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ENERGY FINANCE
THE CASE OF DERIVATIVE MARKETS

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Since a few years, energy derivative markets rise at a tremendous rate. So are prices of energy commodities. Such sustained growths naturally give rise to questions. Should we be worried about such a development? Has it gone too far? Are derivatives markets really characterized by high leverage effect, opacity, liquidity problems? Do all these markets and transactions really respond to a need? Should we restrain the transactions of speculators on such markets, before they introduce an excess volatility, capable of destabilizing the underlying physical markets?

This chapter aims to propose answers to these questions, or part of an answer, whenever it is possible. It is focused on derivatives markets[2], and more specifically on energy derivative markets. In a first section, we give an overview of energy derivative markets today. It is very important to understand that, like every derivative markets, energy markets appeared when the need for protection against fluctuations in prices become really important. In the second section, we explain how energy derivative markets are organized today, and how this organization evolves since a few years. More precisely, there is a progressive fusion of organized and over-the-counter markets, which has a lot of consequences on their functioning. In the third section, we present the economic functions of derivative markets. Indeed, such markets do not only allow the management of prices risks. They also authorize speculation and arbitrage –it is important to know whether this is a good or a bad thing – price and volatility discovery – which is useful not only for market participants, but also for worldwide producers and consumers – and transactional efficiency – creating thus benchmarks that are used as a reference for many transactions. In the fourth section, we examine the influence of derivative markets on physical markets, systemic risk and we give our opinion concerning the idea that derivative markets might be intrinsically dangerous.

1. ENERGY DERIVATIVE MARKETS: AN OVERVIEW

In this section, we first present the historical background of energy derivative markets, from the creation of petroleum markets to electricity markets. Then we comment upon the recent evolution of these markets: their sustained growth – in volumes and in prices – and their introduction in asset portfolio management strategies. We also compare them with traditional financial assets.

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[2] Thus, we will talk about capital markets, i.e. markets aiming at raising funds.

1.1. The creation of derivative markets in the energy industry

The history of energy derivative markets is in line with the history of other derivatives instruments. Whatever the underlying asset is concerned, the same rule prevails: derivative markets are always created when the volatility on the physical asset appears, or becomes important.

Table 1, which summarizes the introduction dates of the most important derivative contracts on energy markets, gives a good illustration of that point. The first energy derivative instrument was launched in 1978, on a petroleum product. This is not by chance; indeed, at the end of the 1970s, the second petroleum shock definitively indicates the end of stability for petroleum prices. Moreover, on a petroleum product, there was no threat of an oligopoly's action, as could have been the case with crude oil.

The fear of volatility induced, during the next ten years, the creation of derivatives instruments for all important petroleum products, at first in the United States, then in Europe: crude oil, heating oil and gas oil. 1983 is an important milestone as the two futures contracts on crude oil are, in 2008, the two energy contracts that are the most intensively traded worldwide.

Table 1. Energy derivatives – key dates

Year	Futures contract's underlying asset	Exchange
1978	Heating oil	Nymex[3]
1981	Gas oil	IPE[4]
1983	Crude oil (West Texas Intermediate) Crude oil (Brent)	Nymex IPE
1984	Unleaded gasoline	Nymex
1987	Propane	Nymex
1990	Natural gas	Nymex
1996	Electricity	Nymex
1997	Natural gas	IPE
2001	Electricity	IPE
2001	Coal	Nymex
2007	Uranium	Nymex

Sources: Exchanges

The 1990s testify the apparition on derivative markets on electricity and natural gas. This corresponds to the period succeeding the deregulation of the underlying markets. The movement was once again initiated by the United States and followed a few years later by Europe. As 5 to 10 years are needed for a derivatives market to

[3] Nymex stands for New York Mercantile Exchange.
[4] IPE stands for International Petroleum Exchange.

mature, it is not sure, today, that the coal and uranium futures markets will survive.

1.2. The recent evolution of energy derivative markets

The growth rate of energy derivative markets is tremendous. In 2006, transactions on energy futures markets progressed at a rate of 37.8%. This is the second highest rate recorded worldwide on organized markets, whatever the underlying asset is considered. With a 43.6% of rise recorded in the activity on futures markets, currencies are at the first place[5]. The third and fourth places are occupied by, respectively agriculture commodity products (+28.4%) and metals (+27.8%).

Among energy derivatives, crude oil stands at a specific place. As shown by Table 2, the futures contracts on crude oil negotiated on the Nymex are at a first place worldwide, with 71.05 millions contracts exchanged in 2006. If we add the 28.67 millions contracts negotiated on the Intercontinental Exchange (Ice), the transactions volume turns into 99.62 millions! Let us remind that the volume of this futures contract is 1 000 barrels… Moreover other energy derivative instruments occupy the 4th, 8th, 10th, 11th, 14th, 15th, 17th places: energy derivative instruments are thus very important in the commodity futures industry. Last but not least, futures contracts on electricity do not appear in Table 2.

Table 2. Top 20 Commodity Contracts in 2006 (in millions)

Rank	Contract	2006	2005	% change
1	WTI Crude Oil Futures, Nymex	71.05	59.65	19.12
2	Corn Futures, DCE	64.98	21.86	197.24
3	Corn Futures, CBOT	47.24	27.97	68.92
4	Brent Crude Oil Futures, Ice Futures	44.35	30.41	45.82
5	High Grade Primary Aluminium, LME	36.42	30.43	19.69
6	Soy Meal Futures, DCE	31.55	36.74	-14.12
7	White Sugar Futures, ZCE	29.34	**	NA
8	WTI Crude Oil Futures, Ice Futures	28.67	**	NA
9	Rubber Futures, SHFE	26.05	9.50	174.09
10	Henry Hub Swap Futures, Nymex	24.16	10.41	132.14
11	Natural Gas Futures, Nymex	23.03	19.14	20.31
12	Soybean Futures, CBOT	22.65	20.22	12.03
13	Gold Futures, Tocom	22.23	17.96	23.78
14	WTI Crude Oil Options, Nymex	21.02	14.73	42.71
15	Natural Gas Options, Nymex	19.52	6.97	180.06
16	Copper Futures, LME	18.87	19.23	-1.91
17	Gas Oil Futures, Ice Futures	18.29	10.97	66.70
18	Wheat Futures, CBOT	16.22	10.11	60.42
19	Gold Futures, Nymex Comex Division	15.92	15.89	0.17
20	Sugar #11 Futures, Nybot	15.10	13.01	16.10

[5] This extremely high progression level is mainly due to a reorganization of the market, which is similar to the changes observed in energy markets (see section 2 for more details on that point).

*** Introduced in 2006*
Source : Futures Industry Association

Another important feature of energy derivative markets is their volatility. As Table 3 illustrates it, commodities at large appear as more volatile than traditional financial markets (with the exception of the interest rate on the Japanese currency) and, among commodities, natural gas and crude oil record the highest prices fluctuations.

Table 3. Volatility Comparison (annualized volatility, in %)

Market	2005	2006
Interest Rates (money market)		
Eurodollar	14.4	10.3
Euribor	13.6	10.7
Euroyen	53.0	56.6
Interest Rates (government bonds)		
10-year Treasury notes (US)	04.5	03.8
Bunds (Germany)	03.8	03.8
Japanese Government Bonds	02.9	03.6
Equity		
S&P500	10.0	09.7
Euro Stoxx 50	11.0	14.4
Topix	13.7	18.9
Foreign Currencies		
British Pound	08.2	07.6
Euro	08.8	07.2
Japanese Yen	08.5	08.0
Commodities		
Crude oil	31.6	26.4
Natural gas	48.6	62.2
Wheat	24.6	29.5
Corn	24.2	28.3
Copper	24.0	38.5
Aluminium	19.7	32.2

Sources: Futures Industry Association & Calyon Financial

These different characteristics, combined with a sustained rise in the prices of the underlying physical markets, explain why energy derivative markets have been at the centre of attention since a few years. Recently, these markets have attracted new operators, like hedge funds or institutional investors. This is not a real surprise: the majority of energy markets are now mature: they can be considered as free of liquidity problems, at least on the shortest delivery dates (for more detail on that point, see section 4). This is precisely the kind of markets that speculators best appreciate. Nowadays, these markets are even considered as a new asset class for portfolio management which, as we will see a bit later, might create some difficulties.

To complete this overview, let us however remind that, among derivatives at large, the energy futures markets still occupy a very modest place, as Table 4 states it.

Table 4. Global Futures and Options Volume (in millions)

	2006	**2005**	**% Change**
Equity Indices	4,453.95	4,080.33	09.16
Interest Rates	3,193.44	2,536.77	25.89
Individual Equities	2,876.49	2,356.87	22.05
Currency	240.05	167.19	43.59
Agriculturals	486.37	378.90	28.37
Energies	385.97	280.13	37.78
Metals	218.68	171.06	27.84
Other	4.31	2.59	66.69
Total	11,859.27	9,973.82	18.90

Source: Futures Industry Association

Even with a tremendous growth rate, energy derivatives are far less important, in the futures industry, than interest rates or equities. Moreover, as the gap between these different classes of asset is very high, energy derivative will stay for a long time at this place.

2. The organization of energy derivative markets

A first step towards the understanding of energy derivatives markets' functioning is to explain what a derivative is. Then, it is important to make a distinction – at least at first – between organized and over-the-counter (OTC) markets. Once this distinction has been established, it will be possible to explain what happens today in derivative markets: the progressive fusion of organized and over-the-counter markets. This evolution began in energy derivative markets. Step by step, this movement spreads over the other underlying assets and transforms the organization of all derivative markets.

2.1. What is a derivative product?

Derivatives instruments are financial contracts whose price is *derived* from that of an underlying asset such as exchange rate, interest rate, credit risk or commodity. The nature of the underlying asset may be very various. More precisely, the underlying asset may not be a physical or a financial or even a traded asset. Indeed, financial markets have recently witnessed, for example, the apparition of derivatives markets on climate, or credit risk. Another interesting point is that the underlying asset may be… another derivative product! This kind of construction is widespread in energy derivative markets where the underlying asset of options – a specific category of derivative instruments – is very often a futures contract, namely another derivative product. Such a phenomenon naturally nourishes the fear of a systemic risk in derivative markets, the latter being viewed as Russian dolls.

Once this general presentation has been made, what are the most commonly used derivative instruments? The answer is: forward, futures, swaps and options.

A forward contract is a private agreement negotiated between two counterparts. It aims to exchange a given quantity of the underlying asset – let us say, for example, 100,000 barrels of crude oil – in a fixed point in the future. Such a contract defines: the volume of the merchandise, its quality, its delivery place, its delivery date and the forward price of the transaction. The latter generally leads to a physical delivery and is traded on the OTC market.

Futures contracts are the most important energy derivative products. They may be defined as standardized forward contracts. The former are negotiated in organized markets, whereas the latter are used in over-the-counter markets. The standardization concerns each characteristic of the transaction except for its price (which is a futures price). The degree of standardization is usually extremely high (see Box 1 for an illustration on the American crude oil futures contract). This rigidity in the specifications of the futures contract is compensated by facilitating its transfer between different counterparts and avoiding the problems of liquidity and delivery (the latter are quite frequent with forward contracts). A consequence of the standardization is that the transactions on futures contracts rarely lead to a physical delivery. Futures contracts are purely financial instruments.

Box 1. The standardization of the American crude oil futures contract:
The light sweet crude oil contract[6]

● **Trading unit**: 1,000 US barrels (42,000 gallons)

● **Price Quotation**: U.S. dollars and cents per barrel

● **Trading hours**:

Open outcry trading is conducted from 10:00 AM until 2:30 PM.

Electronic trading is conducted from 6:00 PM until 5:15 PM via the CME Globex® trading platform, Sunday through Friday. There is a 45-minute break each day between 5:15PM (current trade date) and 6:00 PM (next trade date).

● **Trading months**:

The current year and the next nine years. A new calendar year will be added following the termination of trading in the December contract of the current year

● […]

● **Delivery**:

F.O.B. seller's facility, Cushing, Oklahoma, at any pipeline or storage facility with pipeline access to TEPPCO, Cushing storage, or Equilon Pipeline Co., by in-tank transfer, in-line transfer, book-out, or inter-facility transfer (pumpover).

[6] Extracted from the characteristics of the futures contract on Light Sweet Crude Oil, Nymex Mercantile Exchange.

● **Deliverable grades:**
Specific domestic crudes with 0.42% sulfur by weight or less, not less than 37° API gravity nor more than 42° API gravity.
The following domestic crude streams are deliverable: West Texas Intermediate, Low Sweet Mix, New Mexican Sweet, North Texas Sweet, Oklahoma Sweet, South Texas Sweet. Specific foreign crudes of not less than 34° API nor more than 42° API.
The following foreign streams are deliverable: U.K. Brent and Forties, for which the seller shall receive a 30 cent per barrel discount below the final settlement price; Norwegian Oseberg Blend is delivered at a 55¢–per–barrel discount; Nigerian Bonny Light, Qua Iboe, and Colombian Cusiana are delivered at 15¢ premiums.

Swaps are the most important derivative products: they reassemble at least 50% of the total transactions on OTC derivatives worldwide, whatever the underlying asset is considered. Swaps are also private agreements negotiated between two counterparts. They lead to the exchange of floating and fixed prices, at regular intervals. Thus, there is no physical delivery with a swap. Most of the time, these instruments are used for a long-term horizon. For example, in the gas market, one has witnessed swaps for a 20 years commitment. Lastly, swaps may be considered, on a financial point of view (i.e. for valuation purposes) as portfolios of forward contracts. The former insure a protection against a recurrent price's risk, whereas the latter are particularly useful when hedging a punctual risk.

Contrary to forward, futures and swaps, options give the right and not the obligation to buy (call option) or sell (put option) the underlying asset. This right may be used at or before a specified expiration date and at a fixed price, which is usually called the strike. As a result of the flexibility associated to the right given by the option, this instrument is more costly than are firm derivatives like futures and forward contracts. Options are also fundamentally asymmetrical assets: whereas the buyer of the option has a right, the seller undertakes an obligation; moreover, the value of the option is nonlinear, at it corresponds to the maximum value of zero (when the right is not used) and a positive value. Lastly, options may be traded as well on organized markets as on OTC markets.

2.2. Organized versus over-the-counter markets

Derivative markets can be separated into two different but complementary categories: organized and over the counter markets. This distinction must be clearly understood, before the time when we will say that it now disappears, because it gives a very useful tool to deal with the new complexity of the organization of energy derivative markets.

2.2.1. Organized markets and exchange-traded derivatives

Organized markets are generally characterized by their centralization around a commercial exchange, where all trade occur (this characteristic becomes nowadays less important as electronic trading and quotation grow in importance). They are also characterised by the presence of a clearing house.

The clearing house fulfils two economic functions: the management of credit risk trough the mechanism of initial margin and margin calls (see Box 2) and the management of market's liquidity trough the centralization of the transactions. Liquidity is also insured, as mentioned before, by the extreme standardization of the contracts. Thus, on organized markets, it is easy to find a counterpart. The owner of a futures contract will always be able to sell it easily and quickly – which is not the case for a forward contract.

A last characteristic of futures markets is their transparency: prices are free and publicly available, immediately. This is why an economic function fulfilled by organized market is, as we will see a bit later, price discovery.

Box 2. The management of credit risk through initial margin and margin calls

Initial margin and margin calls are tools used by the clearing house in order to insure the management of credit risk in the commercial exchange.

Margin calls aim to prevent a participant from accumulating day after day a financial loss and from becoming unable to fulfil his financial commitments. The clearing house determines every day, at the end of the transactions session, the settlement price that will be used for the valuation of all existing positions in the market. If, on the basis of this settlement price, a participant has loosed some money since the previous day, he will have to pay to the clearing house the difference between the present and former values of his position: he is "called at the margin". This money will go to the participants whose positions' value increased since the previous day (this illustrates the fact that the markets are zero sum games).

Each day, the transactions on the exchange can begin only once all margin calls are paid. Otherwise, where a participant unable to fulfil his commitment, he would be pushed out of the market. In such a situation, the clearing house uses the initial margin in order to compensate for his losses. Thus, the initial margin is an amount of money[7] which aims to cover the maximal loss an operator may encounter during one day on the exchange. Every participant, buyer or seller, has to make an initial margin. The level of the initial margin, which is determined by the clearing house, represents approximately 1 to 10% of the value of the exchanged contracts[8].

The management of credit risk by the clearing house induces administrative and financial costs for all participants: indeed, they must follow, day after day, the value of their position on the market, and they have to manage daily the cash flows associated with the margin calls. As a

[7] Most of the time, the initial margin is not paid cash. It corresponds to Treasury Bonds, or to a credit line.

[8] Thus, transactions on derivative markets induce a leverage effect, as there is a need to invest only 1 to 10% of the value of the position. However, if the level of initial margin which is necessary to manage the credit risk is correctly appreciated by the clearing house, this should endanger the functioning of the market.

consequence, some of the operators may prefer, at least for a certain proportion of their activity, the use of the OTC market. Thus, organized and over-the-counter markets are more complementary than competing forms of organization.

2.2.2. Over-the-counter (OTC) markets

In over-the-counter markets, contracts are entered into through private negotiation. These markets may be considered as decentralized networks of participants, as there is no clearing house. In the absence of an institution collecting all orders – and prices – OTC markets are quite opaque (which does not mean that they do not perform well).

Instruments negotiated on OTC markets closely match the needs of hedgers. The absence of standardization gives the possibility to ensure a perfect hedge. It also contributes to the opacity of the market, because instruments and prices are not easily comparables. Moreover, as OTC contracts are specific, the liquidity is low in such markets: whenever the buyer of a hedge revises his mind and decides that he no longer needs his protection, he must most of the time sell the contract back to the financial institution which formerly sold it to him. When the product is complex and specific, the negotiation can turn at the advantage of the financial institution, because the competition is not very high on such products.

The absence of a clearing house also signifies that the participants must manage themselves the credit risk associated to their transactions. Each operator is indeed exposed to the risk that his counterpart defaults. The longer is the maturity of the commitment, the higher is the risk. Thus mutual confidence becomes very important. Quite often, the market participants know each others, and they are far less numerous than in organized markets[9].

OTC markets are thus different from organized markets, as Table 5 summarizes it. They are not substitute from each others: the former are particularly useful for industrials looking for a perfect protection against prices risks, whereas the latter are especially important for professionals offering a protection in OTC markets, and seeking for a tool in order to cover their residual risk.

[9] On the currency market, which is the second most important OTC market worldwide (after interest rates), the five most important operators represent more than 60% of the transactions in 2007.

Table 5. Futures versus OTC transactions

	Futures transactions	**OTC transactions**
Standardization	Extreme	Non-existent
Physical delivery	Exceptional	Normal
Liquidity	High	Almost null
Funds required	Initial margin and margin calls	No required funds
Hedge	Imperfect Costless Reversible	Perfect Costly Non-reversible

2.3. The new frontier in derivative markets

Recently, the "landscape" of derivative markets became more complex, especially in the energy field. More precisely, the frontier between organized and OTC markets has become permeable. The reason explaining such an evolution is that operators are more and more concerned about credit risk. In the energy field, the move towards a relative integration of OTC and organized markets has been initiated by the Intercontinental Exchange (Ice). The latter gained in importance after Enron's bankruptcy when it first proposed to the participants of the energy markets an activity of electronic brokerage.

As OTC markets are decentralized, the brokerage activity is essential because it conveys information. The presence of brokers improves the efficiency of the markets simply by facilitating the matching of demand and supply. During a long time, brokerage was undertaken by phone. Nowadays, however, men are replaced by electronic platforms.

An electronic brokerage system is especially efficient in a market when the negotiated instruments are somehow comparable (in other words, as soon as some kind of standardization appears). On energy markets some OTC derivatives, like forward dated Brent or swaps, were quite standardized before Ice' apparition. In such a situation, it becomes very interesting, at least for hedgers, to compare the different prices offered by financial institutions; an electronic platform significantly enhances the possibility to compare prices. It is virtually not limited in the information it conveys and gives real time information. Thus Ice naturally imposed itself as an actor that must be addressed in energy markets.

While becoming essential in the energy OTC markets, Ice bought the most important organized market on energy instruments in Europe: the International Petroleum Exchange (Ipe). Consequently, Ice was very quickly a very important participant of the European energy markets, whatever their organization is concerned. Having acquired, through the purchase of the Ipe, the skills and knowledge of a clearing house, there was one more step to overcome: to give the possibility to manage, through the clearing house, the credit risk associated to OTC derivatives.

Today, Ice gives indeed the possibility to negotiate “cleared OTC derivatives”. The management of credit risk relies on initial margins and margin calls, on the basis of a valuation model which is chosen by the clearing house and which depends, naturally, on the specific derivative instrument under consideration.

Such a system introduces a great flexibility for the participants of the market. Indeed, they have now four possibilities. The first consists in choosing a pure OTC product. This may be interesting when the risk to hedge is very complicated, or when the confidentiality of the deal must be preserved[10]. The second possibility is the choice of an OTC product which is proposed on the electronic brokerage system. This may be interesting when the risk to hedge is rather standard, stimulating thus the competition between several financial institutions. Third possibility: retaining a cleared OTC product. Such a choice is interesting when there is not enough mutual confidence between the two counterparts as far as the credit risk is concerned. It entails, however, financial and administrative costs due to the initial margin and margin costs. Lastly, it is also possible to trade on the basis of pure futures contracts, which are very liquid.

Thus, since the beginning of the XXI° century, the organization of energy derivative markets has dramatically changed. The different segments of the markets are now much more interlinked that a few years ago. Naturally, such an evolution raises the question of systemic risk. We will answer that question a bit later, in the end of this chapter.

3. The economic functions of derivative markets

Derivative markets: what are they done for? If their first function is the management of prices risk, they also authorize speculation and arbitrage, price and volatility discovery, and transactional efficiency.

3.1. Risk management

As mentioned previously, derivative markets are created when there is volatility on the underlying asset. Their main function is to insure a protection against the price fluctuations of the underlying asset[11]. Hedgers are usually willing to pay for such a service. Their transactions on derivative markets do not aim to create a profit.

In derivative markets, the risk is managed in a specific way, by transferring it through different categories of participants. Usually, indeed, hedgers transfer their risk to those willing to assume it. Consequently, risk is not pooled as in insurance. Nor is it

[10] Even if Ice does not act as broker or as a clearing house in this part of the market, it is still active: indeed, it proposes an electronic system which authorizes a very rapid and efficient way to confirm the trades on pure OTC products.

[11] Thus, derivative markets are not capital markets. Their first function is not to raise funds. The explanation of the initial margin mechanism (see box n°2) also explains that derivative markets obviously can do a very poor job in recycling petrodollars.

diversified, as in portfolio management. Transferring the risk implies to reallocate it between operators. It never means that risk disappears. When somebody earns some money in the market, somebody else looses: derivative markets are zero sum games, and they should not be compared with casinos.

Frequently, risk is not only transferred from a hedger to another participant of the market. Through standardization and the very high liquidity of the market, when a hedger gets rid of his risk, the latter is “sliced” into small parts, and it is assumed by several persons. This possibility to distribute the risk among several operators explains why the volume of transactions recorded on derivative markets may by far more important than the quantities produced on the physical market. This is neither a problem, nor the sign of a poor functioning of the market. On the contrary, the possibility to share the risk with numerous counterparts can reduce the price to pay to obtain a protection against prices fluctuations on the underlying asset. Naturally, when there is a possibility to distribute the risk among several operators, it is not always easy – especially on “pure” OTC markets – to know where the risk is and who handles it.

3.2. Speculation and arbitrage

As mentioned before, hedging does not aim to earn money. Conversely, the profit is the explicit objective of speculation. This should not be a surprise: speculators take on the risks that hedgers wish to avoid. Thus, they ask for a remuneration of the service that they offer; and this service is essential. One could think that there is no need to speculators as, in a derivative market hedgers looking for a protection against a fall in prices are facing hedgers looking for a protection against a rise in prices. The trouble is, if they understand correctly the functioning of the physical market, these two kinds of hedgers will have the same kind of expectations concerning the future evolution of the prices; and when all the market thinks that there will be a rise in prices, hedgers looking for a protection against a fall vanish… This is the reason why there is a need for speculators.

It is also important that speculators are numerous in a derivative market, in order to “slice” the risk into several parts. A speculator indeed “bets” that the market as a whole is wrong, a least on a very short horizon of time. Whenever its bet reveals that it was wrong, the speculator must have the possibility to quit the market very quickly: he is not strong enough to fight against the rest of the participants. Meanwhile, he will leave the place to another short term bet on a small part of the risk, undertaken by another speculator.

Thus speculators earn money while allowing the hedger to find a protection against price fluctuations. They have a critical function.

Arbitrage also aims to make a profit. However, it does it on a different way. Arbitrage indeed exploits what is usually referred to as an “abnormal situation”, on an economic point of view. Such an abnormal situation may be due to an unexpected event having a strong impact on prices. As arbitrage is not supposed to be risky (another difference with speculation), the possibility to make a risk-less profit attracts a lot of operators and the abnormal situation disappears. Thus, the presence of arbitragers in a derivative market is also very important because they insure, among other things, that prices on derivative markets remain linked with the prices of the underlying asset. In other words, arbitragers allow for the convergence of derivatives and physical markets … and for stronger links between markets (see Box 3 for more details).

Naturally, things are not so simple. Hedging, speculation and arbitrage are not as separated concepts as they may appear in the preceding lines. Sometimes hedging can turn into speculation, for example when a hedger renounce to his hedge on a futures contract in order to benefit from a favourable evolution in prices. In certain situation, arbitrage can also turn into speculation. And these changes render very difficult the study of hedging, speculation and arbitrage.

Box 3. The role of arbitrage in the convergence between the physical and financial markets

In every futures market, even if this is exceptional, it is always possible to deliver the underlying asset at the expiration of the futures contracts. This possibility, associated with arbitrage operations, insure that there is no disconnection between the financial and the physical markets. Let us illustrate this point with an example.

Suppose that, a few days before delivery, the price on the spot market is 140, and that the futures prices of the contract reaching its expiration dates is 150. In such a situation, an arbitrager may buy spot the merchandise and simultaneously sell it on the futures market. Meanwhile, he announces to the clearing house that he will deliver the physical product at expiration. Doing so, the arbitrager earns 10 (minus the costs associated to the delivery of the merchandise: transport, storage during a few days, etc). Because this operation is profitable and risk-less, there is an incentive for all the participants to do the same thing. Thus, the physical price rises under the pressure of arbitragers buying the merchandise, while, as a result of sales, the futures prices diminishes. Arbitrage operations insure the convergence between the physical and financial markets. They stop only when their profit does not exceed their costs anymore.

3.3. Price discovery

A third important function of derivative markets is price discovery[12]. Derivative markets (especially futures markets) indeed give the possibility to obtain information on prices for different maturities. In futures markets, this information is publicly available and free. Moreover, as futures contracts are standardized, prices are comparable. Last

[12] On the information role of futures markets, one may consult, for example, Grossman, 1977.

but not least, they are reliable, as these markets are characterized by an important transactions' volume[13].

The information conveyed by futures prices is important because they represent an expectation of the value of the future spot price at the delivery date T, conditionally to the current available information (at t, for example). Naturally, information concerning the market will change between the present date and delivery, and these changes are all the more significant that the distance between these two dates is important. Still, futures prices are considered as the best estimators of future spot prices.

Because futures markets fulfil this informational role, they allow for spatial and inter-temporal allocation of resources.

The role of futures markets in spatial allocation may be illustrated by the crude oil market. There are two important futures contracts in the case of crude oil: the Light Sweet Crude Oil and the Brent futures contracts. Prices of the former stand for the American market, whereas the latter is representative of the European market. Usually, the spread between the two futures contracts represents two dollars per barrel. When this spread rises, it becomes interesting to reallocate some tankers from Europe to United States, for example.

The role of futures markets in the inter-temporal allocation of resources comes from the fact that several futures contracts for different delivery dates are simultaneously traded. The relationship between futures prices for different delivery dates is usually referred to as the term structure of futures prices or as the prices curve. The latter may be monotonically increasing, decreasing. It may also sunken or dumped, for example. All these shapes give information on the way to correctly hedge positions that are hold on the physical market. More over, there give also guidelines for production, transformation, storage and even – in certain specific cases, in particular when the maturity of the longer futures contract is important – for investment decisions. For example, when the nearest futures prices are lower than longer one – then, the market is in contango – there is an incentive for the participants of the physical market to buy the merchandise in order to constitute physical stocks. When, conversely, the prices curve is decreasing, the market is in backwardation, and the operators are prompted to sell their inventories.

Thus, futures prices motivate financial operations, like hedging, speculation and arbitrage, but also industrial operations. This is one of the reasons why one may think about derivative markets as a way to stabilize prices in the physical market through optimal production decisions. Thus, prices established in futures markets are very important because they are used by producers, industrials and consumers. And more importantly, as futures prices give a reference to trade quality differentials, they are also used by those, throughout the world, that are not directly involved in the exchange, but concerned by the underlying asset.

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[13] Moreover, in over-the-counter markets, prices reporting mechanism does not force the operators to disclose their transactions prices.

3.4. Volatility discovery

Provided that there are options traded in the exchange, the informational role of derivative markets extends itself to volatility. The latter is the main determinant of options prices. It is so important that options markets are usually referred to as volatility markets.

There are several possible definitions of volatility. The most well-known is historical volatility, which is computed on the basis of the fluctuation of past prices on a certain period of time. In the presence of actively traded options, there is a possibility to compute another kind of volatility, usually called implied volatility. The latter is the standard deviation which equates the market price and the theoretical price of the option derived from a model. Whereas historical volatility incorporates solely past prices, implied volatility discloses operators' expectations on future volatility (conditionally to the available current information). This information is very important as it gives an estimation of the (past and future) risks associated to the positions hold in the market.

3.5. Transactional efficiency

The last important function of futures market is the reduction of transaction costs. Futures markets give a direct and free access to competitive trading, insuring reliable prices. Meanwhile, they create benchmarks that are used as a reference to trade over the counter transactions and quality differentials. The existence of such benchmarks reduces transaction costs.

4. SHOULD WE BE WORRIED ABOUT THE DEVELOPMENT OF ENERGY DERIVATIVE MARKETS?

The sustained development of derivative markets and their complexity entertains certain fears and raises interrogations. Among them, it is possible to quote the influence of derivative markets on physical markets, the systemic risk, and the worry that derivative markets might be intrinsically dangerous.

4.1. The influence of the derivative markets on the physical markets

A recurrent question about derivative markets is whether their presence creates volatility in excess on physical markets[14]. Where it the case, it would be a real problem, because derivative markets are supposed to be an answer to, and not a source of volatility on the physical market.

One may consider that derivative markets create some volatility in excess, because they allow for very rapid and easy trades. The standardization of futures

[14] Mayhew (2000) proposes a quite extensive literature review on that subject.

contracts, the presence of a clearing house, and the possibility – with electronic platforms – to trade at every hour of the day, indeed gives the possibility to immediately react to information affecting the market of the underlying asset. Moreover, derivatives market allows for noise trading, *i.e.* disturbing actions of operators taking advantage of the existence of such a market to speculate more easily, without special concern for the underlying asset. If that point of view is retained, chances are high that there is an increase of volatility due to the presence of a derivative market. However, this is not a real problem if this volatility is mostly an intra-day one, reflecting the promotion of informative signals and the redistribution of risk between different categories of operators which are more or less risk averse.

More important is the long run volatility (on a monthly, weekly, or even daily basis). This phenomenon may be investigated when a new derivative market – ie futures contracts – is created on a specific underlying asset. Such an introduction gives an occasion to compare prices volatility before and after the creation of the derivative market. Empirical studies on this question[15] usually lead to the conclusion that an abnormal volatility is observed just after the introduction. However, this abnormal volatility disappears quickly, and subsequent introductions of other derivatives – like options, for example – seem to have no effect. Moreover, several studies have examined the influence of derivatives trading on the depth and liquidity of the underlying market. Their analysis reveals quite often a strong inverse relationship between the open interest[16] in futures contracts and the spot market's volatility. This finding indicates that the futures market provides depth and liquidity to the crude oil market.

Another and more important question is whether on the long run, derivative markets become nowadays more volatile, more speculative than before? This question gained in importance during the last decade, as a result of the intensified presence of certain categories of investors such as hedge funds. The untimely and heavy interventions of these actors, using commodity markets for diversification purposes, and considering commodity as a new class of asset, could indeed have an impact on the prices.

The presence of such operators may indeed be disturbing because their transactions do not always depend on information related to commodities: they could also arise from a sudden change in the stock or bond markets, for example. Thus, if these speculators invest a lot of money in commodity markets, there is a fear that they induce prices moves having no relationship with commodity supply, production, inventory and demand. Moreover, as there is a strong correlation between spot and futures prices, a price's shock on the futures prices of a specific commodity may spread to the physical market. The more pessimistic scenario foretells the contagion to other markets,

[15] See for example Fleming and Ostdiek (1999).

[16] The open interest is a very interesting statistics for derivative markets. It represents the number of contracts still hold by operators at the end of a trading day. Thus, it gives an idea of how many participants hold their position more than one day. As usually, arbitragers and speculators compensate their position in one day (creating intra-day volatility). Thus, open interest is often considered as a way to appreciate how much hedgers are present in the market.

especially in energy markets, as we will see in 4.2. However, as far as we know, no serious study has reached such a conclusion. On the contrary, Robes *et al* (2008) show that until now, it is not possible to prove that portfolio diversification towards commodities has a specific impact on their prices.

4.2. Contagion effect and the integration of commodity markets

Another source of questions about commodity markets comes from the fact that they are more and more integrated, raising the fear of systemic risk. As a result of tightened cross market linkages, a shock induced by traders or speculators may spread, not only to the physical market, but also to other derivative markets. This question has been investigated through different ways. The first is the study of the impact of traders on derivative markets through the such-called "herding phenomenon". The second is the study of spatial and temporal integration.

In 1990, Pindyck and Rotenberg propose to define herding by a situation where traders are alternatively bullish or bearish on all commodities for no plausible economic reasons. Herding is a possible explanation for the excess co-movement that is observed on the prices of different commodities, namely their persistent tendency to move together. This co-movement can be observed on quite a broad set of markets. It can partially be explained by macro-economic variables: the expected inflation, the growth in industrial production, the consumer price index, several exchange rates, interest rates, money supply, etc. However, if the co-movement is in excess of anything that could be explained by these common variables, herding could explain this excess. Several studies have been performed on commodity markets in order to confirm this hypothesis. Pindyck and Rotenberg conclude that there is herding on commodity prices. The results of Booth and Cinner (2001) on Asian agricultural commodity prices support, on the contrary, the common economic fundamentals assumption.

Another way to deal with the subject of derivatives and their impact on commodity prices is to focus on the spatial integration of commodity prices. Jumah, and Karbuz (1999) study the spatial integration in the cocoa market, using prices extracted from London and New York futures markets. Interest rates are found to play a key role in establishing long-run relationship between prices. The authors also show that futures prices adjust more quickly to new information, compared to spot prices. Ewing and Harter (2000) study the co-movements of Alaska North Slope and UK Brent crude oil prices. Their results show that these oil markets share a long-run common trend, which suggests that the two markets are "unified": there is price convergence in the markets. Kleit (2001) also examines the spatial integration of the crude oil markets. He studies seven types of crude oils. All of them are light crude oils, in order to reduce problems associated with quality differentials. His results show that oil markets are growing more unified. All these works are important because spatial integration could exaggerate the possible negative influence of derivatives on commodity markets. This question is especially important for energy markets, as they become more and more integrated: many energy derivatives involve cross-market counterparties. Thus, derivatives can spread the disturbance or crisis in one energy market to another.

The debate on the effects of derivatives trading and contagion effect is also closely related to the issue of temporal integration. Whereas the spatial integration has already been examined in commodity markets, temporal integration was not widely studied. Relying on the "preferred habitat" theory, which is applied to the American crude oil market, Lautier (2005) investigates whether this market is segmented or not. Segmentation is defined as a situation in which different parts of the prices curve are disconnected from each others. The study shows that the crude oil futures market is segmented into three parts. The first corresponds to maturities below 28 months, the second is situated between the 29th and 47th months, and the third consists of maturities ranging from the 4th to 7th years. Moreover, chances are high that this segmentation would evolve trough time, because since the date it was launched, the crude oil futures market has matured. Indeed, the American futures market has experienced a sustained growth in its transactions volume, pushing away the boundary of actively traded contracts. This phenomenon is reported in most derivatives markets – and it is especially important, since 2000, in commodity markets at large, and more specifically, in energy markets – and one can expect that segmentation will move to longer maturities in the future.

The question of temporal segmentation has crucial implications. Where the markets perfectly integrated, a shock induced on one part of the curve could spread out to the other parts of the curve. There would be a kind of a temporal systemic risk. However, the existence of a partial segmentation also raises some difficulty. Indeed, segmentation has an impact for financial decisions, particularly for all the hedging and valuation operations relying on the relationship between different futures prices. The efficiency of these strategies can be affected by differences in the information content of futures prices. It is also the case of investment decision, when the latter is based on the extrapolation from observed prices curves to value cash flows for maturities that are not available on the market[17]. All these operations rely on term structure models of commodity prices. Such a tool aims to reproduce the futures prices observed in the market as accurately as possible and to extend the curve for very long maturities. However, its use requires the estimation of its parameters, and the latter may depend on the informational content of futures prices.

[17] For this kind of analysis, see for example Brennan and Schwartz (1985), Schwartz (1997, 1998), Cortazar and Schwartz (1998), Schwartz and Smith (2000), Cortazar *et al* (2001).

4.3. Are derivative markets intrinsically dangerous?

Apart from the fear of systematic risk, a question remains: are derivative markets intrinsically dangerous? Once again, the answer is not straightforward. There are some reasons to fear, associated to leverage effect, complexity, opacity, and liquidity. However, all fears are not necessarily justified.

The presence of a leverage effect is one of the most important characteristic of derivative markets. Leverage means that there is an important difference between the price exposure of a position, which is measured by the value of the derivative contract, and which depends on the volatility of the underlying asset, and the investment required in order to enter the contract. In the case of organized markets, this investment is materialized by the initial margin, which represents 1 to 10% of the positions value. In the case of over-the-counter markets, this investment is sometimes equal to zero, or equivalent to the implicit value of the confidence of the counterpart in the transaction. In other words, derivatives lower the cost of taking on price exposure. This is perfectly true. Moreover, in the case of organized markets, the cost is even lower because the presence of the clearing house and the use of electronic platforms reduce strongly transaction costs. Last but not least, the cost is also reduced by the very important liquidity on such markets.

Are there some counterweights to leverage effect? Part of the answer is yes, part is no. The counterweight, in the case of organized markets, lies essentially on margin calls. There is a possibility to suffer huge financial losses in organized markets. However, a participant can not stay in the market if he is not able to absorb these losses, day after day. Moreover, there are rules in these markets in order to avoid the possibility, for a trader, to take a very large position (*i.e.* more than 10% of the market) and to suffer, in one day, dramatic losses. In the case of over-the-counter markets, when the clearing house does not interfere in the transactions, the only counterweights are, first the mutual confidence between the participants of the market, second the ability to measure correctly the risk undertaken through transactions involving derivative products. Whenever this confidence relies on bad foundations, or this ability is not as good as supposed, there may be difficulties. Part of the crisis linked with the derivative transactions on sub-primes credit is due to risk underestimation. On this point of view, the movement of the frontier between organized and OTC market is good news. Reminds that, when a clearing house interferes in a transaction, it assumes credit risk, chooses the valuation model that will be applied to the transaction, and estimates the price risk associated to the transaction, in order to define the amount of the initial margin.

The second potential problem with derivatives is the complexity of instruments traded. The markets always offer new products – there is a marketing dimension in derivatives, as well as in other goods – and the functioning of these products are not always perfectly understood by all of their potential users, at least at the beginning (problems usually arise in markets that are not matures). The use of derivative products requires clearly technical competences, and the more the markets evolve, the more these competences rise. Once again, complexity is more important in OTC markets, for a very simple reason. These markets indeed give the possibility to find the perfect hedge, i.e. potentially very specific protections against prices fluctuations. These perfect hedges would not be possible in the case of organized markets, because of the necessarily standardization. However, such a benefit afforded by OTC markets signifies, in return, that the negotiated products are sometimes very complicated. Is this complexity always totally explained by a real necessity to offer a protection against a very specific exposition? We leave this question open.

Complexity of the products, absence of a systematic price reporting system – which would be difficult to maintain and not really useful because the negotiated products are not standardized – transactions based on mutual agreements…, all these characteristics of over-the-counter markets favour their opacity. The lack of transparency in these markets is undeniable, at least for some transactions – remember that in order to facilitate the transfer of certain derivative products, some of them are standardized, and that this part of the activity on OTC markets is rising very quickly. For financial institutions offering hedging services against prices fluctuations, opacity may be a way to restore commercial margins that are, simultaneously, dramatically endangered by electronic trading and by the severe competition on organized markets. Nevertheless, there is a real need for specific hedging products and it is not absurd that financial institutions are paid for assuming the risk transferred by their client – which is not always easy to hedge, especially when the derivative products are complex. Moreover, some participants of the markets might appreciate opacity as it gives them the possibility to undertake discretely some transactions. The OTC market gives the possibility to realize huge deals which, where they known, would have been able to punctually destabilize the market.

As far as liquidity is concerned, there are three problems with derivatives. First, the high liquidity of organized markets is an incitation for noise traders to take positions that may create intra-day volatility. Noise arises from the action of agents who falsely believe that they possess valuable information about what should be the correct price and trade accordingly. Noise traders include investors using technical – as opposed to fundamental – analysis, trend followers, herders, etc. Although these traders are useful as they serve as liquidity providers for informed investors, they may be responsible for excessive short-term volatility due to over-trading, bad timing of their trades, over-reactions to good and bad news, etc. This point has already been commented in 4.1. Second problem, liquidity is not regularly organised through time. Third, over-the-counter markets are prone to illiquidity problems.

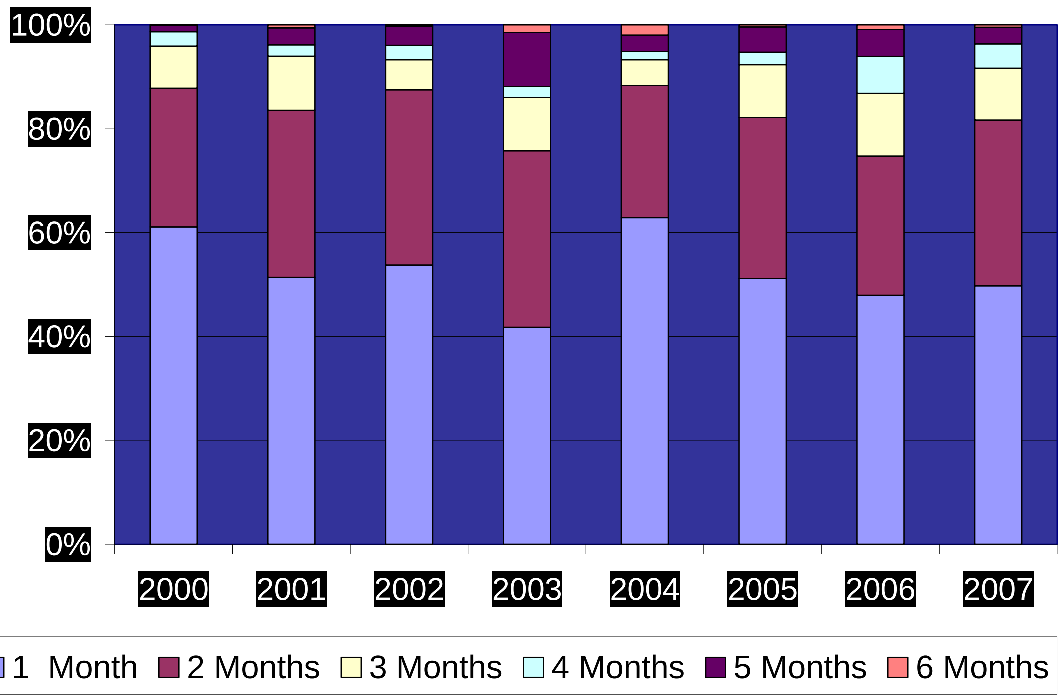
In most derivative markets, the transactions volume is not regularly distributed along the prices curve[18]. Indeed, the short-term maturities are highly traded, whereas

[18] This is also true for open interest.

liquidity may be very poor on long-term maturities. For example, as depicted by Figure 1, on the European petroleum market, between 2000 and 2007, the one-month Brent futures contract represents 45.93% of the total volume on the first six maturities, the two-months futures contracts amounts for 33.91% of the volume, and the three-months contracts, 11.89%. This distribution of transaction volumes might create difficulties for long term operations on the derivative markets. Indeed, as long-term prices do not rely on actively traded contract, one might ask whether these prices are reliable. Three answers can be given to this problem.

First, the prices can be considered as all the more reliable that the integration of the prices curve is strong. Where the markets fully integrated on their temporal dimension, the information conveyed by short term prices would spread rapidly to long-term maturities. Still, it is true that long term prices are supposed to depend on specific variables which do not affect short-term prices: changes in technologies, inflation, demand pattern, prices for competing energy and changes in environmental constraints are more important for long term prices than inventories, temporarily supply disruption, strikes, or seasonality, for example.

Figure 1. Transactions volumes, in percentage by maturity, on the Brent futures contract, 2000-2007



A second possible answer is that transactions' volume is not necessarily the best criterion that may be used in order to appreciate the informational content of long-term futures prices. Indeed, when investment banks use long-term futures contracts to hedge their residual risk, one transaction per year may be sufficient – for example to hedge swaps having a one-year periodicity. And investment banks are more and more active on long-term futures contracts, as Haigh *et al* (2007) stated it.

Third, it is always possible to cover long-term positions with short-term instruments. Naturally, such a strategy is more risky and requires high technical competences. Just recall of Metallgesellschaft[19], which in 1994 tried to do this… and lost USD 2.4 billions!

Whereas organized markets are characterized by an irregular distribution of liquidity along the term structure, over-the-counter markets are prone to illiquidity problems, whatever the maturity is concerned. These problems are directly linked with the organization of such markets. Reminds that OTC markets are informal networks, organized around the most important and active operators. At critical times, the latter can vanish or, if they have to stay and offer some prices – such is the case for "market makers" – they might propose prices with no economical sense or, to put it in financial words, with an extraordinarily high liquidity premium. The evolution of the credit market during the summer 2007 is a perfect example of such a problem.

There are undoubtedly some dangers with derivative markets, as explained above. However, the most important are probably linked with not mature markets, complex products and above all, unadvised traders. A lot of worries about derivative markets come from misunderstanding. Such misunderstanding can create some real difficulties, as was the case, for example, with securitization in 2007-2008. They are entertained by the tremendous transactions volume, volatility, and by the sustained developments of such markets. Consequently, there is probably a need to explain more often, more clearly, what derivative markets are and how they work. All other problems – ie leverage effect, opacity, liquidity – may be overcome, provided that there is no possibility to enforce the rules governing the markets, especially the organized markets. A vast majority of the problems recorded on derivative markets indeed finds its roots in fraud or in a lack of control: Metallgesellschaft, Enron, Baring, Société Générale, …

5. Conclusion

Since the turning of the XXIst century, energy derivative grow at a tremendous rate. They are the most actively traded commodities, and also the more volatile. Is it dangerous? By explaining what energy derivative markets are today, how they work, what their economic function is, and what their possible risks are, this chapter tries to bring an answer to that difficult question. Naturally, the answer is not straightforward. Moreover, it is difficult to summarize it in a few words.

One important feature of derivative markets is their complexity. Undoubtedly, derivative instruments are complex. So is the organization of derivative markets, especially in the energy field. This characteristic is harmful, as it may turn away some potential users (for example, developing countries) of energy derivative markets. Yet,

[19] For more details on the Metallgesellschaft case, see for example Edwards and Canter (1995), Culp and Miller (1994) or Lautier (1998).

they could be extremely useful, especially when the wealth of these countries relies strongly on energy resources.

The complexity of derivative markets does not mean, however, that they do not work well. Remember that in 2006 11,859.27 millions of futures and options contracts were traded in the world. Moreover, this number represents only the deals on organized markets. Would it be possible to make such an amount of transactions with an inefficient trading scheme? Probably not. Derivative markets do not only work well. They also fulfil economic functions rendering them extremely useful, especially in the energy field, which is characterized by a high volatility.

REFERENCES

Büyükşahin B, Haigh MS, Robe MA, 2008. Commodities and equities: a market of one? Working Paper, January.

Ciner C, 2001. On the long run relationship between gold and silver prices: A note, Global Finance Journal, 12(2), 299-303.

Brennan MJ, Schwartz ES, 1985. Evaluating Natural Resource Investments. Journal of Business, 58, 135-157.

Cortazar J, Schwartz ES, 1998. Monte-Carlo Evaluation Model of an Undeveloped Oil Field. Journal of Energy Finance and Development, 3, 73-84.

Cortazar J, Schwartz ES, Casassus J, 2001. Optimal Exploration Investments Under Price and Geological-Technical Uncertainty: a Real Options Model. R & D Management, 31, 181-189.

Culp CL, Miller MH, 1994. Hedging a Flow of Commodity Deliveries with Futures: Lessons from Metallgesellschaft. Derivatives Quarterly, 1, 7-15.

Culp CL, Miller MH, 1995. Metallgesellschaft and the Economics of Synthetic Storage. Journal of Applied Corporate Finance, 7, 62-76.

Edwards FR, Canter MS, 1995. The Collapse of Metallgesellschaft: Unhedgeable Risks, Poor Hedging Strategy, or Just Bad Luck? Journal of Futures Markets, 15, 221-264.

Ewing BT, Harter CL, 2000. Co-movements of Alaska North Slope and UK Brent crude oil prices, Applied Economics Letters, August, 7(8), 553-558.

Fleming J, Ostdiek B, 1999. The impact of energy derivatives on the crude oil market, Energy Economics, April, 21(2), 135-168.

Haigh MS, Harris JH, Overdahl JA, Robe MA, 2007. Market growth, trader participation and pricing in energy futures markets, Working Paper, December.

Jumah A, Karbuz S., 1999. Interest rate differentials, market integration, and the efficiency of commodity futures markets, Applied Financial Economics, Feb., 9(1), 101-109.

Kleit, A. N., 2001. Are Regional Oil Markets Growing Closer Together? An Arbitrage Cost Approach, Energy Journal, 22(2), 1-15.

Lautier D, 1998. Les opérations de Metallgesellschaft sur les marchés à terme de produits pétroliers : spéculation ou couverture ? Finance - Contrôle - Stratégie, 1, 107-129.

Lautier D, 2005. Segmentation in the crude oil term structure. Quarterly Journal of Finance, IX(4), 1003-1020.

Mayhew S., 2000. The impact of derivatives on cash markets: what have we learned? Working Paper, University of Georgia, Athens.

Pindyck R., Rotenberg J., 1990. The excess co-movement of commodity prices, Economic Journal, 100, 1173-89.

Schwartz ES, 1997. The Stochastic Behavior of Commodity Prices: Implications for Valuation and Hedging. Journal of Finance, 52, 923-973.

Schwartz ES, 1998. Valuing Long-Term Commodity Assets. Journal of Energy Finance and Development, 3, 85-99.

Schwartz ES, Smith JE, 2000. Short-Term Variations and Long-Term Dynamics in Commodity Prices. Management Science, 46, 893-911.

Simon Y., Lautier D., 2006. *Marchés dérivés de matières premières*, 3ème éd. Economica, Paris, 548 p.

Simon Y., 2006. Développement et fusion des bourses de produits dérivés, *in* Hamon J., Jacquillat B., Saint-Etienne C., : « *La place financière de Paris et la consolidation des bourses mondiales* », Rapport pour le Conseil d'Analyse Economique, La Documentation Française, novembre.