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Relationship between coffee prices in physical and futures markets

Background

In the context of its programme of activities, the Organization pays particular attention to the behaviour of coffee prices on the international market and risks associated with their volatility. This document contains an analysis of the relationship between cash or physical market prices and futures market prices for coffee.

Action

The Council is requested to take note of this document.

RELATIONSHIP BETWEEN COFFEE PRICES IN PHYSICAL AND FUTURES MARKETS

EXECUTIVE SUMMARY

1. Prices for coffee can fluctuate significantly over time. This volatility brings with it monetary risks for all participants in the market. Futures markets allow some of this risk to be managed through the use of hedging operations.

2. This paper explores the relationship between physical and futures markets by analysing coffee prices between 1990 and 2011. It uses the ICO indicator prices of the four groups (Colombian Milds, Other Milds, Brazilian Naturals and Robustas) as spot prices and the average of the 2nd and 3rd positions of the Inter-Continental Exchange (ICE) in New York (for Arabica) and the NYSE Liffe Futures and Options in London (for Robusta) as futures contracts prices.

3. A regression analysis reveals a very strong relationship between futures contracts and spot prices for all four groups of coffee. Futures prices are therefore very closely related to physical prices.

4. However, price risk management in the futures market through hedging can only protect against changes in the spot price. Indeed, the risk related to the volatility of the differential between spot and futures prices, known as the basis, is not covered. An analysis of the basis risk shows that it is quite unstable, and is therefore considered a significant risk for commercial transactions. Furthermore, although volatility in the physical price may have fallen in recent years, basis risk for three out of four groups of coffee has increased.

INTRODUCTION

5. As in the case of many other agricultural commodities, effective risk management of coffee price movements requires a proper understanding of the relationship between cash or spot prices and prices in the futures markets. Many commodity markets have both a cash market in physical transactions and a futures market for trading contracts relating to various future delivery dates. The difference between the prices formed in these two markets can determine whether a particular commodity market is speculative or not. The aim of this study is to analyse the relationship between spot prices and prices in the futures markets. In other words, it will carry out an empirical evaluation of the size and volatility of the differential between cash prices and futures prices.

6. The methodology adopted uses statistical tests to establish the relationship between cash and futures prices before analysing developments in this relationship over a long-term period extending from 1990 to 2011. This period corresponds to the free market era following the abolition in July 1989 of the market regulation system that had been in effect during the preceding decades. In addition, changes in the relationship between the two prices will also be examined taking into account two distinct sub-periods, namely recent developments since 2000 compared to the preceding decade. In carrying out this analysis, ICO indicator prices for each of the four coffee groups, whose weighting in the calculation of the average reflects the importance of the main markets, are used as approximations of the spot prices¹. Futures prices are represented by the average of 2nd and 3rd positions in the New York and London futures markets. The New York futures market (ICE) represents Arabica transactions while the London futures market (NYSE Euronext – Liffe) handles transactions for Robusta contracts. The following points will be covered:

- I. Behaviour of cash and futures coffee prices
- II. Correlation between indicator prices and futures prices
- III. Regression analysis of indicator prices and futures prices
- IV. Differential between spot and futures prices

I. BEHAVIOUR OF CASH AND FUTURES COFFEE PRICES

7. Since coffee is traded on commodity exchanges, coffee prices can be divided into three main categories: cash (*spot*) prices; prices for transactions relating to a set future date (*forward prices*); and futures contract prices (*futures prices*). Spot prices relate to the cash market, which deals in transactions to buy and sell physical coffee of different qualities for immediate delivery at a specified price. The spot price reflects the state of the market for an immediate transaction. The price for a forward contract is the price established in a verbal or written agreement for buying or selling a given quantity of coffee on a set future date and at a predetermined price (or sometimes at a price to be determined). Delivery and payment take place on a set date.

8. The futures price relates to a fully coded and standardized paper contract for a particular quantity and grade of coffee deliverable at a specific place on a specified date. Unlike forward contracts, futures contracts do not necessarily lead to delivery of the

¹ According to the Rules on Statistics of the Organization, the share of each market for the four groups of coffee is as follows (document ICC-105-17):

- Colombian Milds: 46% for the United States and 54% for the European Union;
- Other Milds: 40% for the United States and 60% for the European Union;
- Brazilian Naturals: 24% for the United States and 76% for the European Union;
- Robustas: 16% for the United States and 84% for the European Union.

physical coffee to honour the agreement. The contract is negotiated daily in the futures market. The futures market is a financial institution that enables participants to buy and sell futures contracts with expiry dates between 3 and 18 months. The main futures markets dealing in coffee transactions are:

- The New York futures market (ICE) for Contract 'C' transactions relating to washed Arabica coffees;
- The London futures market (NYSE Euronext – Liffe) for Robusta transactions;
- São Paulo: Bolsa de Mercadorias & Futuros – BM&F – (Brazilian Mercantile and Futures Exchange);
- Tokyo: Tokyo Grain Exchange (TGE)

9. The New York and London futures markets are the main exchanges for the international coffee trade.

10. As indicated above, in the context of this study spot prices are represented by the indicator prices for the four groups of coffee. Futures prices are represented by the average of the 2nd and 3rd positions on the New York futures market for Arabicas and on the London futures market for Robustas. Table 1 shows average annual prices since 1990.

Table 1: Average annual prices in spot and futures markets (US cents/lb)

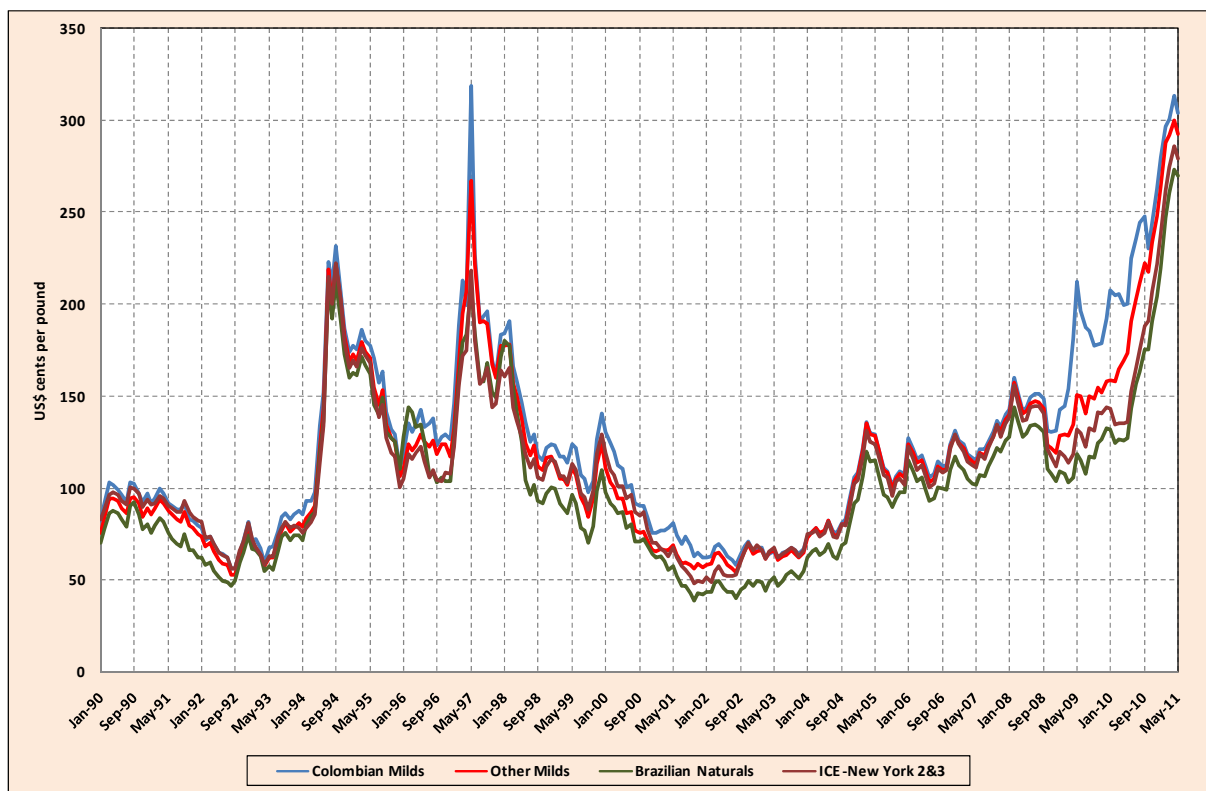
	Colombian Milds	Other Milds	Brazilian Naturals	Robustas	ICE -New York 2&3	London - LIFFE 2&3
1990	96.53	89.46	82.97	53.60	93.78	50.03
1991	89.76	84.98	72.91	48.62	89.18	44.53
1992	67.97	64.04	56.49	42.66	68.14	38.33
1993	75.79	70.76	66.58	52.50	71.32	47.15
1994	157.27	150.04	143.24	118.87	145.93	113.13
1995	158.33	151.15	145.95	125.68	145.54	118.31
1996	131.23	122.21	119.77	81.92	111.17	74.51
1997	198.92	189.06	166.80	78.75	163.04	75.02
1998	142.83	135.23	121.81	82.67	126.27	76.39
1999	116.45	103.90	88.84	67.53	106.48	64.07
2000	102.60	87.07	79.86	41.41	94.58	40.11
2001	72.05	62.28	50.70	27.54	58.86	23.92
2002	64.90	61.52	45.23	30.01	57.02	25.88
2003	65.33	64.20	50.31	36.95	65.24	34.11
2004	81.44	80.47	68.97	35.99	79.53	32.85
2005	115.73	114.86	102.29	50.55	111.38	46.80
2006	116.80	114.40	103.92	67.55	112.30	59.77
2007	125.57	123.55	111.79	86.60	121.83	78.56
2008	144.32	139.78	126.59	105.28	136.46	97.18
2009	177.43	143.84	115.33	74.58	128.40	67.69
2010	225.46	195.96	153.68	78.74	165.20	71.98
2011	298.77	287.33	254.30	113.51	267.55	107.96

* 2011: Partial average

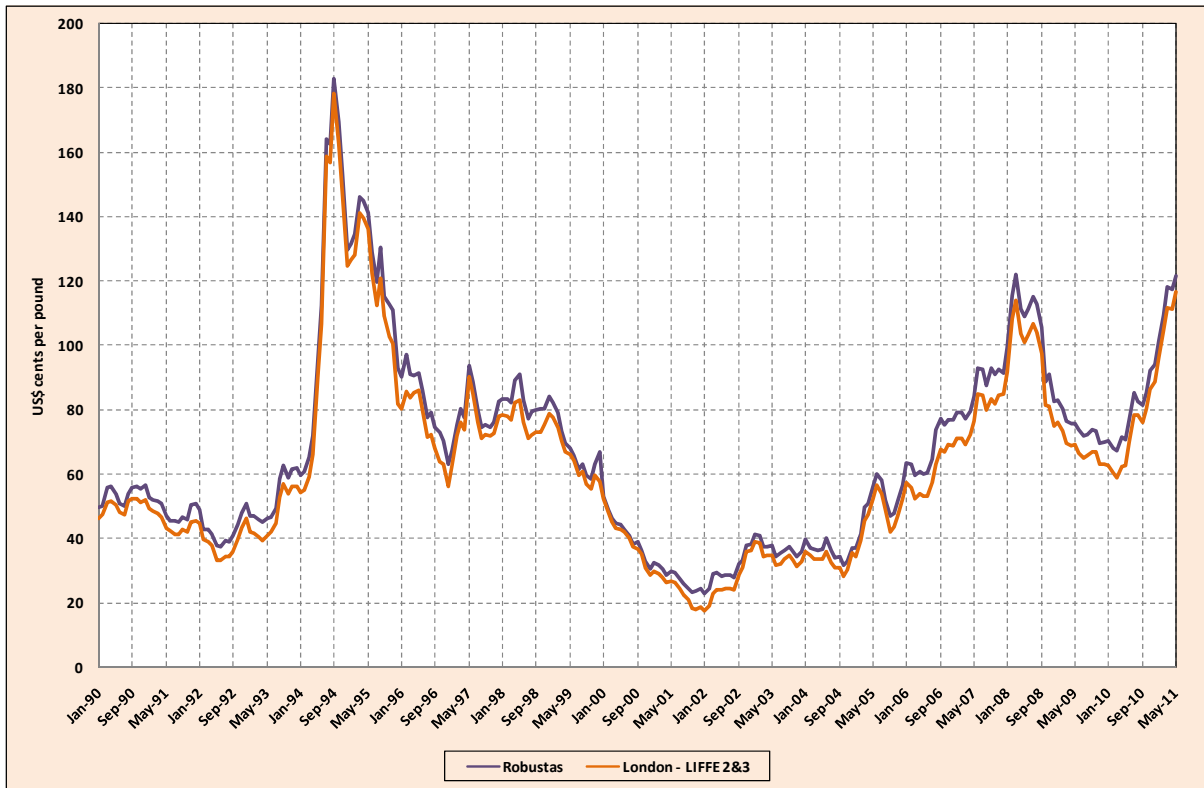
11. Graph 1 shows indicator prices for Arabicas and average prices for the 2nd and 3rd positions on the New York futures market. Graph 2 shows the indicator price for Robusta and average prices for the 2nd and 3rd positions on the London futures market.

12. These graphs indicate a link between the spot and futures markets, which exercise a mutual influence on the determination of coffee prices. It should be noted that prices in the physical or spot market reflect the short-term availability of coffee and the current conditions of fundamental factors. Prices in the futures markets reflect expectations relating to market developments and consequently integrate any new information on the market very rapidly.

Graph 1: Indicator prices for Arabicas and prices on the New York futures market



Graph 2: Indicator price for Robustas and prices on the London futures market



II. CORRELATION BETWEEN INDICATOR PRICES AND FUTURES PRICES

13. The nature of the relationship between spot and futures prices must be established. Table 2 shows correlation coefficients for these two variables based on 257 monthly observations from January 1990 to May 2011. It will be seen that there are strong positive correlation coefficients between spot prices and futures prices, both during the entire period from 1990 to 2011 and during the sub-periods. In the case of prices for Arabicas, the correlation between the spot price for Brazilian Naturals and the price on the New York futures market became even stronger during the last ten years since the coefficient for the period from 2000 to 2011 is 1 compared to 0.97 for the period from 1990 to 1999, indicating a perfect correlation.

Table 2: Correlation coefficients for spot prices in relation to futures prices

1990-2011	CM	OM	BN	Rob	ICE	LIFFE
NY	0.96	0.99	0.98	0.81	1.00	0.82
London	0.73	0.77	0.83	1.00	0.82	1.00

1990-99	CM	OM	BN	Rob	ICE	LIFFE
NY	0.98	0.98	0.97	0.84	1.00	0.85
London	0.78	0.79	0.84	1.00	0.85	1.00

2000-11	CM	OM	BN	Rob	ICE	LIFFE
NY	0.95	0.99	1.00	0.84	1.00	0.85
London	0.78	0.82	0.86	1.00	0.85	1.00

14. A strong positive correlation was also observed between Arabica prices and prices on the London futures market, which deals in Robusta transactions, and between Robusta prices and prices on the New York futures market, which deals only in contracts for washed Arabicas. There is, therefore, a strong interdependence between futures markets, which often favours transmission of price movements from one market to the other.

III. REGRESSION ANALYSIS OF INDICATOR PRICES AND FUTURES PRICES

15. The extent to which futures prices are good estimators of spot prices should therefore be determined. For this purpose, a simple regression analysis will be carried out since only one variable is involved. The following equation will be calculated using a regression line.

$$Y = aX + b$$

Where,

Y = the dependent variable and represents the spot price

X = the explanatory variable and represents the futures price

b = a random or residual variable

a = the slope of the regression line, indicating the strength of the relationship between the spot and futures prices.

16. Table 3 shows the results of the regression for spot and futures prices and Graphs 3 to 6 show the regression lines.

Table 3: Results of regressions for spot and futures prices

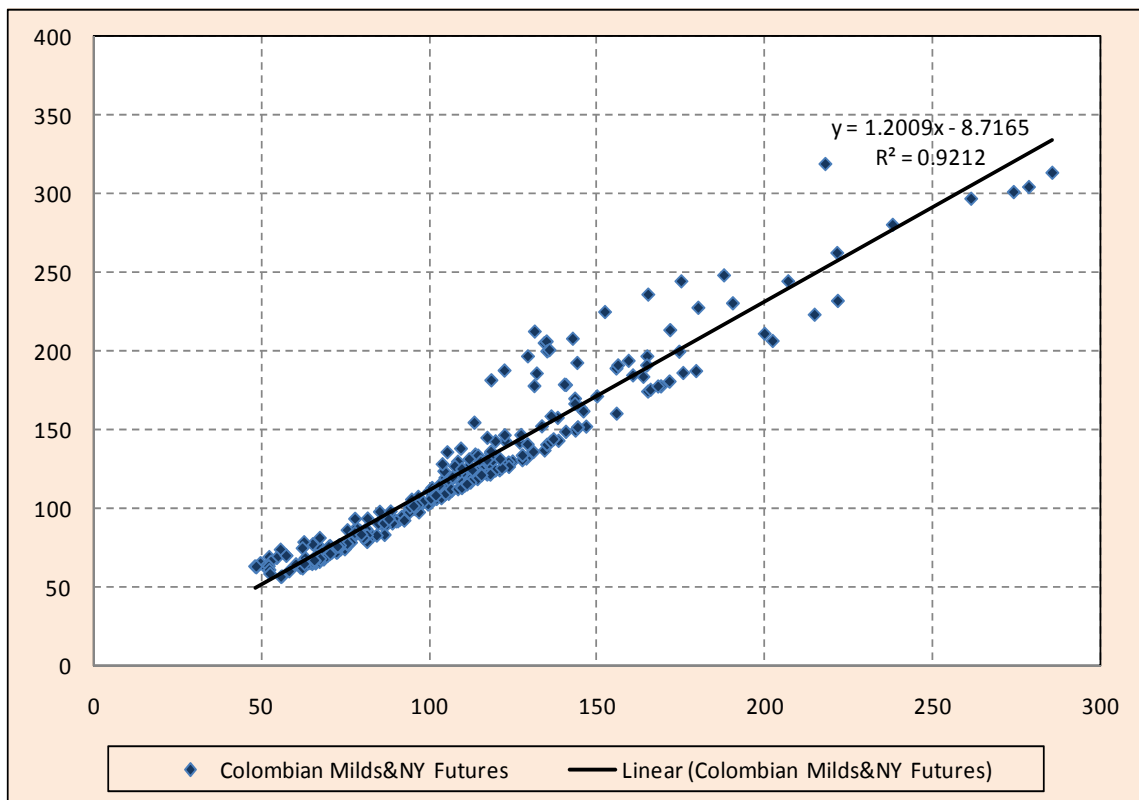
$$Y = aX + b$$

$$Y = \text{Spot price}$$

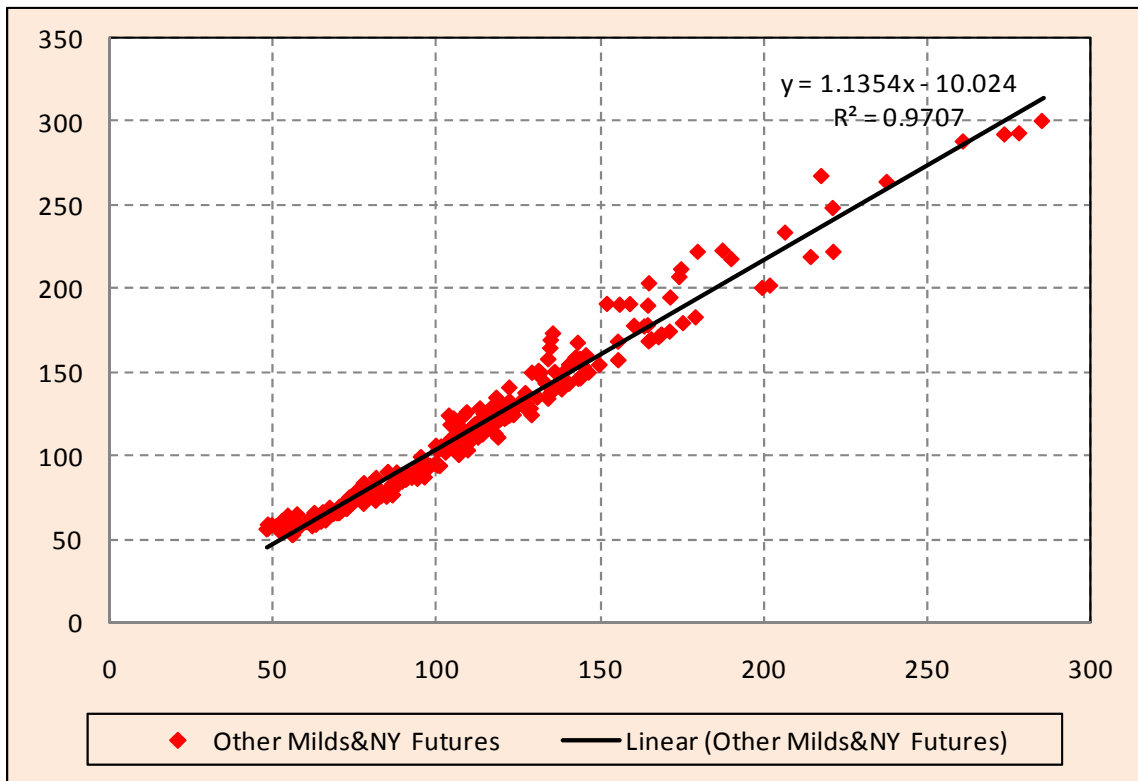
$$X = \text{Futures price}$$

	Colombian Milds & New York	Other Milds & New York	Brazilian Naturals & New York	Robustas & London
r	0.9598	0.9852	0.9844	0.9980
r ²	0.9212	0.9707	0.9690	0.9960
a	1.2009	1.1354	1.0291	1.0377
b	-8.7165	-10.0236	-11.7632	2.8056

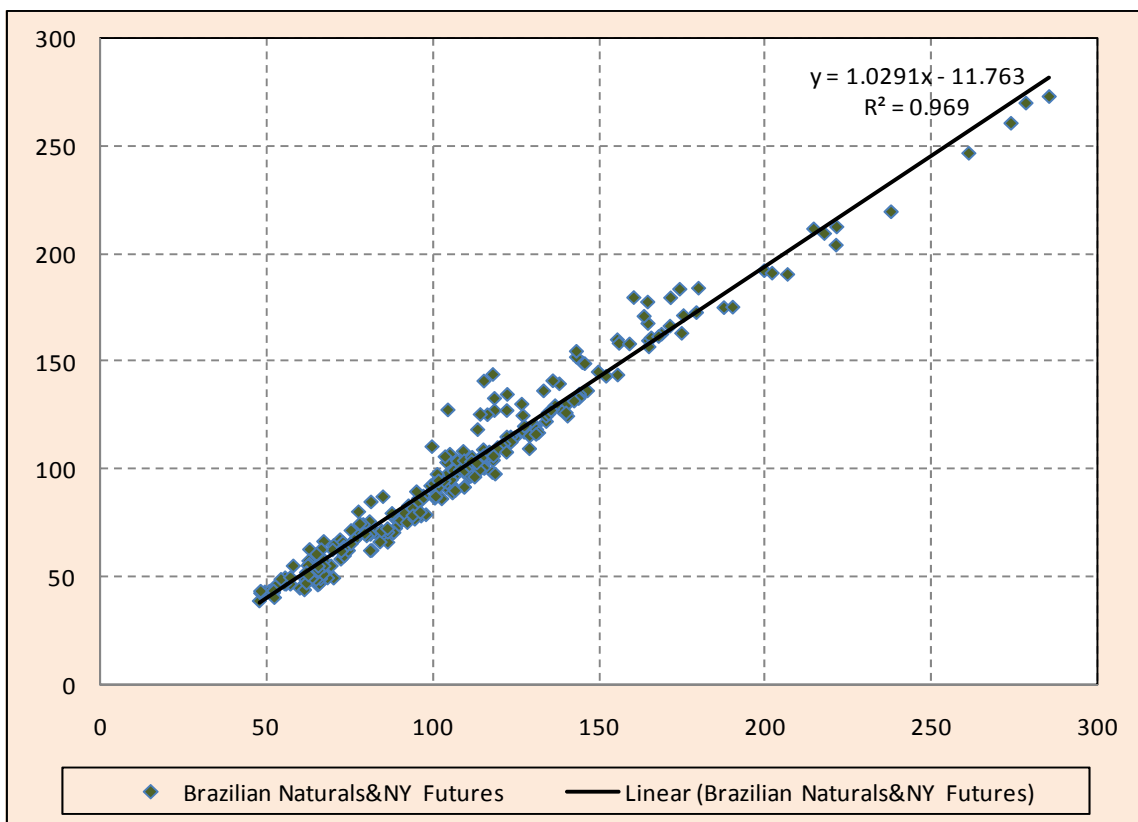
Graph 3: Regression chart for spot and futures prices (Colombian Milds)



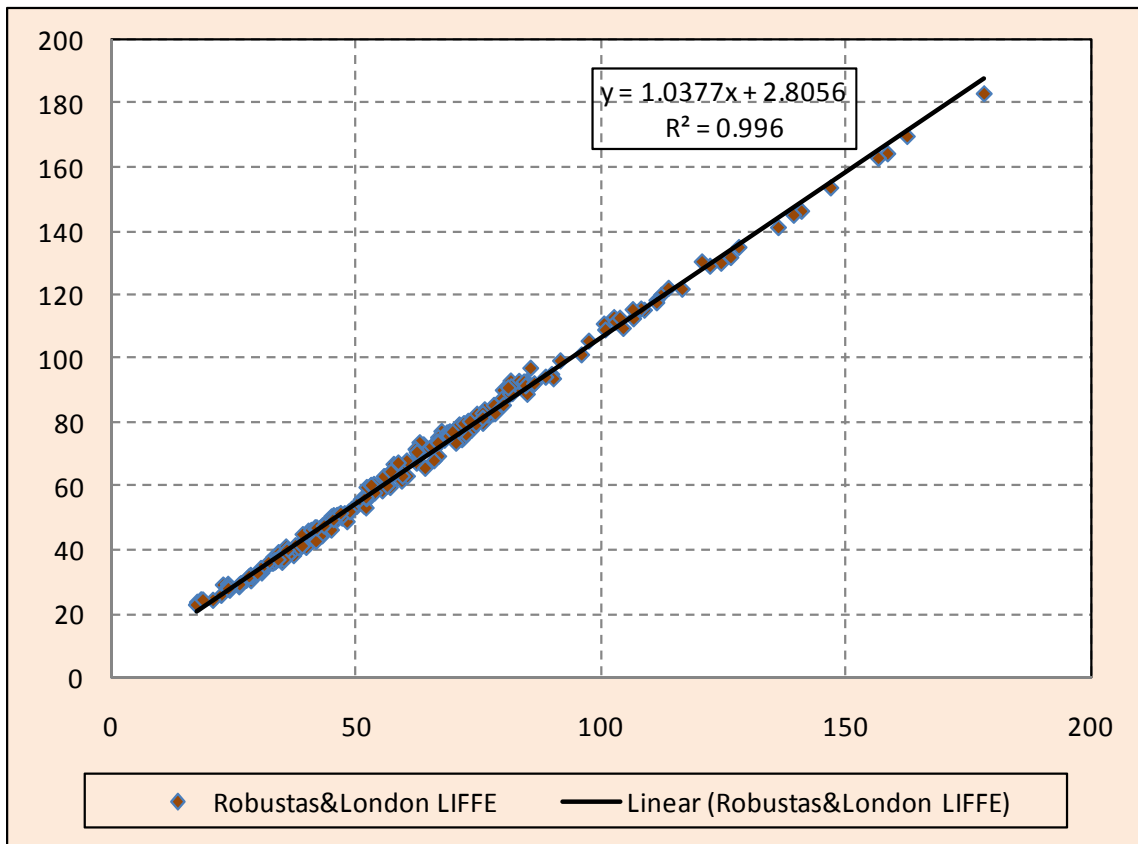
Graph 4: Regression chart for spot and futures prices (Other Milds)



Graph 5: Regression chart for spot and futures prices (Brazilian Naturals)



Graph 6: Regression chart for spot and futures prices (Robustas)



17. The regression results confirm the strong positive relation between ICO indicator prices and futures prices. This indicates that the two futures markets are good estimators of the physical markets. Specifically, however, a certain amount of dispersion can be observed in the case of Arabicas (Graphs 3 to 5). This may indicate that the empirical relationship between spot and futures market prices might not be of a straight line. In the case of Robustas, the correlation is nearly perfect.

IV. DIFFERENTIAL BETWEEN SPOT AND FUTURES PRICES

IV.1 DETERMINATION OF THE DIFFERENTIAL OR BASIS

18. The difference between the two market prices is known as the *basis* or differential. The basis or differential is the difference at a given time between the spot price and the futures contract price. The following formula is used for calculating the basis:

$$B_t = S_t - F_t$$

B_t = the basis at time t

S_t = the spot price at time t

F_t = the futures contract price at time t

19. The futures price is often considered to be an anticipation of the spot price and changes whenever new information likely to affect market fundamentals becomes available. The difference between futures and spot prices or the basis can be an indicator of market conditions. In fact, spot prices reflect short-term availability while futures prices reflect market expectations of future developments. The differential or basis is, therefore, an indicator of market conditions.

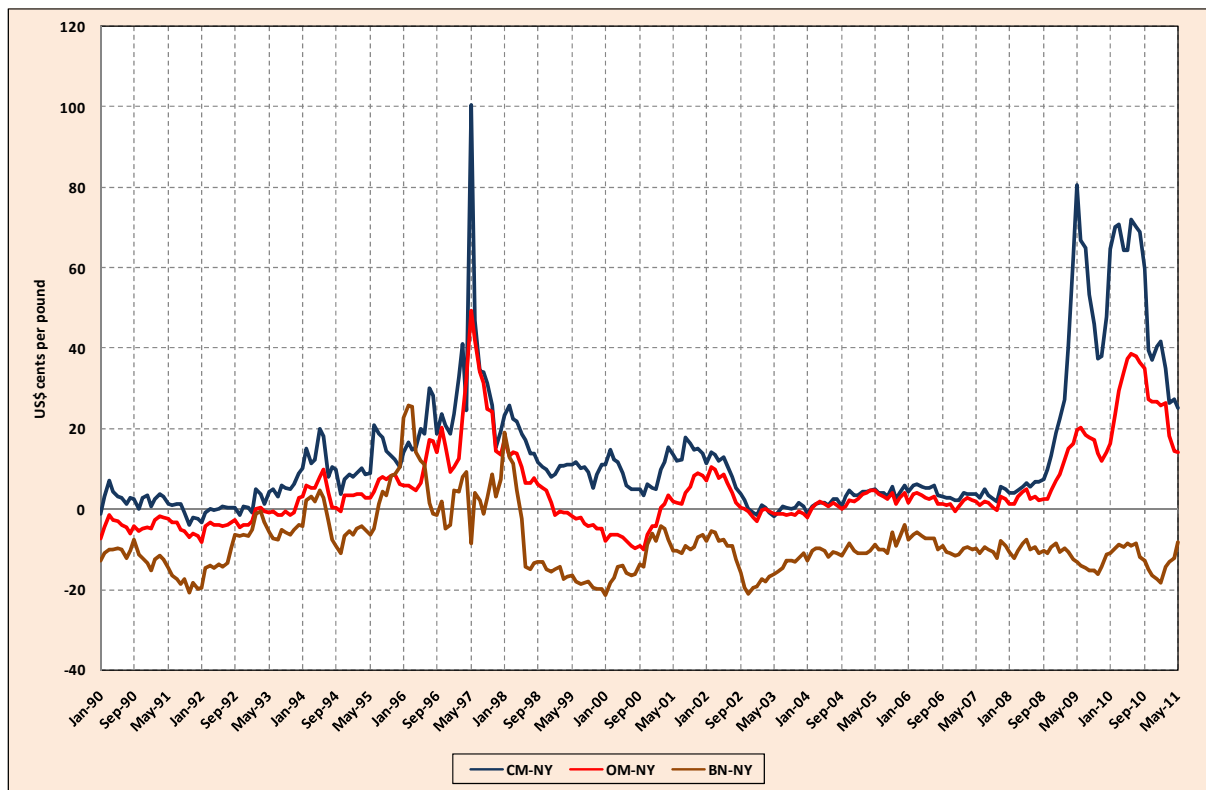
20. The basis is often used in the coffee trade to secure transactions on physical markets through the mechanism known as price-to-be-fixed. This is a system of contracts without immediately determining a price but by agreeing on relevant futures contract as reference against which a required quality of the coffee is paid with a premium or a discount, leaving the final price to be established at a later date. This type of transaction allows buyers to separate the physical movement of coffee from the financial decision of fixing its cost. Under this contract, the seller has an obligation to deliver and the buyer has an obligation to accept coffee of agreed quality, allowing both parties to continue playing the market.

21. The market is said to be in *backwardation* when the spot price is higher than the futures price. Backwardation occurs more frequently in situations of relative short-term supply shortages or when there is a shock which can considerably reduce supply and lead to a tight balance between the supply and demand for the physical commodity.

22. In the opposite case where the spot price is lower than the futures price the market is said to be in a *contango*. In theory the basis reflects the costs of warehousing, transport and variations in the quality of the underlying commodity. The contango situation is far more frequent in cases of surpluses in the physical markets. When there are sizeable stocks, transactions tend to go forward. The market will then cover part of the warehousing costs through the revaluation of futures prices.

23. Graph 7 shows the differential between Arabica spot prices and the New York futures market (ICE). Graph 8 shows the differential between the spot price for Robustas and the price in the London futures market (NYSE Euronext – Liffe).

Graph 7: Differential between Arabica spot prices and the New York futures market



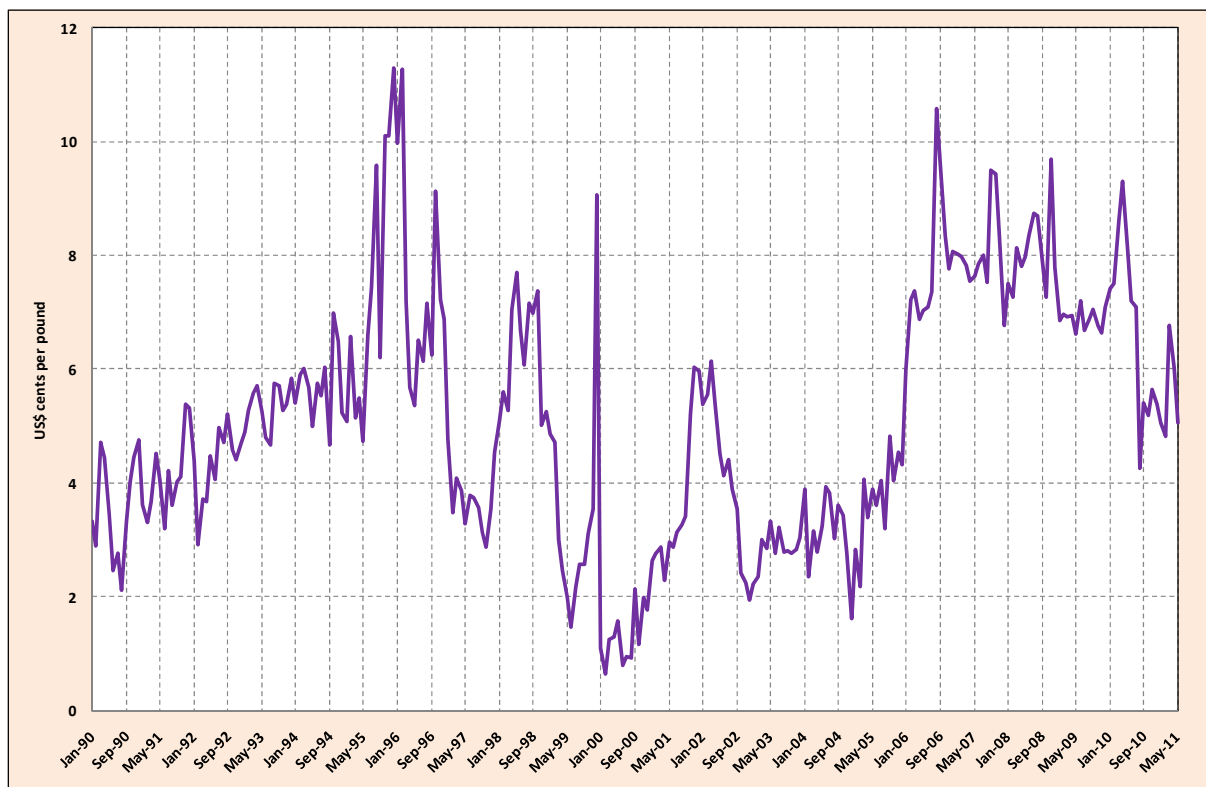
24. During the entire period from January 1990 to May 2011 the basis was mostly positive in the case of Colombian Milds with lengthy periods of positive differentials occasionally interrupted by negative differentials of short duration. In 257 monthly observations, there were only 11 observations of negative differentials, the last of which was recorded in January 2004. The differential reached a record level in May 1997 before declining once again. More specifically, it remained positive without interruption from February 2004 to May 2011, indicating a backwardation situation that reflected conditions of short supply in relation to demand. Developments in recent years indicate strong increases in the basis, particularly since September 2008.

25. In the case of Other Milds, the period was marked by the alternation between a lengthy contango period followed by a period of backwardation. Since February 2004, however, the market has remained in backwardation. The differential between spot and futures prices for washed Arabicas has widened considerably in the course of the last few years.

26. In the case of Brazilian Naturals, the basis has remained consistently negative since 1998, indicating a contango market. Since Brazilian Naturals are not deliverable against New York futures market contracts, this inversion is much more linked to quality in relation to deliverable origins. Deliverable origins for the New York futures market at the price of the futures contract are Costa Rica, El Salvador, Guatemala, Honduras, Kenya, Mexico, Nicaragua, Panama, Papua New Guinea, Peru, Tanzania and Uganda. Colombian coffee trades at a 200 point premium, whereas coffees from Burundi, India and Venezuela are deliverable at a 100 point discount, Rwanda at a 300 point discount, and the Dominican Republic and Ecuador at a 400 point discount. Washed Arabica coffee from Brazil will be deliverable from March 2013 onwards. During recent years the basis has remained relatively stable.

27. The Robustas basis remained positive during the entire period with levels moving within a relatively narrow range of between 0.65 to 10.30 US cents/lb. The spot prices refer to specific origins with characteristics that afford them premiums in relation to the London futures market. Nearly all Robusta origins, including Brazilian *Conillons* are deliverable on the London futures market.

Graph 8: Differential between Robusta spot prices and London futures market prices



IV.2 BASIS RISK

28. The strength of the relationship between spot and futures prices can determine whether the market for a particular commodity is speculative in nature or not. Effective hedging operations in futures markets depend on anticipating the basis. An empirical evaluation of volatility during the period under observation can be made, therefore, by determining volatility indices. The difference between spot and future prices recorded daily was used to determine the monthly volatility index, as well as the annual average. The method indicated below was used to measure the volatility index².

$$\text{Var}(B_t, B_{t-1}) = \text{Ln}(B_t/B_{t-1})$$

Var = variation in basis from one day to the next

B_t = basis at time t (Daily differential between spot price and futures price)

B_{t-1} = basis on previous day

Ln = Napierian logarithm

$$\sigma = \sqrt{\sum_{t=1}^N \text{Ln}(B_t/B_{t-1})}$$

N = number of days

σ = standard deviation for the month

$$\text{Volatility} = \sigma \times \sqrt{N}$$

29. Table 4 shows annual averages of volatility indices for the basis as well as averages for the period under observation. For the entire period from January 1990 to May 2011 the Other Milds group recorded the highest basis volatility index compared to the other coffee groups (140.9%). The volatility index for the Colombian Milds basis was also relatively high (107.3%). It may also be noted, however, that with the exception of Brazilian Naturals, the basis volatility increased in the case of the other coffee groups during the last decade (2000 to 2011) compared to the previous decade (1990 to 1999). In the case of Brazilian Naturals, despite occasional peaks there was a consolidation of the downward trend in the basis volatility index since 1998.

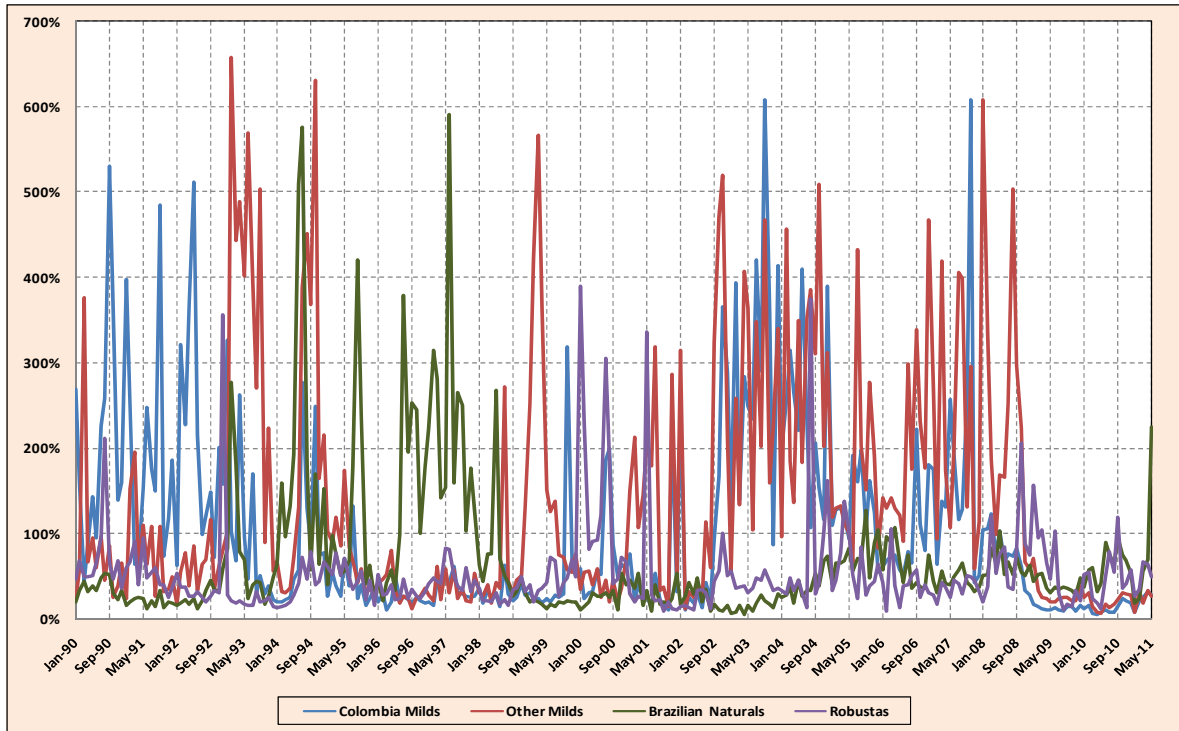
² Calculations of the volatility index based on other methods give slightly different results.

Table 4: Average of basis volatility indexes for ICO indicator prices and futures prices

	Colombia Milds	Other Milds	Brazilian Naturals	Robustas
1990	206.4%	86.4%	35.8%	71.2%
1991	197.4%	80.9%	19.3%	55.0%
1992	208.8%	61.4%	27.1%	59.1%
1993	104.0%	350.3%	76.9%	21.3%
1994	90.8%	216.1%	195.5%	40.4%
1995	44.2%	77.5%	112.4%	48.7%
1996	24.5%	35.7%	136.7%	32.4%
1997	34.1%	36.3%	231.6%	50.5%
1998	31.0%	64.2%	68.0%	28.2%
1999	55.6%	196.4%	18.0%	46.0%
2000	76.6%	43.2%	27.6%	122.3%
2001	46.8%	145.2%	29.4%	47.0%
2002	111.5%	179.4%	22.6%	34.9%
2003	301.6%	255.6%	14.9%	41.8%
2004	239.0%	290.3%	39.2%	79.0%
2005	131.6%	166.5%	72.9%	61.2%
2006	94.2%	203.9%	62.7%	41.3%
2007	180.5%	222.3%	43.9%	37.4%
2008	78.2%	247.0%	63.2%	76.5%
2009	13.1%	29.1%	38.3%	58.8%
2010	13.1%	20.4%	61.7%	50.3%
2011	23.3%	23.7%	78.0%	48.5%
Averages				
1990-2011	104.8%	137.8%	67.1%	52.4%
1990-99	99.7%	120.5%	92.1%	45.3%
2000-11	109.1%	152.2%	46.2%	58.3%

30. Graph 9 shows movements in the basis volatility index for each of the four groups of coffee. A highly volatile basis offers profit possibilities for speculators but increases the risk of commercial transactions. It should be noted that factors influencing the basis include the location of stocks, national or international supply conditions, demand, quality, transport and seasonality.

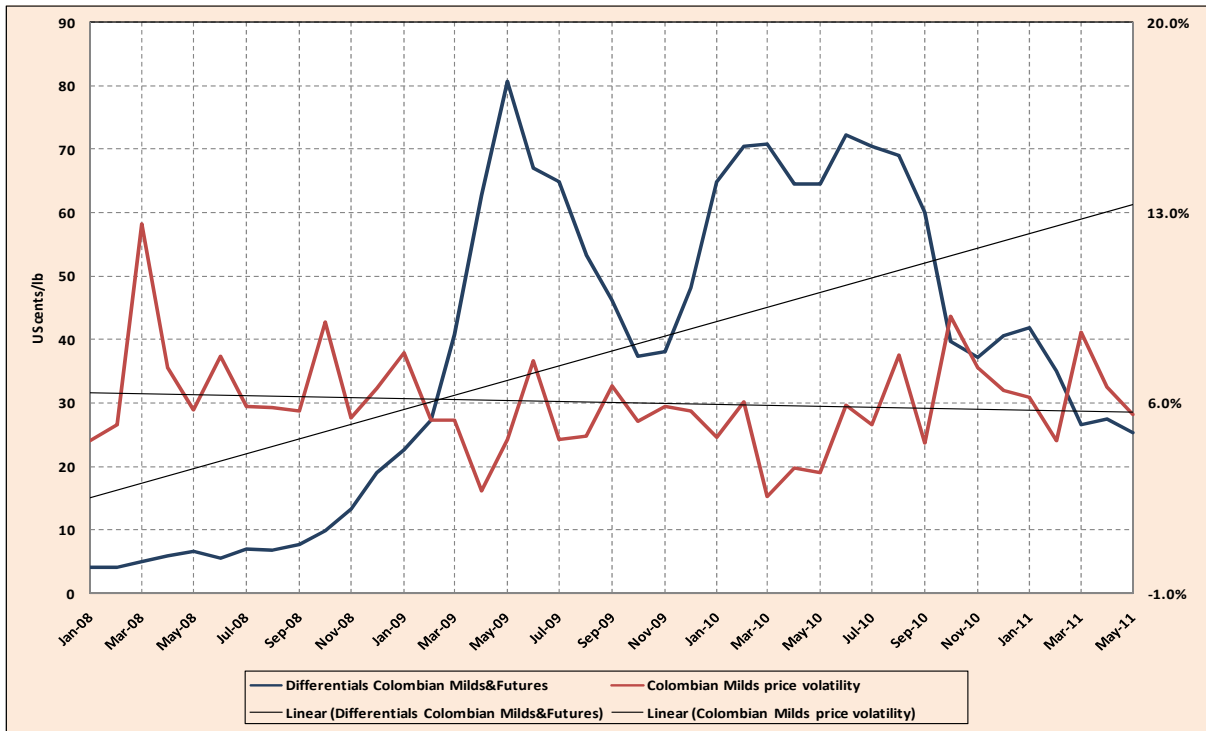
Graph 9: Volatility index for the four groups of coffee



IV.3 RECENT MOVEMENTS IN THE BASIS

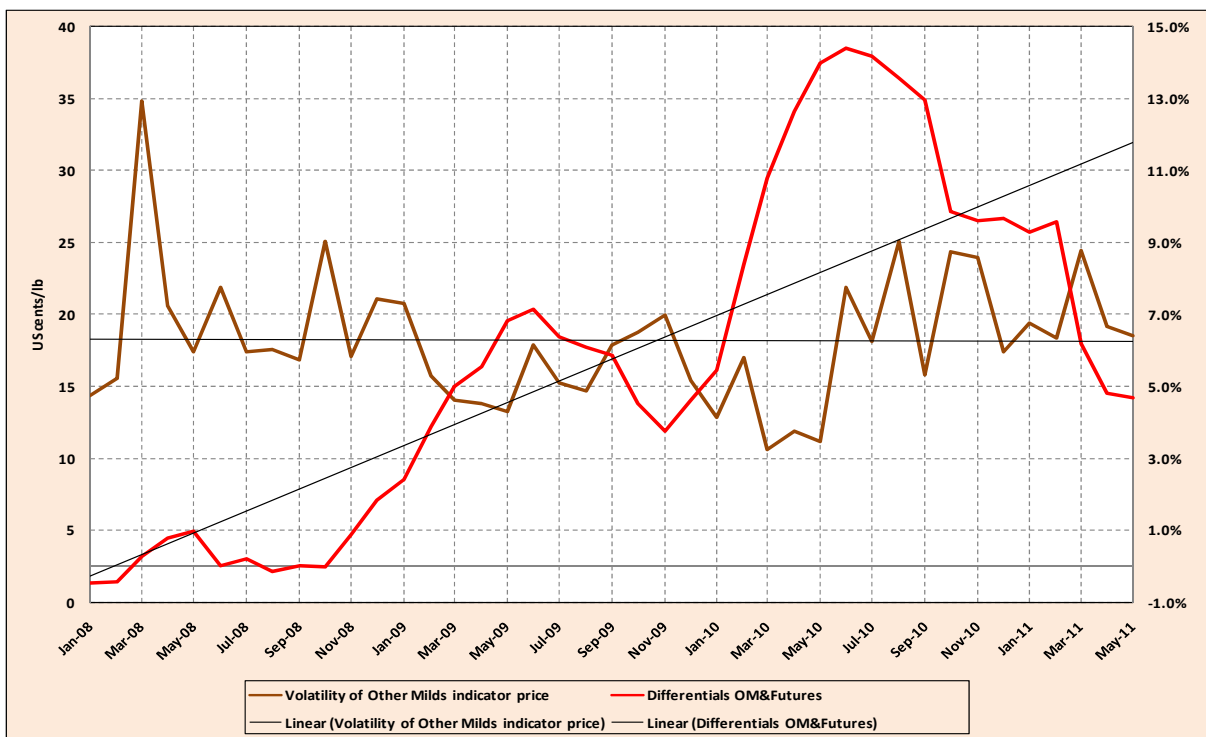
31. Observations for the period from 2008 to 2011 indicate high levels of the differential between indicator prices and New York futures market prices for washed Arabicas. More specifically, Colombian Milds recorded very high differential levels while the volatility index showed a downward trend (Graph 10). Short-term supply problems for this coffee group may explain this situation of very strong levels of backwardation.

Graph 10: Colombian Milds: Volatility index and differential with New York



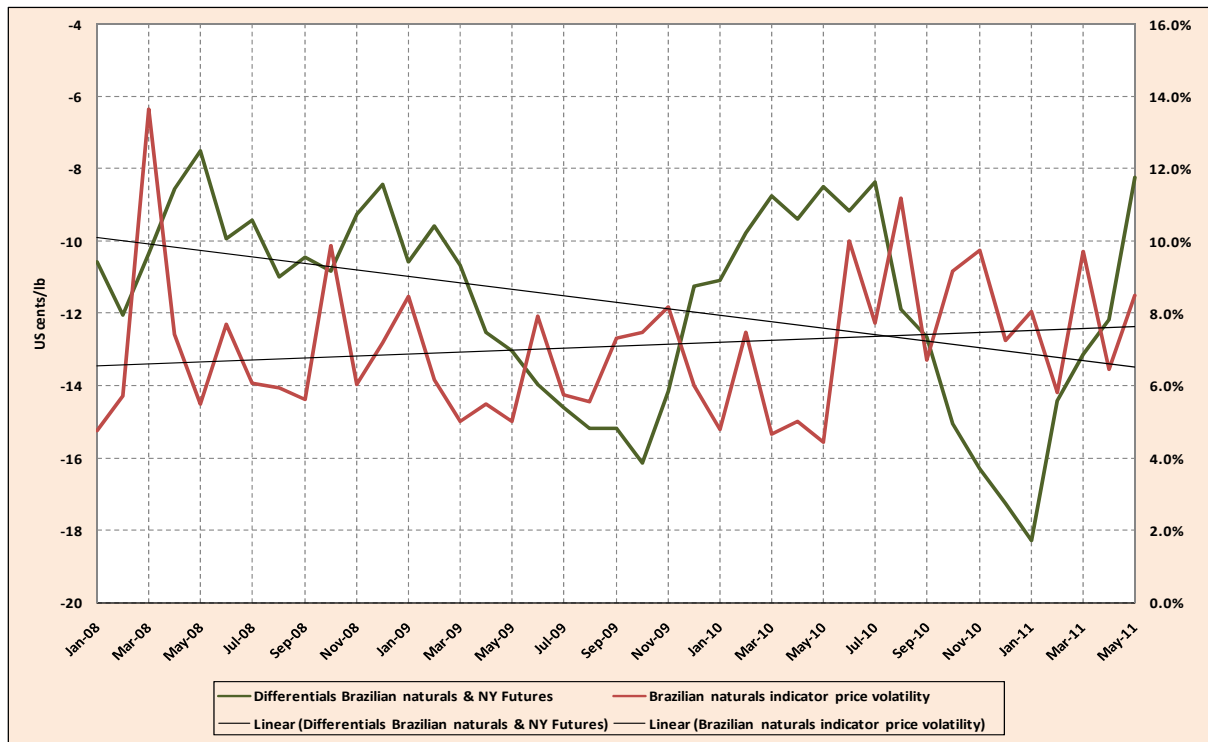
32. Other Milds were in the same situation but to a lesser extent since the differential increased considerably but volatility was relatively weak (Graph 11).

Graph 11: Other Milds: Volatility index and differential with New York



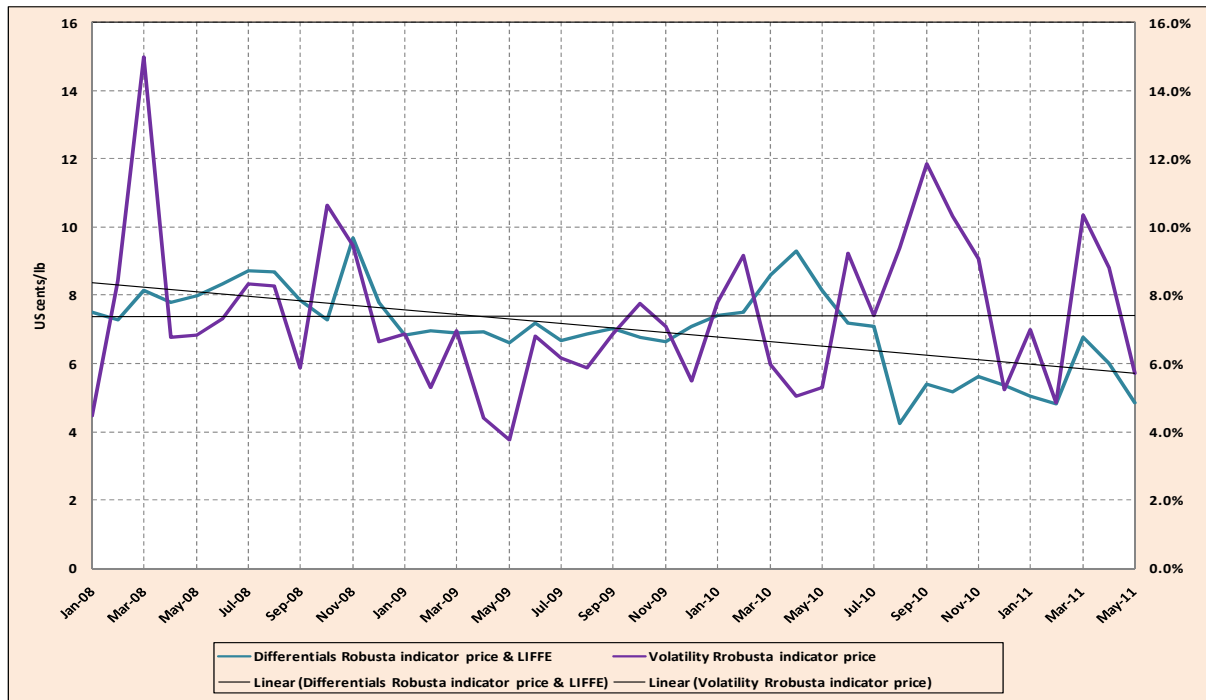
33. The differential for Brazilian Naturals fell during the period under consideration with a volatility index slightly down in relation to levels in previous years (Graph 12).

Graph 12: Brazilian Naturals: Volatility index and differential with New York



34. In the case of the Robusta price, which is continually in backwardation, the differential narrowed and volatility was less marked (Graph 13).

Graph 13: Robustas: Volatility index and differential with London



CONCLUSION

35. In conclusion, it should be noted that there was a strong correlation between spot prices and prices in the coffee futures markets. Moreover the two principal coffee futures markets are closely linked, which accounts for mutual influences in price movements. The differential between spot and futures prices, which serves as a basis for hedging and arbitrage operations is unstable and is therefore a source of risk. Changes in differentials are independent of price levels, which means that differentials can be very volatile even when prices are generally weak as was the case at the end of the 1990s.

36. Changes in the basis constitute the principal risk for coffee traders. Hedging does not guarantee that a gain or loss in the futures market will be completely offset by a loss or gain in the spot market.

37. Developments in the coffee markets indicate that washed Arabicas and, to a lesser extent, Robustas pose serious risks for hedging operations since their differentials are highly volatile, particularly during the period from 2000 to 2011. Furthermore, the volatility of ICO indicator prices has decreased in recent years although price differentials continue to be significant, particularly in the case of washed Arabicas deliverable on the New York futures market.