that the mean and variance of the distribution increase in the most recent part of the sample. Clearly, these elements should be investigated further through formal tests.

Figure A7 – *Weekly weighted average of the futures price of HRW wheat, January 1986-April 2011 ($/bushel)*



Source: Elaboration on KCBT historical data (available online at the URL: http://www.kcbt.com /historical_data.asp).

Non-stationarity was confirmed by an augmented Dickey-Fuller test for the presence of a unit-root. Without intercept and trend, the one-sided p-value for the null hypothesis that the series has a unit root is 74%. The series is non-stationary. We selected a second-order autoregressive structure, AR(2), on the basis of the minimization of the Schwarz Info Criterion (or BIC, Bayesian Info Criterion). The result is robust to the use of the Akaike Info Criterion (AIC), which would select a 24-lags autoregressive structure, AR(24) (in this case the one-sided p-value for the null of non-stationarity is 68%).

Table A1 – *Augmented Dickey-Fuller test for a unit root (series in levels)*

Null Hypothesis: FUTURES has a unit root
Exogenous: None
Lag Length: 2 (Automatic based on SIC, MAXLAG=25)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		**0.193693**	**0.7425**
Test critical values:	1% level	-2.566031	
	5% level	-1.940970	
	10% level	-1.616601	

*MacKinnon (1996) one-sided p-values.

To eliminate non-stationarity in the data, we express the series as first-differenced natural logarithms, i.e. we take the rate of change of the series. The augmented Dickey-Fuller test (without trend and intercept and with an AR(1) structure selected by the BIC criterion) rejects at any conventional significance level the null hypothesis of a unit autoregressive root. The result is robust to the use of the AIC criterion instead of the BIC to select the number of lags.

Several previous studies have shown that the empirical distribution of commodity futures price changes is typically not normal but leptokurtic, i.e. it has a more acute peak around the mean and fatter tails, and so it is better approximated by a Student-*t* distribution than by a normal distribution (Kang and Brorsen, 1995). Other typical main features pointed out by the literature on commodity futures price changes are asymmetry and auto-correlation (Taylor, 1985; Yang and Brorsen, 1993; Kang and Brorsen, 1995). The empirical distribution of the first-differenced logarithms of our weekly average HRW wheat futures price fits this description fairly well (see figure A8).

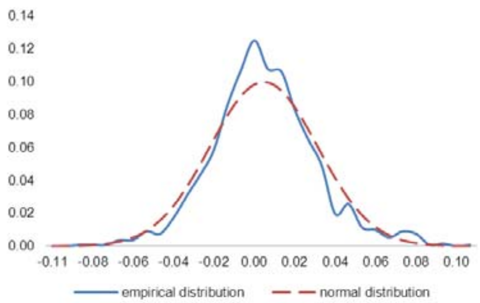
Table A2 – *Augmented Dickey-Fuller test for a unit root (series in Δln)*

Null Hypothesis: DLOG(FUTURES) has a unit root
Exogenous: None
Lag Length: 0 (Automatic based on SIC, MAXLAG = 25)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		**-37.54431**	**0.0000**
Test critical values:	1% level	-2.566031	
	5% level	-1.940970	
	10% level	-1.616601	

*MacKinnon (1996) one-sided p-values.

Figure A8 – *Empirical distribution of the logarithmic changes of the weekly weighted average HRW wheat futures price (sample: January 1986 – April 2011)*



Observations	1,328
Mean	0.0008
Median	-0.0026
Max.	0.13
Min.	-0.12
Std. Dev.	0.028
Skewness	0.31
Kurtosis	4.71

The autocorrelation function (ACF) and the partial autocorrelation function (PACF) of the series and the corresponding Ljung-Box Q–Statistics confirm the presence of serial correlation. The structure of the autocorrelation is not clear-cut, but overall it is suggestive of an AR(1) model: the PACF presents an isolated peak on the first lag, even if the ACF function declines quite sharply after the first lag, instead of decreasing gradually as we would expect in the case of an AR(1) structure. However, the AR(1) seems to fit the time-series better than any other model, with a highly significant first-order autoregressive coefficient, and with no serial correlation left in the residuals. Furthermore, the AR(1) model is selected by the Bayesian Information Criterion (BIC).

The ACF and PACF of the squared residuals of the AR(1) equation suggest that the series presents conditional heteroskedasticity (see table A4). This is confirmed by a McLeod-Li (1983) test using a lag length of four quarters: the value of the F-statistic is 36.6 and the coefficients of the first three lags are highly significant, thus the null hypothesis of no conditional heteroskedasticity is rejected at any conventional level.

Using the AR(1) model for the mean and an ARCH(1) model for the conditional variance we still find significant serial correlation in the squared standardized residuals, so ARCH(1) specification is not sufficient to capture all of the dynamics of the conditional variance. A GARCH(1,1) would seem to be more appropriate, since both the coefficients of the Arch and Garch terms in the variance equation are highly significant, and there is no serial correlation left in the standardized squared residuals.

Table A3 – *ACF, PACF and Q-Statistics for the logarithmic changes of the weekly weighted average HRW wheat futures price (sample: January 1986 – April 2011)*

Included observations: 1328

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.182	0.182	44.057	0.000
		2	0.051	0.019	47.540	0.000
		3	0.009	-0.003	47.657	0.000
		4	0.039	0.038	49.637	0.000
		5	-0.008	-0.022	49.726	0.000
		6	-0.000	0.003	49.726	0.000
		7	0.037	0.040	51.582	0.000
		8	0.012	-0.003	51.772	0.000
		9	-0.042	-0.046	54.095	0.000
		10	0.011	0.028	54.263	0.000
		11	-0.023	-0.031	54.969	0.000
		12	0.010	0.019	55.106	0.000
		13	0.060	0.063	59.872	0.000
		14	0.017	-0.011	60.266	0.000
		15	-0.031	-0.036	61.523	0.000

Table A4 – *ACF, PACF and Q-Statistics for the squared residuals of the AR(1) model (sample: January 1986 – April 2011)*

Included observations: 1327
Q-statistic probabilities adjusted for 1 ARMA term(s)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.206	0.206	56.592	
		2	0.199	0.164	109.54	0.000
		3	0.237	0.181	184.32	0.000
		4	0.091	-0.008	195.30	0.000
		5	0.136	0.063	220.07	0.000
		6	0.123	0.046	240.24	0.000
		7	0.101	0.040	253.81	0.000
		8	0.122	0.049	273.63	0.000
		9	0.116	0.047	291.74	0.000
		10	0.056	-0.023	295.91	0.000
		11	0.090	0.027	306.87	0.000
		12	0.056	-0.006	311.10	0.000
		13	0.094	0.057	323.09	0.000
		14	0.074	0.009	330.43	0.000
		15	0.086	0.038	340.44	0.000

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