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Commodity futures markets: are they an effective price risk management tool for the European wheat supply chain?

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Abstract. The instability of commodity prices and the hypothesis that speculative behaviour was one of its causes has brought renewed interest in futures markets. The paper analyses the European wheat futures markets (feed and milling) and the Chicago Board of Trade's wheat contract as a comparison. Although the main purpose of the paper is to analyse whether futures markets are still useful for hedging (considering the demands from different market participants), implicitly this can be seen as testing whether the increasing presence of speculation has made futures markets divorced from physical markets. The results indicate that hedging with futures markets is still a viable alternative for dealing with price risk. This is particularly true in short period hedges (e.g. merchants and processors), where the basis seems to have been affected by the observed price instability.

Keywords. Futures markets, wheat, hedging, commodity prices, price risk.

JEL Codes. G13, Q14, G01

1. Introduction

The relatively recent instability of commodity prices has brought back the interest on futures markets and their use for hedging as a device to reduce vulnerability to risk. As pointed out by Lence (2009), vulnerability to risks is amongst the most important problems faced by commodity producers in developing and developed countries. Furthermore, this renewed interest has extended use of futures and options contracts to the area of food security, as they have been proposed as a way in which importing countries could manage price volatility (Sarris *et al.*, 2011).

As it is well known futures markets perform several functions: they provide the instruments to transfer price risk, they facilitate price discovery and they are offering commodities as an asset class for financial investors, such as fund and money managers who had not previously been present in these markets.

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Commercial participants use futures contracts to hedge their crops or inventories against the risk of fluctuating prices, e.g., processors of agricultural commodities, who need to obtain raw materials, would buy futures contracts to guard against future price rises. If prices rise (i.e., both cash and futures prices), then they use the increased value of the futures contract to offset the higher cost of the physical quantities they need to purchase. However, hedgers are not the only agents operating in futures markets, as one can also find non-commercial participants, who do not have any involvement in the physical commodity trade in contrast to commercial participants, such as farmers, traders and processors. These are called "speculators" and they buy and sell futures contracts in order to obtain a profit. It's a matter of fact the massive increase in trading in commodity derivatives over the past decade; commodity derivatives include futures and options traded on organised Exchanges as well as the forwards and the options traded over the counter. Trading in commodity derivatives also increased along with the rapid expansion of the presence of the commodity index traders (United Nations, 2011).

This paper focuses on the usefulness of futures prices for hedging against price risk, paying particular attention to the hedging performance in recent years. In addition, the work can be considered as an indirect test of whether the increasing presence of speculation in futures markets has made them divorced from the physical markets, and therefore, not useful for price hedging. The reason behind this is because from all the reasons mentioned behind the increasing volatility in commodity prices (e.g., increasing demand for biofuels, draughts, China's increasing demand for food), speculation, as applied by index funds, seems to be the only one that might imply a divorce between futures and physical markets, all the other reasons can be considered as movements on the fundamentals within the commodity markets.

The paper is structured as follows: first, we provide a brief overview of the discussion of how events in futures markets are affecting commodity price volatility. This is followed by the empirical part of the paper where the data and the methods are explained. The next section presents the results of the different tests and the last section offers some conclusions.

2. Evidence on volatility and speculation

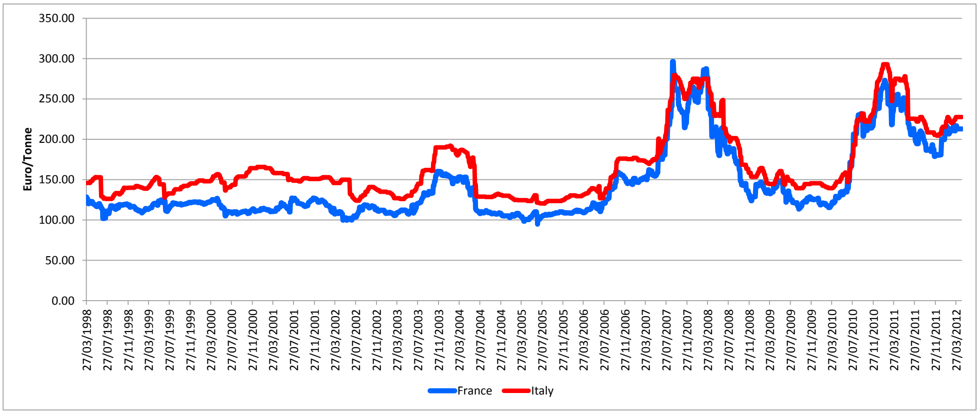
The purpose of this section is to briefly review evidence on both the rise in volatility in commodity prices, focusing on the wheat market, and the effects of speculation on futures markets.

2.1 Volatility in wheat prices

Most of the studies on the behaviour of commodity prices in recent years assert that food price volatility has increased. In fact, Figures 1 to 3, which present the evolution of wheat spot prices in three EU countries (France, Italy and UK) during a 25 years interval and in Chicago, show increasing dispersion in commodity prices since 2007.

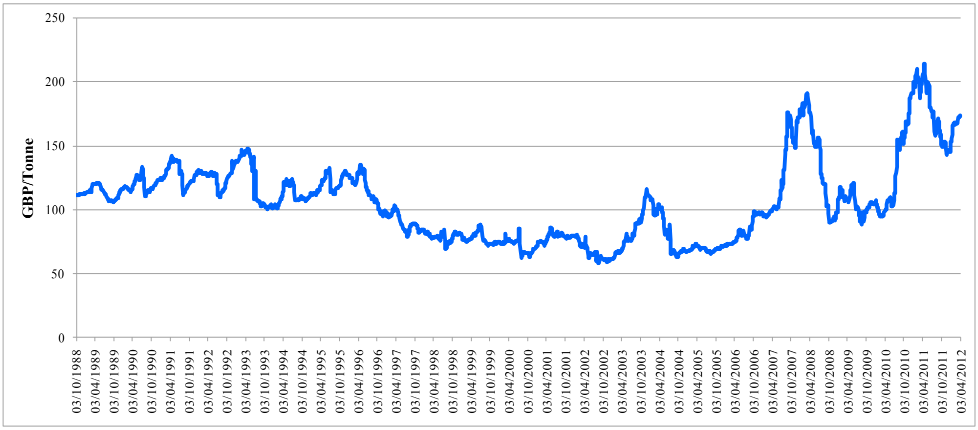
To quantify the increasing dispersion observed in commodity prices Table 1 was constructed. It presents the volatility of the returns (i.e., first differences of logarithmic nomi-

Figure 1. France and Italy: Evolution milling wheat spot prices, 1998-2012.



Source: La Depeche Agricole and AGER Borsa Merci di Bologna.
Note: Figures correspond to standard milling wheat in Rouen (France) and Bologna (Italy).

Figure 2. UK: Evolution of feed wheat spot prices, 1988-2012.

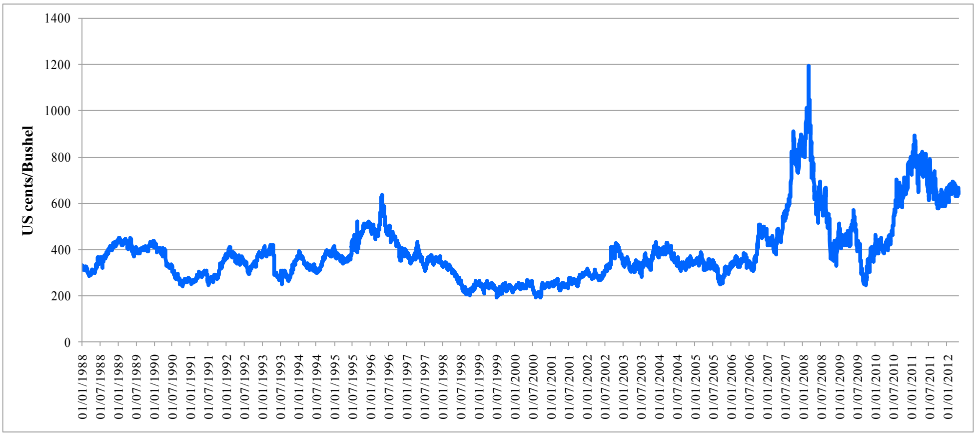


Source: Agricultural and Horticultural Development Board (AHDB).
Note: Figures correspond to East Anglia feed wheat.

nal prices) of the four spot prices presented in figures 1 to 3 and it considers three periods 1988-97, 1998-2005 and 2006-12. As shown in Table 1 the volatility of the returns increases over time in all the markets.

It is important to note that while Table 1 shows that recent volatility (i.e., since 2007) increased since the 1980s, Gilbert and Morgan (2010) pointed out in the past that there have been also periods of high volatility and the recent levels could return to historical levels over the coming years.

Figure 3. Chicago: Evolution of wheat spot prices, 1988-2012.



Source: Chicago Mercantile Exchange (CBOT).
Note: Figures correspond to soft red winter wheat.

Table 1. Wheat spot price volatility by period.

Cash market	1988 - 1997	1998 - 2006	2007 - 2012
Chicago	0.280	0.313	0.495
Rouen	n.a.	0.168	0.286
Bologna	n.a.	0.142	0.196
East Anglia	0.180	0.217	0.233

Source: Own calculations based on data from AHDB, CBOT, La Depeche Agricole and AGER Borsa Merci di Bologna.
Note: The volatility indicator was computed as the standard deviations of annualized (i.e., multiplied by √250, where 250 approximates the trading days in the year) logarithmic daily nominal spot price returns.

2.2 Speculation in futures markets

From all the possible reasons behind the surge in commodity prices (e.g., draughts, use of food crops for biofuels), the only one that could imply a break in the relationship between the futures and spot market is the increasing presence of speculation on the futures market (e.g., Bohl and Stephan (2012) for a recent literature review on the issue).

A number of authors – e.g. Gheit (2008); Masters (2008); Masters and White (2008) – have asserted that speculative buying by index funds in commodity futures and over–the–counter (OTC) derivatives markets (i.e., trading is done directly between two parties, without any supervision of an exchange) created a "bubble," with the result that commodity prices, and crude oil prices, in particular, far exceeded fundamental values at the peak (Irwin, *et al.*, 2009. p. 377). Furthermore, according UNCTAD (2009):

"Financial investors in commodity futures exchanges have been treating commodities increasingly as an alternative asset class to optimize the risk-return profile of their portfolios. In doing so, they have paid little attention to fundamental supply and demand relationships in the markets for specific commodities. A particular concern with respect to this financialization of commodity trading is the growing influence of so called index traders, who tend to take only long positions that exert upward pressure on prices. The average size of their positions has become so large that they can significantly influence prices and create speculative bubbles, with extremely detrimental effects on normal trading activities and market efficiency. Under these conditions, hedging against commodity price risk becomes more complex, more expensive, and perhaps unaffordable for developing-country users. Moreover, the signals emanating from commodity exchanges are getting to be less reliable as a basis for investment decisions and for supply and demand management by producers and consumers." (UNCTAD, 2009, p. iv).

In contrast with the aforementioned view, Irwin *et al.* (2009) considered that fundamentals offer the best explanation for the rise in commodity prices. Four of their points are worth noting: first, the arguments of bubble proponents are conceptually flawed and reflect misunderstanding of how commodity futures markets actually work, as they state that the money flows that go into futures and derivatives markets pressures the demand for physical commodities, when that money only operates in the futures market.[2] Second, a number of facts about the situation in commodity markets are inconsistent with the existence of a substantial bubble in commodity prices such as the fact that the available data do not indicate a change in the relative level of speculation to hedging. Third, the available statistical evidence does not indicate that positions for any group of investors in commodity futures markets, including long–only index funds, consistently lead futures price changes and fourth, there is a historical pattern of attacks upon speculation as scapegoat during periods of extreme market volatility.

It is clear that if futures market prices follow factors that are not related to fundamentals, one should expect futures and spot prices to become divorced or less correlated. This disassociation would necessarily bring a reduction in the effectiveness of hedging spot price risk using futures markets.

As it is well known the correlation between both prices (futures and spot) is fundamental for the traditional minimum variance calculation of the optimal hedging ratio (Ederington, 1979; Sanders and Manfredo, 2004). Therefore, one could say that, if after computing the hedging ratio and the hedging effectiveness measures one finds that hedging in futures markets is still a useful tool for risk management, then it means that both markets are still related and the financialization of futures markets has not broken that link. This is the topic of the work of the next section.

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[2] Note that there are at least two ways in which futures markets can affect the physical markets: the first one is through arbitraging between the two markets. The second way is through the use that commercial entities make of futures prices for pricing their products (e.g., processors selling flour for future delivery). Clearly, the latter strategy makes sense only if the entities believe that the two markets are related. As regards the former reason, note that arbitrage will force both prices (futures and spot) to converge at the delivery time.

3. Data and methodology

3.1 Data description

The futures market price data used for the analysis was from the feed wheat contracts from the London International Financial Futures and Options Exchange (LIFFE) and for milling wheat contracts from the Marché à Terme International de France (MATIF). In order to provide a comparison wheat contracts (i.e., the deliverable varieties correspond to milling wheat) data from the Chicago Mercantile Exchange Group (CBOT) were also used. For LIFFE and CBOT contracts the data comprised the period 1988 until 2012, while for MATIF contracts the data were available only since 1998.

As hedging performance requires the contemporary evaluation of cash price changes, spot prices from East Anglia (UK), Rouen (France), Bologna (Italy) and Chicago (USA) were also collected.

3.2 Methodology

The methodology of the paper is based on Carter (1984) and it comprises two parts: first, it explores the efficiency of wheat future markets, and second, hedging effectiveness is addressed for the periods before and after 2006, i.e., two periods of very different volatility levels. The choice of studying the efficiency of the markets and not only the hedging effectiveness is due to the fact that if the markets do not operate efficiently (e.g., they are thin) then they cannot be useful for hedging.

3.2.1 *Efficiency analysis*

The efficiency analysis of the studied futures markets comprised three complementary analyses: (1) price efficiency; (2) market unbiasedness; and (3) forecasting predictability of futures markets.

As regards **price efficiency**, in this paper it is limited only to information conveyed from historical prices, i.e., only the so-called "weak price efficiency" was tested (Fama, 1970).[3] It consisted of studying the autocorrelation of the returns (i.e., first difference of futures price logarithms) and verifying that they show low autocorrelations (i.e., because past information of returns would be not useful to predict future returns).

The **market unbiasedness** is associated to the theory of "normal backwardation" and the possibility that speculators would perceive profits for absorbing the taking risks (i.e., an inefficient market should give a structural advantage to the long positions taken by speculators with respect to the short positions taken by hedgers). According to Carter (1984) this characteristic is typical of thin markets where the hedgers, interested in transferring the risk to other agents, would accept returns favouring in the long-run the buyers of the contracts.

Market unbiasedness was tested using the implication simulating a trade routine, such as the long position taken by speculators in futures market, should earn them positive

[3] Other notions of efficiency, i.e., semi-strong or strong, would have required either availability of public information on the market fundamentals (e.g., supply-demand sheets, ending stocks, stock to use ratio) or private information.

profits over time (in contrast to hedgers who are supposed to be continuously net short and making losses equivalent to the price insurance they pay for their reduction in price risk). In this paper, following Carter, we used the trading routines designed by Cootner (1960) and Gray (1961).

The Gray's trading routine assumes that the speculator takes a net long position all the year round. If the annual harvest is immediately hedged, the price at harvest time must be low enough to induce speculators to invest on the long side of the hedge. Futures prices must rise continuously over the postharvest life of the contracts in order to insure profits for speculators as a whole. The hypothetical Gray's trading routine involves purchasing the futures contract closest to maturity buying it on the first trading day in the delivery month of the preceding futures contract. Then, every contract is sold on the first trading day of its own delivery month.

In contrast to Gray's routine, Cootner noted that hedgers were not always net short, in fact, when commitments to deliver at fixed prices are larger than commitments to buy, hedging may be net long. Therefore, during the period of declining interest on short-hedging, prices must fall. Under this condition a rational behaviour of speculators is to be long not for all the months but only for a part of the year (being short the other periods).

To apply Cootner's routine, information on price seasonality was extracted from the data. This allowed us to adapt the trading routine to the actual price dynamics determining the months which are better for taking long and short positions.

The **forecasting ability of futures markets** of the spot price at the delivery time comprised two aspects: first, whether futures prices were good predictors of spot prices at the delivery time (considering the average futures prices at the planting month and the average spot prices at the delivery month) was measured using the mean squared errors of the prediction divided by the average spot price at the delivery month (i.e., the coefficient of variation).[4] The second aspect was to observe the sign of the prediction error to verify whether there was an apparent bias (i.e., whether the errors were all positive or negative).

3.2.2 *Hedging effectiveness analysis*

The optimal hedging ratio was computed using equation (1) (Ederington's, 1979; Leuthold *et al.*, 1989; Sanders and Manfredo, 2004), where ΔP_{st} the change in the spot price at time period t, ΔP_{ft} the change in the futures price at time period t, β is the hedging ratio α is the intercept of the regression and ε_t is the regression error) and the R^2 values give the proportionate reduction of price risk attainable (i.e., the measure of hedging effectiveness, Hull, 2008).

$$\Delta P_{st} = \alpha + \beta \Delta P_{ft} + \varepsilon_t \quad (1)$$

Myers and Thompson (1989) found that the model with the prices in levels provided a poor estimation of the ratio (since the variables are normally non-stationary), instead the estimation of a model such as (1) provided reasonably accurate estimates (Myers and Thompson, p. 859).

[4] A coefficient of variation was used instead of just the mean square prediction error to allow for a comparison of the results for the studied markets (given the fact that the each of the studied markets are in different currencies).

To test the stability of the hedging ratios over time slope dummy variables were introduced for the years 2006 until 2012. The augmented model with dummies is given by (2):

$$\Delta P_{st} = \alpha + \beta \Delta P_{ft} + \sum_{i=2006}^{2012} \gamma_i \cdot d_i \cdot \Delta P_{ft} + \varepsilon_t \tag{2}$$

Where d_i the dummy variable that takes the value of 1 in year i and 0 otherwise, the γ_i are the coefficients associated to the slope dummy, so the hedging ratio corresponding to year i is equal $(\beta + \gamma_i)$ Furthermore, in equation (2) β represents the coefficient for the period before 2006.

Note that a model such as (1) allows us to consider hedging for different future markets users along the wheat supply chain, e.g., for merchants and processors one would consider hedging on short intervals such as 7-days or 30-days, in contrast to farmers that might be interested on hedging over considering longer intervals such between planting and harvesting.[5]

As regards the hedging model for wheat farmers, this needs to take into account that growing season for wheat is a lengthy one (generally 10 to 11 months), and moreover, the cultivation calendar differs in all the studied countries. In the UK, the cultivation of winter wheat begins approximately between mid September to 3rd week October; in a normal season harvesting starts mid-August ending at the beginning of September. In France, and mostly in Italy, cultivation starts later than UK. It begins between October and mid November and finishes at the end of June (Italy) or July to early August (France). For the US the cropping calendar is approximately the same as in Northern Europe, i.e., planting in September and harvesting in July. Therefore, for Italy and the US, the post-harvest price should be taken during July while for UK and France during August would be better.

Table 2 presents the information used for computing farmers' optimal hedging. It was considered that the farmer opened the hedge at the month of the planting time and the hedging was lifted after nine, ten or eleven months depending on the country (see Table 2).

Table 2. Parameters adopted for farmers' hedging by countries

Country	Exchange	Contract delivery month	Planting time (month of year t)	Post-harvest time (month of year t+1)
US	CBOT	September	September	July
Italy	MATIF	September / August (*)	October	July
France	MATIF	September / November (*)	October	August
UK	LIFFE	November	October	August

Notes: (*) The September contract is available on MATIF only until 2007.

For merchants and processors it was assumed that the hedging was not "seasonally specified". This was due to the fact that merchants and processors usually hedge their

[5] In this paper only price risk is considered and ignores production risk in the computation of the optimal hedging ratios for farmers.

physical (spot) positions all over the year holding position in the futures market for less than 10-11 month. Therefore, the lengths of the hedging were assumed to 30, 60 and 90 trading days. These intervals imply, approximately, one month and a half, three months and four months period respectively. Finally, such as in Carter (1984) a very interval hedging was included (7 trading days, i.e., approximately 10 calendar days).

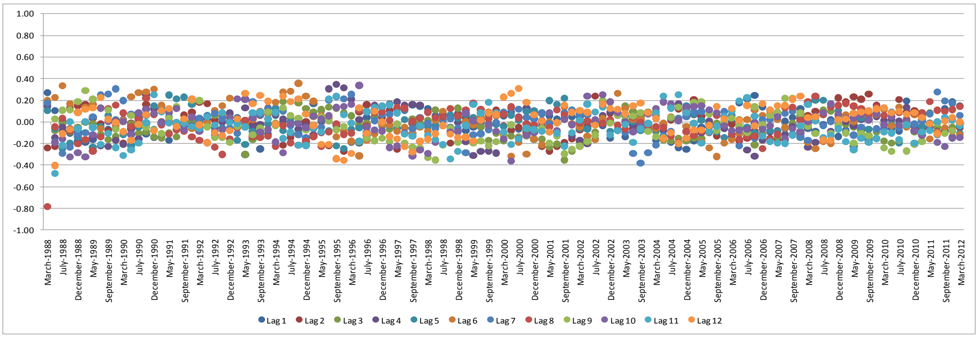
4. Results and discussion

4.1 Results from the efficiency analysis

4.1.1 Price efficiency analysis

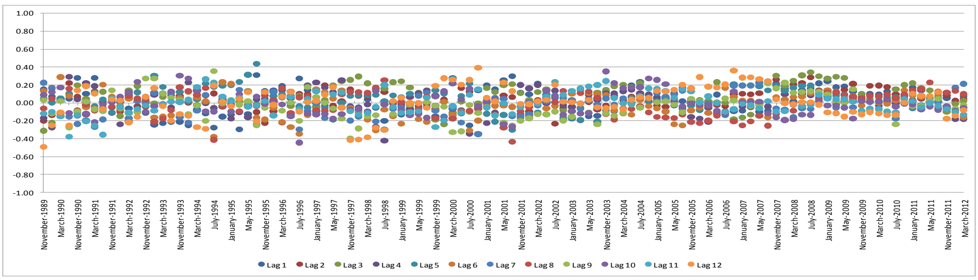
Figures 4 to 6 show that the autocorrelation coefficients for the returns for time lags from 1 to 12 (each lag represented with a different colour) working days for each contract. The values of the coefficients are relatively low (concentrated between -0.2 and 0.2) for all the contracts and markets, suggesting that the current returns are relatively independent from the past information and therefore price efficient in Fama's sense. Furthermore, in comparative terms, the MATIF market (see Figure 6) seems to perform better in terms of price efficiency than the other two markets as its autocorrelations are closer to zero.

Figure 4. CBOT - Autocorrelation coefficients for wheat futures returns, 1988-2012.



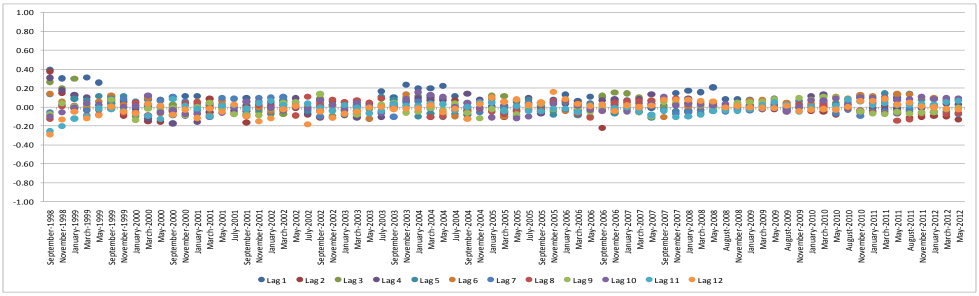
Source: Own calculation based on data presented in section 3.1.

Figure 5. LIFFE - Autocorrelation coefficients for wheat futures returns, 1988-2012.



Source: Own calculation based on data presented in section 3.1.

Figure 6. MATIF - Autocorrelation coefficients for wheat futures returns, 1998-2012.

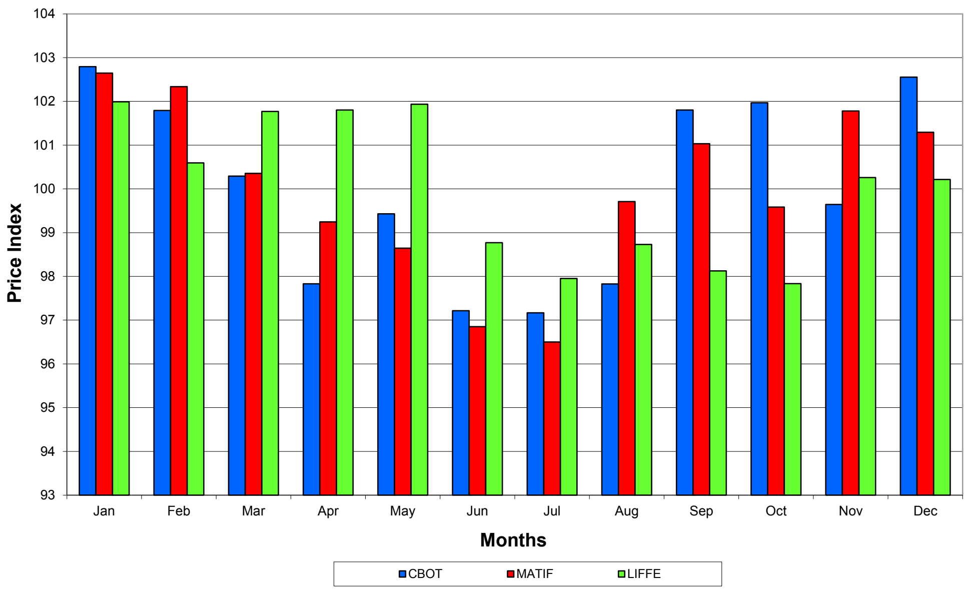


Source: Own calculation based on data presented in section 3.1.

4.1.2 Market unbiasedness analysis

As explained in the methodology before implementing the trading routines it is necessary to estimate the seasonality of futures prices for each of the markets. Figure 7 presents the seasonality analysis using nearby futures prices. As regards the seasonality for CBOT prices, on average, prices approximately have a decreasing trend from January to July and rose steadily thereafter. The seasonality in MATIF prices is similar to the observed for CBOT prices. In contrast, LIFFE seasonal pattern is not that clear and it shows an approximate a two step seasonal pattern: one between May and June (decreasing) and another between October and November (increasing).

Figure 7. Average monthly price indexes of wheat futures.



Source: Own calculation based on data presented in section 3.1.

Table 3 reports the results from implementing Gray's trading routine (i.e., 'long only') and Cootner's trading routine (i.e., 'long and short'). The Table shows the average profits per trade that could be earned, before brokerage fees. Cootner's routine shows profits higher than Gray's routine for all the markets.

Table 3. Results of trading routines in wheat futures.

Exchange	Speculative market position	Dates	Price at beginning and ending dates	Number of trades	Average Profit / Loss per trade	t-Ratio
LIFFE	Long only	1/11/89 -1/03/12	£/t. 110.5-164.8	112.00	£/t. -1.01	-0.06
LIFFE	Long and short	1/11/94 – 1/11/11	£/t. 107.1-147.8	102.00	£/t. 0.39	0.03
MATIF	Long only	1/09/98 – 1/03/12	€/t. 118.9-214.5	73.00	€/t. 2.36	0.11
MATIF	Long and short	2/11/98 – 1/11/12	€/t.124.3-187.8	78.00	€/t. 2.74	0.14
CBOT	Long only	1/03/88 – 1/03/12	$/bu. 3.2-6.6	120.00	$/bu. -0.06	-0.08
CBOT	Long and short	1/03/88 – 1/12/11	$/bu. 3.2-6.0	143.00	$/bu. 0.06	0.10

Source: Own calculation based on data presented in section 3.1.
Note: "Long only" refers to Gray's trading routine and "Long and short" to Cootner's trading routine.

While in CBOT and LIFFE markets the Gray's routine show losses, Cootner's routine in those markets resulted in profits. In the MATIF market, both routines showed a profit (slightly higher in the case of Cootner's (€2.74) than Gray's (€2.36)). However, it should ne noted that in none of the cases the average profits were statistically different from zero (using a t student test) at 95 per cent significance. Therefore, conclusion from Table 3 is that none of markets show a systematic bias in favour of speculators.

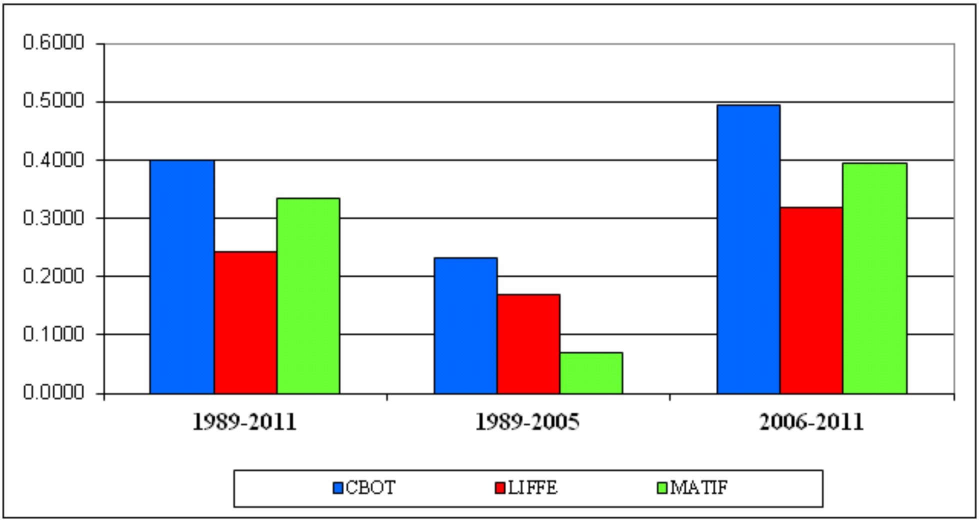
4.1.3 Forecasting ability analysis

With respect to the forecasting ability of the futures markets, Figure 8 presents the results of the analysis (i.e., in terms of the forecasting errors). It shows that the prediction power in all the markets[6] was between 60 and 70 per cent when the entire sample is considered (first set of columns in Figure 8). If the sample period is broken down into 1989-2005 and 2006-11, it is clear that the prediction errors worsen during the period 2006-11.

On the possible bias of the errors, Figures 9 to 11 show that the sign of the errors were both positive and negative without indicating any clear bias.

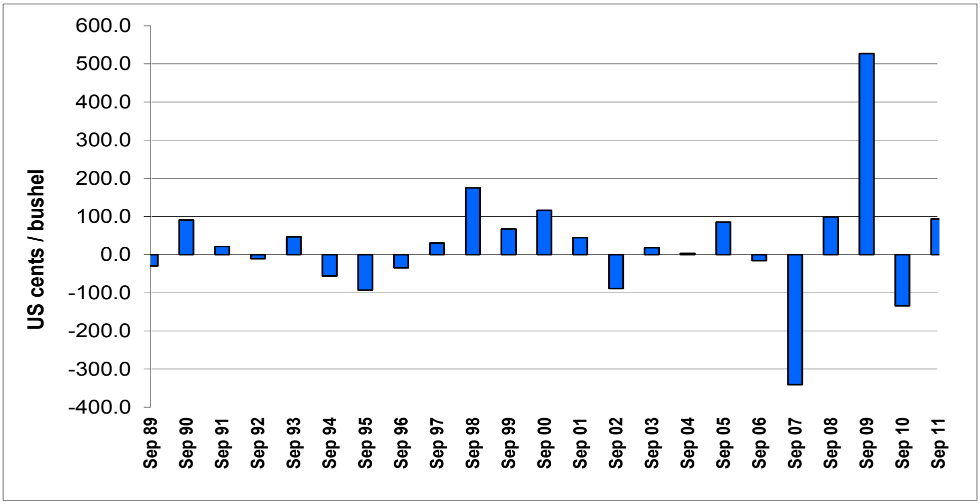
[6] For the MATIF Exchange, the prediction test was carried out considering the spot prices from the Rouen market.

Figure 8. Coefficient of variation of the prediction errors.



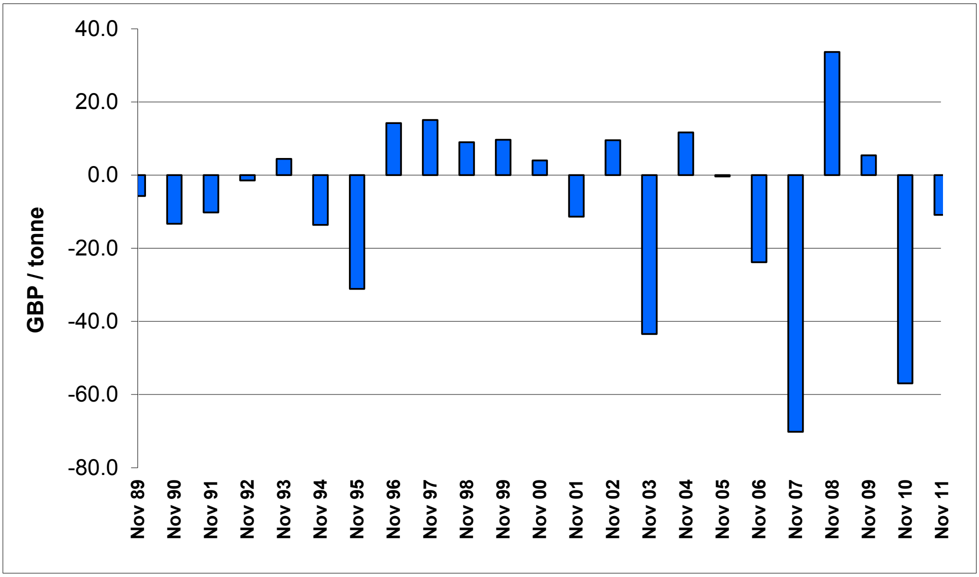
Source: Own calculation based on data presented in section 3.1.
Note: Data for MATIF Exchange are available since year 1999 instead of 1989.

Figure 9. CBOT – Forecasting errors of futures markets by contract.



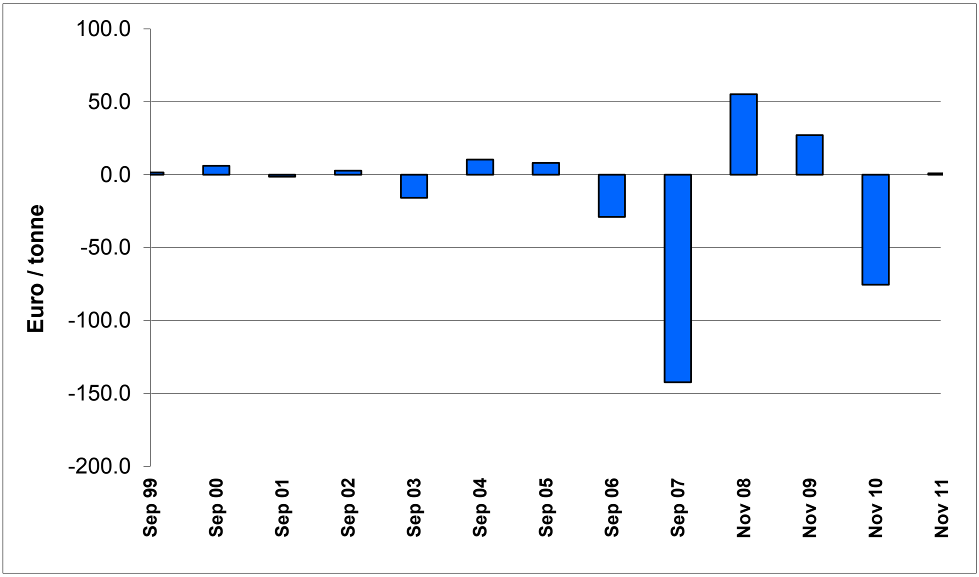
Source: Own calculation based on data presented in section 3.1.

Figure 10. LIFFE – Forecasting errors of futures markets by contract.



Source: Own calculation based on data presented in section 3.1.

Figure 11. MATIF – Forecasting errors of futures markets by contract.



Source: Own calculation based on data presented in section 3.1.
Note: To evaluate MATIF futures price forecasting power, spot price from Rouen were used.

4.2 Results from the hedging effectiveness analysis

Tables from 5 to 9 provide the results of the analysis of the hedging effectiveness of futures contracts for all the studied markets. As mentioned different operators along the supply chain have their own particular hedging needs and this was taken into account by considering different hedging lengths.

As equations (1) and (2) were estimated using time series, in order to avoid spurious associations, the series used (i.e., the price differences) were tested for unit roots using the Phillips–Perron test (Phillips and Perron, 1988), which considers that the process generating data might have a higher order of autocorrelation. In addition, the test is robust with respect to unspecified autocorrelation and heteroscedasticity in the disturbance process of the test equation. All the series were found stationary, and therefore, it was possible to estimate equations (1) and (2) by ordinary least squares.

The results for the farmers' hedging exercise are presented in Table 5. They show that when the entire sample is used, the performance of the European Exchanges, in terms of the variance reduction that farmers could have attained through hedging is better than in the Chicago market. Thus, a US farmer hedging 39 per cent of his wheat using the Chicago wheat futures would have reduced his price risk only by 14 per cent; whilst the reduction using the European Exchanges ranged from 40 per cent (for the case of spot prices from Bologna and the MATIF Futures Markets) to 73 per cent (for the East Anglia spot prices and the LIFFE Futures Markets). However, the results for the entire sample hide the dramatic changes in the hedging ratios since 2007 for all the cases. As shown in Table, the optimal ratios changed significantly during the period 2006-07 to 2010-11.

It is clear from Table 5 that if farmers had computed their hedging ratios based only on historical price information; the errors on the strategy would have been significant. In this sense, probably the most appropriate strategy for computing hedging ratios would have been that proposed by Myers and Thompson (1989), which consists of incorporating additional relevant information (e.g., supply and demand conditions).

The results for hedges for lengths of 7, 30, 60 and 90 days are presented in Tables 6 to 9 for the different Exchanges and spot markets. These are supposed to represent other supply chain operators such as merchants or processors, who do not need to hedge in a specific season of the year, as in the case of farmers.

As shown in the Tables, the short-term hedges report a substantive reduction in price risk with R^2 that are, in general, high (with more than 75 per cent of price risk reduction). Furthermore, for all the studied markets, the performance of the short-term hedges improves with the increase of the hedge length. In fact, the 7 days hedges are relatively low, particularly if wheat from Bologna is hedged using MATIF.

In contrast with the results from the farmers' hedging exercise, the inclusion of the slope dummy variables do not improve much the R^2 of the hedging regressions (despite the fact that in many cases the coefficients are statistically significant), i.e., the changes in the hedging ratios add little to the reduction in price risk.

Table 5. Estimates of hedging ratios and effectiveness for farmers' hedging.

Cases	Coefficients		R^2	Slope dummies for years with high variability					Obs.
	α	β		2006-07	2007-08	2008-09	2009-10	2010-11	
CBOT - Chicago									
Farmer's hedging	10.25	0.39	0.14						448
	(2.36)	(8.55)							
With year dummies	11.94	0.86	0.67	0.19	-1.67	-0.42	2.15	-0.73	448
	(3.92)	(13.51)		(1.85)	(-18.29)	(-5.39)	(10.81)	(-3.93)	
LIFFE - East Anglia									
Farmer's hedging	-5.79	1.01	0.73						330
	(-7.58)	(29.95)							
With year dummies	-6.12	1.12	0.87	-0.15	6.73	-1.62	0.39	-0.85	330
	(-10.26)	(23.41)		(-2.53)	(8.72)	(-8.79)	(5.30)	(-9.01)	
MATIF - Rouen									
Farmer's hedging	-8.71	0.82	0.64						249
	(-7.71)	(21.10)							
With year dummies	-7.71	1.26	0.70	-0.47	2.93	-0.54		-1.41	249
	(-6.73)	(8.69)		(-3.13)	(4.65)	(-2.57)	(0.00)	(-3.35)	
MATIF - Bologna									
Farmer's hedging	-10.61	0.78	0.40						286
	(-9.67)	(13.81)							
With year dummies	-11.26	0.78	0.46	-0.10	2.60	-0.05	0.78	0.27	286
	(-8.77)	(4.41)		(-0.51)	(2.82)	(-0.20)	(2.91)	(0.63)	

Note: The numbers in parenthesis below the coefficients are the t-statistics.

5. Conclusions

The primary aim of this paper has been to study whether hedging in futures markets is useful instrument for price risk reduction for commercial entities operating with commodities along the wheat supply chain. Thus, the focus was on two European wheat futures markets, LIFFE and MATIF, in addition of CBOT market for comparison purposes. The evaluation comprised two stages: first, the efficiency analysis of the futures markets, which consisted of three sub-analyses: price efficiency, market unbiasedness, and the forecasting ability; and second, the effectiveness for hedging.

As regards the efficiency analysis, the results indicate that the increasing participation of speculative investors mentioned in the recent literature, have not reduced the market price efficiency. The same result was found with respect to the market unbiasedness. In this respect, the test show that holding a speculative position showed that the average profits during the last 20 years were not statistically different from zero. The forecasting performance of futures markets showed that the prediction capacity of in the three markets was modest with a coefficient of variation of the error that was between 25 to 40 per cent.

Table 6. CBOT – Chicago: estimates of effectiveness of short-term wheat hedging.

Cases	Coefficients		R^2	Slope dummies for years with high variability							Obs.
	α	β		2006	2007	2008	2009	2010	2011	2012	
7 days hedge	0.06	0.86	0.72								6,297
	(0.37)	(128.01)									
With year dummies	0.10	0.84	0.73	-0.08	0.07	0.01	0.14	-0.08	0.09	0.06	6,297
	(0.61)	(63.47)		(-2.04)	(2.83)	(0.76)	(4.62)	(-3.44)	(3.70)	(0.91)	
30 days hedge	0.33	0.85	0.77								6,274
	(1.11)	(145.77)									
With year dummies	0.26	0.86	0.78	0.12	0.04	-0.03	0.21	-0.21	-0.02	0.11	6.274
	(0.86)	(72.05)		(3.37)	(2.04)	(-1.82)	(7.76)	(-9.73)	(-0.79)	(1.26)	
60 days hedge	0.44	0.92	0.80								6,244
	(1.10)	(158.84)									
With year dummies	0.22	0.92	0.81	0.17	0.04	-0.03	0.42	-0.16	-0.02	0.15	6,244
	(0.56)	(79.54)		(4.79)	(1.99)	(-1.84)	(14.41)	(-7.75)	(-0.79)	(1.18)	
90 days hedge	0.54	0.94	0.81								6,214
	(1.13)	(161.34)									
With year dummies	0.41	0.93	0.81	0.11	0.03	-0.04	0.18	-0.01	0.16	-0.36	6,214
	(0.83)	(80.89)		(3.00)	(1.68)	(-2.65)	(5.44)	(-0.68)	(6.32)	(-4.48)	

Note: The numbers in parenthesis below the coefficients are the t-statistics.

Table 7. LIFFE – East Anglia: estimates of effectiveness of short-term wheat hedging.

Cases	Coefficients		R^2	Slope dummies for years with high variability							Obs.
	α	β		2006	2007	2008	2009	2010	2011	2012	
7 days hedge	0.03	0.55	0.32								6,101
	(0.65)	(53.07)									
With year dummies	0.00	0.35	0.34	0.22	0.33	0.39	0.27	0.33	0.24	0.57	6,101
	(0.08)	(21.45)		(2.69)	(10.49)	(11.09)	(6.23)	(10.23)	(7.79)	(5.45)	
30 days hedge	0.04	0.80	0.65								6,078
	(0.56)	(106.93)									
With year dummies	-0.07	0.60	0.68	0.30	0.32	0.38	0.29	0.31	0.17	0.45	6,078
	(-0.99)	(48.12)		(4.46)	(15.16)	(16.28)	(8.66)	(13.91)	(6.80)	(8.14)	
60 days hedge	0.00	0.89	0.78								6,048
	(0.04)	(145.41)									
With year dummies	-0.06	0.77	0.78	0.24	0.15	0.22	0.20	0.15	0.15	0.25	6,048
	(-0.70)	(70.11)		(4.56)	(8.43)	(12.34)	(6.31)	(8.15)	(7.32)	(3.79)	
90 days hedge	-0.05	0.95	0.86								6,018
	(-0.54)	(192.66)									
With year dummies	0.01	0.88	0.86	0.04	0.06	0.12	0.13	0.05	0.12	0.04	6,018
	(0.08)	(96.53)		(0.99)	(4.29)	(8.59)	(3.88)	(3.51)	(7.03)	(0.55)	

Note: The numbers in parenthesis below the coefficients are the t-statistics.

Table 8. MATIF - Rouen: estimates of effectiveness of short-term wheat hedging.

Cases	Coefficients		R^2	Slope dummies for years with high variability							Obs.
	α	β		2006	2007	2008	2009	2010	2011	2012	
7 days hedge	0.04	0.72	0.48								3,670
	(0.51)	(58.40)									
With year dummies	0.03	0.54	0.50	0.22	0.35	0.32	0.21	0.15	0.01	-0.05	3,670
	(0.36)	(14.33)		(2.55)	(7.58)	(6.90)	(2.74)	(3.21)	(0.15)	(-0.53)	
30 days hedge	0.07	0.93	0.85								3,647
	(0.68)	(141.03)									
With year dummies	-0.09	0.82	0.85	0.16	0.21	0.12	0.10	0.08	-0.01	0.25	3,647
	(-0.84)	(39.42)		(3.42)	(8.60)	(5.03)	(2.37)	(3.26)	(-0.52)	(4.68)	
60 days hedge	0.12	0.95	0.91								3,617
	(1.05)	(191.33)									
With year dummies	-0.06	0.92	0.91	0.04	0.07	0.03	0.10	0.05	-0.05	0.10	3,617
	(-0.51)	(60.41)		(1.22)	(3.96)	(1.50)	(2.36)	(2.61)	(-2.43)	(2.48)	
90 days hedge	0.15	0.99	0.94								3,587
	(1.28)	(241.48)									
With year dummies	0.25	0.95	0.94	-0.01	0.04	0.07	0.22	0.06	-0.02	0.03	3,587
	(1.98)	(79.64)		(-0.29)	(2.74)	(4.65)	(6.47)	(3.87)	(-1.42)	(0.89)	

Note: The numbers in parenthesis below the coefficients are the t-statistics.

Table 9. MATIF – Bologna: estimates of effectiveness of short-term wheat hedging.

Cases	Coefficients		R^2	Slope dummies for years with high variability							Obs.
	α	β		2006	2007	2008	2009	2010	2011	2012	
7 days hedge	0.09	0.35	0.18								3,670
	(1.13)	(28.85)									
With year dummies	0.11	0.34	0.19	0.07	0.02	-0.03	-0.04	-0.05	0.12	-0.07	3,670
	(1.27)	(8.92)		(0.78)	(0.33)	(-0.57)	(-0.52)	(-1.02)	(2.49)	(-0.67)	
30 days hedge	0.15	0.70	0.57								3,647
	(0.94)	(70.20)									
With year dummies	-0.07	0.71	0.59	0.19	0.02	-0.19	-0.09	0.04	0.15	-0.12	3,647
	(-0.45)	(22.51)		(2.72)	(0.50)	(-5.16)	(-1.44)	(1.10)	(3.81)	(-1.53)	
60 days hedge	0.04	0.81	0.71								3,617
	(0.20)	(93.43)									
With year dummies	-0.29	0.92	0.73	0.07	-0.03	-0.31	-0.37	-0.12	0.12	-0.30	3,617
	(-1.45)	(35.70)		(1.29)	(-0.86)	(-10.05)	(-5.17)	(-3.74)	(3.45)	(-4.69)	
90 days hedge	0.00	0.90	0.78								3,587
	(0.01)	(114.28)									
With year dummies	-0.13	1.00	0.80	-0.06	-0.06	-0.27	-0.10	-0.13	0.11	-0.40	3,587
	(-0.54)	(45.09)		(-1.26)	(-2.27)	(-9.85)	(-1.49)	(-4.78)	(3.53)	(-6.58)	

Note: The numbers in parenthesis below the coefficients are the t-statistics.

With respect to the hedging effectiveness analysis, the results can be divided into: first, farmers' hedging, and second, by other supply chain members. For farmers, although some of the results indicate a significant reduction in the price risk (e.g., LIFFE-East Anglia and MATIF-Rouen), it is clear that the instability of the period 2006-07 to 2010-11 affected significantly the estimation of the optimal hedging ratios. Furthermore, the introduction of dummy variables to control for the variability shows an important improvement in the reduction of the price risk. This is common to all the markets. Therefore, one can conclude that price volatility affected significantly the hedging effectiveness for farmers.

The results for the other participants of the wheat supply chain (i.e., short hedging) show, for most of the cases, higher price risk reduction than that observed for farmers' hedges (although an exception are the 7-day hedges for wheat from Bologna being hedged at the MATIF market). In addition, the inclusion of dummies in the regression to estimate the optimal hedging ratio do not increased much the R^2 (such as in the case of the farmers' hedge), showing that short-term hedges were not much affected by the increasing price volatility.

The above results imply that the studied futures markets are not only still efficient but may also be a useful tool for the reduction of price risk (e.g., they might be useful for food security purposes). However, it is important to stress that the analysis carried out in this paper is only valid for the regions where the Exchanges are and cannot be extrapolated to other regions without careful evaluation.

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