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Which factors drive which volatility in the grain sector?

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Abstract

The present paper attempts to find empirical evidence on volatility in the grain sector (wheat, corn and soybean). The first challenge is to measure volatility. Intra-year volatility, inter-year volatility in level and return, also conditional volatility are defined and then calculated. The second challenge is to determine which factors impact volatility. The results show that depending on how volatility is measured, factors driving volatility are very different regarding their quantitative importance. Low stock to use ratio drives up mostly intra-year volatility but only moderately inter-year volatility and has almost no impact on conditional volatility. In contrast, a well functioning international market (trade flows without restriction) lowers considerable conditional volatility but has almost no effect on intra-year volatility.

Keywords: volatility, agricultural commodities

JEL classification: Enter JEL codes. C26, C32, Q11

1. INTRODUCTION

Currently, the literature on agricultural price volatility debates on possible causes driving it. Unfortunately there is no consensus. The observation shows a strong commonality among agricultural commodities (including non-agricultural commodities) especially in periods of large peaks 1973/74 and 2006/08. Based on this observation, Gilbert (2010) analyses, by means of Granger causality tests, the impact of global common factors like exchange rate, investment in future markets, monetary expansion and world economic activity on volatility. In contrast, other authors stress the importance of market specific shocks (e.g. weather shocks, bio-fuel mandate) and so the low stock as theorized by the storage theory (William and Wright, 1991). In his empirical analyzes, Wright (2011) suggests that the bio-fuel mandate over the last years lowered dangerously the stock which in turn were not able to act as buffer against the yield shocks (droughts in Australia, fire break out in Russia). Furthermore, Heady and Fan (2008) argue that government trade policies (export bans, taxes to export etc.) exacerbated the volatility in the international grain market.

Another controversial influence debate is the importance of the derivative market on the spot grain price. Gheit (2008) and Frenk (2008) argue that since the Commodity Futures Modernization Act[1] `speculative money' is flowing into the commodity derivatives which in turn drive upward and downward the commodity price on the spot market far beyond its

1. [1] The Commodity Futures Modernization Act of 2000 clarifies the regulatory and supervisory roles between the CFTC (Commodity Futures Trading Commission) and the SEC (Securities Exchange Commission). It specifies the OTC derivatives transactions outside of the jurisdiction of the CFTC. The Act also allows under certain conditions the trading of futures contracts based on single stocks and narrowly–based stock indices. It also limits the the scope of the CEA on e.g. swap agreements (including credit and equity swaps), hybrid instruments and other products commonly offered by banks.

fundamental values. According to them a new class of investors, the index funds essentially in order to diversify their portfolio entered the commodity derivative market, and their strong long positions inflated the spot prices. This view is however not supported by Sanders and Irwin (2010) and Irwin and al. (2009) who are unable to prove empirically that the derivative market impinges on the spot price. In contrast, they argue that the argument of a `speculators' moving the spot is empirically and theoretically flawed.

This paper tries to shed light on the controversy by proposing numerous measures of volatility. Indeed, depending on how volatility is measured, the drivers may be different. As a result, the purpose of this study is twofold: (1) to define and calculate volatility of the *price level* and of the *return*, (2) to find empirical evidence on the quantitative importance of the factors explaining the different volatilities.

The remainder of the paper is organized as follows: Section 2 proposes a univariate analysis of the prices of wheat, corn and soybean. Section 3 defines different measure of volatility. Section 4 introduces the proxies and specifies the model. Section 5 explains the factors driving the different volatilities. Section 6 concludes.

2. UNIVARIATE ANALYSIS OF THE GRAIN PRICES

Regarding the monthly commodity prices, some remarks are important. First, price-series are not deflated because as shown by Wang and Tomek (2007) deflating alters the features of the price-series and more importantly the subject of the research is the volatility of the nominal price level. The source and sample size of the dataset (monthly as well as annual) are summarized in Table 1. Second, as shown by Labys (2006), the 1973 and the year 1978 are two break points in the price data of grains. Thus, starting from 1978 avoids the structural breaks of the 70's, which is convenient as most of unit root test allow only one structural break. Moreover, in section 4 where is investigated which factors affect the volatilities, the annual data only starts in 1980 (especially the financial ones). Third, monthly frequency is chosen as it is the most convenient frequency to deal with seasonality inherent to agricultural commodities.

Table 1: source of monthly grain price data

Category	unit	sample	obs.	freq.	mean	SD[a]	Source
wheat #2 soft red	US cts/bushel	1978m1-2011m3	399	month[b]	367.86	116.60	CBOT/CME[c]
corn #2 yellow	US cts/bushel	1978m1-2011m3	399	month	262.11	85.68	CBOT/CME
soybean #1 yellow	US cts/bushel	1978m1-2011m3	399	month	629.90	132.21	CBOT/CME

[a] Standard Deviation
[b] Average of daily prices
[c] Chicago Board of Trade/Chicago Mercantile Exchange (spot price of Central Illinois)

The stationarity property of the monthly nominal price-series (in level and without log) of wheat, corn and soybean are investigated. The strategy adopted to distinguish between TS (Trend Stationary) and DS (Difference Stationary) process is the one described for instance in Bourbonnais and Terraza (2010). The ADF (Augmented Dickey and Fuller, 1981) and the PP (Phillips and Perron, 1988) unit root tests are performed firstly with a deterministic time trend and a constant in the specification. As reported in Table 2 for wheat, Table 3 for corn and Table 4 for soybean the deterministic time trend were never significant at 5% level. Regarding soybean, the deterministic time trend is significant at 10% level (albeit only in the ADF test). Consequently, the unit root tests are also performed without deterministic time trend and solely with a constant (second half of the respective Tables). The power of unit root tests diminish as deterministic terms are added to the test regressions; so if the time trend is not significant, it is better to omit it. According to both tests (ADF and PP), the null hypothesis of unit root cannot be rejected for any commodities. Although the PP test deals with the serial correlation issue and is robust with respect to unspecified autocorrelation and heteroscedasticity in the disturbance process, it renders the same results as the ADF test. The ADF and PP tests have very low power against I(0) alternatives for series which are close to be I(1). For maximum power against very persistent alternatives the ERS test (Elliott, Rothenberg, Stock, 1996) is more robust than the ADF and PP tests. Moreover, ERS test allows errors to be ARMA. However, the ERS test does not change the conclusions of the ADF and PP test for two reasons: First the time span (33 years) is relatively long and the series might be characterized by structural breaks. Second, commodity prices are closer to a GARCH process than an ARMA process as highlighted by Williams and Wright (1991). Due to storage, agricultural commodity prices display autocorrelation due to storage and the variance might not be constant over time.

The next step consists of performing unit root tests which are robust to structural breaks and allow non-stationary variance like the CHLT (Cavaliere, Harvey, Leybourne, and Taylor, 2011). The CHLT test extends the original Harris et. al (2009) test by assuming time varying variance. This unit root test uses quasi-difference GLS detrending method, and so avoids the issue whether a deterministic time trend should be included or not. The MSB statistic is lower tailed, i.e. the null hypothesis of unit root is rejected if the test statistic is inferior to the critical values which are constructed by 499 bootstrap replications. The null hypothesis is rejected at 5% for wheat and soybean and also for corn but only at 10%. Consequently we can conclude that cereal price-series are mean reverting with a break in cereal prices after the mid 00's. Finally to make sure that this statement is robust, two unit root tests with structural breaks (but constant variance) are performed: the AZ (Andrews and Zivot, 1992) and the SL (Saikkonen and Lütkepohl, 2004). As shown in Table 2, 3, and 4 the null hypothesis is always rejected and the structural break is always statistically significant.

Furthermore, the raw commodity prices (*pwhe*: wheat, *pcorn*: corn and *psoy*: soybean) are transformed according to the SL estimates. By subtracting from the raw series the coefficient of the shift dummy (0 until the break, and 1 after) new series for wheat: *sweh*, corn: *scorn* and soybean: *ssoy* are derived. More precisely, these transformed series equals the raw series until the break, and then the raw series minus the shift dummy multiplied by the raw series. The ADF, the PP and the ERS were performed on these transformed series and the null hypothesis was strongly rejected. This proves again that by considering a break around the mid 2007, the grain prices are stationary. The results are reported in the bottom part of Table 2, 3 and 4. It is well known that the ADF type tests (ADF, PP, ERS) tend to over-reject the null hypothesis as it confuses the structural break as evidence of nonstationarity, this explains why the raw series are found non-stationary whereas the transformed series are found to be stationary. To conclude, according to the unit root tests, all three commodity price-series from 1978 to 2011 are mean-reverting with one structural around 2007, and even the variance seems bounded and not-infinite.

This empirical result allows reconciling the storage theory (Williams and Wright, 1991). As argued by Wang and Tomek (2007) and Sarris (2000) non-stationary commodity prices would mean that a shock would have a permanent effect on the price dynamic and never die out. Bessembinder et al. (1995) proved that agricultural commodities revert back to production costs because of the supply response. However, some previous empirical studies concluded that grain prices are non-stationary, e.g. Newbold et al. (2000). This study shows that it is impossible to reject the null hypothesis of unit root except if the structural break (and/or non constant variance) is taking into account. This empirical study confirms Hanawa et al. (2000) and Labys (2006) that grain prices are mean reverting. Conclusion: we reconcile the theory Williams and Wright (1991) with empirical tests.

Table 2: WHEAT: unit root tests of monthly raw price (pwhe) and stationarized price (swhe)

Test & statistics		critical values			lag[a]	cst & p-val		trend & p-val		break
		1%	5%	10%						
raw price, *pwhe*										
ADF, $Z(t)$	-2.73	-3.98	-3.42	-3.13	8	12.46	(0.03)	0.02	(0.18)	-
PP, $Z(t)$	-2.98	-3.98	-3.42	-3.13	8	9.51	(0.09)	0.02	(0.22)	-
ERS, τ	-2.82	-3.48	-2.89	-2.57	8	(b)	-	-	-	-
AZ, $Min\, t$	-4.94	-5.57	-5.08	-4.82	3	(c)	-	-	-	2007.04
CHLT, MSB	0.14	0.13	0.16	0.17	8	(d)	-	-	-	2005.11
SL, t	1.37	-3.55	-3.03	-2.76	8	372.01	(0.00)	1.69	(0.99)	2008.04
ADF, $Z(t)$	-2.48	-3.45	-2.87	-2.57	8	14.35	(0.01)	-	-	-
PP, $Z(t)$	-2.74	-3.45	-2.87	-2.57	8	11.41	(0.03)	-	-	-
ERS, μ	-1.63	-2.58	-1.95	-1.62	8	(e)	-	-	-	-
AZ, $Min\, t$	-4.46	-5.43	-4.80	-4.58	3	(f)	-	-	-	2006.09
SL, t	-3.74	-3.48	-2.88	-2.58	8	380.24	(0.00)	-	-	2006.09
transf. price, *swhe*										
ADF, $Z(t)$	-4.24	-3.45	-2.87	-2.57	7	29.66	(0.00)	-	-	-
PP, $Z(t)$	-4.16	-3.45	-2.87	-2.57	7	24.37	(0.00)	-	-	-
ERS, μ	-3.27	-2.58	-1.95	-1.62	7	(e)	-	-	-	-

[a] number of lags based on $MAIC$ lag selection rule of Ng-Perron (2001) and modifications of Perron-Qu (2007).
[b] DF-GLS detrending with *trend* and *constant* (Eliott-Rothemberg-Watson, 1996).
[c] breaks allowed in *trend* and *intercept*; trim 5% (Andrews-Zivot, 1992).
[d] DF-GLS detrending with *trend* and *constant* (Cavaliere-Harvey-Leybourne-Taylor, 2011).
[e] DF-GLS detrending only with *constant* (Eliott-Rothemberg-Watson, 1996).
[f] break allowed only in *intercept*; trim 5% (Andrews-Zivot, 1992).

Table 3: CORN: unit root tests of monthly raw price (pcorn) and stationarized price (scorn)

Test & statistics		critical values 1%	5%	10%	lag[a]	cst & p-val		trend & p-val		break
raw price, *pcorn*										
ADF, $Z(t)$	-1.66	-3.98	-3.42	-3.13	15	4.69	(0.26)	0.01	(0.11)	-
PP, $Z(t)$	-1.58	-3.98	-3.42	-3.13	15	0.48	(0.89)	0.01	(0.13)	-
ERS, τ	-2.07	-3.48	-2.89	-2.57	15	(b)	-	-	-	-
AZ, $Min\,t$	-5.03	-5.57	-5.08	-4.82	4	(c)	-	-	-	2006.09
CHLT, MSB	0.17	0.13	0.16	0.17	15	(d)	-	-	-	2005.10
SL, t	-1.41	-3.55	-3.03	-2.76	15	120.77	(0.00)	1.44	(0.99)	2008.10
ADF, $Z(t)$	-1.51	-3.45	-2.87	-2.57	15	6.88	(0.09)	-	-	-
PP, $Z(t)$	-1.17	-3.45	-2.87	-2.57	15	1.85	(0.53)	-	-	-
ERS, μ	-0.46	-2.58	-1.95	-1.62	15	(e)	-	-	-	-
AZ, $Min\,t$	-4.78	-5.43	-4.80	-4.58	4	(f)	-	-	-	2006.09
SL, t	-3.77	-3.48	-2.88	-2.58	15	91.69	(0.00)	-	-	2006.09
transf. price, *scorn*										
ADF, $Z(t)$	-3.43	-3.45	-2.87	-2.57	14	19.23	(0.00)	-	-	-
PP, $Z(t)$	-3.29	-3.45	-2.87	-2.57	14	10.56	(0.01)	-	-	-
ERS, μ	-2.19	-2.58	-1.95	-1.62	14	(e)	-	-	-	-

[a] number of lags based on *MAIC* lag selection rule of Ng-Perron (2001) and modifications of Perron-Qu (2007).
[b] DF-GLS detrending with *trend* and *constant* (Eliott-Rothemberg-Watson, 1996).
[c] breaks allowed in *trend* and *intercept*; trim 5% (Andrews-Zivot, 1992).
[d] DF-GLS detrending with *trend* and *constant* (Cavaliere-Harvey-Leybourne-Taylor, 2011).
[e] DF-GLS detrending only with *constant* (Eliott-Rothemberg-Watson, 1996).
[f] break allowed only in *intercept*; trim 5% (Andrews-Zivot, 1992).

Table 4: SOYBEAN: unit root tests of monthly raw price (psoy) and stationarized price (ssoy)

Test & statistics		critical values 1%	5%	10%	lag[a]	cst & p-val		trend & p-val		break
raw price, *psoy*										
ADF, $Z(t)$	-2.05	-3.98	-3.42	-3.13	11	13.90	(0.14)	0.04	(0.08)	-
PP, $Z(t)$	-2.16	-3.98	-3.42	-3.13	11	9.29	(0.28)	0.04	(0.13)	-
ERS, τ	-2.28	-3.48	-2.89	-2.57	11	(b)	-	-	-	-
AZ, $Min\,t$	-5.16	-5.57	-5.08	-4.82	3	(c)	-	-	-	2007m5
CHLT, MSB	0.12	0.13	0.16	0.17	11	(d)	-	-	-	2006m2
SL, t	-2.10	-3.55	-3.03	-2.76	11	409.97	(0.00)	1.20	(0.99)	1988.06
ADF, $Z(t)$	-1.35	-3.45	-2.87	-2.57	11	14.76	(0.07)	-	-	-
PP, $Z(t)$	-1.58	-3.45	-2.87	-2.57	11	11.41	(0.15)	-	-	-
ERS, μ	-1.18	-2.58	-1.95	-1.62	11	(e)	-	-	-	-
AZ, $Min\,t$	-5.19	-5.43	-4.80	-4.58	3	(f)	-	-	-	2007m5
SL, t	-4.10	-3.48	-2.88	-2.58	11	410.32	(0.00)	-	-	2007.03
transf. price, *ssoy*										
ADF, $Z(t)$	-4.48	-3.45	-2.87	-2.57	11	69.95	(0.00)	-	-	-
PP, $Z(t)$	-4.27	-3.45	-2.87	-2.57	11	47.27	(0.00)	-	-	-
ERS, μ	-3.96	-2.58	-1.95	-1.62	11	(e)	-	-	-	-

[a] number of lags based on *MAIC* lag selection rule of Ng-Perron (2001) and modifications of Perron-Qu (2007).
[b] DF-GLS detrending with *trend* and *constant* (Eliott-Rothemberg-Watson, 1996).
[c] breaks allowed in *trend* and *intercept*; trim 5% (Andrews-Zivot, 1992).
[d] DF-GLS detrending with *trend* and *constant* (Cavaliere-Harvey-Leybourne-Taylor, 2011).
[e] DF-GLS detrending only with *constant* (Eliott-Rothemberg-Watson, 1996).
[f] break allowed only in *intercept*; trim 5% (Andrews-Zivot, 1992).

3. HOW TO MEASURE VOLATILITY?

Volatility refers to the dispersion of price around a deterministic component (constant, trend, seasonality). The majority of the empirical literature on commodity price volatility analyzes the *return* of price (see Piot-Lepetit and M'Barek (2011) for a review) for two reasons.

First, it is a convenient way to avoid the trend issue (determinisitc and/or stochastic). Indeed the log differentiation cancels out any trend. Second, it replicates the asset return widely used in finance. Investors are interested in the *return* of the asset and its associated risk (measured by volatility). In contrast, farmers and consumers are directly hit by the volatility of the price *level*. Typically the producer struggles with the question what is the "good price" ensuring positive revenue and the risk (volatility) associated to the predicted price level. Moment) of an asset and the risk associated to the asset (second moment).

3.1. Volatility of the price level

Annual commodity price volatility over one year with monthly data is defined as the coefficient of variation (*CV*) of the price level, more precisely:

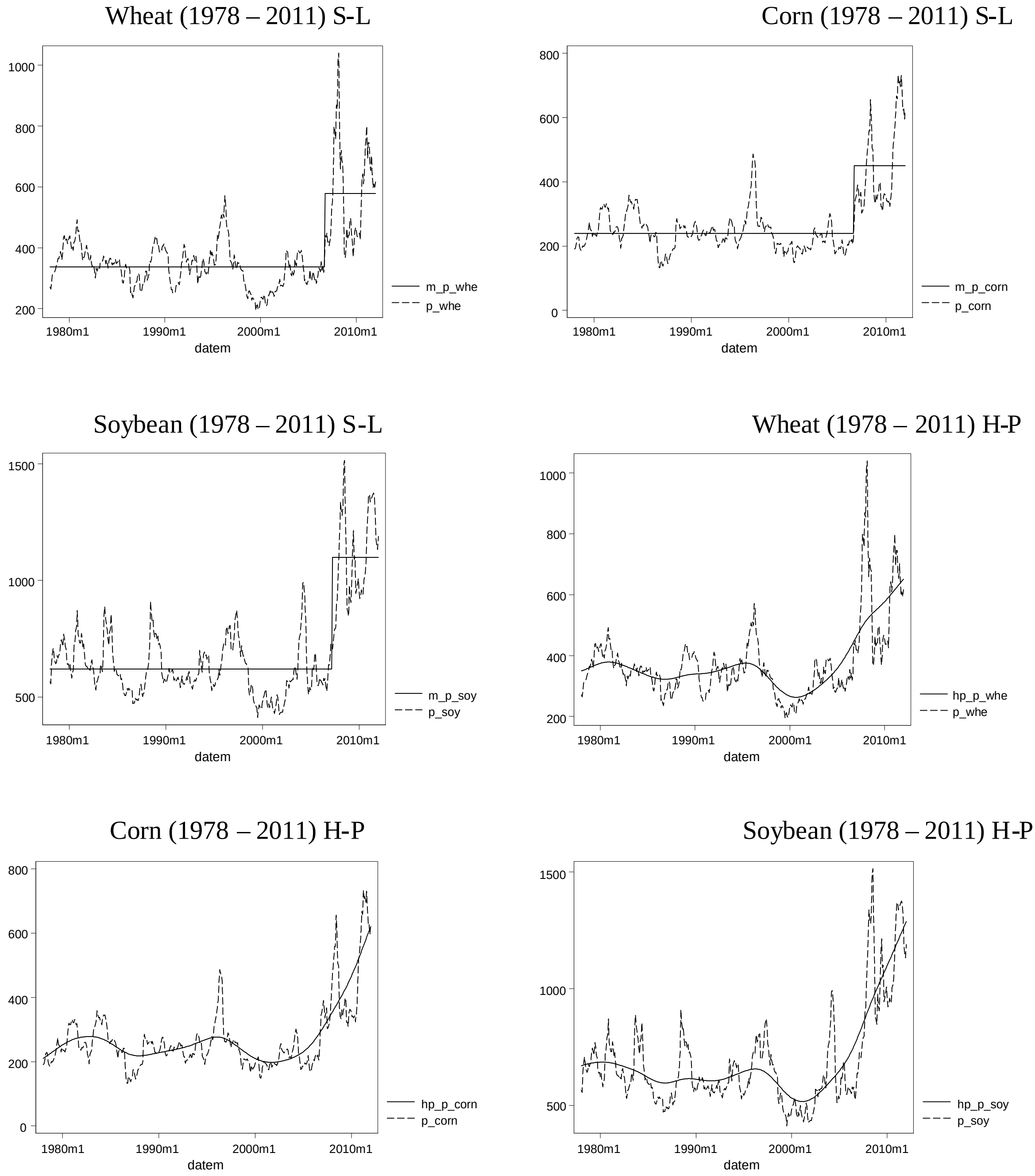
$$CV = \frac{\sqrt{\sum_{i=1}^{12}(P_i - K)^2 / 12}}{\overline{P}} \quad (1),$$

and P (Capital) is the nominal price, i is index of the month, and K the mean. If the mean of the price K is calculated over one year, the CV measures the intra-year volatility, and $\overline{P}$ is the mean over one year.

Annual inter-year volatility is defined as the price dispersion beyond one year. As a result, to calculate the CV as defined in (1), the price level must be mean reverting. A stationary process is necessarily mean reverting. The previous section proved that all three commodity prices in level are mean reverting with no time trend but with a structural break after the mid-2000. Consequently over the entire sample from 1978 to 2011, and using for instance the results of the Saikkonen and Luetkepohl (2004) tests, there are two means, the one for the subsample before the structural break (K1), and the one after which is larger (K2); and $\overline{P}$ is the mean over the entire sample. Thus, inter-year volatility is defined as the price dispersion around the respective means as depicted in Figure 1 (first three graphs).

The *predictable* component of the price should not be accounted for volatility. The question is how much the agents can forecast and anticipate. By calculating the inter-year volatility of the price level, it is supposed that markets participants are able to recognize the mean over the two periods determined by the structural break (k1 and k2). Many economists would argue however that this volatility is still overestimated because agents (farmers and consumers) can recognize the long-term price trend based on passed observations (adaptative expectation). Thus, market participants might be able to estimate the time-varying trend of the price level (but not the deviation around this moving trend). Volatility is thus measured as the price dispersion around the moving trend. Methods to disentangle trend from the irregular components are numerous. The most commonly used technique in applied time series is the Hodrick-Prescott (1997) filter (HP). The lamda was set to 129,6000 as suggested by Ravn-Uhlig (2002). The time moving trend is reported in figure 1 (last three graphs), and so the price dispersion calculated around this time varying trend (K) is called HP inter-year volatility.

Figure 1: Grain prices (US cts/bushel), period of mean reversion following Saikkonen-Luetkepohl (2004) and Hodrick-Prescott trend



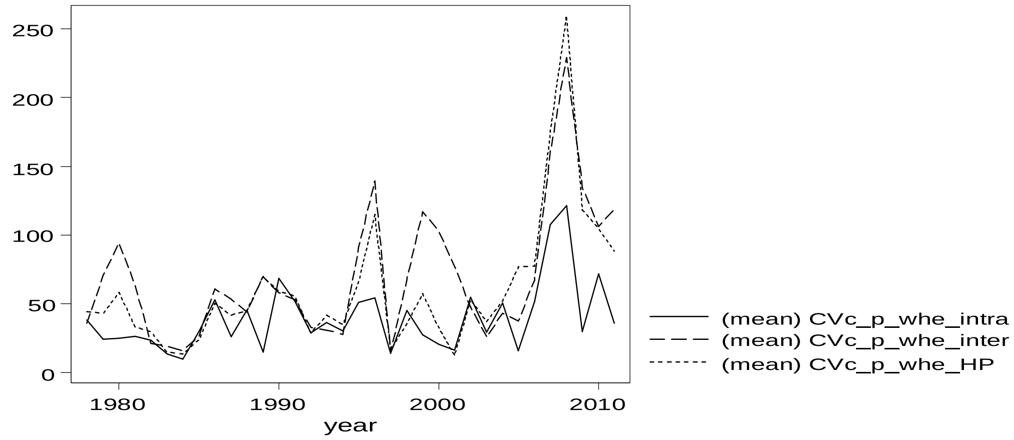
3.2. Volatility of the return

The most straightforward measure of volatility is the standard deviation, and so:

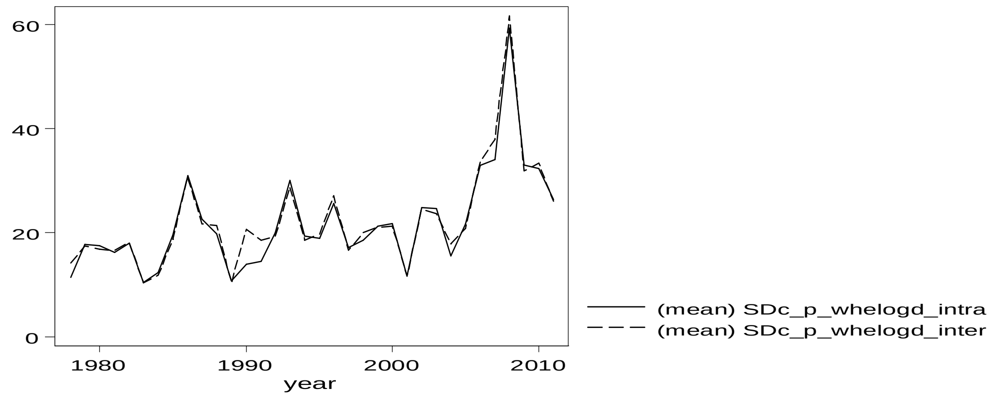
$$SD = \sqrt{\sum_{i=1}^{12} (p_i - k)^2 / 12}\ ,$$

Figure 2: Volatility of wheat

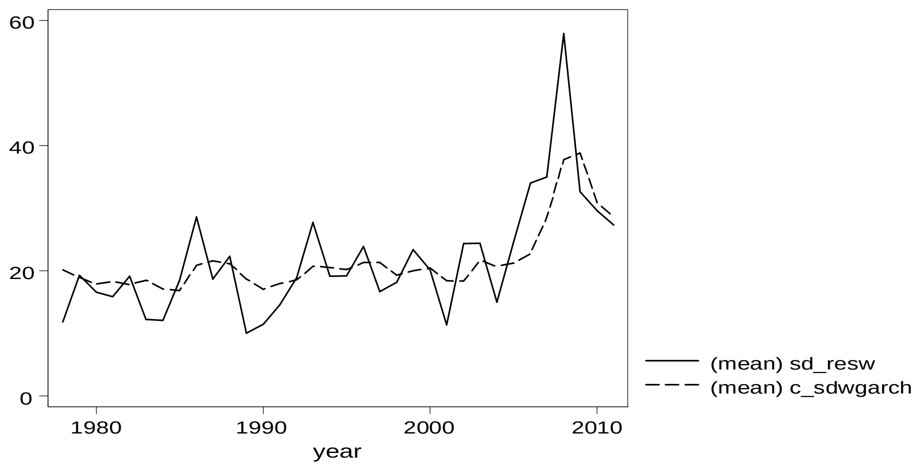
Volatility of the price level (intra, inter and HP)



Volatility of the return (intra and inter)



Volatility of the return (residual of the ARMA andconditional GARCH)



and *p* (small) is the return which equals log(P_t/P_{t-1}). There is almost no difference between the intra year (k the mean over one year) and inter year (k the mean over the entire sample) because the log difference of the grain prices are mean reverting at a very high speed (as proved by the unit root tests which are not reported). This can be seen in Figure 2 (second graph) for wheat, the intra year and inter year volatility of the return are almost alike.

Only the unexpected shocks should account for volatility as already explained. Market participants can be seen as rational agents who are able to produce a relatively sophisticated forecast based on the previous prices but also other information. Kenyon (2001) show that producer price expectations are highly correlated wit futures prices traded on the future market, previous harvest and current cash prices. However, Kenyon (2001) shows that producers substantially underestimate the probability of large price variation. Market participants seems to be semi-rational. By all means, deterministic parts as seasonality cannot be assimilated to volatility. Consequently, an ARMA model is assumed:

$$p_{i,t}(r) = c_1 + \sum_{k=1}^{k} \alpha_k p_{i,t-k} + \sum_{m=1}^{m} \beta_m \epsilon_{i,t-m} + \sum_{n=1}^{12} \delta_n D1_t + \varphi D2_{i,t} + \epsilon_{i,t},$$

With *p* (small) the return, D1 is the seasonal dummy, and the epsilon is the residual of the ARMA specification. To specify the autoregressive and the moving average order of the ARMA model, the Hannan and Rissanen (1982) procedure was used. The standard errors of the residuals of the ARMA model may be used as proxy of volatility. The residuals of the ARMA estimates exhibit strong heteroscedasticity as reported in (Table 5) by the ARCH-LM test (Engle, 1982).

Table 5: ARCH-LM test

lag, d.f.	wheat		corn		soybean	
	χ^2	p-val.	χ^2	p-val.	χ^2	p-val.
1	4.37	0.04	13.41	0.00	0.82	0.37
2	89.82	0.00	20.23	0.00	27.32	0.00
3	100.36	0.00	26.33	0.00	27.83	0.00
4	102.91	0.00	50.94	0.00	31.21	0.00
5	110.98	0.00	52.84	0.00	33.89	0.00
6	112.88	0.00	52.76	0.00	34.76	0.00
7	119.20	0.00	54.47	0.00	34.76	0.00
8	125.90	0.00	56.81	0.00	36.31	0.00
9	131.72	0.00	64.43	0.00	36.26	0.00
10	133.82	0.00	64.71	0.00	37.06	0.00
11	137.64	0.00	72.71	0.00	48.75	0.00
12	140.69	0.00	74.67	0.00	49.10	0.00
13	141.69	0.00	74.64	0.00	50.32	0.00
14	141.51	0.00	74.45	0.00	50.73	0.00
15	141.11	0.00	74.34	0.00	52.70	0.00
16	141.17	0.00	76.05	0.00	53.96	0.00
17	147.69	0.00	77.52	0.00	54.63	0.00
18	149.51	0.00	77.71	0.00	55.13	0.00
19	149.91	0.00	77.75	0.00	54.63	0.00
20	150.41	0.00	77.66	0.00	55.13	0.00

Since there are ARCH elements in the residuals, a GARCH type (Bollerslev, 1986) of modelling is more appropriate to measure the *conditional* volatility of the return. Gilbert and Morgan, 2010 among many others used this type of models to measure agricultural commodity price volatility. All the volatilities are reported in Figure 2 (only for wheat due to limited space)

4. MODEL SPECIFICATON AND DATA

4.1. Model specification

First, to assess the quantitative importance of the factors the different volatilities in the grain sector, the annual frequency is chosen. Thus, the explained variable-series σ are the different volatilities for consecutive, non-overlapping, one year periods from 1980 to 2011. No rolling window is applied to avoid serial correlation by construction. The conditional volatility (GARCH) is the average over the year. Finally, the model is a panel fixed effect estimator in its most heterogeneous form, i.e. commodity specific coefficients with fixed effect. Thus, the following model is investigated:

– $$\sigma_{i,t} = \Phi_i X_{i,t} + \Gamma Y_t + \beta_i t + \eta_i + \varepsilon_{i,t}$$

The matrix X contains the commodity specific market factors whereas the matrix Y contains all common macro-factors. The endogeneous variables are instrumented

4.2. Data and proxies

Stock to use ratio

The storage theory explains price volatility as the interaction between the consumption market and the storage market, as highlighted in the seminal book of Williams and Wright (1991) and empirically by (Peterson and Tomek, 2005). The stock to use ratio stems for USDA (Source) world ending stocks.

Internationalization and market structure

Two proxies are constructed: the *export shares* and the *Herfindahl index*. The former equals the volume of world exports divided by the world production; this proxy identifies the long-term trend but also short-term political measures like export bans. The latter measures the degree of concentration of exporting countries for a given commodity. The Herfindahl index consists of sum of the square of the share of each exporting countries relative to the world total volume.

Agricultural policy and political instability index

New agricultural market regulations and policy decisions impacting commodity markets must be considered. In the USA, the FAIR Act[2] has removed public interventions by eliminating the safety net which granted income support payments and target prices. Since 1996, market conditions prevail in the allocation, storage level and trade decisions. Consequently a dummy variable equaling 0 until 1995 and then 1 has been constructed. The USA produces all

2. [2] The Federal Agriculture Improvement and Reform (FAIR) Act of 1996 significantly changed U.S. agricultural policy. It removed the link between income support payments and farm prices by providing for seven annual fixed but declining `production flexibility contract payments' whereby participating producers may receive government payments largely independent of farm prices, in contrast to the past when deficiency payments were dependent on farm prices.

commodities considered in this study except coffee, and so the FAIR Act cannot have impacted coffee.

Financial market variables

For many years, the political sphere and interest groups have claimed that `speculators' and future trading drive up the spot price. Currently the US congress and Senate, and in particular the Permanent Subcommittee on Investigations on the CBOT wheat futures contract blames the derivative market for destabilizing the physical market. The traditional measure of speculative activity is the *speculative T index*, SI, where *open interest* held by speculators (non-commercials) and hedgers (commercials) is defined in Working (1960) as follows:

SI =1+SS/(HL+HS) if HS>HL,
or SI =1+SL/(HL+HS) if HL>HS,

and SL means speculation short, SS speculation short, HL hedger long, and HS hedger short. This index was calculated on a daily basis.

Another measure is the *scalping index* which is the ratio open interest to trading volume expressed in percentage points. The scalping index shows the liquidity of the derivative market. It also reflects the small profits realized by speculators by opening and closing contract positions within a very short period of time. The daily scalping index was calculated. To conclude, the proxies for the `traditional' speculator are: working index and scalping index.

Common macro-factors

Commodity and energy are linked through three channels. Firstly, energy price enters the cost of production through input use (e.g. nitrogen fertilizer) and transport costs. Also, some commodities have been used to produce bio-fuels since the launch of bio-ethanol (US) and bio-diesel (EU) programs. The proxy used is the crude oil price.

The *exchange rate* movements might also play an important role in explaining commodity price volatility due to trade distortion effects as highlighted by Bahmani-Oskooee and Kovyryalova (2008). International trade is essentially denominated in US dollars.

The *business cycle* and the overall growth of the economy might be of major importance (GDP, industrial production index). Also the *money* indicators might play a role. For instance, the interest rate represents the opportunity costs of holding commodities either as storage costs or as portfolio assets. High interest rates lead to high storage costs and so demand for primary commodities will fall as explained by Deaton and Laroque (1992). Furthermore, the interest rate is also a monetary policy stance indicator, which is blamed by Calvo (2008) for fuelling commodity price increases.

5. EMPIRICAL RESULTS

The empirical results are reported in Table (5) and the wheat case is depicted in Figure 6. The scalping index and the speculative index have been lumped together, as well as the business cycle (industrial production, GDP), the monetary stance indicator (interest rate, m2 growth rate), and also the exchange rate volatility and crude oil price volatility.

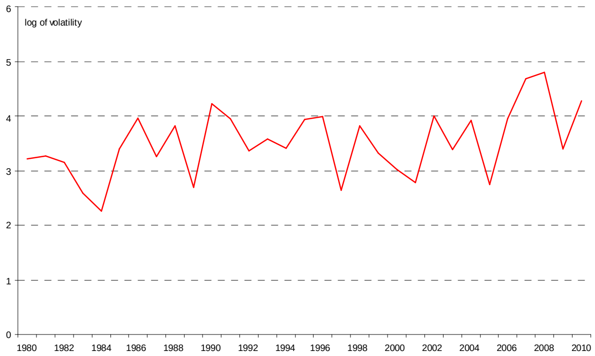
Table 5: Coefficient estimates of intra-year volatility of the price level (1) and the conditional volatility based on GARCH (2)

	wheat		corn		soybean	
	(1)[a]	(2)[b]	(1)	(2)	(1)	(2)
stock to use ratio[e]	-1.11 (0.01)	-0.05[c]	-0.70 (0.00)	-	-0.53 (0.06)	-
world export share[e]	-0.12 (0.00)	-1.45	-0.15 (0.02)	-0.51 (0.11)	0.1 (0.00)	-
Herfindahl index[e]	0.25 (0.00)	0.98 (0.00)	0.12 (0.14)	-0.21	0.05	-1.63 (0.05)
speculative index[e]	-0.12 (0.00	-0.24 (0.00	-0.22 (0.00	-0.21 (0.04)	/	-1.17 (0.15)
scalping index[e]	-0.2	- (0.00)	/	-	/	-
dummy FAIR	1.02 (0.00)	-	-0.68 (0.00)	-	0.45 (0.13)	-0.89 (0.01)
			(0.02)	(0.00)		
crude oil volatility[e]	-	0.49 (0.04)	-	0.59 (0.13)	-	-
exchange rate volatility[e]	0.45 (0.00)	0.11 (0.01)	-	-0.41 (0.00)	0.12 (0.00)	-0.55 (0.09)
industrial production[g]	-	-	-	-	-	-
world demand: GDP[f]	0.03 (0.01)	-	-	0.01 (0.13)	-	-
US stock of money M2[f]	-0.09 (0.00)	-	0.15 (0.01)	0.03 (0.01)	-0.05 (0.01)	0.11 (0.05)
nominal interest rate[a]	-0.07 (0.00)	-0.07 (0.00)	-	-	-0.06 (0.06)	-0.13 (0.05)
CPI[c]	-0.07 (0.02)	-	-	-	-	0.19 (0.00)
Fixed Effect	6.98 (0.07)	-	2.80 (0.00)	17.28 (0.02)	4.43 (0.00)	16.19 (0.00)
Uncentered R^2	0.78	0.58	0.47	0.88	0.52	0.69
Centered R^2	0.54	0.42	0.27	0.42	0.39	0.45
Root MSE	0.	0.21	0.29	0.21	0.44	0.33
p-value of F test	0.00	0.00	0.00	0.00	0.00	0.00
Observations	32	32	32	32	32	32

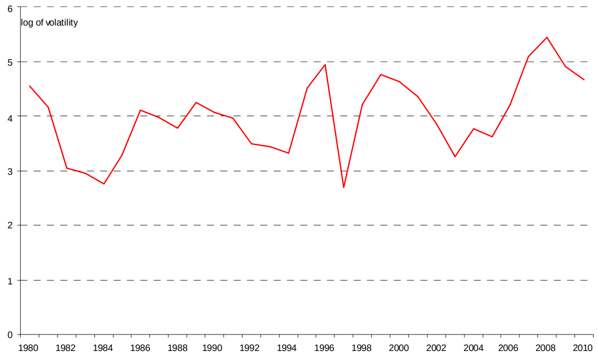
Figure 6: WHEAT: factors explaining the volatility of price level

- stock to use ratio
- agricultural policy and political instability
- volatility of petrol and exchange rate
- economic activity and inflation
- market structure and internationalization
- speculation
- monetary policy stance

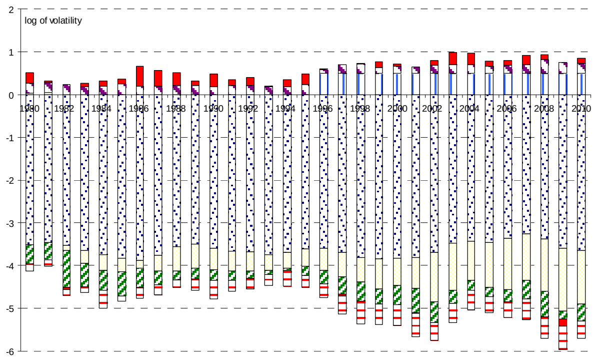
intra year volatility of price level



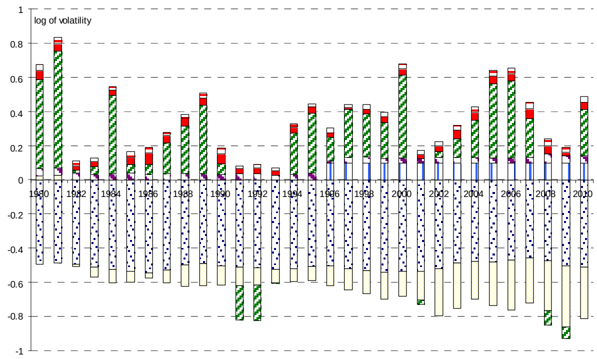
inter year volatility of price level



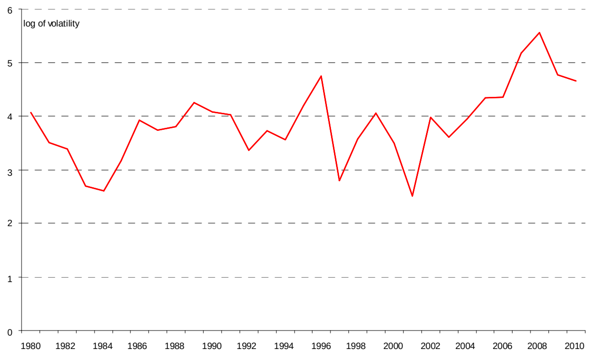
explanatory factors intra year volatility



explanatory factors inter year volatility



HP inter year volatility of price level



explanatory factors HP inter year volatility

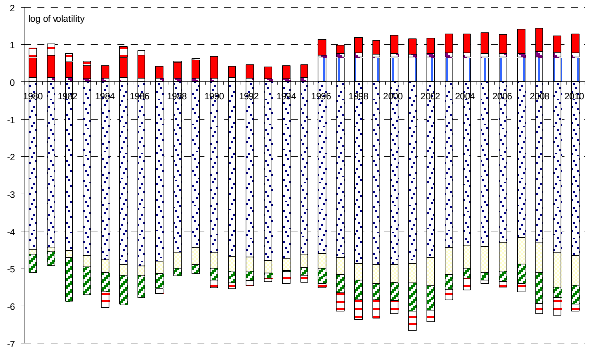
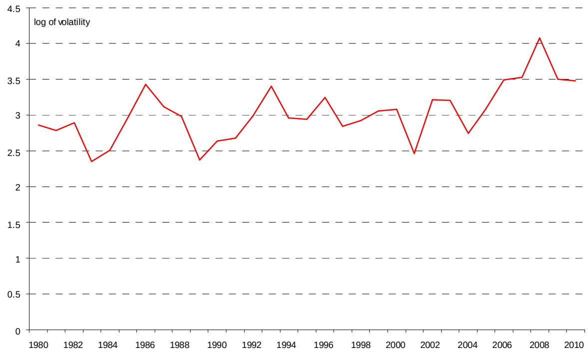


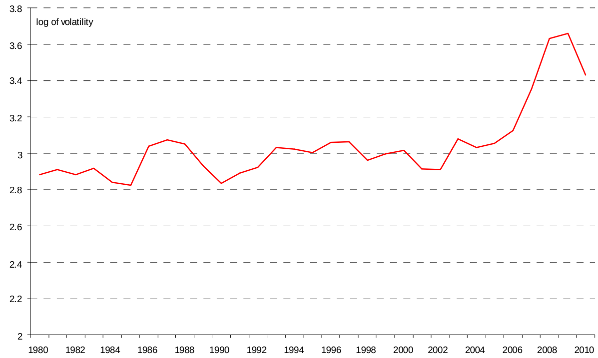
Figure 7: WHEAT: factors explaining the volatility of return

- stock to use ratio
- agricultural policy and political instability
- volatility of petrol and exchange rate
- economic activity and inflation
- market structure and internationalization
- speculation
- monetary policy stance

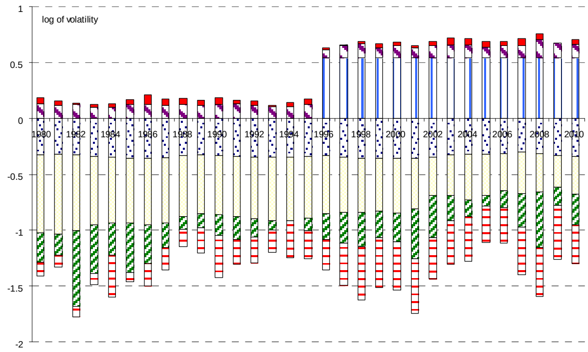
intra year volatility of return



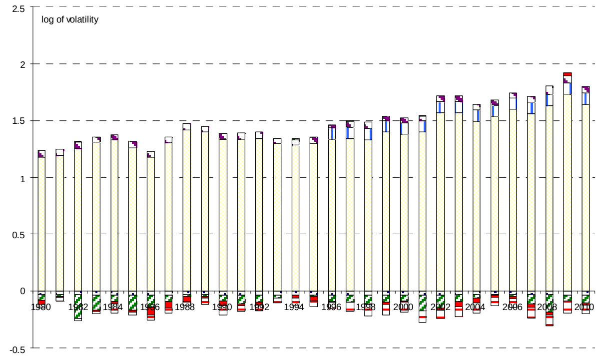
conditional volatility GARCH



explanatory factors intra year volatility of return



explanatory factors conditional volatility GARCH



6. CONCLUDING REMARKS

This study analyzes the characteristics of the grain prices (wheat, corn and soybean), and shows that they are mean reverting but only by period. The unit root tests with structural breaks prove that all grain prices experienced a new period of higher prices which starts around 2007. Furthermore, the different methods to calculate volatility are reviewed, volatility in price level (intra, inter and smoothed trend) but also volatility of the return (intra, inter and conditional volatility). The last 5 years, volatility increased especially for inter-year volatility of the price level but also the volatility of the return and especially the conditional volatility but to a lesser extent intra-year volatility of the price level.

This study also shows that very factors driving volatility depends crucially on the type of volatility. Low stock to use ratio is the most important driver of intra-year volatility of the price level, and macro-factors like exchange rate, petrol, business cycle play a minor role. In contrast, conditional volatility of the return is not driven by the state of the stock to use ratio. The degree of competition and the importance of the international trade volumes are the essential drivers.. Deep international market lowers significantly the inter-year volatility, and so exports bans or other elements reducing the internal trade volume drive it significantly up. Finally, the inter-year volatility of the price level is between the two previous cases. The level of stock plays a moderate role and the long-term market structure (internationalization, free trade) play a relatively more important role. Macro factors seems relatively more important, especially loose monetary policy, but also volatility of the crude oil and the exchange rate.

Finally, speculation activity in the very short term or over a longer time span rather diminishes price volatility. Indeed, the derivative market dampens volatility of the intra-year volatility in level but also the conditional volatility.

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