EU ENERGY DERIVATIVES MARKETS: STRUCTURE AND RISKS

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Abstract

Energy derivatives markets were thrown into turmoil following Russia's invasion of Ukraine, as the prices of natural gas and power soared amid high volatility and a significant deterioration in market liquidity. Prices surged in March 2022, before declining in Spring and then rebounding to reach historical peaks at end-August 2022. The sharp price increases triggered large margin calls on derivatives positions, resulting in liquidity stress for some firms using derivatives as hedges against price declines, energy utilities in particular. The liquidity demands were so high that some EU countries introduced public support mechanisms in the form of loans and public guarantees, and a few energy firms were bailed out. Therefore, it is crucial to understand the structure and functioning of energy derivatives markets. This article provides an overview of EU energy derivatives markets and assesses the risks for financial stability. Unlike other financial markets, non-financial corporates play a key role in energy markets by trading on exchanges and over the counter. The market is characterised by a high degree of concentration in clearing and trading activities, as evidenced by network analysis, and some energy firms hold relatively large positions in the market. In this context, liquidity and concentration risks are among the main vulnerabilities identified, along with data fragmentation and data gaps. The recent migration of some of this activity from exchange-traded to over-the-counter derivatives markets raises concerns over limited transparency and more bespoke margin and collateral requirements.

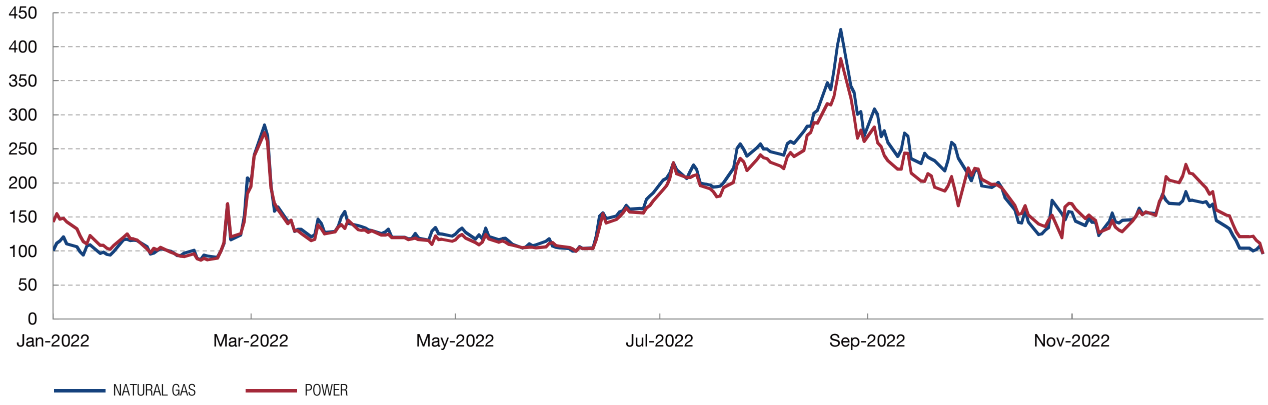
Keywords: Financial stability, energy derivatives, collateral, margins.

1 Introduction

Russia's invasion of Ukraine at the end of February 2022 triggered a sharp rise in the price and volatility of commodities, energy in particular. The price of natural gas and power futures rose by 200% between the end of February and early March, before declining and settling at pre-war levels in Spring. Prices again increased in July, hitting historical heights in late August 2022, at close to four times their pre-war levels (Chart 1). Since then, energy prices have been trending downwards and had returned to their pre-war levels by end-2022.

Beyond certain fundamental factors, such as the fall in the supply of natural gas from Russia, the rise in the demand for gas owing to the build-up of inventories ahead of the winter, and issues surrounding electricity production by nuclear plants in some EU countries, the extreme volatility observed on derivatives markets was also attributable to the structure and functioning of these markets.

Chart 1
ENERGY DERIVATIVE PRICES



SOURCES: Refinitiv Datastream and ESMA.
NOTE: Future prices of natural gas (Dutch TTF front-month contract) and power (Phelix front-month) in EUR, rebased at 22 Feb. 2022 = 100.

Across all commodities, derivatives markets play a key role in price discovery (Shrestha, 2014; ECA, 2015). Market participants can take directional positions on the future prices of the underlying energy products for speculative or hedging purposes.

Energy derivatives markets, which encompass natural gas and power (electricity),[1] display certain characteristics common to all financial markets: trading activity is concentrated in exchanges where market members can send buy and sell orders to a central limit order book, and trades are mainly cleared through central counterparties (CCPs), where clearing members have to post initial and variation margins to reduce market and counterparty risk. In addition to on-venue trading, derivatives trades can be also executed over-the-counter (OTC) and cleared bilaterally between counterparties.

At the same time, energy derivatives markets also display certain features that set them apart from traditional financial markets: much of the activity is carried out by non-financial corporates (mainly energy firms), while the role of financial intermediaries (such as banks) is less prominent than is the case on traditional financial markets. In addition, constraints on the physical delivery and storage of the underlying commodity can have an impact on how the market functions.[2]

1 From a regulatory perspective, under MiFID II only natural gas and power derivatives are considered energy derivatives. As per the regulatory definition, in the remainder of the article energy derivatives refer to natural gas and power derivatives.

2 For example, in electricity markets, Cartea and González-Pedraz (2012) show that date and location are crucial determinants of market clearing prices and use real options to model the valuation of an interconnector (an asset that gives the owner the option to transmit electricity between two locations).

This article provides an overview of the structure and functioning of EU energy derivatives markets by expanding the analysis of natural gas markets performed by ESMA (2023b) to include power markets.[3] The analysis shows that EU energy derivatives markets are characterised by a high degree of concentration in terms of clearing activity, and that a few energy firms have a large market footprint. Following the rise in margins on exchange-traded derivatives (ETDs), a migration to OTC derivatives has taken place, leading to the further fragmentation of the energy derivatives network. This development may make energy markets less resilient, since OTC markets are less transparent and counterparty risk is managed on a bilateral basis, instead of centrally through CCPs.

The following section describes the structure and size of the energy derivatives markets, along with the main types of market participant. The third section looks at risks in energy markets in light of recent developments observed since the start of the Russian invasion of Ukraine. The fourth section focuses on changes in the network structure of EU energy derivatives markets and on concentration risk. The final section sets out some closing observations and conclusions.

2 The structure of energy derivatives markets in the EU

The energy derivatives ecosystem

Across all commodities, derivatives markets play a key role in price discovery (Shrestha, 2014; ECA, 2015). Market participants can take directional positions on the future prices of the underlying energy products for speculative or hedging purposes. By using derivatives, market participants can hedge their positions (e.g. a natural gas producer can take a short position in derivatives to hedge against future price declines, while a firm needing natural gas or power in the future can take a long position to hedge against a price rise), take directional views on future prices and contribute to price discovery. The trading of ETDs also boosts liquidity through standardisation and reduces counterparty risk through the use of CCPs. Indeed, CCPs act as systemic risk managers that cover counterparty risk on a centralised basis thanks to a sophisticated set of models and the financial resources needed to foster transparent and liquid markets.

Aside from the benefits derivatives have to offer, they can also entail risks, including liquidity and counterparty risks. The use of derivatives can pose two types of liquidity risk: market liquidity risk and funding liquidity risk (Brunnermeier and Pedersen, 2009). Market liquidity refers to the ability of the market to absorb large trades quickly

3 This article does not cover in detail the monitoring and regular reporting of natural gas markets, including in the context of the market correction mechanism introduced at end-2022. See ACER (2023) and ESMA (2023a) for further details on this mechanism.

without moving the price too much. Funding liquidity is the ability to borrow money quickly to finance positions. Counterparty risks refers to the risk of one counterparty failing to deliver on its derivatives obligations, leaving the other exposed to potential losses.

The use of derivatives usually requires that the counterparties post initial margins at the inception of the derivative contract (this is mandatory for ETDs and optional for OTC derivatives) to protect against counterparty default, followed by daily variation margins (generally in the form of cash) to reflect the current market value of the trade for the counterparty exposed to mark-to-market loss. In the event of a steep price increase, the counterparty with a short position has to post variation margins (since its position has incurred mark-to-market losses) and, in some cases, both counterparties have to post additional initial margins (since the margin models used by CCPs require higher levels of collateral to compensate for the heightened volatility of energy derivatives).[4] While eligible collateral and margin requirements may differ across clients and clearing members, all clearing members are subject to similar requirements regarding the initial and variation margins posted with the CCP.

In the OTC space, counterparties enter into derivatives transactions that may have bespoke, more customised characteristics. Margin rules for non-cleared derivatives include the mandatory posting of initial and variation margins when firms' derivatives exposures (average aggregate notional amounts) exceed certain thresholds.[5] Otherwise, counterparties can structure their margin arrangements at their discretion. Eligible collateral is defined bilaterally by the counterparties, although, in practice, cash and sovereign bonds are the norm (ISDA, 2021).

Before looking at such risks in more detail in the context of Russia's February 2022 invasion of Ukraine, it is worth reflecting on the structure of EU energy derivatives markets. This structure can be broken down into different components (Figure 1).

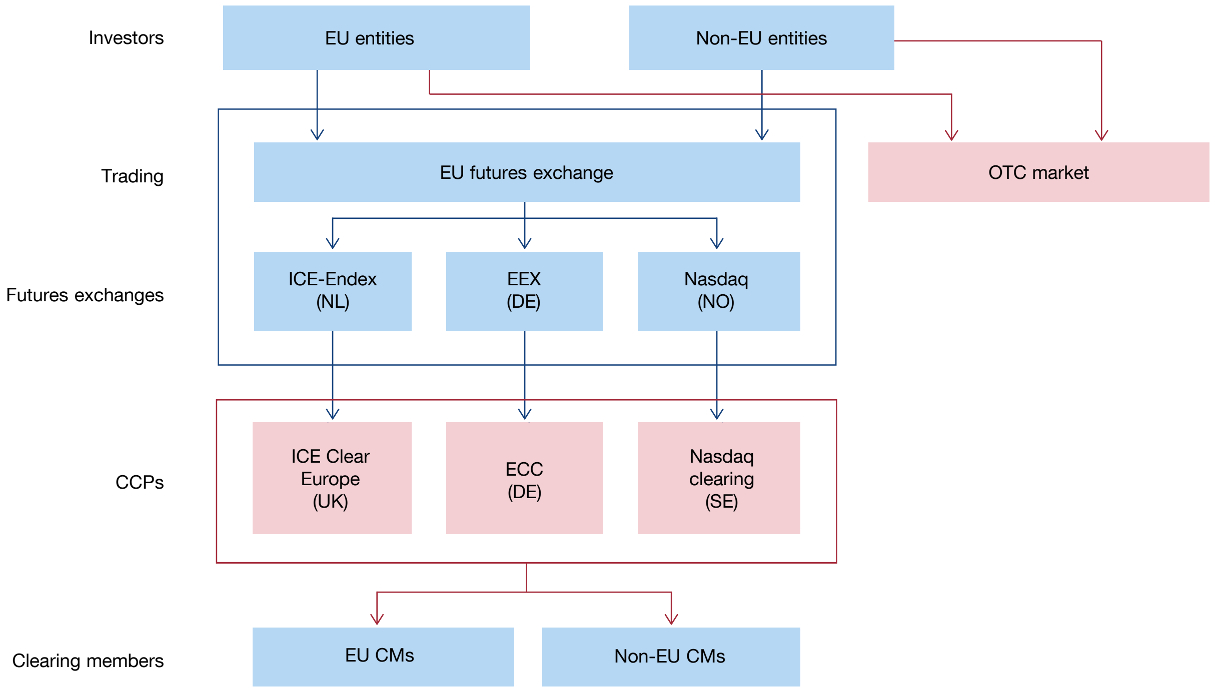
First, the ultimate investors can be EU or non-EU entities. Investors can be financial institutions such as banks or investment funds, or non-financial corporates such as energy producers (utilities), entities specialised in commodity trading (independent commodity trading firms) or corporates that use energy as an input for their production processes (e.g. manufacturing firms).

Investors can trade on futures exchanges or bilaterally on the OTC market. There are three main regulated markets for the trading of natural gas and power derivatives in

4 CCPs use internal models for determining initial and variation margins. High volatility triggers variation margins for counterparties with mark-to-market losses and can also result in higher initial margins for both counterparties.

5 For commodity derivative contracts, the clearing threshold is EUR 4 billion in gross notional value. If a NFC's positions exceed this clearing threshold, it becomes subject to bilateral margin requirements (initial and variation margins). For further details, see ESMA (2022b).

Figure 1
TRADING AND CLEARING ECOSYSTEM



SOURCE: ESMA (2023b).

the EU: ICE Endex in the Netherlands (the main exchange for natural gas, Chart 9), European Energy Exchange (EEX) in Germany (the main exchange for power and a significant exchange for natural gas, Charts 9 and 10) and Nasdaq Oslo in Norway (a significant exchange for power, with a more limited role in natural gas).

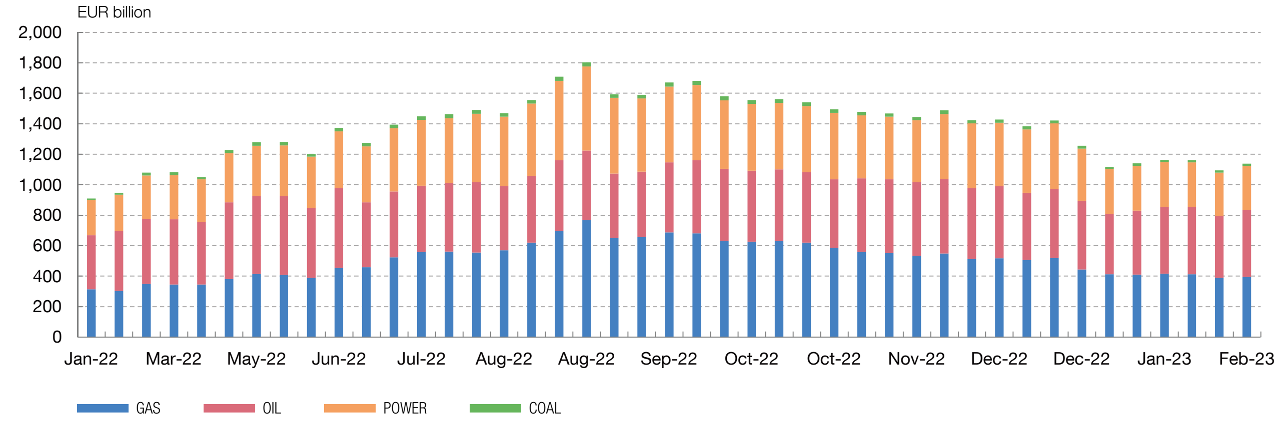
Trades on these exchanges are cleared centrally through three CCPs: ICE Clear Europe in the UK for ICE Endex, European Commodity Clearing (ECC) in Germany for EEX and Nasdaq Clearing in Sweden for Nasdaq Oslo.

CCPs have clearing members (CMs), which can be EU or non-EU firms. EU CMs for energy derivatives are mainly large banks and, to a lesser extent, NFCs.

Finally, clearing members have clients, which can be financial or non-financial entities. Such clients clear their ETD trades with CMs by posting collateral. In turn, CMs post collateral to the CCP on behalf of their clients.

In the ETD space, market participants trade standardised futures and options on regulated markets as market members or through direct market access (whereby a market participant trades using the trading code of a market member).

Chart 2
OUTSTANDING NOTIONAL AMOUNTS BY ENERGY DERIVATIVE AND DATE



SOURCES: EMIR and ESMA.
NOTE: All sectors included, intragroup trades excluded.

Size of EU energy derivatives markets

Overall, exposures of EU entities to energy derivatives markets totalled around EUR 1.1 trillion[6] at February 2023, with natural gas and power derivatives representing 60% of the gross notional amounts (Chart 2).[7] In February 2023 natural gas and power-related derivative exposures amounted to EUR 400bn and EUR 290bn, respectively, as compared with EUR 440bn for oil and less than EUR 15bn for coal. The size of such exposures shows that energy derivatives markets (for natural gas and power in particular) are essential for the functioning of energy markets in the EU.

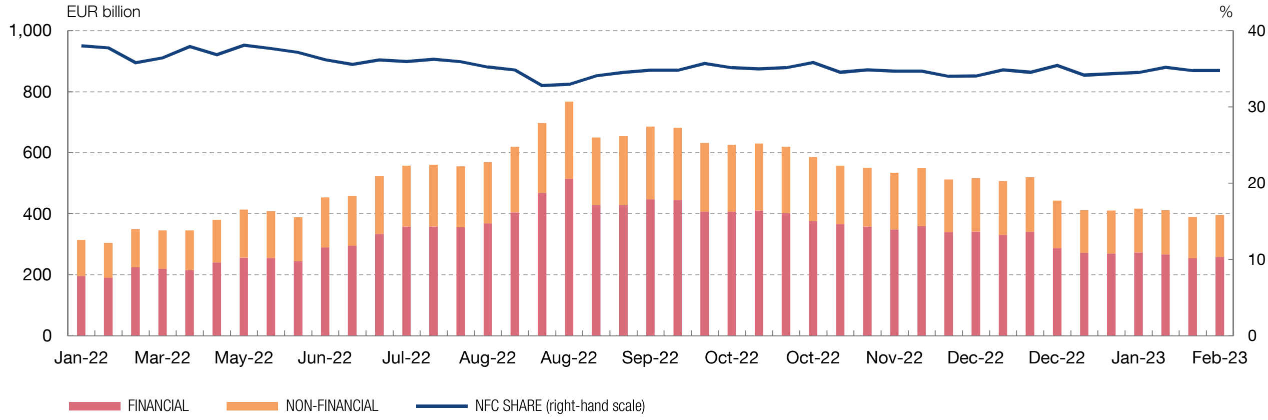
Non-financial corporations (NFCs) play a significant role in energy derivatives markets. On average, 35% of the outstanding notional amounts in gas derivatives over the period analysed were reported by NFCs (Chart 3), not including intragroup trades. This share has decreased slightly, from 38% in January 2022 to 35% in February 2023. Conversely, it has risen steadily in the case of power, from 35% to 50% (Chart 4).

Energy derivatives can be traded on regulated markets, using ETDs such as futures and options, or OTC, mainly in the form of swaps and forwards. Overall, the gross notional exposures of EU counterparties to gas derivatives consists mainly of ETDs,

6 This number includes all outstanding derivatives, including positions between CCPs and clearing members.

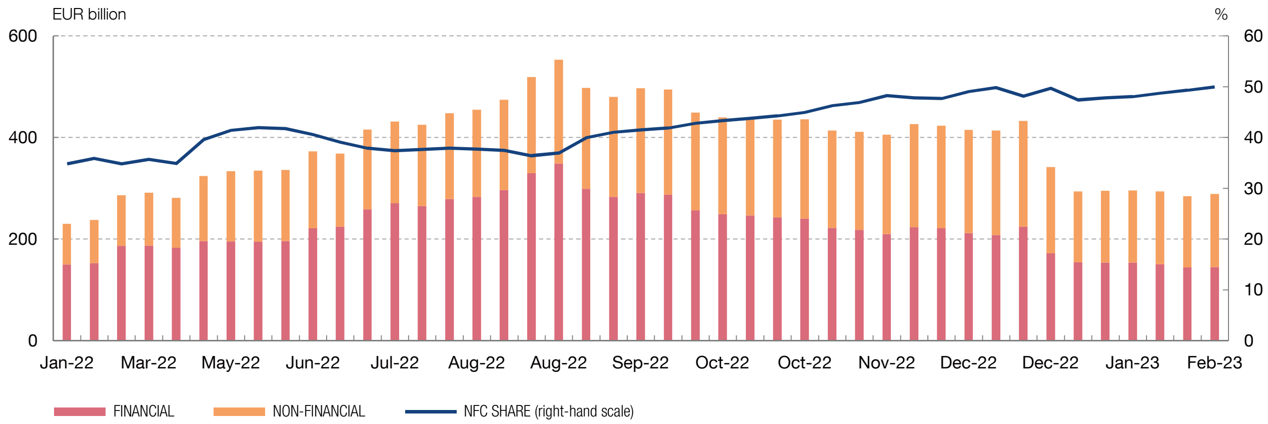
7 Under the European Market Infrastructure Regulation (EMIR), counterparties domiciled in the European Economic Area are subject to detailed reporting requirements on derivatives trades and positions. The data used in the article come from European Economic Area (EEA) entities, covering counterparties domiciled in the 27 EU countries and Iceland, Liechtenstein and Norway. For presentational purposes, the term EU is used throughout the document to cover the EEA.

Chart 3
GAS NOTIONAL AMOUNTS BY SECTOR



SOURCES: EMIR and ESMA.
NOTE: Sector of the reporting counterparty, intragroup trades excluded.

Chart 4
POWER NOTIONAL AMOUNTS BY SECTOR

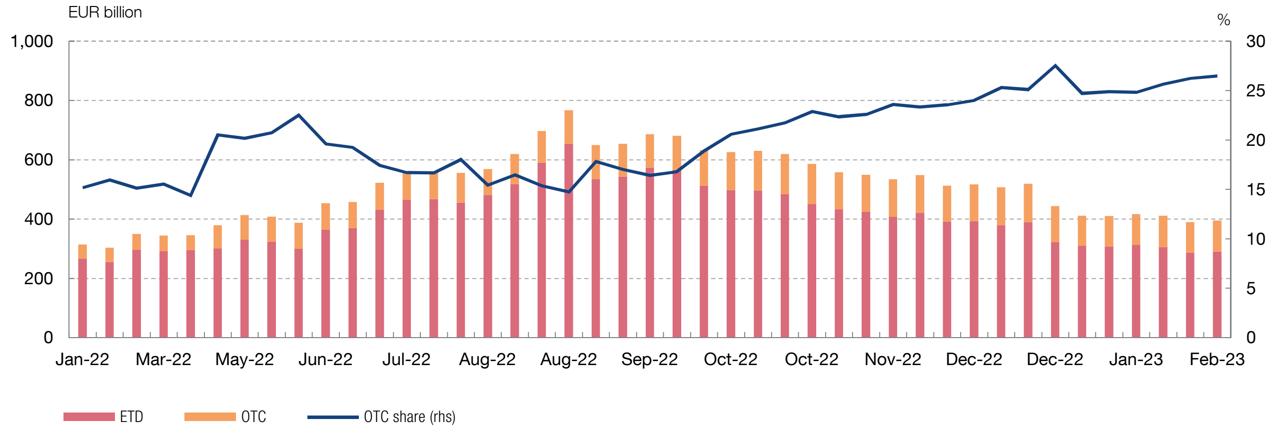


SOURCES: EMIR and ESMA.
NOTE: Sector of the reporting counterparty, intragroup trades excluded.

accounting for 75% of the total. However, since summer 2022 the OTC share of outstanding positions has increased from 15% to 25% (Chart 5). Similar patterns can be observed for power derivatives: around 2/3 of gross exposures are through ETDs and 1/3 via OTC derivatives. The share of OTC derivatives has also increased markedly, from less than 10% in early 2022 to more than 30% (Chart 6). While the outstanding notional amounts of both types of commodities have decreased since late summer 2022, the number of open transactions has remained relatively stable, pointing to the influence price changes have on notional amounts.

Chart 5

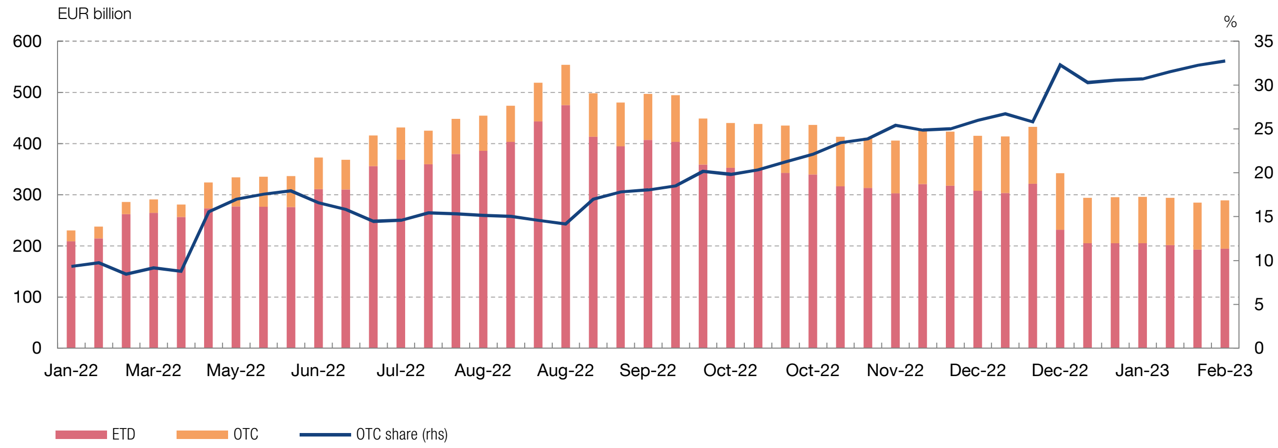
GAS NOTIONAL AMOUNTS BY ETD/OTC SPLIT



SOURCES: EMIR and ESMA.
NOTE: All sectors included, intragroup trades excluded.

Chart 6

POWER NOTIONAL AMOUNTS BY ETD/OTC SPLIT

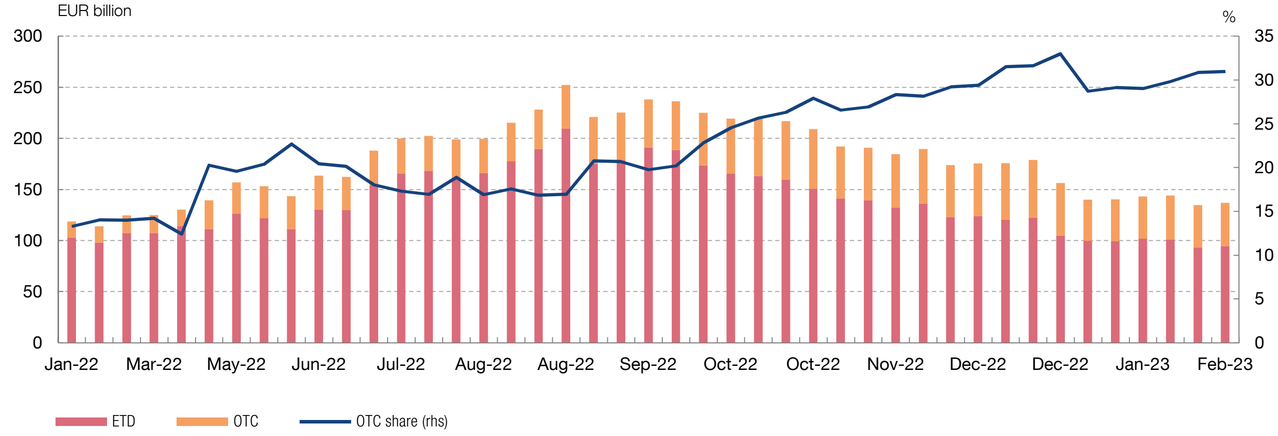


SOURCES: EMIR and ESMA.
NOTE: All sectors included, intragroup trades excluded.

Within ETDs, futures represent around 80% of the gross notional amounts of gas and power derivatives. In the OTC space, excluding intragroup trades, swaps account for 74% of these markets, followed by forwards (13%) and options (6%).

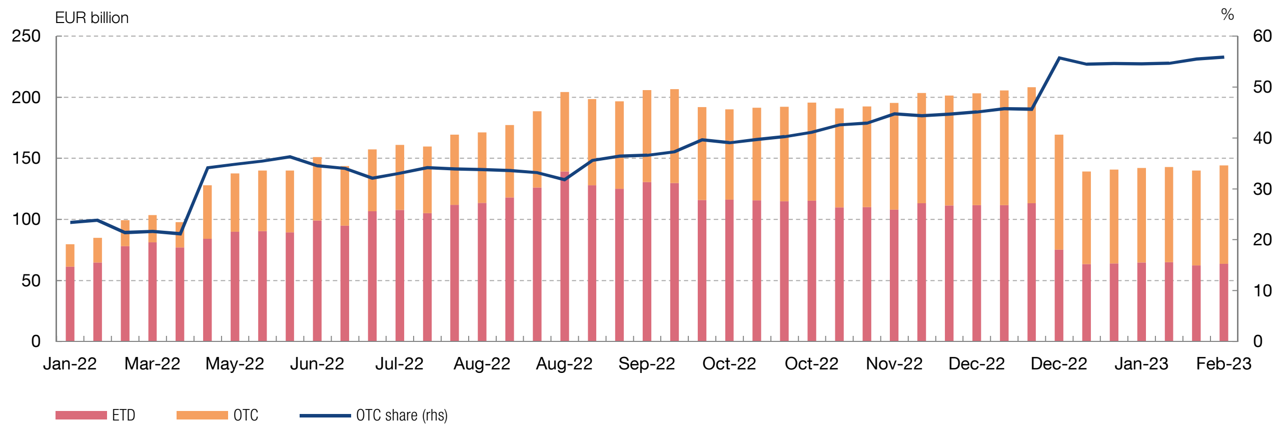
Most exposures to natural gas and power derivatives still take the form of ETDs. However, there has been a significant shift towards the OTC market since the summer, in particular for NFCs and, above all, energy firms (FSB, 2023). Charts 7 and 8 show that the overall share of OTC during 2022 and early 2023 has increased from less than 15% to more than 30% for natural gas and from 20% to over 50% for

Chart 7
GAS NOTIONAL AMOUNTS REPORTED BY NFCs, BY ETD/OTC SPLIT



SOURCES: EMIR and ESMA.
NOTE: Only trades reported by NFCs, intragroup trades excluded.

Chart 8
POWER NOTIONAL AMOUNTS REPORTED BY NFCs, BY ETD/OTC SPLIT

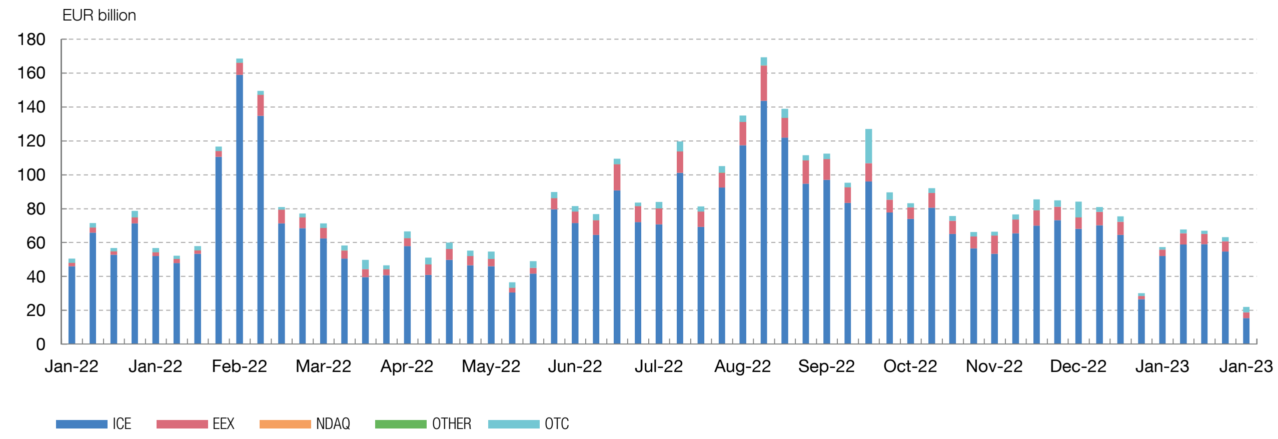


SOURCES: EMIR and ESMA.
NOTE: Only trades reported by NFCs, intragroup trades excluded. Eur billion.

power. Firms may have migrated to OTC to reduce margin requirements, as bilateral contracts can provide counterparties with greater flexibility, even doing away with initial margins in some cases (FSB, 2023). By doing so, firms can trade off liquidity risk for counterparty risk and reduce the liquidity available on trading venues. This shift to OTC is influenced by the different distribution of maturities between ETD and OTC derivatives, as ETD trades tend to have shorter tenors. While prices have come down since the summer of 2022, and notional amounts have decreased accordingly, ETD trades have expired and been renewed comparatively more frequently than OTC trades.

Chart 9

GAS TRADED NOTIONALS BY VENUE AND OTC



SOURCES: FITRS, EMIR, ESMA.
NOTE: Trades reported by CCPs, intragroup trades excluded.

Main trading participants on EU energy derivatives markets

Trading patterns can be analysed by comparing ETD and OTC positions and by comparing trading volumes across both execution methods. Trading volume data show that trading tends to be concentrated on one exchange.[8] ICE is the dominant futures exchange for ETD trades of natural gas derivatives (Chart 9), accounting for 91% of all ETDs in the period between January 2022 and January 2023. This share has decreased slightly, from 96% on average in January 2022 to 89% in January 2023, but trading volumes on other futures exchanges remain small when compared to ICE.

The amount traded OTC is small compared to the volume of ETDs. On average, OTC trades account for only 5% of total trading volumes, and this share has remained stable.

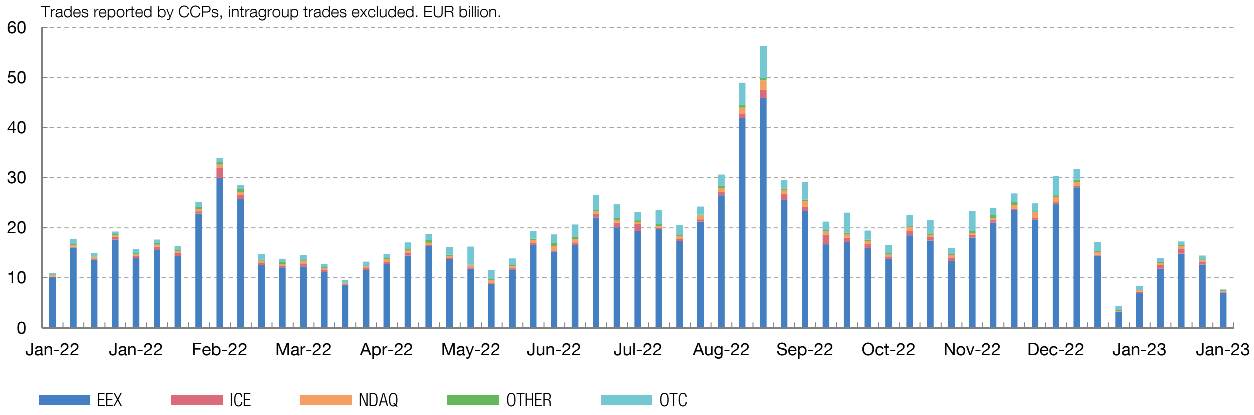
For power derivatives, trading activity is also concentrated on one exchange. EEX accounts for 92% of ETD volumes (Chart 10), with a slight decrease between January 2022 and January 2023, from 95% to 91%.

The share of OTC trading is also small, although higher than in the case of natural gas, accounting for 8% of total trading volumes.

On futures exchanges, the main types of market participant can be analysed using ETD trading data, as well as position reporting at exchange level, since exchanges have to report position information on market participants to the National Competent

8 These figures do not include trades reported by CCPs to EMIR, to avoid overestimating amounts where the counterparty is in the EEA30.

Chart 10
POWER TRADED NOTIONALS BY VENUE AND OTC



SOURCES: FITRS, EMIR and ESMA.

Authorities (NCAs) on a daily basis. In terms of trading activity, a sizeable portion of the volumes traded on futures exchanges are performed by proprietary trading firms such as high-frequency traders, as well as by banks and energy firms (FSB, 2023). As in other electronic markets, proprietary trading firms tend to be very active in terms of trading volumes, but do not generally take directional positions overnight. For the natural gas derivatives markets, ESMA (2023b) shows that non-EU firms accounted for close to 60% of positions in early 2022, before declining to less than 50% in 2022 Q3, with more activity by non-EU firms on ICE Endex than on EEX. In terms of types of market participant, ESMA (2023b) reports that more than 70% of positions are held by non-financial corporates, typically energy firms and non-EU commodity trading firms, followed by banks at around 22%, while investment fund positions declined substantially from 16% in early 2022 to 4% in 2022 Q3, reflecting a sharp reduction in the positions of non-EU hedge funds.

Data fragmentation and data gaps

However, the analysis of risks in natural gas derivatives markets is hampered by data fragmentation and the shortage of data available to ESMA and NCAs. Data fragmentation refers to the fact that information on some derivatives is reported only to energy regulators or NCAs. Data gaps relate to the reporting requirements for energy firms.

First, while transactions in physically settled wholesale energy derivatives are reported to the European Union Agency for the Cooperation of Energy Regulators (ACER), such instruments do not qualify as financial instruments under MiFID. As such, they are excluded from MiFID transparency and reporting requirements under EMIR.

Second, the open positions of market participants at trading venue level, excluding positions in OTC derivatives, are reported to NCAs, but are not directly available to ESMA. Similarly, while EMIR provides detailed information on EU entities, it does not cover non-EU counterparties even if they trade on EU venues, making any analysis of the concentration of positions or trading activity at EU level a challenging prospect.

Finally, most energy firms are not regulated as investment firms, and are therefore exempt from a range of reporting requirements, making it hard to analyse liquidity risk at entity level. In addition, some large (non-EU) commodity trading firms are not listed, further reducing the information publically available on such entities.

3 Risks and vulnerabilities in energy derivatives markets following the Russian invasion of Ukraine

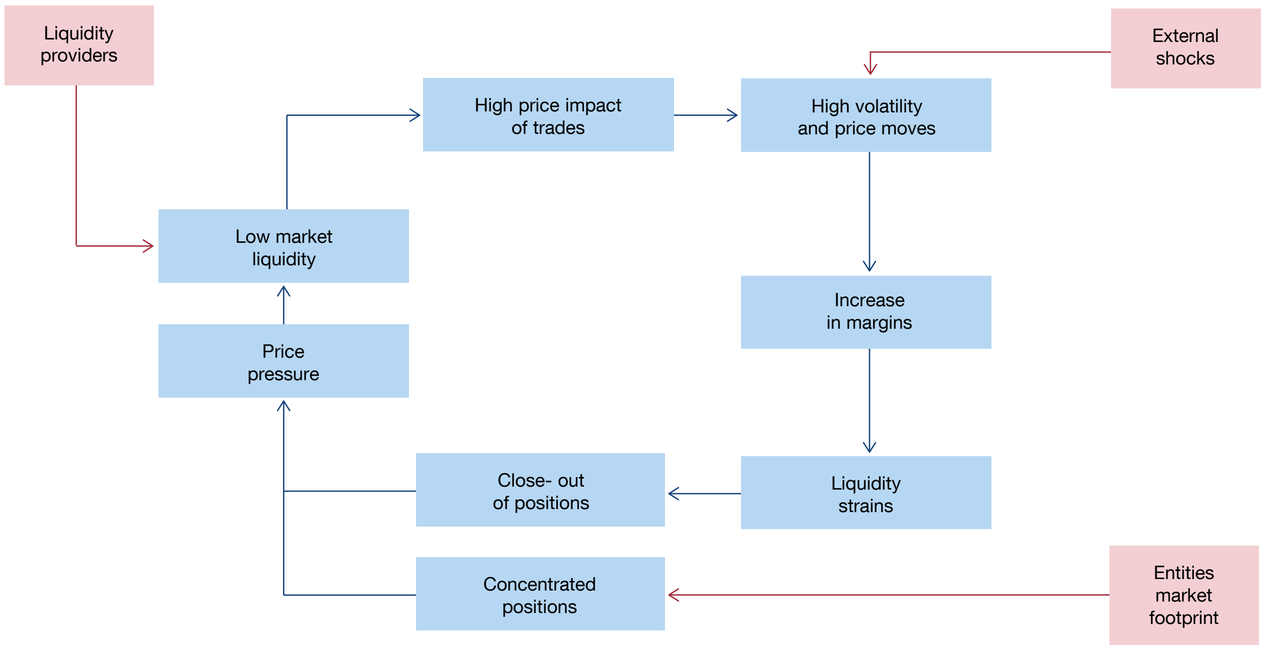
Natural gas and power derivatives markets have come under significant strain following the invasion of Ukraine by Russia in late February 2022. The surge in prices and volatility and the corresponding increase in margin requirements have shown how market and liquidity risks can be mutually reinforcing, as shown in Figure 2.

External shocks can result in large price moves and an increase in volatility. As volatility surges, margins are increased to protect market participants against counterparty and market risk. Some firms, especially non-financial corporates, may then face liquidity strains as they are required to post cash as collateral over a short period. Entities can choose to reduce their exposures by taking opposite positions, but this could amplify the price pressure on derivatives markets. This risk is magnified for entities with large and concentrated positions, as the liquidation of these positions is likely to result in heightened price pressure on markets already under stress. Given high levels of volatility and acute price pressure, along with risk management constraints or a reduction in risk appetite, liquidity providers may withdraw from the markets, resulting in lower liquidity. This, in turn, could amplify the price impact of each trade, resulting in further changes in prices and higher volatility, leading to a mutually reinforcing loop. Some of these risks crystallised in 2022, along the transmission channels outlined above.

Following the Russian invasion of Ukraine, natural gas and power derivatives markets experienced very high volatility amid low liquidity. Prices doubled in March 2022 for both commodities before settling at levels close to their pre-war levels from April to June. Prices then spiked again over the summer, peaking in late August. Prices were at that point around four times higher than their pre-war levels, as concerns arose about supply and the increased demand to fill natural gas storage facilities. Natural gas price tensions were also reflected in power markets, as power prices are strongly correlated with natural gas, reflecting the marginal pricing model used in the EU.[9]

9 For further details on the marginal pricing model used in the EU, see ACER (2022).

Figure 2
MUTUALLY REINFORCING LOOP IN ENERGY DERIVATIVES MARKETS



SOURCE: Devised by authors.

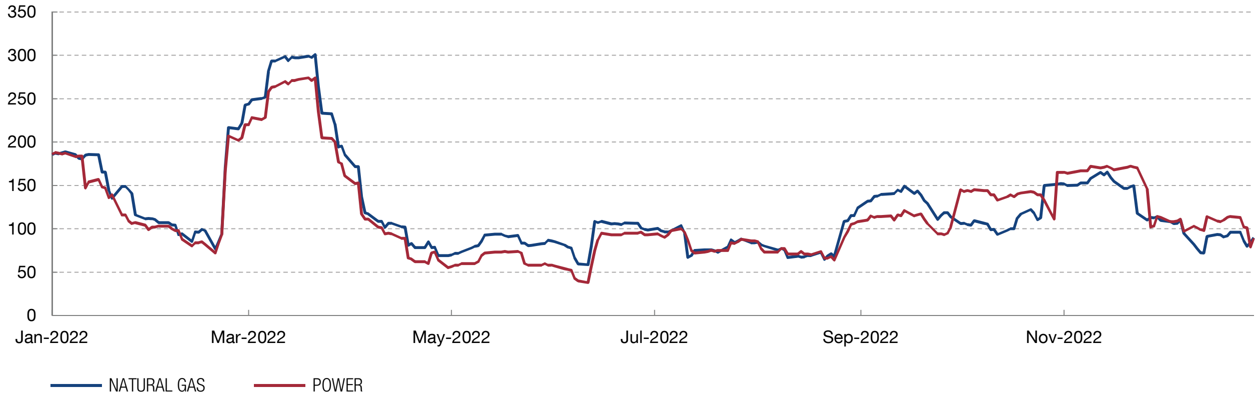
Volatility also spiked, reaching 300% in annualised terms in March and close to 150% in August (Chart 11). Since then, volatility and prices have declined substantially and both had fallen to below pre-war levels by the end of 2022.

The extreme volatility of prices was associated with a sharp deterioration in market liquidity: bid-ask spreads widened and market depth (a measure of the liquidity available to buyers and sellers) plummeted. For example, bid-ask spreads on ICE-Endex rose to more than 2% in March 2022 (up from 0.5% pre-war) and reached similar levels at the end of August as liquidity dried up (Chart 12). Similar patterns were observed in power derivatives, which are structurally less liquid due to the high volatility of power prices.[10] Bid-ask spreads widened to more than 50% in July and August 2022, as liquidity dried up in power derivatives markets. Since then, liquidity has improved and was close to pre-war levels by early 2023 (Chart 13).

As price volatility surged, margin requirements on derivatives positions also increased, in line with CCP risk models. For natural gas ETDs, initial margins rose from around 20% of the notional in November 2021 to 40% in February 2022 on both ICE Endex and EEX, and up to 70% on ICE in March 2022 (Chart 14). Variation

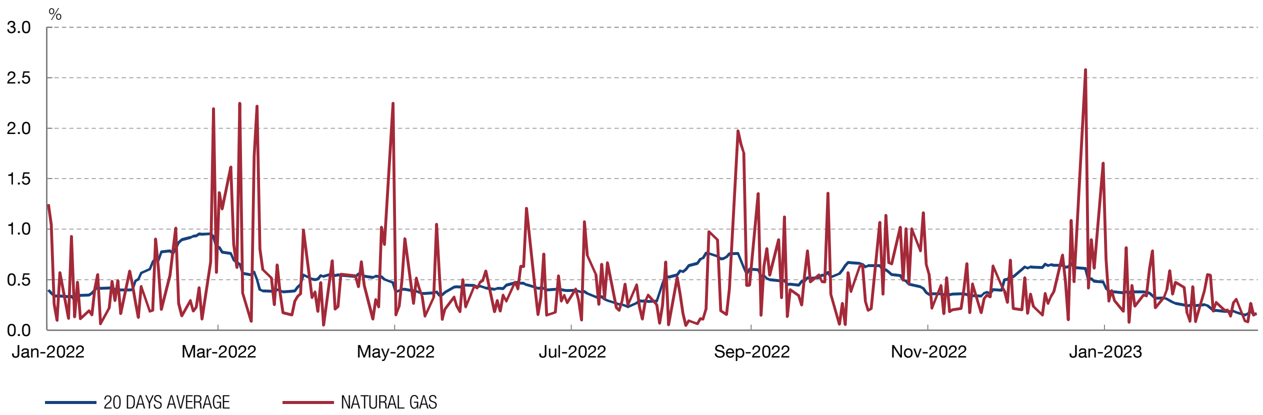
10 Power derivatives markets are characterised by seasonality, mean-reverting behaviour, high volatilities and the occurrence of jumps and spikes (Weron et al., 2004; Bierbrauer et al., 2007 and Culot et al. 2013).

Chart 11
FUTURES' VOLATILITY



SOURCES: Refinitiv Datastream and ESMA.
NOTE: 20D annualised volatility of future prices of natural gas (Dutch TTF front-month contract) and power (Phelix front-month), in %.

Chart 12
GAS BID-ASK SPREAD

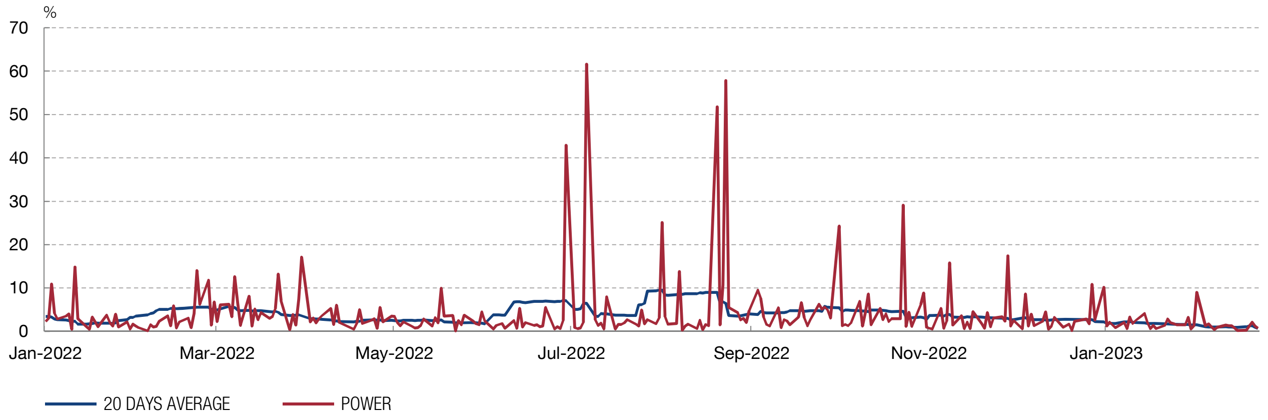


SOURCES: Refinitiv EIKON and ESMA.
NOTE: Bid-ask spread for Dutch front-month future traded on ICE-Endex. Basis points.

margins also increased for counterparties with mark-to-market losses, mainly firms with short positions on natural gas derivatives.

As counterparties faced margin calls, some non-financial corporates were hard pressed to obtain liquidity on a short-time horizon, as their balance sheet is typically less liquid than is the case for financial firms, and they have limited access to funding sources. In short, the price shock and the increase in margin calls led to liquidity strains for some firms (JA, 2022). In several EU countries and the UK, public support for energy firms has been introduced in the form of loans and credit guarantees and, in some cases, bailouts of troubled firms. Sgaravatti et al. (2023) estimate that such facilities amounted to EUR 194bn, representing more than 4% of GDP in some EU countries.

Chart 13
POWER BID-ASK SPREAD



SOURCES: Refinitiv EIKON and ESMA.
NOTE: Bid-ask spread for Phelix front-month future traded on EEX. Basis points.

Chart 14
INITIAL MARGINS (% OF NOTIONALS)

SOURCES: ICE, EEX, ESMA.
NOTE: Initial margin on front-month Dutch TTF future contract on ICE-Endex and EEX. Basis points.

4 Changes in the structure of the energy derivatives network and liquidation risk

The severe stress experienced by EU energy derivatives markets following the Russian invasion of Ukraine has shown how some of the risks discussed above can crystallize. Market participants have also changed their behaviour, with some migrating from ETDs to OTCs. This section assesses the changes in the structure of the network of EU energy derivatives markets and takes a closer look at concentration risk, in particular as regards clearing activity and the existence of significant derivatives positions that might be challenging to liquidate.

a) The network of EU natural gas and power derivatives exposures

Understanding the interconnectedness between market participants is key to assessing risks. EMIR data can be used to further examine energy derivatives and their use in the EU and to assess potential concentration risk. Due to limitations, data on non-EU counterparties with exposures to EU energy derivatives through non-EU entities are not included, even though non-EU entities can play a significant role in EU markets.[11]

Chart 15 displays the network of natural gas derivatives exposures in gross notional amounts among the top 30 EEA counterparties at the end of November 2022. In the ETD space (blue curved lines), most of the activity took place between energy firms (red squares) and clearing members (CMs), which are mainly banks (blue triangles). CMs tend to have a range of different clients, which are predominantly energy firms. A few energy firms trade ETDs on both futures exchanges, as shown by the links between those clients and CMs at the two different CCPs (yellow circles). The two CCPs clearing EEA natural gas futures have exposures to several EU CMs. The width of the blue edges — which is proportional to the relative size of gross exposures between CMs and CCPs — indicates that clearing is concentrated in a few banks.

Turning to the OTC space (red curved lines), most of the activity occurs between energy firms or through a few banks (blue triangles), which are not usually EU clearing members.[12] There are only a few 'other' firms (such as non-bank financial entities) in the network (green circles), showing that other financial firms play a limited role in EU natural gas derivatives markets.

Chart 16 sets out a similar analysis for power derivatives markets. In the ETD space (blue curved lines), the three CCPs clearing EU power futures (orange circles) have exposures to several EU CMs, most of them banks (blue triangles) for two CCPs, while another CCP has a higher diversity of CMs, including banks but also energy firms (red squares) and other firms (green ovals). The width of the blue edges indicates that, as in the case of natural gas, clearing is concentrated in a few banks. Most clients of CMs are energy firms or other non-financial firms (including municipalities in some EU countries), and the CMs that account for most of the clearing activity tend to have a range of different energy and other non-financial firms as clients. A few energy firms trade ETDs on both exchanges, as shown by the links between those clients and CMs at the three different CCPs. Turning to the OTC space (red curved lines), most of the activity occurs between energy firms or through

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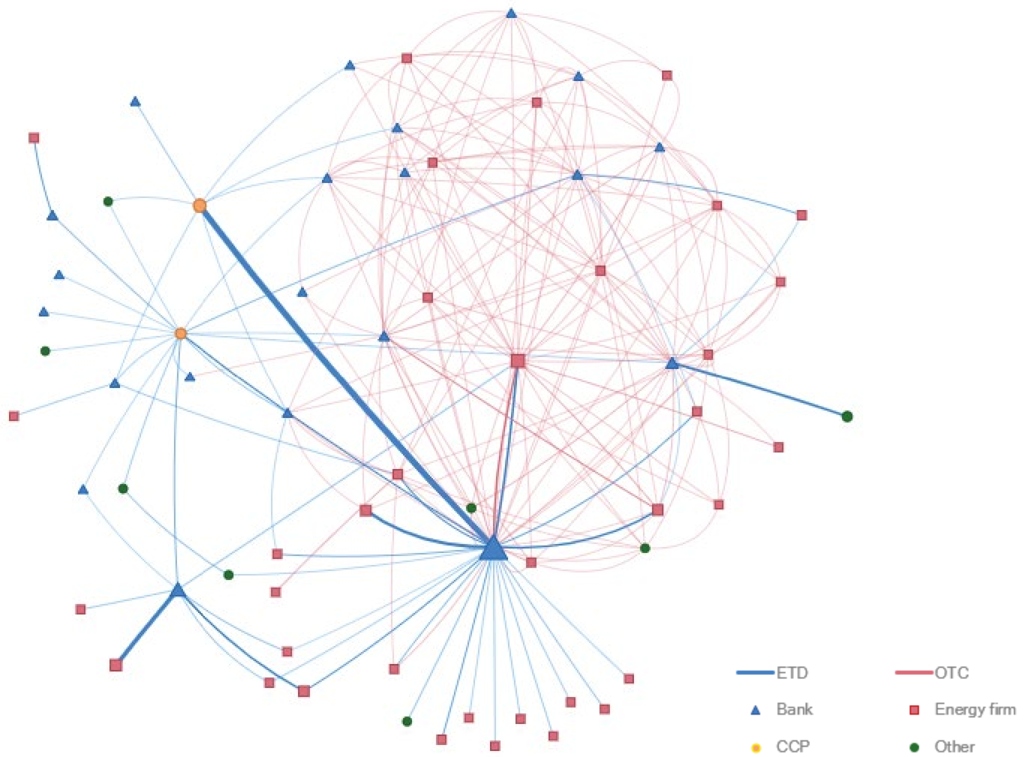
11 More precisely, entities domiciled in the EEA have to report derivatives information under EMIR, which provides a broader scope than the EU. Thus, non-EEA entities trading on EU regulated markets, whose clearing is done in a third country CCP, are not covered, unless these entities clear their trades with an EU clearing member.

12 Since ESMA only has access to information reported by EU counterparties, non-EU clearing members are covered only if they are CMs of an EU CCP or to the extent that they have EU clients. Thus, the network only shows a partial overview of the market.

Chart 15
NATURAL GAS DERIVATES NETWORK



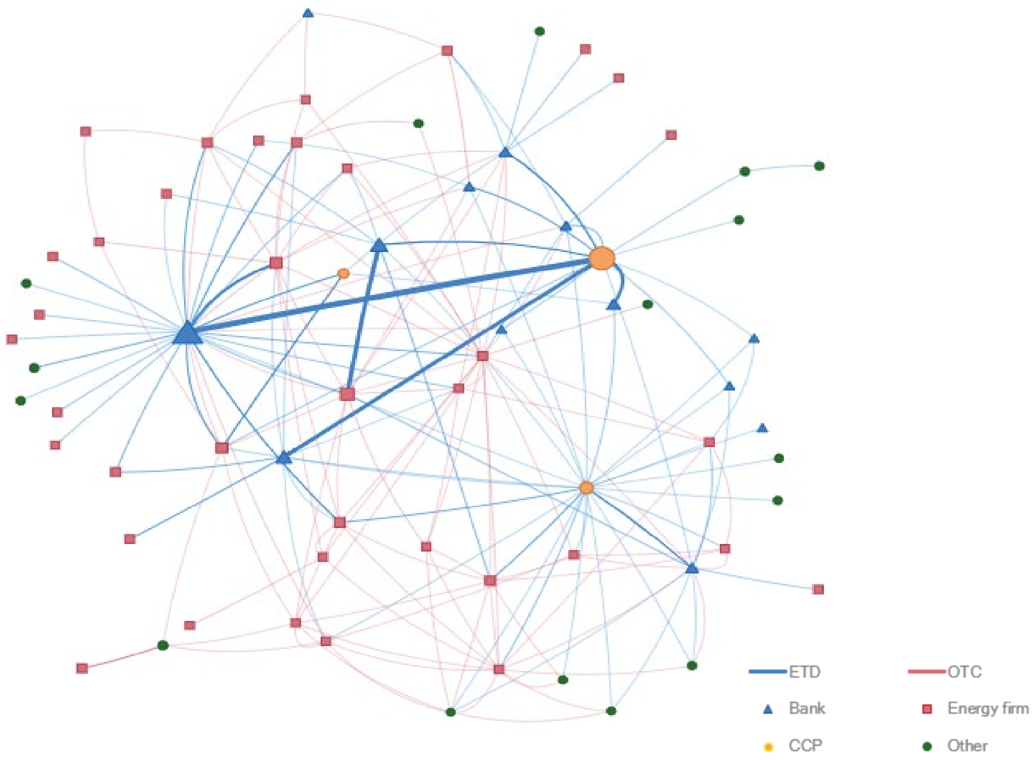
SOURCES: EMIR, ESMA.
NOTE: Central counterparties, clearing members and largest 30 clients in all gas derivatives. Data as of end-November 2022, aggregated at group level, with intragroup trades excluded.

a few banks (blue triangles), which are not usually clearing members. Compared to the natural gas network, there are more other non-financial firms in the network, showing that they play a more significant role in power derivatives markets than in natural gas markets.

Overall, the network analysis indicates a degree of significant concentration of clearing activity in a few banks. This means that, in times of stress, those CMs will have to post additional collateral, and request that their clients do likewise. Since a large portion of the clients are energy firms, such entities (unlike banks) may not have ample liquidity pools or liquidity facilities that can be mobilised quickly. While some firms used credit facilities provided by banks, financing conditions tightened, creating liquidity strains for energy firms (ECB; 2022a; 2022b). In addition, the network is characterised by a degree of separation between ETD and OTC activity, with only a few firms trading on exchanges and OTC, which might point to some preference for one type of execution over the other.

The features of the natural gas and power networks are further explored using a range of network metrics (see Korniyenko et al., 2018 for a discussion of centrality

Chart 16
POWER DERIVATES NETWORK



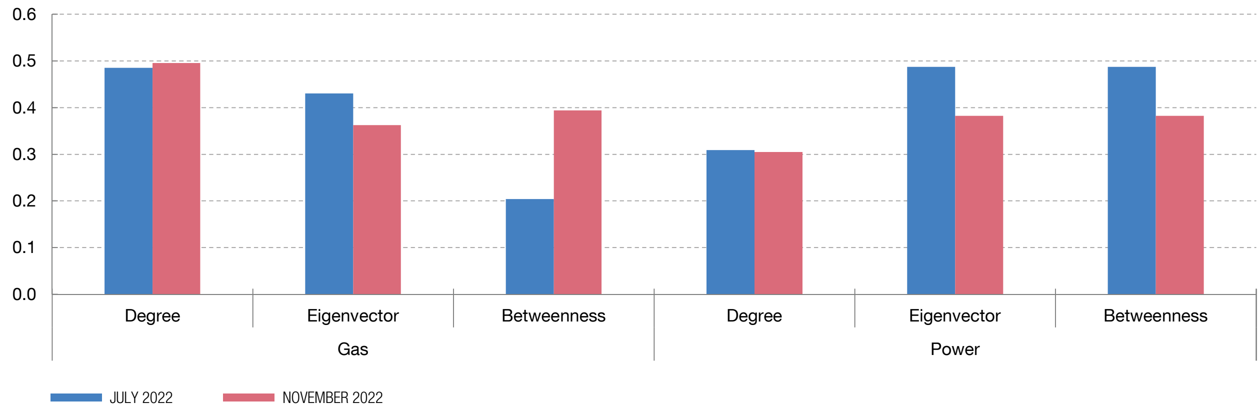
SOURCES: EMIR, ESMA.
NOTE: Central counterparties, clearing members and largest 30 clients in power derivatives. Data as of end-November 2022, aggregated at group level, with intragroup trades excluded.

measures), which can then be compared over time and across derivatives.[13] Chart 17 displays different indicators of centrality for the natural gas and power networks over two time periods: July and end-November 2022. Each centrality indicator is normalised and ranges between 0 and 1, with 0 being the minimum level of interconnectedness and 1 the theoretical maximum.

The first measure is the degree centrality, which indicates the number of connections that each node (i.e., market participant) has to other nodes, with higher values indicating that such market participants are exposed to a wide range of counterparties. A high degree centrality implies that shocks tend to be transmitted more broadly to other entities in the network. For natural gas, the normalised degree centrality increased slightly throughout 2022 (from 0.48 to 0.50), implying that market participants have kept their number of counterparties stable over time. Compared to other derivatives, degree centrality tends to be higher for natural gas derivatives than other asset classes which have degree measures below 0.50 (ESMA, 2021). We observe a similar pattern of stability for power derivatives, although the degree

13 See appendix for further details on network centrality measures.

Chart 17
NETWORK STATISTICS BY DATE AND MARKET



SOURCES: EMIR and ESMA.

centrality is lower (around 0.30), implying a lower number of connections compared with natural gas derivatives.

The second measure is the eigenvector centrality, which estimates the influence of a node by its connections to other influential nodes. High values indicate that some entities play a central role in the network, as they are exposed to other entities of significant importance.

Eigenvector centrality declined during 2022 for both natural gas (from 0.51 to 0.36) and power (from 0.49 to 0.38). This decline indicates that market participants have reduced their relative exposures to 'central' nodes. Compared to other derivatives, the natural gas and power networks have lower eigenvector centrality, implying more fragmented exposures across counterparties.

The third indicator is the betweenness centrality, which measures the number of times an entity lies in the shortest path between two other entities. A high value shows that some entities play the role of 'bridges' between other entities in the network.

The betweenness indicator increased during 2022, from around 0.20 in July to 0.39 in November 2022 for natural gas and from 0.12 to 0.23 for power.

Overall, centrality measures indicate that the importance of central nodes has declined (as shown by the fall in eigenvector centrality), which is consistent with the migration from ETD to OTC. At the same time, the increase in betweenness centrality suggests that more entities play the role of 'bridges' within the network (irrespective of the importance of their counterparties) than was the case before the war. One example would be where multiple EEA counterparties started trading with the same new energy suppliers. This would increase fragmentation in notional amounts, further decreasing the eigenvector, while at the same time increasing interconnectedness, since fewer steps are needed to cross the whole network. The effect on the degree would be slightly positive as, on average, nodes have more edges.

b) Concentration risks and liquidity

Concentration risk encompasses a range of dimensions along the trade value chain. First, as shown above, there is a high degree of concentration at clearing level: a few CMs account for most of the clearing activity performed by EU entities on behalf of EU and non-EU clients. Second, trading tends to be concentrated in a few firms which account for most of the trading volumes. Some of those entities, such as proprietary trading firms (e.g. high-frequency trading firms), may withdraw from the market in times of stress, resulting in a significant reduction in the liquidity offered to market participants just when it is most needed.

Some degree of concentration is also visible at position and trading venue level, although market participants are subject to position limits on EU venues for critical or significant commodity derivatives.[14] ESMA (2023b) reports that the positions of the top 5 largest EU clients on the natural gas derivatives markets amount to more than 50% of EU exchange traded positions, and around 40% of the broad EU natural gas derivative market (clients only). For power, these shares stand at 47% and 32%, respectively. The potential impact of liquidating such positions can be estimated by combining exposure information from EMIR with market data on trading volumes.

The ability to liquidate a position also depends on the behaviour of other market participants. In the case of a large symmetric shock to prices and liquidity, as seen in summer during power shortages, several energy firms may try to move out of their positions at the same time, making it more difficult for each of them to dispose of their assets. To assess this scenario, we estimate the time it would take to liquidate the short and long positions of the top 5 energy firms if these participants were to reduce their positions in those two highly liquid futures at the same time. We broaden the analysis of the gas market performed by ESMA (2023b) to include European power markets.

EMIR data from November 2022 is used to obtain positions in the two most liquid power futures contracts (based on notional amounts traded between October and November 2022) on the two largest European exchanges, i.e. EEX and NASDAQ OMX. For each EEA 30 counterparty, positions are totalled by long and short positions, resulting in net notional amounts. These net notional amounts are then

14 A commodity derivative whose net open interest is above 300,000 contracts on average over a one-year period is considered a critical or significant commodity derivative under MiFID II and hence subject to position limits. Currently, only TTF futures traded on ICE Endex are subject to position limits. Spot month positions are limited to 10% of deliverable supply and other months' positions to 10% of open interest (ESMA, 2022d).

combined with a measure of market liquidity based on average daily trading volumes (over October and November 2022). We use data from the MiFID Financial Instrument Transparency System (FITRS), which provides (among other information) daily trading volumes at instrument level.

Following this approach, two measures of concentration are calculated: one at the market level and another one at the instrument (i.e. futures) level. For the top 5 NFCs with the biggest long and short net exposures, their aggregated position is expressed as a percentage of average daily trading volumes (ADV), to indicate how long it would take to unwind those positions.[15] A high figure implies that the liquidation of positions would either take a long time or would result in large price moves if executed quickly, as the trades could be multiples of the daily average trading volumes.[16] It should be noted that this approach might underestimate the time needed to close out positions during periods of stress, as liquidity tends to vanish during times of crisis. On the other hand, it might be possible to close out positions faster than in the approach presented by using futures with different maturities. Nevertheless, we are convinced that the following calculation will give a sense of how strong the concentration in the positions of the two futures is.

Chart 18 shows the result of the calculation on the most liquid power future traded on EEX. It reveals that the net long and short positions of these top 5 NFCs combined are fairly comparable (EUR 4.5bn short vs EUR 4.9bn long). Putting these amounts into perspective, using trade data it emerges that these positions account for 551% of the ADV for short positions and around 593% of the ADV for long positions. This means that it would take more than five days if the top 5 NFCs (with net short or net long positions) were to try to close out their power derivatives portfolio at the same time.

Chart 19 shows a similar analysis for the most liquid power future on Nasdaq Oslo, where gross exposures are significantly smaller. In line with earlier results, we observe that the net long and net short positions of these top 5 NFCs combined are fairly comparable (EUR 641m short vs EUR 733m long). However, these positions account for a larger multiple of average trading volumes: 1,670% of the ADV for short positions and around 1,883% of the ADV for long positions. This means that it would take more than 16 days if the top 5 NFCs short or long were to try to close out their positions.

These results suggest that if several firms with similar directional positions were to reduce their exposures, they could amplify market moves. In turn, these market

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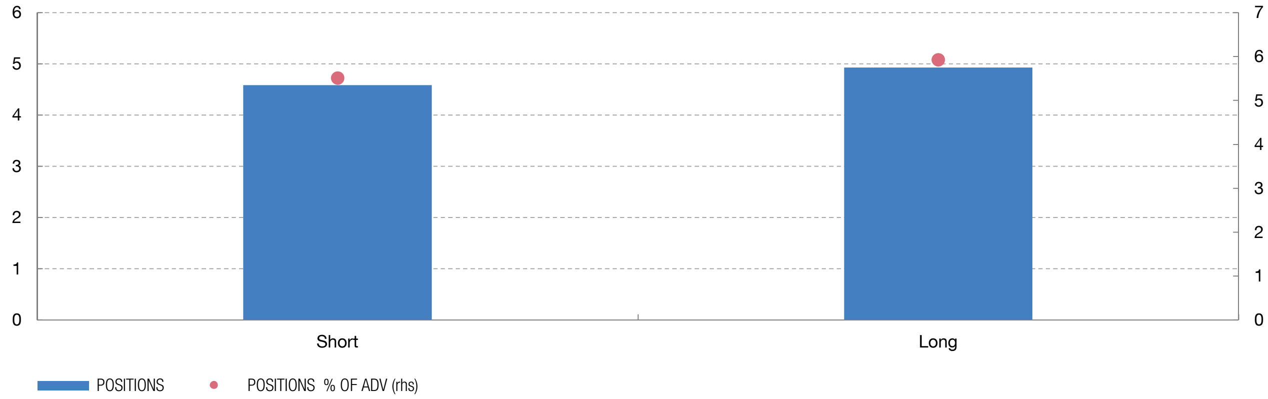
15 This approach is in line with the methodology used for concentration modelling in the ESMA CCP stress tests (ESMA, 2022a).

16 The default of a clearing member with large positions can result in losses for the CCP and other clearing members, as observed in September 2018 for Nasdaq Clearing (Bell and Holden, 2018; Finansinpektionen, 2021), and, in extreme cases, the failure of the CCP, as occurred in 1974 in France (Bignon and Vuillemey, 2020).

Chart 18

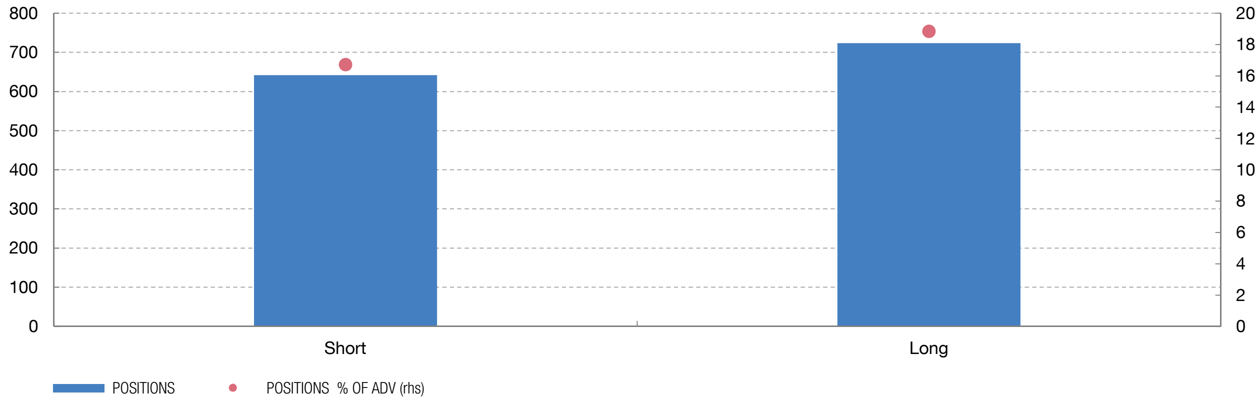
COMBINED POSITIONS OF FIVE LARGEST NFCS IN THE FRONT MONTH FUTURE AT EEX



SOURCES: EMIR, FITRS, authors' calculations.
NOTE: Ratio of net exposures of top 5 NFCs on front-month Phelix futures on EEX in percent of average daily trading volumes.

Chart 19

COMBINED POSITIONS OF FIVE LARGEST NFCs IN THE FRONT MONTH FUTURE AT NASDAQ OSLO



SOURCES: EMIR, FITRS and ESMA.
NOTE: Ratio of net exposures of top 5 NFCs on front-month Nordic power futures on Nasdaq Oslo as a percentage of average daily trading volumes.

moves could lead to other firms liquidating their positions, creating the vicious circle observed in other markets.[17] Overall, the results show that liquidation costs could be significant in the case of a simultaneous winding-up of positions, pointing to concentration risk.

17 For example, in September 2022 an abrupt rise in GBP sovereign yields led to a surge in liquidity demands for leveraged funds using Liability Driven Investment strategies, as the sovereign bonds used as collateral in repo transactions fell in value, while the funds also faced margin calls on their interest rate derivatives portfolios. To meet these liquidity demands, some funds began liquidating their GBP sovereign bonds, resulting in heightened pressure on the bond market and an inability to trade. Tensions waned after an intervention by the Bank of England (Breeden, 2022).

5 Conclusions and financial stability implications

The structure and functioning of EU energy derivatives markets can shed light on risks to financial stability.

First, while the aggregate direct exposures of financial institutions to energy derivatives markets are small in comparison with their size or capital, stress in the natural gas or power markets can spread throughout the real economy due to the exposures of non-financial corporations. Such firms tend to have less access to liquidity than financial institutions and can therefore be subject to liquidity strains as a result of margin calls on ETD and OTC positions (ECB, 2022b).

Second, concentration risk is high in energy markets across a range of areas, including concentration of clearing activity, the existence of large positions in ETD and OTC markets and the reliance on a few key liquidity providers (ESMA, 2023b). The unwinding of large positions could result in further pressure on prices, amplified by a reduction in market liquidity, ultimately leading to a substantial price impact on trades.

Third, natural gas and power prices can influence (in particular, through derivatives contracts) pricing on electricity markets as a whole (ACER, 2022). This interconnection is further strengthened by the EU system of marginal pricing in electricity markets. Thus, natural gas and power derivatives markets ultimately play a crucial role in price formation on energy markets.

Lastly, given that natural gas and power are key inputs in most production processes and critical infrastructures, financial instability in this market can soon spill over to the broader economy.

The Russian invasion of Ukraine triggered a surge in natural gas prices amid heightened volatility and a deterioration in liquidity.

An analysis of EU energy derivatives markets has shown that the concentration of clearing activity in a limited number of clearing members and the large market footprint of a small number of energy firms can amplify risks for financial stability through liquidation costs and funding liquidity issues for counterparties. In this context, the recent migration of some activity from ETD to OTC has resulted in a more fragmented market network, with a smaller role for central nodes, and an increase in the number of highly interconnected entities, which could exacerbate the propagation of shocks to a wider range of counterparties.

In addition, energy firms play a central role in natural gas and power derivatives markets as suppliers and consumers of such commodities. This suggests that energy firms and financial institutions have very direct interconnections. Such tight linkages can transmit shocks from one sector to the other and may pose risks to financial stability through liquidity and concentration risks. Since energy firms are often non-financial companies, they are subject to less stringent oversight and reporting requirements than financial institutions (e.g. investment firms or credit institutions), and there is less transparency in terms of the balance sheet and liquidity profile of such firms.

Lastly, as with any commodity and unlike standard financial instruments, natural gas is subject to storage and supply constraints, making the pricing of derivatives more dependent on external factors, including geopolitical events.

Looking forward, the analysis of risks in energy derivatives markets requires further work in order to address data gaps and data fragmentation. With this in mind, further cooperation between energy and financial market regulators is warranted (ESMA; 2022c).

REFERENCES

ACER. (2022). "ACER's Final Assessment of the EU Wholesale Electricity Market Design", April. https://acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER's%2520Final%2520Assessment%2520of%2520the%2520EU%2520Wholesale%2520Electricity%2520Market%2520Design.pdf

ACER. (2023). "Market Correction Mechanism. Preliminary data report". https://acer.europa.eu/sites/default/files/documents/Publications/ACER_PreliminaryReport_MCM.pdf

Bardoscia, Marco, Ginestra Bianconi and Gerardo Ferrara. (2019). "Multiplex network analysis of the UK over-the-counter derivatives market", *International Journal of Finance & Economics,* Vol. 24(4). https://doi.org/10.1002/ijfe.1745

Bell, Sarah and Henry Holden. (2018). "Two defaults at CCPs, 10 years apart", *BIS Quarterly Review,* December. https://www.bis.org/publ/qtrpdf/r_qt1812x.htm

Bierbrauer, Michael, Christian Menn, Svetlozar T. Rachev and Stefan Trück. (2007). "Spot and derivative pricing in the EEX power market", *Journal of Banking & Finance,* Volume 31, Issue 11, 2007, Pages 3462-3485. https://doi.org/10.1016/j.jbankfin.2007.04.011

Bignon, Vincent and Guillaume Vuillemey. (2020). "The Failure of a Clearinghouse: Empirical Evidence", *The Review of Finance,* Vol. 24(1). https://academic.oup.com/rof/article/24/1/99/5255887

Breeden, Sarah. (2022). "Risks from leverage: how did a small corner of the pensions industry threaten financial stability?", Speech. https://www.bankofengland.co.uk/speech/2022/november/sarah-breeden-speech-at-isda-aimi-boe-on-nbfi-and-leverage

Brunnermeier, Marcus and Lasse Pedersen. (2009). "Market liquidity and funding liquidity", *The Review of Financial Studies,* Vol. 22(6). https://doi.org/10.1093/rfs/hhn098

Cartea, Álvaro and Carlos González-Pedraz. (2012). "How much should we pay for interconnecting electricity markets? A real options approach", Energy Economics, Vol. 34(1), pp 14-30. https://doi.org/10.1016/j.eneco.2011.06.002

Culot, Michel, Valérie Goffin, Steve Lawford, Sébastien de Menten and Yves Smeers. (2013). "Practical stochastic modelling of electricity prices", *The Journal of Energy Markets,* Vol. 6 (1), pp 1-40. https://doi.org/10.21314/JEM.2013.085

ECB. (2022a). "Survey on credit terms and conditions in euro-denominated securities financing and OTC derivatives markets (SESFOD)", June. https://www.ecb.europa.eu/pub/pdf/other/SESFOD_2022_Q2_Summary~0a0940a826.en.pdf

ECB. (2022b). "Financial stability risks from energy derivatives markets", *Financial Stability Review,* November. https://www.ecb.europa.eu/pub/financial-stability/fsr/special/html/ecb.fsrart202211_01~173476301a.en.html

Economic Consulting Associates. (2015). "European electricity forward markets and hedging products — state of play and elements for monitoring", Final report submitted to ACER, September. https://www.acer.europa.eu/en/Electricity/Market%20monitoring/Documents_Public/ECA%20Report%20on%20European%20Electricity%20Forward%20Markets.pdf

ESMA. (2021). "EU Derivatives markets", *Annual statistical report.* https://www.esma.europa.eu/sites/default/files/library/esma50-165-2001_emir_asr_derivatives_2021.pdf

ESMA. (2022a). "4th ESMA Stress Test Exercise for Central Counterparties", Report. https://www.esma.europa.eu/sites/default/files/library/esma91-372-2060_4th_esma_ccp_stress_test_report.pdf

ESMA. (2022b). "EMIR RTS on the commodity derivative clearing threshold", Final Report, June. https://www.esma.europa.eu/sites/default/files/library/esma70-451-114_final_report_review_of_the_commodity_derivative_clearing_threshold_under_emir.pdf

ESMA. (2022c). "ACER and ESMA enhance cooperation to strengthen oversight of energy and energy derivative markets", Press release, 18 October. https://www.esma.europa.eu/press-news/esma-news/acer-and-esma-enhance-cooperation-strengthen-oversight-energy-and-energy

ESMA. (2022d). "Opinion on position limits on ICE Endex Dutch TTF Gas contracts". https://www.esma.europa.eu/sites/default/files/library/esma70-55-12400_opinion_on_position_limits_on_ice_endex_dutch_ttf_gas_contracts_significant_contracts.pdf

ESMA. (2023a). "Preliminary data report on the introduction of the market correction mechanism". https://www.esma.europa.eu/sites/default/files/library/esma70-446-775_preliminary_data_report_on_mcm.pdf

ESMA. (2023b). "EU natural gas derivatives markets: risks and trends", *Trends, Risks and Vulnerabilities* article, forthcoming April 2023.

Financial Conduct Authority. (2022). "Joint statement from UK Financial Regulation Authorities on London Metal Exchange and LME Clear", April. https://www.fca.org.uk/news/statements/uk-financial-regulation-authorities-london-metal-exchange-lme-clear

Financial Stability Board. (2023). "The financial stability aspects of commodities markets", February. https://www.fsb.org/wp-content/uploads/P200223-2.pdf

Finaninspektionen. (2021). "Warning and administrative fine — Nasdaq Clearing Aktiebolag", January. https://www.fi.se/contentassets/09352ee009544b288f6298ecddd8f995/beslut-nca-2021-01-26-eng.pdf

International Swap and Derivatives Association. (2022). "ISDA Margin Survey Year-End 2021", May. https://www.isda.org/a/TwVgE/ISDA-Margin-Survey-Year-End-2021.pdf

Joint Associations. (2022). "Access to short-term liquidity or guarantees provided by public entities and extension of eligible collateral will maintain the functioning of EU energy markets in times of extreme wholesale price development", position paper by the European Association of CCP Clearing Houses, the European Federation of Energy Traders, Eurelectric, Eurogas and Europex. https://www.europex.org/wp-content/uploads/2022/05/20220419_Joint-associations-position-on-support-for-well-functioning-energy-markets_Executed.pdf

Korniyenko, Yevgeniya, Manasa Patnam, Rita Maria del Rio-Chanon and Mason A. Porter. (2018). "Evolution of the Global Financial Network and Contagion: A New Approach", *IMF Working Paper* No. 18/113. https://doi.org/10.5089/9781484353240.001

Oliver Wyman. (2023). "Independent Review of Events in the Nickel Market in March 2022", Final Report. https://www.lme.com/Trading/Initiatives/Nickel-market-independent-review

Sgaravatti, Giovanni, Simone Tagliapietra, Cecilia Trasi and Georg Zachmann. (2023). "National fiscal policy responses to the energy crisis", Bruegel dataset. https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices

Shrestha, Keshab. (2014). "Price discovery in energy markets", *Energy Economics,* Volume 45, 229-233. https://doi.org/10.1016/j.eneco.2014.06.007

Weron, R., Bierbrauer, M. and S. Trück. (2004). "Modeling electricity prices: jump diffusion and regime switching", *Physica A: Statistical Mechanics and its Applications,* Volume 336, Issues 1–2, 2004, Pages 39-48, https://doi.org/10.1016/j.physa.2004.01.008

This appendix provides additional details on the centrality measures used to analyse changes in the natural gas and power derivatives networks.

Degree centrality

The degree centrality C_D (i) of a node i (before the normalization) can be defined as the sum of its relationships (or edges) x:

$$C_D(i) = \sum_{\substack{j=1 \\ (i \neq j)}}^{N} x_{ij}$$

Eigenvector centrality

The eigenvector centrality C_E (i) of node i can be defined as:

$$C_E(i) = \frac{1}{\ddot{e}} \sum_{t \in N(i)}^{N} x_n$$

Where λ is a constant and N(i) is the neighbourhood of node i.

Betweenness centrality

The betweenness centrality C_B (i) of node i can be defined as:

$$C_B(i) = \sum_{a \neq i \neq b \in E} \frac{\acute{o}_{ab}(i)}{\acute{o}_{ab}}$$

Where $\acute{o}_{ab}$ is the sum of the shortest paths between nodes a and b, out of the total set of edges E. $\acute{o}_{ab}$ (i) is the set of those edges that pass through i.

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