Changes in the relationship between the financial and real sector and the present economic financial crisis: study of energy sector and market.

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Abstract: The goal of D 3.08 to which this paper contributes, is to examine whether financialisation has tended to increase price instability in international energy markets, generating ‘price bubbles’, and whether these markets have been significant transmitters of the effects of the financial crisis. The paper starts by briefly outlining the evolution of energy markets’ regulation (oil, natural gas, coal and electricity) in Europe and in OECD countries, from the late 1990 to now, with the aim of establishing whether liberalization has led to: 1) price reductions, and 2) increased price (?) volatility. Empirical evidence suggest that in all energy markets, since the 2000s, prices rose dramatically and volatility increased slightly. However, the most remarkable result is that in the 21st century, prices of energy commodities began to be locked to the price of oil, showing a level of correlation not seen in previous decades. A possible explanation for the synchronization of energy prices with oil price lies in the “commodity bubble” in futures markets that occurred in the second half of the 2000s. Nevertheless, according to most of the existing literature, oil markets in the long run still seem to be dominated by spot markets rather than future markets, indicating that fundamentals are pivotal in determining the price of oil. In order to test this, we performed an analysis of the dynamical Hurst exponent of two crude oil (WTI and Brent) prices, spot and futures, from the 1980s to now, on a daily basis, aimed at assessing the long memory (autocorrelation) of returns.

Key words: Finance; Energy Markets; Financialisation of Energy Markets; Commodity Bubble; Oil Price; Hurst Exponent; Multifractality.
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1. Introduction

When it comes to the concept of the real economy, as opposed to the financial economy, nothing is more representative of the real, tangible, thus measurable, manifestation of markets than commodities. Commodities are goods and services traded in units of mass or volume, whereas products are sold in countable units. Crude oil, both in terms of mass and value, is the most traded commodity in the world and gas is the second. Not only are oil and gas the largest commodity markets in the world, but, in the modern economy, they are also a major input of production, not to mention the key role they have played since the Second World War onwards, in shaping the global geopolitical map.

In what follows, it will be shown how the financial sector beginning in the early 1980’s, used energy commodities as a form of sustenance and how the financialisation of energy markets accelerated in the late 2000’s. Yet, what do we mean by financialisation of energy markets? Historically, financialisation in energy markets has unfolded itself along two main lines: 1) the re-investment of revenues from royalties and profits deriving from a sudden increase in the price (i.e., the petrodollars); 2) the development of financial derivative instruments underlying the physical trades in commodity markets. In this paper we will explore this latter form of financialisation. Finance invests in commodity markets in two main ways: with Futures and Option Contracts.¹ Future Contracts, rather than Option Contracts dominate the commodity market and, therefore, are often taken as a measure of the degree of financialisation (liquidity) of a commodity market and have received most attention in academic research. In general, for example, to answer the question whether in a commodity market the price is determined by speculators or by producers/consumers, it is customary to study the dynamic between Spot prices, representative of the demand/supply

¹ In finance Futures contract (more colloquially, Futures) is a standardised contract between two parties to buy or sell a specified asset of standardised quantity and quality for a price agreed upon today (the Futures price) with delivery and payment occurring at a specified future date, the delivery date. An Option Contract, or simply Option, is defined as a promise which meets the requirements for the formation of a contract and limits the promisor's power to revoke an offer (Wikipedia).
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mechanism, and Futures prices, indicating the behaviour of financial operators. Futures and Spot markets compete, in a fashion which is often obscure and has always attracted the attention of researchers, to determine the price on wholesale markets, which ultimately impacts on retail prices. The aim of this study is to understand how the financialisation of energy markets affected the dynamic of retail prices in the long run, in terms of stability, transparency and trend.

The paper is structured as follows: in section 2) the four energy markets (oil, gas, coal and electricity) are introduced, describing how the most important milestones in the process of liberalisation and financialisation occurred in each market in recent decades. For every sector, for a sample of countries and for the OECD and Europe, the long-term volatility (quarterly-based) is observed together with the evolution of retail prices. In section 3) the short-term, high-frequency (daily or hourly), volatility in the oil and electricity markets is analysed with new statistical tools, in order to assess how financialisation affected price fluctuations. In section 4) the correlation of energy prices with oil is analysed and how this correlation evolved according to the process of financialisation of the markets. In section 5) we draw some conclusions, with a particular focus on the new prospect for the market price envisaged by an increasing share of renewable energy sources in the production mix of the European electricity grid.

2. Energy markets and liberalisation

2.1. Oil and oil products

In the years 1986-88, most oil exporting countries switched from an administrated to a market-related pricing system. This shift ended a time in which prices were first administered by the large multinational oil companies in the 1950s and 1960s and then by OPEC for the period 1973-1988. The first to switch to the market-based system was the Mexican national oil company PEMEX in 1986 and by 1988, it had become the main method for pricing crude oil in international trade:

The end of the concession system and the waves of nationalisation which disrupted oil supplies to multinational oil companies established the basis of arm’s-length deals and exchange outside the vertically and horizontally integrated multinational companies. The emergence of many suppliers outside OPEC and many buyers further increased the prevalence of such arm’s-length deals. This led to the development of a complex structure
of interlinked oil markets which consist of Spot and also physical Forwards, Futures, Options and other derivative markets referred to as paper markets. Technological innovations which made electronic trading possible revolutionised these markets by allowing 24-hour trading from any place in the world. It also opened access to a wider set of market participants and allowed the development of a large number of trading instruments both on regulated exchanges and over the counter (Fattouh, 2011).

The derivatives on oil and oil products were the first to be traded on international markets. The two major markets for oil are the New York Mercantile Exchange (NYMEX) for WTI oil and the Intercontinental Exchange (ICE) (USA and Europe) for Brent oil. The NYMEX is a commodity Futures exchange owned and operated by the CME Group of Chicago. Trading of WTI crude oil Futures at the NYMEX began in March 1983, following five years of Futures trading on heating oil which began in November 1978. The ICE became a centre for global petroleum risk management and trading with its acquisition of the International Petroleum Exchange (IPE) in June 2001, which is today known as ICE Futures Europe. The IPE was established in 1980 in response to the immense volatility that resulted from the oil price shocks of the 1970s. As the IPE’s short-term physical markets evolved and the need to hedge emerged, the exchange offered its first contract: gas oil Futures. In June 1988, the exchange successfully launched the Brent crude Futures Contract. Today, the ICE’s FSA-regulated energy Futures exchange conducts nearly half the world’s trade in crude oil Futures.

\[\text{\underline{2}}\] Initially Future Contracts were developed and Options followed. Today, in terms of volume, Futures are the dominant derivative market (Table 1). Nevertheless, in the process of price formation, both Options and Futures play a determinant role. In the Brent market, for example, the oil price in the Forward market is priced as a differential to the price of the Brent Futures Contract using the Exchange for Physicals (EFP) market. The price of Brent priced as a differential to the Forward market through the market of Contract for Differences (CFDs), a Swap market (Fattouh, 2011).

\[\text{\underline{3}}\] Two other important markets, though marginal for traded volumes compared to NYMEX and ICE, are TOCOM in Japan (with a daily volume of 3999 lots in 2013) and DME in Dubai (with a daily average volume of 9000 lots in 2014). Nevertheless, since 2009 DME switched to one of the leading platforms, CME Globex. This helped make the access to the DME contracts easier for market participants, as all three benchmarks (WTI, Brent and DME Oman) can be traded on the same electronic platform.
2010, the daily average volume traded of ICE- Brent exceeded 400,000 contracts or 400 million barrels, more than five times the volume of global oil production (Fattouh 2011). The remaining Futures on crude oil are traded predominantly at NYMEX. The monthly average volume of Light Sweet Crude Oil Futures (WTI) traded at NYMEX exceeds 14 million contracts or 14 billion barrels. On a daily basis, this amounts to more than 475 million barrels of oil, around 6 times the size of daily global oil production (Fattouh, 2011). In contrast to the Brent market, trading in the US pipeline market is smaller with typical volumes of around 30,000 barrels compared to 600,000 barrels in the Brent market. Nevertheless, the US market has maintained its liquidity despite the decline in physical production. In 2009, the combined Spot-market traded volume for twelve US domestic grades stood at more than 1.8 mb/d (million barrels a day) which is much higher than other benchmarks including Brent, Oman and Dubai (Fattouh, 2011).

In April 2005, the entire ICE portfolio of energy Futures became fully electronic and the high profile and historic ICE trading floor was closed. In the years 2006–2008 the shift from a primarily telephone/open outcry trading platform (Pit) to a computer/electronic order matching platform (IT technologies) led immediately to an upswing in future transactions (Irwin and Sanders, 2012). On the ICE, for example, contracts doubled in two years, from 2006 to 2008 (Figure 1). On the NYMEX, where IT technologies became effective later, the shift occurred in 2007.

Therefore, the roadmap to the financialisation of the oil market can be sketched as follows:

1. In 1971, Nixon declares the non convertibility of dollar.
2. 1978-83, first derivatives on oil and oil products at NYMEX
3. In 1986-88, there was a shift towards a market-related pricing system from a system of prices administered initially by large multinationals in the 1950s and 1960s and then by OPEC from 1973-88.

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4 Only few of Futures contacts translate into physical delivery, i.e. Forward markets, for Brent. In 2010, the daily average of Forward Contracts were 1.4 million b/d.
5 Unlike the Brent Futures Contract, the Light Sweet Crude Oil Futures Contract is fully physically delivered for every contract left open at expiry by default. It is important to note though that only a small percentage of the volume traded is physically settled with most of the physical settlement occurring through the Exchange for Physicals (EFP) mechanism.
4. 2005, the ICE becomes a public company.

5. 2005-2008, implementation of the computer trading system.

6. 2007, first Oman Crude Oil Futures Contract launched at Dubai Mercantile Exchange (DME)

7. 2008, the NYMEX is acquired by CME group and TOCOM became a for-profit stock company.

What was the effect of the process of deregulation and financialisation of the global oil market on local retail prices of oil products? In Figure 2, we show the price of diesel for selected OECD countries, from 1980 to 2014. From 2001 to 2014, prices increased dramatically and the volatility of log of returns increased by 24% in Europe and 39% in OECD countries.

2.2. Natural gas

Natural gas is the most important energy commodity, for daily volumes, after crude oil and oil products at NYMEX and ICE (Table 1). Nevertheless, in difference to oil, gas is also traded locally. This is why gas is generally considered a *regional market* while oil is a truly global market. The financialisation of gas started in the early 1990s, when NYMEX launched the first Futures Contracts on natural gas (NG). Natural gas Futures, including the most popular Henry Hub Futures, trade on the NYMEX and the Chicago Mercantile Exchange (CBOT) in the United States. A contract represents 10,000 million British thermal units (mmBtu) and trade under the symbol “NG”. These are highly liquid, extremely active contracts that trade throughout the year. Contracts are listed for the current year plus the next 12 years and are priced in dollars and cents per mmBtu. The contract is based on delivery at the Henry Hub in Louisiana—where 16 natural gas pipelines converge. Natural gas Futures also trade on the ICE, which offers both UK Natural Gas Contracts and Title Transfer Facility (TTF) Futures. The Multi Commodity Exchange (MCX) in India and the TOCOM in Japan also offer natural gas Futures throughout the year.

In Europe, liberalisation of the market began in the late 1990s, with the first of two European Union directives concerning gas (98/30/EC and 2003/55/EC). Generally, the trading of gas and related financial derivatives became effective with the rise, in the first half of the 2000s, of companies managing electricity wholesale markets, such as Powernext (France), Nord Pol (Norway, Sweden, Netherlands), OMIE (Spain), EPEX (France and Germany), ENDEX (Netherlands), EXXA (Austria), GME (Italy). These companies, formerly public agencies, provided the platform for the trading of energy commodities, Futures and Options, from electricity, gas and Emission Trading System (ETS). Nevertheless, the liquidity of the gas market in Europe is still very low, with the exception of the UK
and the NL (Figure 3). After the rush to gas of the 1990s, it seems that gas is becoming less attractive for European and American power utilities which might partially explain the difficulties of the gas market to take off.  

In the US and the UK, gas prices are set in competitive short-term gas markets (Henry Hub and National Balancing Point). In continental Europe, prices for imported gas are related to oil prices by formulas, but this is changing due to the pressure from current lower short-term markets, such as the above mentioned European energy exchanges companies (Mitchel and Mitchel, 2014). Nevertheless, competition on wholesale markets seems to have failed to spare the UK from soaring prices in NG (Figure 4). Furthermore, volatility in Europe increased in the last 15 years, both on prices (20%) and on log returns (29%). However, it is worth noting that the increase in volatility in gas regional markets is also due to the price of oil. Recent studies suggest that the volatility of international crude oil prices has a negative impact on regional natural gas import prices and the shock impact is weak in North America and stronger in Europe and that this correlation increased in the 21st century (Quiang et al. 2014; Brigida, 2014; Nick and Thoenes, 2014).

2.3. Coal

Coal is the second primary energy source after oil worldwide, in OECD countries and even in the European Union (IEA, 2014b). While the United States has the world's largest reserves of coal, China has been the world's leading producer of coal since the early 1980s. It currently produces nearly half of the world's coal. In 2013, total world production of coal was 6986 Mt, with Chinese production accounting for 3567 Mt, followed by USA with 935 Mt and India with 595 Mt. Global trade has been growing faster than global consumption on a relatively consistent basis, which comprises regional trade data as a portion of the corresponding consumption (IEA, 2014b). Global exports reached a record share of total consumption of 21.7% in 2013, up from 11.0% in 1980, 16.5% in 1990 and 18.4%  

6 In 2013, global natural gas demand gained only 1.2%, reaching around 3.500 billion cubic metres (bcm). Against the backdrop of a sluggish economic economy, competition from coal and renewable energies in the power generation sector and supply constraints, consumption increased less than forecast in the previous Medium-Term Gas Market Report (MTGMR) for that year (1.6%). There is nothing new in gas being outpaced by coal and renewable electricity generation; this has been the case over the past decade, but it is unusual that gas demand growth is behind oil too, which increased by 1.4% in 2013.” (IEA, 2014a)
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in 2000. In one sense, this can be explained by globalisation, as while World total primary energy supply (TPES) for steam and coking coal combined, grew by 308% since 1971, combined exports grew by 811%. Major exporters are Indonesia (426 Mt), Australia (336 Mt) and Russia (140 Mt). Coal worldwide is considered a substitute for gas in power generation and the soaring costs of gas were partially responsible for an increasing demand for coal in OECD countries and in fast developing economies.

Although trades in coal increased in recent decades, coal is still the least financialised energy commodity and contracts are prominently bilateral and its market regional. The NYMEX only started trading Futures on coal in 2001 and currently, the top ten energy products at NYMEX don’t comprise coal Futures (Table 1).

Nevertheless, since coal is now the largest single power generating fuel in the United States, the once relatively stable market in coal has become more volatile. Thus, electric utilities are no longer eager to enter into long-term coal supply contracts that were once the industry norm. Instead, there is now a preference for short-term and more price-flexible contracts. In Europe, the once regional and state-controlled market, with significant price spreads across countries, prices began to converge in the late 1990s, after a process of market deregulation and privatisation in Germany, the UK, Poland and Estonia (Figure 5). A further thrust toward price volatility came in the late 2000s, from the largest coal market in the world, China. Since China decontrolled coal prices in the second half of the 2000s, its coal price has risen steadily and been unusually volatile (Chi-Jen et al., 2012). These coal-price fluctuations could be symptomatic of a major change in the pricing dynamics of global fossil-fuel markets, with increasing correlation between coal and oil prices globally. Nevertheless, in Europe, volatility of log-returns has decreased by 11% from 2001-2013, compared to the decades 1980-2000. In OECD countries, price volatility increased in the lag 2001-2013 compared to 1980-2000 by 16% and 14% on log returns remained (Figure 6).

2.4. Electricity

Electricity is a very peculiar energy commodity: it is not storable and it has high costs of transmission due to physical constraints (15% losses on average). Therefore, until recently electricity has always been a public monopoly. Since the second half of the 1990s, European electricity networks have underwent an extensive liberalisation process and have changed their structure from a regulated
monopoly to a competitive open market. At the end of 1996, the first EU Directive on electricity (1996/92/EC), later replaced by the second Directive (2003/54/EC), set the initial common rules for the creation of an internal competitive electricity market. Most European markets started functioning between 2002 and 2004. Parallel to the process of liberalisation in the EU, the USA has also undertaken its own deregulation and privatisation of the electricity sectors. Now, in the USA, 5 major companies trade electricity, the most important of which is PJM. PJM Interconnection was established in 1997 as the first bid-based energy market in the United States. It has since evolved into the largest deregulated wholesale electricity market in the world (Longstaff and Wang, 2004).

What is a wholesale electricity market? National wholesale electricity markets are generally composed of the Spot Electricity Market, the Forward Electricity Market and the Platform for physical delivery of financial contracts concluded on the IDEX. The IDEX is the segment of the financial derivatives market organised and managed by national stock exchanges, where financial electricity derivatives are traded. In Europe, the Spot electricity markets comprises the Day-Ahead Market and the Intra-Day and Compensations Markets.

In spite of decreasing electricity consumption, the traded volume of day-ahead power contracts on European trading platforms grew until 2013 (EU, 2013). Figures show that the liberalisation of the electricity sector in Europe was successful and the liquidity of the European wholesale electricity market has now reached a level of above 50%, meaning that more than half of the electricity consumed in Europe was traded on markets (Fig 6). Nevertheless, the market succeeded in reducing the volatility of retail prices for both, the household and the industry sectors, but failed in reducing the cost of energy (Fig 7 and 8). Volatility in the household sector grew slightly by 5% in the period 2001-2013 compared to 1980-2000, in Europe but decreased by 5% in the OECD. However, volatility in the industry sector grew during the same period both in Europe and in OECD countries.

3. Instability and efficiency in the oil market.

In the previous section, we observed the volatility of retail prices on a quarterly basis and over a long range of time, comparing two times periods: 1980-2000 with 2001-2013. However, this is an
imprecise measure of volatility and may underestimate the effect of financialisation on market volatility. In wholesale markets, commodities or financial derivatives are traded daily and hourly. Energy markets have traditionally been very volatile. High volatility levels, irregularity in production and seasonal effects make hedging of paramount importance. Financial derivatives such as Futures or Forward Contracts, Options and Swaps depend on the underlying commodity and should reflect its Spot price. Futures Contracts, for example, at expiring date (maturity) must match Spot Contracts and these latter should, in principle, reflect market fundamentals. The theory of storage postulates that basis as well as Futures spread is related through the cost of storage, the convenience yield and the risk premium, which arises from holding a physical commodity in inventory form (Maslyuk and Smyth, 2009). Nevertheless, in the short-run, Futures Contracts, during their life, can significantly depart from their price of their underlying commodity. Therefore, spread between Spot and Futures can fluctuate significantly. Volatility in finance is a measure of the variation of prices or returns (the ration between \( p_2 \) and \( p_1 \) between the time interval \( t_2-t_1 \)), and it is customarily assessed with the standard deviations on the logarithm of returns. This measure, however, is affected by the trend in prices and it assumes normal distribution, therefore, it is a biased estimation of the instability of prices/returns. Hence, in this section we will investigate the instability of prices with a more refined measure, based on the study of fractality of time series, the Hurst exponent (Mandelbrot, 1997). The present analysis will address high frequency time series of Spot

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8 The Hurst exponent is used as a measure of long-term memory of time series. It relates to the autocorrelations of the time series, and the rate at which these decrease as the lag between pairs of values increases. Studies involving the Hurst exponent were originally developed in hydrology for the practical matter of determining optimum dam sizing for the Nile River’s volatile rain and drought conditions that had been observed over a long period of time. In fractal geometry, the generalised Hurst exponent has been denoted by H or Hq in honor of both Harold Edwin Hurst and Ludwig Otto Hölder (1859–1937) by Benoît Mandelbrot (1924–2010). H is directly related to fractal dimension, D, and is a measure of a data series’ “mild” or “wild” randomness. The Hurst exponent is referred to as the “index of dependence” or “index of long-range dependence”. It quantifies the relative tendency of a time series either to regress strongly to the mean or to cluster in a direction. A value H in the range 0.5–1 indicates a time series with long-term positive autocorrelation, meaning both that a high value in the series will probably be followed by another high value and that the values a long time into the future will also tend to be high. A value in the range 0–0.5 indicates a time series with long-term switching between high and low values in adjacent pairs, meaning that a single high value will probably be followed by a low value and that the value after that will tend to be high, with this tendency to switch between high
and Futures Contracts of oil, for WTI and Brent, on a daily basis, between 1980 and 2013. We investigate, by evaluating the generalised Hurst exponent,\(^9\) dynamically computed over a moving time-window, the level of stability/instability of log returns of Futures and Spot prices (Morales et al, 2012). The Hurst exponent scores 0.5 when a time series is random (Brownian motion) and between 0.5 and 1 when it is persistent (positive autocorrelation). When the Hurst exponent is lower than 0.5, it means that a time series is anti-persistent, i.e. more unstable than a random walk, though more predictable (Mandelbrot, 1997).

3.1 Oil Futures market: Generalised Hurst

Autocorrelation in oil Futures markets has received growing attention in recent years by the scientific milieu. The interest has mainly focused on establishing whether the market was efficient or inefficient, i.e., according to the economic theory, if the Hurst exponent signalled a random walk or not.\(^10\) The underlying concept is that in a fully efficient market, returns on Futures, filtered by the trend and settled by the fundamentals, should be random and unpredictable. Futures should only pay a premium for the risk and the cost of storage.

Although there is general consensus on the fact the oil markets are inefficient, it is still unclear whether the autocorrelation (long memory) is persistent or anti-persistent (Serletis and Rosenberg, 2010).

\(^9\) “The generalised Hurst exponent is a tool to study directly the scaling properties of the data via the qth-order moments of the distribution of the increments and it is associated with the long-term statistical dependence of a certain time series \(S(t)\), with \(t = (1, 2, \ldots, k, \ldots, \Delta t)\), defined over a time-window \(\Delta t\) with unitary time-steps. Being a measure of correlation persistence, it is necessarily related to fundamental statistical quantities which turn out to be the qth-order moments of the distribution of the increments (Morales, 2012)”

\(^10\) For the scope and the sake of the present analysis, the question of multifractality of time series, that is, of the different fractal dimension of different time scales of the series, will not be addressed. A multidimensional time series means that a series might be random above a certain time interval. For example, some studies found that Futures oil prices are random on the time scales of weeks (Alvarez-Ramirez et al., 2002; He and Chen, 2009). Nevertheless, this is still a debated issue and it would require a more profound analysis that goes beyond the time constrains of the present study.
2007; Zanotti et al. 2009; Wang and Wu, 2012). Some studies found that energy Futures returns are weakly persistent (Alvarez-Ramirez et al., 2002, 2008; He and Chen, 2009; Calum and Turvey, 2010). Other studies suggest that the particular form of long memory of log-returns is anti-persistent, characterised by the variance of each series being dominated by high frequency components (Serletis and Rosenberg, 2007; Elder and Serletis, 2008).

We analysed 4 Futures markets from 1982 to 2014 on a daily basis,11 for WTI crude oil and Spot crude oil (Brent and WTI) (Table 4). Spot and Futures markets, for oil (Brent and WTI) and for oil products, are found to be generally anti-persistent, but, notably, financialisation led to a decrease in the stability of prices, marked by a sharp increase of the Hurst exponent in all markets, beginning in 2000 (Fig 9). Notably, the Hurst exponent remained stable overall until 2008 when it received a further thrust, though not very pronounced. Since 2008, indeed, in most of the markets analysed, the Hurst exponent fluctuates around 0.5, signalling that the market became efficient, i.e., purely random.

3.2 Oil Futures market: Multifractality

A multifractal system is a generalisation of a fractal system in which a single exponent (the fractal dimension) is not enough to describe its dynamics. In the field of time-series analysis this can be broadly translated into the existence of more than one H on different time-scales. This happens when H(q) is a non-linear function of the generalised exponent q and the time series is a multifractal system. In this case, the scaling behaviour can be observed for many interlocked fractal subsets of the time series (Kantelhardt, 2011). When, for example, a two-dimensional process scales the exponents describing the scaling behaviour in the same range of time scales, that system displays autocorrelation (memory) on both long-range and short-range scales.

Figures 10 and 11 show the multifractality for the Spot Contracts of Brent and WTI at NYMEX. Figures 12 to 15 show the multifractality for the Futures Contracts 1 to 4 at NYMEX.12 The difference

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11 NYMEX, Crude Oil: Light-Sweet, Cushing, Oklahoma. 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. In addition, 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, and Norwegian Oseberg Blend.

12 For crude oil, each contract expires on the third business day prior to the 25th calendar day of the month preceding the delivery month. If the 25th calendar day of the month is a non-business day, trading ceases on the third
between $H(1)$ and $H(1.5)$ is zero when the time series is uni-fractal. It is interesting, but not surprising, that all the series show multifractality. What is of paramount interest, and somehow unexpected, is that for all the series the difference between $H(1)$ and $H(1.5)$ utures declines along the timeline, approaching zero in the last decade. It is noteworthy that in the Spot Market, foremost for Brent, the difference drops sharply after 2004. However, 2004 seems to be a turning point also for the Futures-Contract 1 (one month ahead). These results suggest that the scale of autocorrelation in all markets converged, meaning that the behaviour (comprising the volatility) of the series on long and short time scales becomes similar. This hints to a collapse of long-term and short-term dynamics of the series, particularly for Spot Brent and Futures Contract 1, but more research is needed. Indeed, the fact that the year 2004 is clearly a turning point in the multifractality, but not on the dynamical Hurst (Figure 9) for Spot and Futures Contract 1 is highly informative in relation to the underlying process that affects the scaling behaviour of the series (the interplay between short-term and long-term behaviour). However, this result must be addressed with a more profound and detailed analysis.

4. Correlation with oil price and financialisation of commodities markets

After the first wave of liberalisations which occurred mainly in the US and the UK during the 1970s and the 1980s, the energy sector underwent a second, more profound, course of liberalisation/deregulation that began in the 1990s but became fully effective in the beginning of the 21st century. Indeed, the 21st century, as was previously highlighted, witnessed the dramatic rise of the financialisation of the energy sector. The financialisation process followed two main lines: on a global scale, with the flourishing of international markets (NYMEX, ICE, Dubai, TOCOM) and the upturn of volumes of trades on financial products based on energy commodities; on a regional/national scale, with the advent of electricity/gas wholesale markets. Deceptively, the financialisation of the energy sector did not lead to a decrease in retail energy prices. On the contrary, energy prices soared in the 21st century, and even after the 2008 global crisis,
after a momentary collapse in demand, began increasing again. Volatility also generally increased. Many argue that this was the effect of oil prices, to which most energy commodities are still attached through regional price indices or structural reasons, like generating costs (Mohammadi, 2009; Oberndorfer, 2009; Fattouh, 2010; Ji et al., 2014; Brigida, 2014). In this view, fundamentals, that are inflating oil costs because of the pressure on resources demand exerted by fast rising economies, would be underpinning the present increasing trend in energy commodities. This is indisputably true, but it might not be the end of the story. Figures 16 and 17 depict the retail energy prices compared to oil (prices at import costs) for European OECD countries (Fig 16) and for OECD countries (Fig 17). It is striking how prices start swinging univocally from the early 2000s. In Tables 2 and 4, the volatility and correlations (Pearson correlation index) between energy commodities and oil prices in the two time-spans: 1980-2000 and 2001-2013 is reported. Remarkably, all energy commodities show a correlation above 90% in the second time-span, compared to weaker correlations or even negative correlations, like in the case of electricity and household gas.

4.1 The financialisation of Futures market and the commodity bubble

As it was previously highlighted, volumes in oil Futures, after decades of stagnancy, began steadily increasing in the mid 2000s and sky rocketed before the crisis. However, this bull cycle was not limited to Future energy markets. Since the early 2000s, commodity Futures have emerged as a popular asset class for many financial institutions and pension funds. This phenomenon, in the literature and in the financial milieu, is sometimes named: the commodity bubble (Winters, 2008; Tang and Xiong, 2010; UN, 2011; Irwin and Sanders, 2012). How did the commodity bubble begin? There are five main factors:

1. Bull cycle: during periods of strong economic performance, especially driven by fast growing, emerging countries, the commodity markets tend to appeal to institutional investors hedging against inflation (Winters, 2008; UN, 2011)

2. Cassandra's voice: in the early 2000s, academic literature highlighted that commodity Futures Contracts exhibit the same average returns as investments in equities, while over the business cycle their returns are negatively correlated with those on equities and bonds, attracting the attention of institutions and pension funds. Institutional investors, after the
collapse of equity markets, were looking for safe investments and the widely publicised
discovery of a small negative correlation between commodity returns and stock returns led
to a belief that commodity Futures could be used to reduce portfolio risk (Gorton and
Rouwenhorst, 2006).

3. IT technology: trades on Futures were boosted by the new electronic platform that
dramatically reduced costs of transactions and enhanced access to the market (Sanders, 2010).

4. Financial innovation: financial innovation has played a facilitating role, for example, tracking
commodity indexes, such as the Standard and Poor’s Goldman Sachs Commodity Index
(S&P GSCI).

5. Market Deregulation: commodity market deregulation in the USA, as enacted by the
Commodity Futures Modernization Act (CFMA) of 2000, was a further facilitating factor. The effects of the financialisation of commodities are still debated, some claim that their traditional functions have been altered by speculative traders. Commodity Futures markets are meant to facilitate the transfer of price risk from producers and consumers to other agents that are prepared to assume the price risk. These functions are “impaired to the extent that trading by financial investors increases price volatility and drives prices away from levels that would be determined by physical commodity supply and demand relations” (UN, 2011). There is a different view which claims that financialisation had positive effects on commodity markets. According to this view, the expanding market participation may have: decreased risk premia and the cost of hedging, reduced price volatility, and enhanced the integration of commodity markets with financial markets (Irwin and Sanders, 2012). Nevertheless, it seems indisputable that the commodity bubble contributed

13 “The Commodity Futures Modernisation Act of 2000 (CFMA) is United States federal legislation that officially ensured modernised regulation of financial products known as over-the-counter derivatives. It was signed into law on December 21, 2000 by President Bill Clinton. It clarified the law so that most over-the-counter (OTC) derivatives transactions between “sophisticated parties” would not be regulated as “Futures” under the Commodity Exchange Act of 1936 (CEA) or as “securities” under federal securities laws. Instead, the major dealers of those products (banks and securities firms) would continue to have their dealings in OTC derivatives supervised by their federal regulators under general “safety and soundness” standards (Wikipedia)”.
significantly, albeit it was not the main factor, to the hike in oil prices that occurred in 2008. According to the hedge fund manager Michael W. Masters, index investment created a massive bubble in commodity Futures prices (Masters and White, 2008):

“\textit{Institutional Investors, with nearly $30 trillion in assets under management, have decided \textit{en masse} to embrace commodities Futures as an investable asset class. In the last five years, they have poured hundreds of billions of dollars into the commodities Futures markets, a large fraction of which has gone into energy Futures. While individually these investors are trying to do the right thing for their portfolios (and stakeholders), they are unaware that collectively they are having a massive impact on the Futures markets that makes the Hunt brothers\textsuperscript{14} pale in comparison. In the last four and half years assets allocated to commodity index replication trading strategies have grown from $13 billion in 2003 to $317 billion in July 2008. At the same time, the prices for the 25 commodities that make up these indices have risen by an average of over 200%. Today’s commodities Futures markets are excessively speculative, and the speculative position limits designed to protect the markets have been raised, or in some cases, eliminated.}”\textsuperscript{15}

Nevertheless, there was a further effect of financialisation on Future commodity markets that went almost unnoticed: the astonishing increasing correlation between the price of commodities with the price of oil. Tang and Xiong (2010) found that “concurrent with the rapid growth of index investment to commodities markets, prices of non-energy commodities became increasingly correlated with oil

\footnotetext{14}{Beginning in the early 1970s, Hunt and his brother William Herbert Hunt began accumulating large amounts of silver. By 1979, they had nearly cornered the global market. In the last nine months of 1979, the brothers profited by an estimated $2 billion to $4 billion in silver speculation, with estimated silver holdings of 100 million troy ounces (3,100,000 kg). During the Hunt brothers’ accumulation of the precious metal, prices of silver Futures Contracts and silver bullion during 1979 and 1980 rose from $11 an ounce in September 1979 to $50 an ounce in January 1980. Silver prices ultimately collapsed to below $11 an ounce two months later. The largest single day drop in the price of silver occurred on Silver Thursday. Hunt filed for bankruptcy under Chapter 11 of the Federal Bankruptcy Code in September 1988, largely due to lawsuits incurred as a result of his silver speculation (Source: Wikipedia).}
prices […]. This finding reveals a fundamental process of financialisation amongst commodities markets, through which commodity prices became more correlated with prices of financial assets and with each other. This result also helps explain the synchronised price boom and bust of a large set of seemingly unrelated commodities in 2006-2008”. According to their studies, the increasing correlation with oil prices concerns index-related commodities. For example, Figure 18 depicts average return correlations of commodities in the Goldman Sachs Commodity Index (GSCI) and Dow-Jones UBS Commodity Index (DJ-UBS) and commodities off these indices. They found that Futures prices of non-energy commodities became increasingly correlated with oil after 2004 and that this trend was significantly more pronounced for indexed commodities than for those off the indices.

The explanation is that index investors typically focus on strategic portfolio allocation between the commodity class and other asset classes such as stocks and bonds, they tend to trade in and out of all commodities in a chosen index at the same time (Tang and Xiong, 2010). Commodities in the index, therefore, should immediately be synchronised with fluctuations on financial markets by means of speculative, though risk-averse, movements of index investors.\textsuperscript{16} Likewise, the increasing financialisation of Future energy markets, through the same mechanism, would increase the co-movement of energy Futures with financial markets and thereby, with oil prices.

4.2 The role of paper markets in the price formation of oil

\textsuperscript{16} “A number of studies find evidence of commodity price bubbles. Analyses show that position-taking by index investors, that passively replicate the price movements of an index based on a basket of commodities, has an impact on price developments, particularly of crude oil and maize. The fact that these effects are persistent – especially in the case of crude oil – points to the presence of herd behavior [...]. Financial investors are usually active in several financial markets at the same time. Information collected in one market or for the economy as a whole tends to be used to form expectations about the significant price swings in other markets, regardless of the specifics of supply and demand in the latter. This mechanism creates new or reinforces existing cross-market linkages, and it increases or alters correlations between two asset classes. An increasing correlation between two markets over time indicates that the markets have been moving more and more in tandem” (UN, 2011).
Although the theory on the synchronisation of commodity markets is supported by strong evidence, it still remains inexplicable why *everything* should be correlated to oil? If financialisation of commodities paved the way for a deeper integration of markets, and therefore, of energy markets, why did oil emerge as the benchmark? And if oil is the benchmark, a notion that is as trivial as uncompromising, where does the driving force leading the markets lie? Is it in speculators operating in oil markets or in fundamentals?

Indeed, the answer to this question rests on three unspoken assumptions:

1. Future prices lead Spot prices in energy markets.
2. Financial markets are strictly correlated to oil prices.
3. Oil price is univocally determined on a global scale.

The question whether Spot prices determine Futures prices or, *vice-versa*, are affected by them, links to the more fundamental question of whether commodity markets are driven by fundamentals of the economy or financial speculation. The correlation of the economy, and thereby financial markets, to oil price is also a complex issue and goes beyond the interplay of structural and financial factors in the energy sector. It has been subject to vast interest from the scientific community, foremost during or in the immediate aftermath of the economic crisis, yet, the reason why the economy is so bound to the price of oil, is somehow still debated (Hamilton, 2013). Several studies found that prices for crude oil from different parts of the globe are correlated (Gulen, 1999; Ewing and Harter, 2000; Bachmeier and Griffin, 2006; Bentzen, 2007, Maslyuk and Smyth, 2009; Ghoshray and Johnson, 2010). The long-run tight relationship among oil prices and their derivatives implies that the world oil market is unified. A consensus that the world oil market is unified, however, poses the question, where do innovations in world oil prices enter the market?

Kaufmann and Ullman(2009), traced the correlation and the Granger causality among Spot and Futures crude oil prices across different regions of the world with the aim of testing the hypothesis

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17 “The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another. Ordinarily, regressions reflect mere correlations, but Clive Granger argued that causality in economics could be reflected by measuring the ability of predicting the future values of a time series using past values of another time series. Since the question of *true causality* is deeply philosophical, econometricians assert that the Granger test finds only *predictive causality* (Wikipedia)”.

20
of the role of speculation vs. market fundamentals. If the hypothesis about the importance of market fundamentals is correct, we would expect to see price innovations enter the oil market via Spot markets. They found that the rise in crude oil prices through March 2008 was driven in part by market fundamentals and that the Spot price for Dubai–Fateh was the "gateway for innovations". The finding that this latter crude oil was driving innovations in oil prices after 2008, seems to support the arguments for the importance of demand growth in developing nations, where this oil is benchmark for bilateral contracts. Nevertheless, they also found evidence of weak causality going from Futures to Spot markets, with growing relevance after September 2004, to conclude that: “together, these results suggest that market fundamentals initiated a long-term increase in oil prices that was exacerbated by speculators, who recognised an increase in the probability that oil prices would rise over time.” (Kaufmann and Ullman, 2009; Kaufmann, 2011).

However, Fattouh(2010;2011) argues that the dichotomy between Spot- and Futures markets as a tool to identify the role of financial speculation versus the role of fundamentals is not well founded. He highlights that, on the one hand, financial instruments enter directly into the price formation process of most of crude oil prices, while on the other hand, financial markets, like Forward markets and some Option markets (i.e, the CFDs), are still dominated by operators in the oil sector, that is, by physical traders rather than financial players.

18 “Since physical benchmarks constitute the pricing basis of the large majority of physical transactions, some observers claim that derivatives instruments such as Futures, Forwards, Options and Swaps derive their value from the price of these physical benchmarks, i.e., the prices of these physical benchmarks drive the prices in paper markets. However, this is a gross over-simplification and does not accurately reflect the process of crude oil price formation. The issue of whether the paper market drives the physical or the other way around is difficult to construct theoretically and test empirically and requires further research.” (Fattouh, 2011).

19 “In recent years, the Futures markets have attracted a wide range of financial players including Swap dealers, pension funds, hedge funds, index investors, technical traders, and high net worth individuals. There are concerns that these financial players and their trading strategies could move the oil price away from the true underlying fundamentals. The fact remains however that the participants in many of the OTC markets such as Forward markets and CFDs which are central to the price discovery process are mainly physical and include entities such as refineries, oil companies, downstream consumers, physical traders, and market makers. Financial players such as pension funds and index investors have limited presence in many of these markets. Thus, any analysis limited to non-commercial participants in
Futures markets determine the oil price in two ways: 1) directly, by the benchmarking system of long term, bilateral contracts; 2) indirectly, by the feed-back loops among the market layers that are ultimately captured by the Price Reporting Agencies (PRAs), like Argus. It is well known that the majority of oil is traded by bilateral, long-term contracts, but what is not known is that in the last years, most oil producers switched from a pricing formula benchmarked to Spot markets to a pricing formula benchmarked either to Futures Contracts\(^\text{20}\) (or a sample of them) or to price indexes reported by PRAs, like the ASCI.\(^\text{21}\) Furthermore, the financial layers of the market (the so called “paper market”) are constantly monitored by the PRAs with the aim of establishing the market price of oil. This happens because it is generally accepted that Spot markets, primarily the Middle-East ones, are very illiquid and therefore, operators in every segment of the oil market play on Futures/Option/Swap markets in order to hedge from price fluctuations, shipment delays and innovation in other market’s layers. The concept is that the level of the oil price is set in the Futures markets and the financial layers, such as Swaps and Forwards, set the price differentials. By trading differentials, market players limit their exposure to risks of time, location, grade and volume. These differentials are then used by oil reporting agencies to identify the price level of a physical benchmark. In what follows, we can no longer clearly divide the financial speculation from the activity of market fundamentals. In the words of Fattouh (2011), we can’t

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\(^{20}\) The pricing may be based on physical benchmarks such as Dated Brent or on the financial layers surrounding these physical benchmarks such as the Brent Weighted Average (BWAVE), which is an index calculated on the basis of prices obtained in the Brent Futures market. Specifically, the BWAVE is the weighted average of all Futures price quotations that arise for a given contract of the futures exchange during a trading day, with the weights being the shares of the relevant volume of transactions on that day. Major oil exporters such as Saudi Arabia, Kuwait and Iran use BWAVE as the basis of pricing crude exports to Europe.

\(^{21}\) Argus Sour Crude Index (ASCI) replaced WTI in the pricing formula of Middle East export to the USA. The fundamentals of the current pricing system have remained the same since the mid 1980s: the price of oil is set by the market with PRAs making use of various methodologies to reflect the market price in their assessments and making use of information in the financial layers surrounding the global benchmarks.
“assume that the process of identifying the price of benchmarks can be isolated from financial layers. [...] As our analysis shows, the different layers in the oil market are highly interconnected and form a complex web of links, all of which play a role in the price discovery process. The information derived from financial layers plays an important role in identifying the price level of the benchmark. In the Brent market, the price of Dated Brent is assessed using information from many layers including CFDs, Forward markets, EFPs and Futures markets. Similarly, in the WTI complex, the prices of the various physical benchmarks are strongly interlinked with the Futures markets. The price of Dubai is often derived using information from the very active OTC Dubai/Brent Swaps market and the inter-Dubai Swap market. Thus, the idea that one can isolate the jointly or co-determined in both layers, depending on differences in timing, location and quality”.

Concluding remarks

Energy markets in OECD countries have undergone a process of deregulation/privatisation, which began in the 1990s, and which ultimately led to a full financialisation process that occurred in the second half of the 2000s in all four major energy commodities: oil, gas, coal and electricity. Financialisation of energy markets developed primarily throughout Futures Contracts and secondarily with Options, with different degree of success: oil markets now display a very high degree of financialisation and market liquidity, and have become fully globalised, while coal markets still lag behind, with low market liquidity and volumes, mainly traded on regional Spot markets or bilaterally. Gas markets fall in the middle of these two extremes, being very liquid in the USA and the UK while still being mainly centrally controlled in continental Europe, where, however, wholesale markets are beginning to take root on the electronic platforms provided by companies managing electricity and ETS trades. Electricity wholesale markets are of a very different nature, being regional for technical reasons. Spot electricity markets achieved a significant liquidity in the EU in recent decades, with Spot trades now accounting for more the half of the electricity consumed. However, due to the structure of the market which is shaped by EU regulations, penetration of speculators is still marginal and mainly limited to the Forward market, whereas most
of the volumes are traded on day-ahead markets, by utilities, distribution companies, traders and other sector’s operators.

In spite of this tide of financialisation and contrary to expectations (or desires?), retail price reductions did not follow and volatility in most sectors increased on a quarterly basis. Many argue that the increase in energy prices was caused by oil prices, rather than financialisation and indeed, what is more striking of 21st century trends in comparison to the two previous decades, is that the retail prices of energy in any sector began co-moving with oil prices in a coherent fashion. The Pearson correlation of energy prices in OECD countries grew dramatically, when comparing the two time intervals: 1980-2000 with 2001-2013.

The reasons why the financialisation of energy markets brought about a higher, almost perfect, correlation between energy commodities, even those that were formerly anti-correlated and oil, is still unclear. Some argue that this strict correlation depends on the higher integration of financial markets with commodity markets caused by a massive indexed investment that began in the 2000s. The so-called commodity bubble produced, between 2004 and 2008, a large inflow of money from the financial sector to the commodity market, which was previously unbound to the highs and lows of the stock exchange, by institutional investors who began to look at Futures on commodities to hedge from the pitfalls of equities and bonds. The speculative behaviour of these big investors eventually interlocked the Futures commodity market, starting with the oil market, to the swinging of the stock market. Truly, there is convincing evidence that commodities in the index of big, institutional investors displayed a significantly higher correlation to oil when compared to commodities not included in the index.

It is noteworthy that correlation started to increase in 2004 (for example, in Figure 18 the two correlation curves of in-indexed and off-indexed commodities start decoupling in the year 2004). The UN report on the financialisation of commodity markets also found empirical evidence to support 2004 being the turning point in the correlation between oil prices and several economic quantities, like commodity indices and currency exchange ratios (UN, 2011). Interestingly, some studies indicate that 2004 is the year when Futures oil markets have been flooded by money, boosting volumes of contracts (Turner et al, 2011). Kaufmann suggests that there is empirical evidence which shows that from 2004, price innovations in the oil market came from Futures markets rather than Spot markets (Kaufmann, 2011). Fattouh (2010;2011), also highlights the
increasing role of Futures markets in the price formation of oil, suggesting though that the price-level of oil is currently set on Futures market by physical players rather than financial players. (Our study on the generalised Hurst exponent of Spot and Futures oil prices at the NYMEX confirm that 2004 is a pivotal year in the oil market and corroborate the hypothesis that some structural change occurred in both the Futures (and prominently the Contract 1) and Spot markets. The dramatic decrease in multifractality which occurred in 2004 suggests a flattening of the time horizon in oil markets and the merging of long-termism with short-termism. This notion seems to confirm the view of Fattouh who claims that it is no longer possible to distinguish sharply between financial and physical layers in the oil market structure, although it is possible to differentiate between Spot purely speculative actors and sector’s operators (Fattouh, 2010).

However, one conclusion can be drawn: Futures markets are now the place where the oil price level is set and this is particularly true since 2004, when the integration of markets and the flattening of the time horizon began. Furthermore, this process clearly depended on the financialisation of commodity markets, starting with the oil market. How and why this happened in that particular year remains an open question that needs more research and investigation.

References


Table 1 Top ten traded products at NYMEX (New York), year 2013. Source: NYMEX.

<table>
<thead>
<tr>
<th>Product name</th>
<th>Sub Group</th>
<th>Volume (adv. daily lots)</th>
<th>Open Interest</th>
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<tr>
<td>Crude Oil Futures</td>
<td>Crude Oil</td>
<td>554,905</td>
<td>1,503,283</td>
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<tr>
<td>Henry Hub Natural Gas</td>
<td>Natural Gas</td>
<td>203,791</td>
<td>933,270</td>
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<tr>
<td>RBOB Gasoline Physical Futures</td>
<td>Refined Products</td>
<td>143,798</td>
<td>288,175</td>
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<tr>
<td>NY Harbor ULSD Futures</td>
<td>Refined Products</td>
<td>112,423</td>
<td>387,752</td>
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<tr>
<td>Crude Oil Options</td>
<td>Crude Oil</td>
<td>111,856</td>
<td>2,469,637</td>
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<td>Brent Last Day Financial Futures</td>
<td>Crude Oil</td>
<td>81,632</td>
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<td>Natural Gas Options (European)</td>
<td>Natural Gas</td>
<td>42,973</td>
<td>3,889,864</td>
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<tr>
<td>ISO New England Mass Hub Day-Ahead Off-Peak MW Futures</td>
<td>Electricity</td>
<td>12,888</td>
<td>330,635</td>
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<td>Henry Hub Natural Gas Last Day Financial Futures</td>
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<td>11,489</td>
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<td>Natural Gas Options</td>
<td>Natural Gas</td>
<td>7,010</td>
<td>129,145</td>
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Table 2 Structural change in correlation between energy prices and oil price, European OECD countries. 

**Source: IEA**

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<tr>
<td>Electricity Households</td>
<td>-19.42%</td>
<td>27.88%</td>
<td>-71.13%</td>
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<td>-18.75%</td>
<td>29.72%</td>
<td>-68.75%</td>
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<td>Steam coal elect. Gen.</td>
<td>24.63%</td>
<td>39.69%</td>
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<td>Coal steam household</td>
<td>15.74%</td>
<td>31.55%</td>
<td>5.38%</td>
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<td>Gas households</td>
<td>-9.17%</td>
<td>33.07%</td>
<td>-26.69%</td>
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<td>Diesel automotive</td>
<td>-21.78%</td>
<td>31.52%</td>
<td>-36.59%</td>
<td>98.47%</td>
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Table 3 Structural change in correlation between energy prices and oil price, OECD countries. **Source: IEA**

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<tr>
<td>Electricity Households</td>
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<td>Gas households</td>
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<td>24.96%</td>
<td>-51.18%</td>
<td>84.56%</td>
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<tr>
<td>Diesel automotive</td>
<td>-18.28%</td>
<td>33.00%</td>
<td>-22.60%</td>
<td>99.07%</td>
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Table 4 Spot and Future Contracts, figure 10.

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<th>Cushing, OK WTI Spot Price FOB (Dollars per Barrel)</th>
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<td>RBRTE</td>
<td>Europe Brent Spot Price FOB (Dollars per Barrel)</td>
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This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800

<table>
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<tr>
<th>RCLC1</th>
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<td>RCLC2</td>
<td>Cushing, OK Crude Oil Future Contract 2 (Dollars per Barrel)</td>
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<td>RCLC3</td>
<td>Cushing, OK Crude Oil Future Contract 3 (Dollars per Barrel)</td>
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<tr>
<td>RCLC4</td>
<td>Cushing, OK Crude Oil Future Contract 4 (Dollars per Barrel)</td>
</tr>
</tbody>
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Figure 1 ICE Futures crude oil Brent, volumes. Source: ICE
Figure 2 Diesel retail price in selected OECD countries. Source: IEA
Figure 3 Liquidity of NG Spot market in the EU, 2013. Source: Wagner, Elbling & Co.
This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800

**Figure 4** NG retail price in households sector, selected OECD countries. Source: IEA
This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800

Figure 5 Steam coal, retail price in selected OECD countries. Source: IEA

Figure 6 Liquidity of the European electricity wholesale market, 2010-13. Source: UE
This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800

Figure 7 Retail electricity price in the households sector, selected OECD countries. Source: IEA
This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800

Figure 8 Retail electricity price in the industry sector, selected OECD countries. Source: IEA
This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800

**Figure 9** Generalised Hurst exponent in oil markets, Spot and Futures. *Source: our estimations on DOE-IEA data (Legend: Table 4).*

**Figure 10** Multifractality of the Brent Spot Market, 2001-2013
This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800.

Figure 11 Multifractality of the WTI Spot Market, 2000-2013

Figure 12 Multifractality of Oil Futures Market at NYMEX, Contract 1, 1997-2013.
This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800.

Figure 13 Multifractality of Oil Futures Market at NYMEX, Contract 2, 2000-2013

Figure 14 Multifractality of Oil Futures Market, Contract 3, 1998-2013
This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800

Figure 15 Multifractality of Oil Futures Market, Contract 4, 2000-2013
This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800

**Figure 16** Energy retail prices and oil import price, European OECD countries. Source: IEA
This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800.

Figure 17 Retail energy prices and import oil price, OECD. Source: IEA
This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800.

Figure 18 Correlation with oil price of Indexed commodities and off-index commodities. Source: Ke Tang and Wei Xiong, 2010.
Financialisation, Economy, Society and Sustainable Development (FESSUD) is a 10 million euro project largely funded by a near 8 million euro grant from the European Commission under Framework Programme 7 (contract number: 266800). The University of Leeds is the lead coordinator for the research project with a budget of over 2 million euros.

THE ABSTRACT OF THE PROJECT IS:

The research programme will integrate diverse levels, methods and disciplinary traditions with the aim of developing a comprehensive policy agenda for changing the role of the financial system to help achieve a future which is sustainable in environmental, social and economic terms. The programme involves an integrated and balanced consortium involving partners from 14 countries that has unsurpassed experience of deploying diverse perspectives both within economics and across disciplines inclusive of economics. The programme is distinctively pluralistic, and aims to forge alliances across the social sciences, so as to understand how finance can better serve economic, social and environmental needs. The central issues addressed are the ways in which the growth and performance of economies in the last 30 years have been dependent on the characteristics of the processes of financialisation; how has financialisation impacted on the achievement of specific economic, social, and environmental objectives?; the nature of the relationship between financialisation and the sustainability of the financial system, economic development and the environment?; the lessons to be drawn from the crisis about the nature and impacts of financialisation?; what are the requisites of a financial system able to support a process of sustainable development, broadly conceived?

THE PARTNERS IN THE CONSORTIUM ARE:
This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 266800

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<tr>
<td>1 (Coordinator)</td>
<td>University of Leeds</td>
<td>UK</td>
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<td>University of Siena</td>
<td>Italy</td>
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<td>National and Kapodistrian University of Athens</td>
<td>Greece</td>
</tr>
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<td>12</td>
<td>Middle East Technical University, Ankara</td>
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</tr>
<tr>
<td>13</td>
<td>Lund University</td>
<td>Sweden</td>
</tr>
<tr>
<td>14</td>
<td>University of Witwatersrand</td>
<td>South Africa</td>
</tr>
<tr>
<td>15</td>
<td>University of the Basque Country, Bilbao</td>
<td>Spain</td>
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