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Contracts in Crisis: The War in Ukraine and Long-Term Contracts in Energy Markets *

Mats Kröger Karsten Neuhoff Sebastian Schwenen

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Abstract

We examine the impact of the war in Ukraine on long-term contracts in energy markets. We find that traded contract volumes fall by 65 percent in the first months of the war. A collapse in bilateral trading contributes most to this decline. To protect themselves from price shocks, firms increasingly turned to long-term contracts already before the war. In sum, our results show that the market continued to serve firms' hedging needs during the crisis, but bilateral trading networks collapsed, and liquidity was largely provided by centralized markets.

JEL codes: D22, P48, G14
Keywords: Firm behavior, long-term contracts, forward markets, crisis, electricity.

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1 Introduction

Long-term contracts are common in many industries. Firms typically enter into long-term contracts to lock in prices in advance, thereby protecting themselves from market volatility and the risk of bankruptcy (Smith and Stulz, 1985; MacKay and Moeller, 2007; Pérez-González and Yun, 2013). A large literature has shown that such forward transactions also yield social benefits by enabling risk-averse firms to increase output (Baron, 1970; Sandmo, 1971; Holthausen, 1979) and by promoting competition in oligopolistic markets (Allaz and Vila, 1993; Bushnell et al., 2008).

Although long-term contracts are important in many market environments, evidence on firm behavior in contract markets is still limited. One reason for the lack of empirical evidence is that contracts are typically private information. This paper utilizes novel and detailed data from the European energy industry to examine firm behavior in contract markets. The data allow to study firms' contract market behaviour and, at the transaction level, the contracts that firms buy and sell. Furthermore, the data distinguish whether firms choose to participate in bilateral over-the-counter (OTC) contract markets or to trade contracts on centralized markets—in our setting, energy exchanges. Using these data, this paper asks whether contract markets can collapse, and with them the insurance mechanism they provide to firms.

Our focus on the resilience of contract markets is motivated by the recent energy crisis surrounding the war in Ukraine. As well documented, the war in Ukraine was accompanied by long-lasting price increases for energy and high market volatility.[1] Firms that were insufficiently hedged through long-term contracts became vulnerable to unprecedented price volatility and financial distress. To mitigate the crisis, governments began to support long-term contracts, e.g., by providing government-backed collateral to protect firms from the risk

[1]See Bachmann et al. (2022) and Ferriani and Gazzani (2023).

of contract default.[2] In theory, however, the potential for long-term contracts to collapse in a crisis, and hence the need for policy intervention, remains unclear. To examine whether contract markets can collapse, we study the impact of the war in Ukraine, which began in 2022, on long-term contracts for energy. Specifically, we probe into the role of adverse selection in OTC markets and the value of exchanges that serve as platforms for centralized trading.

In the absence of market frictions, firms that sign contracts (say for the delivery of a commodity for a specified future period) can at any point in time add contracts in the opposite direction, thus offsetting their previous position and relieving them from potentially costly forward deals. Countering this view, the frequent adjustment of positions is risky and arguably costlier during crises and higher market volatility, so that firms may refrain from contracting forward. Indeed, operating sophisticated hedging programs can be costly to firms (Brown, 2001; Guay and Kothari, 2003) and anecdotal evidence suggests that firms during the energy crisis abstained from adding new contracts (The Wall Street Journal, 2022). Moreover, firms might be deterred from signing contracts by the increasing need for collateral when prices (and therefore the market value of the contracted delivery respectively off-take) increase. Consequently, firms facing high price volatility during crises may need to unwind their existing positions to avoid the cost of holding large amounts of collateral. Similarly, market liquidity may shrink in the presence of adverse selection (see, e.g. Tirole, 2011) and when firms face transaction costs in adjusting positions. Arguably, this is the case for firms that trade OTC and need to renegotiate previous bilateral commitments.

In sum, theoretical predictions on the impact of crises on long-term contracts depend on whether one is willing to assume the presence of adverse selection and/or transaction costs. Without such frictions, firms may increasingly turn to long-term contracts, that they

[2]Policy measures across Europe also included expanding the list of assets eligible as contract collateral (European Commission, 2024). See Sgaravatti and Zachmann (2021) and Pollitt et al. (2024) for an overview of related policies.

can swiftly offset at any time, to shield them from economic distress. In contrast, where transaction costs and adverse selection are severe, the market for long-term contracts may collapse and leave firms exposed to high and potentially costly price volatility.

So far, empirically quantifying firm behavior in this context has proven challenging due to the paucity of data on firms' conduct on contract markets.[3] In our setting, the availability of detailed data on long-term contracts substantially aids our analysis. We make use of unique data on long-term contracts for electricity. The data not only allow to observe firms' daily buys and sells on the contract market, but also to construct their net positions in the market at any point in time. Importantly, the data distinguish between bilateral long-term contracts, also known as OTC contracts, and long-term contracts settled through centralised trading on energy exchanges.[4]

We use data from the European Agency for the Cooperation of Energy Regulators (ACER). ACER, a European Union regulatory body, complements the EU national energy regulators and collects, among other data, all forward and spot market transactions for electricity concluded within the European Union.

For our analysis, we utilize all forward transactions from January 2019 to July 2022, where each transaction is equivalent to a long-term contract. We obtain a total of about two million contracts for electricity in the European market area. From these transaction-level data, we construct daily trading volumes at the firm level. We construct a balanced sample consisting of the 25 largest European energy utilities.[5] For our analysis we then utilize (i) firms' daily total contract volumes to measure their contracting activity, (ii) firms' daily

[3]An exception is the analysis in Ito and Reguant (2016) on strategic forward market behavior in sequential markets. In the finance literature, extant works on firms' hedging and forward market strategies often rely on hand-collected data and information screened from company reports, see, e.g., Campello et al. (2011).

[4]Notice that while forward contracts settled on exchanges are also referred to as futures contracts, we avoid the term futures in this paper. For simplicity, we use long-term contracts and forward contracts interchangeably, and distinguish only between exchange-traded contracts and bilateral OTC contracts.

[5]We measure firm size by market capitalization. We view our sample to be representative in the sense that all buying and selling positions in our sample approximately net out to zero.

total contract volumes separated for bilateral transactions and exchange-traded transactions, and (iii) firms' daily net position on the market to measure their overall hedging level. We complement these data with additional information on daily electricity demand.

The summary statistics (combining data before and after the start of the war) show that the bilateral contract volumes in our sample are nearly on par with exchange-traded contract volumes. This finding on the importance of bilateral contracts confirms that firms indeed rely to a large extent on bilateral trading networks and bilateral contract negotiation.[6] Notice that while the above mentioned exchange-traded and bilateral contracts are standard forward contracts that typically specify a volume to be exchanged at a fixed price during a fixed delivery period (e.g., during a future month, quarter, or year), the data also contain other contract types, such as option contracts. Yet, these remaining contracts only account for a negligible share of the transaction volume.

Utilizing the data on firms' daily contract volumes, we estimate a treatment effect of the war in Ukraine using a dummy set to one on all days after 24 February 2022 (the first day of the war) and zero otherwise. Depending on the specification and test, the time window comprises several months before and after the start of the war. Our estimates show that daily contract volumes in the first months of the war decrease sharply by about 65 percent compared to pre-war times. This finding is robust to accounting for potential anticipation effects prior to the war, to including monthly fixed effects to control for seasonality, and to the inclusion of firm fixed effects that account for time-invariant firm characteristics during our sample period.

Why do contract volumes collapse with the start the war? To examine the mechanisms behind this, we use the information on whether trade volumes stem from bilateral contracts or from transactions at exchanges, i.e., organized and centralized marketplaces. As argued,

[6] From our discussions with industry experts, firms relying on bilateral contracts are typically smaller firms who lack large trading departments that would allow for more frequent trading on exchanges.

bilateral contracts may be subject to adverse selection and transaction costs from bilateral renegotiation. Both effects suggest that firms may shy away from signing bilateral agreements when facing high uncertainty during the initial phase of the war. Specifically, in our setting adverse selection may occur when high price volatility raises the likelihood of bankruptcy for smaller market participants with little financial backing and limited ability to hold required collateral for trading at exchanges. As a last resort, these firms may search for bilateral contracts, where potential counter-parties however hesitate contracting with such financially weaker firms. Similarly, firms that regularly trade bilaterally may now face higher transaction costs when (re-)negotiating bilateral agreements, which again leads to a decline in bilateral contract activity.

When isolating bilateral contract volumes in our sample, we find that much of the overall market collapse is driven by bilateral transactions. In terms of magnitude, bilateral contract volumes decline by about 86 percent as compared to the pre-war time window. In stark contrast, when re-running our estimations for exchange-traded volumes, we find a small albeit insignificant increase in exchange-traded trading volumes. Taken together, these results suggest that bilateral contracting, where counter-party risk, reputation effects, and transaction costs play a more significant role, cause large parts of the overall decline in forward market liquidity.

Subsequently, we test if the decrease in the overall contracting activity comes with a decline in the firms' net positions on the contract market, i.e., we test whether firms decrease their overall hedging level. Using the history of firms' buys and sells back to the start of our sample, we compute for each firm its daily net contract position by netting out buys and sells. Put differently, for each day, we construct a firm's obligation from all its past forward contracts to deliver (respectively take-off) electricity on that day. Our estimates suggest that, on average, firms' net contract positions moderately increase after the start of the war. Yet, we do find anticipation effects as firms already began increasing their positions significantly ahead of the war. Our results therefore suggest that although overall contract activity has collapsed, the forward market continued to meet the firms' hedging needs. As a result, firms were, on average, able to maintain electricity contract levels that reduced much of their spot price exposure during the crisis. Importantly, we find that it is the availability of contracts with delivery long into the future, e.g., contracts signed by firms up to years in advance, that allow firms to maintain considerable hedging levels that insulate them from the high price volatility during the crisis.

Our findings contribute to several strands of research. First, we contribute to the large literature on energy markets, their market design, and regulation. Since the deregulation of this sector, this literature has devoted significant attention to understanding the role of forward trading for market efficiency. Following theoretical predictions in Allaz and Vila (1993), a large stream of research has shown that forward markets reduce market power on spot markets (e.g. Wolak, 2007; Bushnell et al., 2008; van Eijkel et al., 2016; Jha and Wolak, 2023). Drawing from these findings, De Frutos and Fabra (2012) find that such pro-competitive effects depend on the allocation of forward contracts across the market, while Ito and Reguant (2016) show how restricted entry in forward markets can cause significant price premia. While most of these works take as given firms' forward market participation, our contribution to this literature is to document the determinants of forward market participation and, consequently, forward market liquidity, and to highlight the different participation patterns in bilateral and exchange-based forward markets.[7]

Second, we relate to a considerable stream of literature on the role of forward markets for mitigating market risk and financing investment. Early works in this domain have shown that forward trading avoids financial distress (Smith and Stulz, 1985), reduces firms' risk exposure (Bessembinder and Lemmon, 2002), and decreases transaction costs (Joskow, 1987).

[7] In so doing, we also contribute to a recent literature on market liquidity in over-the-counter and exchange-based trading in financial markets, e.g., in Dugast et al. (2022).

More recent findings confirm empirically that hedging provides economically relevant value to firms (MacKay and Moeller, 2007; Pérez-González and Yun, 2013). Moreover, the benefits of forward contracts for investment have been intensively discussed in the context of energy markets. While Abada et al. (2019) examine the relevance of forward contracting for financing investment in environmentally friendly production, Ausubel and Cramton (2010) highlight the benefits of forward contracting for the coordination and timing of investment. In this context, our results contribute by showing that firms continue to use long-term contracts and that their benefits carry over in times of crisis and market distress. Yet, the resilience of contracting long-term is largely maintained by centralized markets, whereas bilateral contracting (through adverse selection) is hard hit by the crisis. More broadly, these results contribute to ongoing research on market resilience and the impact of economic crises on market performance (Kilian, 2008; Baumeister and Peersman, 2013; Schivardi et al., 2022; Ma et al., 2023).

2 Data and empirical strategy

We use data from the European Agency for the Cooperation of Energy Regulators (ACER). ACER collects various data under the European Regulation on Wholesale Energy Market Integrity and Transparency (REMIT). REMIT is a central piece of legislation within the European Union energy market. Adopted in 2011, the regulation is designed to increase the transparency of wholesale energy markets, as well as compliance with trading rules and competition policy. At its core, REMIT allows ACER and national regulatory authorities to monitor and prevent market abuse, including insider trading and market manipulation, in electricity and natural gas markets.

REMIT introduces a range of reporting obligations, which are implemented and monitored by ACER.[8] The reporting market participants comprise all firms involved in wholesale energy trading. Furthermore, exchanges must report all transactions conducted on their trading platforms. Any non-compliance is sanctioned, this is, where companies do not adhere to the regulation, the regulator can enforce compliance by issuing fines. Under REMIT, firms are required to report their trading activity for various energy products. These products entail all wholesale spot and forward products for electricity and natural gas delivered in the European Union. The main data that we use for our study are the data on forward transactions for electricity, where each single transaction is equivalent to a forward contract.

2.1 Contract data

Our initial sample contains all forward transactions for electricity in the European market area from January 2019 to July 2022. To keep the analysis tractable, we isolate transactions for 25 large European energy companies. The companies in our sample are large power generating utilities and retailing firms. Broadly, their generation portfolios include nuclear plants, natural gas and coal-fired plants, hydro, wind, and solar power plants. We collect from the ACER data the firms' trading activities on a set of major European markets, namely Austria, Czech Republic, Germany, Italy, Netherlands, Poland, the Iberian market (covering Portugal and Spain), and the Nordic market (covering Denmark, Norway, Sweden and Finland). Following this sampling strategy, we in total obtain 2,170,934 transactions, respectively contracts. A full description of our sampling and data cleaning process can be found in Appendix A.

The data cover two main types of contracts. First, there exist standardized forward contracts which are traded on exchanges. As they are standardized, resale is straightforward.

[8] We are indebted to ACER for supporting us in this research and granting access to the data. The data are not publicly available and can be accessed at the ACER data center in Ljubljana, Slovenia. Where the data were not reported in a timely or comprehensive manner, we spent significant effort to clean the data, see Appendix A for details. ACER reserves the right to update all figures and data.

Standardization mainly relates to the contracted delivery period (e.g., continuous delivery for a given future month or year). We refer to these contracts as exchange-traded contracts. The trading of exchange-traded contracts is anonymous and the exchange becomes liable for their fulfilment. For this reason, firms that trade contracts on exchanges must provide the exchange with sufficient collateral in the form of margin accounts and margin calls.[9]

The second type of contracts are bilateral contracts, also referred to as over-the-counter (OTC) contracts. Importantly, the trading of bilateral contracts, unless organized by financial intermediaries such as brokers, relies on the firms' bilateral trading networks. Typically, firms enter into bilateral contracts when they have long-term relationships with individual suppliers or traders. From our discussions with traders and market experts at ACER, firms often turn to bilateral contracts to avoid holding costly collateral (i.e., paying margin calls) associated with trading on exchanges. In terms of delivery period, bilateral contracts typically follow established exchange-traded contracts and specify delivery for a certain period of time, such as weekly, monthly, quarterly and yearly delivery. Finally, in addition to these two types of forward contracts, there are other products such as options and swaps.[10]

For each transaction, we observe information on the traded volume in the contract, the mode of trade (bilateral or exchange-traded) and the start date and duration of delivery (e.g., weekly, monthly, quarterly, yearly). Figure 1 plots the volume and number of bilateral and exchange-traded transactions. About 52 percent of all transacted volume in our sample is traded in bilateral contracts. Exchange-traded contracts account for the bulk of remaining volume with about 42 pecent. Notice that also the number of transactions is again nearly on par for the two contract types. Finally, the remaining group "Other" in Figure 1 shows data for all other forward contracts such as option and swap contracts (which are mostly traded

[9]In the context of our study, a margin call is a demand from an exchange to a firm, whether trading firm or utility, to deposit additional funds into a margin account. Holding a margin account is required to ensure that firms hold sufficient collateral to cover losses from positions they may not be able to fulfill.

[10]Notice that bilateral contracts that are mediated by brokers are sometimes also sent to exchanges for clearing.

at exchanges). These other contract types only account for 6 percent of traded volume and a neglegible share of transactions.

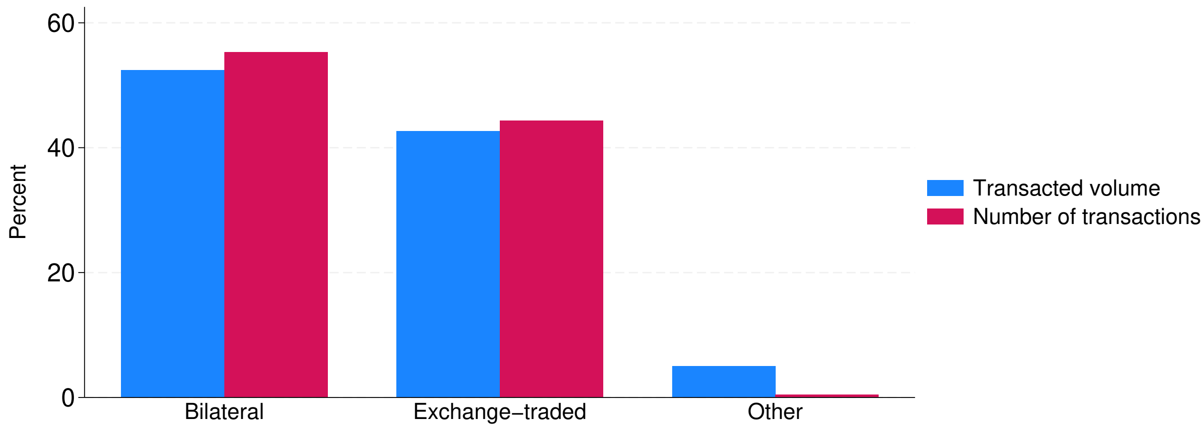

Figure 1: Volumes and numbers of bilateral and exchange-traded transactions.

Figure 2 plots data on the contract duration. In line with industry practice, we plot contract duration that last up to a week, month, quarter, and year. Notice that the data for a certain contract duration exclude the data for all shorter contracts, e.g., the data for contracts that last "up to one month" exclude data for contracts with delivery duration "up to one week". As shown, firms sign contracts with considerable differences in their duration. The bulk of volume is traded in contracts that last up to a year long, indicating that firms to a significant extent seek longer-term protection from market volatility.

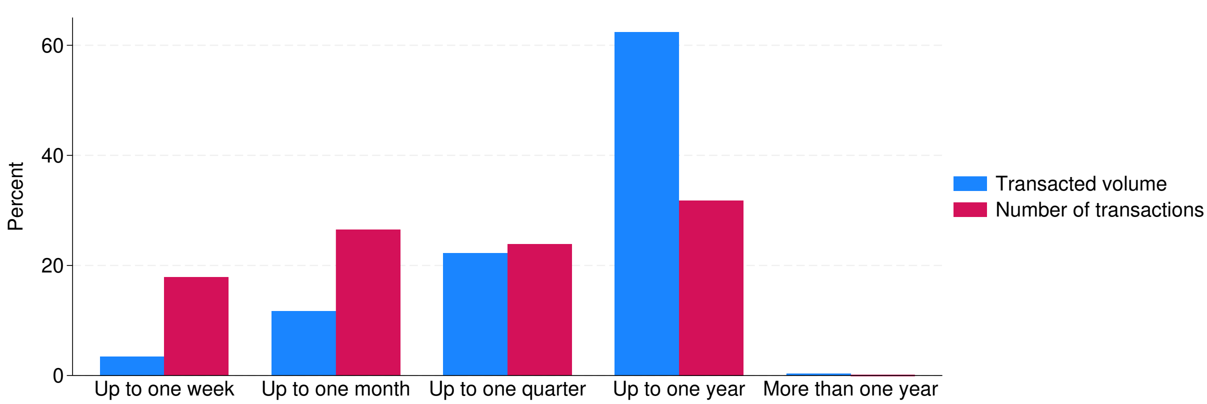

Figure 2: Contract duration.

Finally, more than 90 percent of the contracts are for baseload electricity. That is, the contracts specify the continuous delivery or off-take of electricity 24/7 for a predetermined duration as shown in Figure 2. In sum, the data show that firms typically sign contracts for a homogeneous product, in the sense that they determine the exchange of baseload electricity. As illustrated, however, the contracts differ considerably in that they are either bilaterally written or traded on an exchange and, second, determine a different contract duration.

2.2 Firm-level trading data

From the above transaction-level data, we construct firm-level data to track the firms' contract market behavior over time. As noted, our sample contains transactions from 25 large energy companies that trade the above summarized contracts. Many companies buy and sell contracts on an array of geographic markets, e.g., the same company may buy and sell contracts in the Iberian and in the Nordic market area. For our analysis, we therefore treat subsidiary firms belonging to the same parent company but operating in a different national market as a single firm. We thus assume that contracting decisions are made at the firm-market level rather than at the global headquarters. Discussions with industry have reassured us in making this assumption. In total, from the 25 large European companies, we obtain 89 firm-market pairs for our analysis. For each firm-market pair, we observe the universe of its transacted forward contracts.

To track the firms' behavior over time, we compute, for each firm (i.e., firm-market pair), its daily traded contract volume. We first aggregate all trades of a firm by day, independent of the contract duration or further contract characteristics, to obtain a measure of a firm's total contracting activity for each day in our sample. We compute these daily contract volumes for the entire year 2021 up to the end of our sample in July 2022. Panel A of Table 1 presents the statistics of firms' daily contracting volumes. In total, we obtain 48,594 observations (for the daily contract volumes of the 89 firms during the 546 days in this sample from January 2021 to July 2022). As shown, on average a firm trades contracts with a volume of about 156,000 megawatt-hours (MWh) per day.[11] When isolating bilateral and exchange-traded contracts, Panel A further shows that the share of contract volumes across both types is comparable, with a firm trading on average around 73,000 MWh and 82,000 MWh in bilateral and exchange-traded contracts, respectively, on a daily basis.

Table 1: Descriptive statistics of firms' contract volumes and net positions.

	Mean	Median	Std. deviation	Observations
A. Daily traded contract volume (in MWh)				
Contract volume (all contracts)	156,518	0	566,568	48,594
Bilateral contracts	73,715	0	385,276	48,594
Exchange-traded contracts	82,804	0	278,396	48,594
B. Daily net positions (in MW)				
Net position	-165	-6	1,171	48,594
Net position (absolute value)	531	151	1,057	48,594

Panel B of Table 1 presents statistics on the firms' daily net positions. A firm's net position indicates a firm's obligation to deliver (when being a net seller) or take-off (when being a net buyer) electricity on any given day. We calculate these daily net positions by netting out all of a firm's buy and sell obligations for each day—from all contracts signed before that day. Note that because some contracts are traded years in advance of the first delivery day, determining a firm's net position requires the availability of data on forward contracts signed years in the past. We therefore compute (as we do for firms' daily contract volumes in Panel A of Table 1) firms' net positions for all days from beginning of January 2021 to the end of July 2022. In doing so, we use all previous transactions going back to the

[11]In electricity markets, trading volumes are typically measured in megawatt-hours (MWh) to reflect the fact that electricity is produced and consumed over a given time window. For example, a megawatt hour is the electricity produced by one megawatt of generating capacity in one hour. To put the firms' average daily contract volumes into perspective, 156,000 MWh is roughly equivalent to the electricity produced by about six nuclear power plants over a 24-hour period.

beginning of our transaction-level sample in January 2019.[12]

The first row of Panel B shows the net positions of all firms. Note that a net selling commitment is defined by a negative position, while a net buying commitment is defined by a positive position. On average, a firm has a daily position of -165 MW, i.e., an obligation to supply electricity.[13] Both the low average position and the median average position of zero indicate that our sample is representative of the market in the sense that net buying and net selling positions almost balance out to zero. The second row of Panel B then shows the summary statistics if we ignore the buy and sell positions and instead consider the absolute value of a position. In essence, this variable shows a firm's average hedging level independent of whether it is a net buyer or net seller in the market. Below, we therefore use these absolute positions as one of our main outcome variables to test the impact of the war on firms' hedging levels. Collectively, the data shown in Table 1 constitute our main variables that proxy for a firm's daily contract market activity (Panel A) and a firm's daily hedging level (Panel B).

2.3 Estimating the impact of the war

We seek to estimate the impact of the war and the surrounding energy crisis in 2022 on the above data. The war in Ukraine began on 24 February 2022. Sanctions against Russia and the reduction of Russian gas exports to Europe led to energy shortages and sharp price increases for oil, natural gas, and electricity. As argued, firms may react by reducing the number of long-term contracts they enter into or by signing new contracts to protect themselves against the new market risks ahead.

A standard approach in the literature to identify the impact of policy or regulatory events

[12] We repeated this procedure including transactions before January 2019, but found that adding these earlier transactions left the statistics of firms' net positions almost unchanged.

[13] In line with industry practice, we measure a firm's net position in megawatt (MW). Put differently, we measure the net position at any given hour of the delivery day. For example, a net selling position of -165 MW implies that a firm commits to selling 3,960 MWh (165 MW * 24 hours) of electricity during the day of delivery. As can be seen in comparison to the first row of Panel A, this is only a small fraction of a firm's average daily traded volumes.

is to estimate a treatment effect of the event on the market outcome of interest. In the context of energy markets, such designs have been used to estimate the impact of energy efficiency measures (Boomhower and Davis, 2020), electricity grid expansion (Fell et al., 2021), and the impact of carbon pricing on firm profits (Bushnell et al., 2013), among others.

Following this design, we examine the impact of the war on the contract market and, in our first specification, use the firms' daily contract volumes in Panel (A) of Table 1 as dependent variable. Formally, we estimate

$$log(Contract\ volume)_{it} = \alpha + \beta\, War_t + \delta_i + v_t + \varepsilon_{it} \tag{1}$$

where $log(Contract\ volume)_{it}$ is the logarithm of transacted contract volumes of firm i on day t.[14] The main estimate of interest is for War_t, a dummy set to one for all days after the start of the war (from 24 February 2022 to the end of our sample on 31 July 2022) and zero otherwise (from 1 January 2021 to 24 February 2022).

Depending on the specification, we saturate the estimation with monthly fixed effects, v_t, to account for seasonal trading patterns and firm fixed effects, δ_i, that control for time-invariant firm characteristics such as its location or size (which is arguably constant during our sample comprising less than two years of data). We cluster standard errors at the level of a trading day to account for correlated trading decisions of firms within any given day, for instance in response to other potentially unobserved market shocks. For further tests, we replace the dependent variable with a firm's exchange-traded (or bilateral) contract volume and a firm's net position on day t.

A typical concern in the literature using event studies (for a discussion see, e.g., Bushnell et al., 2013) is that either information about the exact date of the event, here the start of the war, may have leaked or that firms anticipated the event and updated their behaviour

[14] To keep a balanced panel and to not lose days where a firm made zero transactions, we use $log(Contract\ volume + 1)_{it}$.

ex ante. Figure 3 shows daily electricity spot prices before and after the start of the war for a selected set of markets in our sample.[15] The start of the war on 24 February 2022 is indicated by the solid line. As can be seen, while prices started to drastically climb after the start of the war, an upward trend becomes visible as of early October 2021, indicated by the dashed line on 1 October, 2021. Electricity prices began to rise before the war for a number of reasons, including low natural gas supply, low nuclear plant and hydro power availability (due to maintenance and drought), and low renewable production from wind and solar plants. Moreover, the pre-war price increase may have further been driven by the anticipation of war and subsequent shortages of natural gas, which drove up pre-war natural gas prices and, ultimately, pre-war electricity prices.

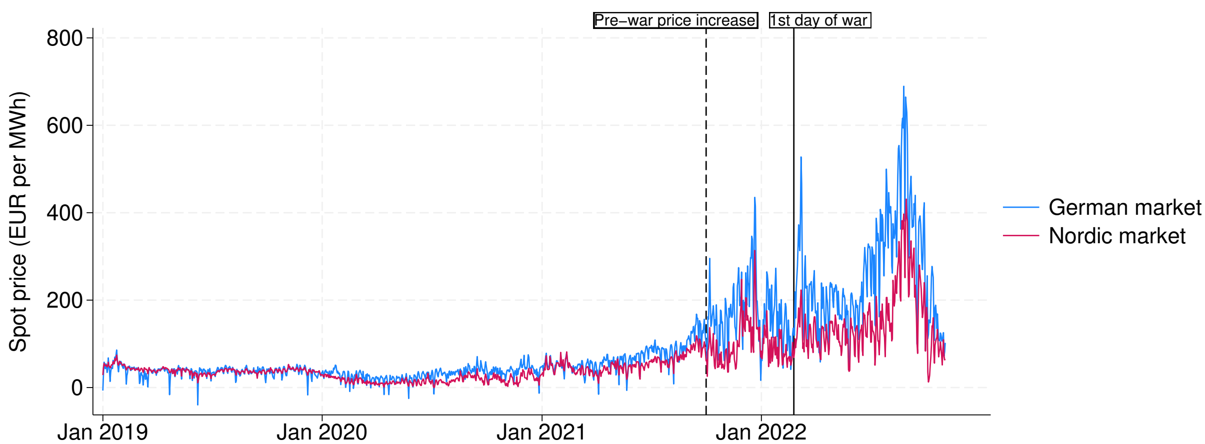

Figure 3: Electricity spot price in the German and Nordic market area from January 2019 to July 2022.

Yet, as illustrated in Figure 3, the magnitude of the post-war price increase remains significantly larger than the pre-war price increase. In our baseline specification, we therefore use the start of the war as the main treatment effect. Notice that if rising prices in the pre-war period already had a significant impact on the contract market, our estimates in equation (1) represent a lower bound on the impact of the war. In other words, we would underestimate the impact of the war as a result of already inflated pre-war prices, firms' expectations of the

[15]The price for the Nordic market is an average of the prices in Denmark, Sweden, Finland, and Norway.

future contract market, and changes in their contracting strategy prior to the outbreak of the war. To rule out any downward bias from anticipation effects in our analysis, we perform several tests where we vary our baseline specification using different samples and pre- and post-war time windows.

3 Main results

This section presents our main results. We first examine the impact of the war on firms' traded contract volumes. Then, we turn to the choice between bilateral and exchange-traded contracts. Finally, we discuss how the war changed the firms' overall level of hedging.

3.1 The impact of the war on contract volumes

Table 2 reports the results when estimating equation (1). As shown in Column (1), contract volumes fall significantly after the start of the war. In terms of magnitude, the point estimate suggests that contract volumes fall, on average, by about 65 percent compared to pre-war levels. In Column (2), we add month fixed effects to control for seasonal trading patterns and seasonal demand. Our results remain virtually unchanged and confirm the decline in contract volumes of around 65 percent.

To rule out potential bias from anticipation effects in our estimates, Column (3) of Table 2 modifies our baseline regression. Here we drop the post-war dummy and instead use a dummy that is set to one when energy prices first start to rise, i.e., from 1 October 2021. Furthermore, we drop all days in our sample *after* the outbreak of the war. Put differently, we test whether there is a significant change in contract volumes from October 2021 onward, when energy prices started to rise, compared to the "regular" market periods before October 2021. This new dummy is labelled *Pre-war increase*. As shown in Column (3), the negative point estimate indeed indicates a dip in traded contract volumes, but the

Table 2: The impact of the war on traded contract volumes.

	Daily traded contract volume			
	(1)	(2)	(3)	(4)
War	-0.639**	-0.649*		
	(0.290)	(0.364)		
Pre-war increase			-0.035	
			(0.595)	
Crisis				-0.454
				(0.316)
Firm FE	Yes	Yes	Yes	Yes
Month FE	No	Yes	Yes	Yes
Observations	48,594	48,594	37,291	48,594

Day-of-sample clustered standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

effect is not statistically significant. That the pre-war slowdown in contract volumes is not significant suggests, first, that our estimates in Columns (1) and (2) do not suffer from significant anticipation bias and, second, that that the firms in our sample did not, at least not on average, adjust their contract market activity significantly prior to the war.

Finally, in Column (4) of Table 2, we present an estimate for a counterfactual treatment effect that considers the impact of the wider energy crisis *surrounding* the start of the war. Specifically, we estimate a treatment effect, denoted *Crisis*, where the dummy is set to zero from 1 January 2021, i.e., the beginning of the sample, until 1 October 2021. The treatment dummy is then set to one for a period combining the initial price rise and the post-war period, i.e., the dummy is equal to one from 1 October 2021 until the end of our sample on 31 July 2022. As shown in Column (4), we again find no significant effect on contract volumes. In sum, the results in Table 2 collectively show that the market for long-term contracts significantly collapsed *after* the outbreak of the war. Moreover, possible anticipation effects did not lead to a significant decline in traded volumes before the war. Finally, if one assumes that the crisis started already before the war, the estimated treatment effect becomes insignificant, corroborating that it indeed is the beginning of the war that caused the decline in forward contracting.

In untabulated robustness tests, we find that these conclusions are robust to (i) using a running 90-day window pseudo-treatment effect (which only becomes significant after the start of the war), (ii) deleting the pre-war period with rising prices and comparing only post-war contract volumes with contract volumes before October 2021, and (iii) using a sample that starts as early as January 2019, which allows to better account for the history of seasonal trading patterns.

3.2 Bilateral versus exchange-traded contracts

To unpack the reasons for the decline in forward contracting, we use information on whether firms buy and sell contracts on exchanges or bilaterally. The results are shown in Table 3. In Column (1) we isolate all contract volume that is traded bilaterally. As can be seen, bilateral contract volumes fall significantly and sharply after the war, by about 86 percent. In Column (2), we again test for any significant pre-war effects, but only find a non-significant decline ahead of the war. Finally, in Column (3), we present the estimated effect when considering the wider crisis surrounding the war as main treatment event. Here, the treatment period again includes the pre-war autumn and winter of 2021. As shown, the effect remains high in magnitude and highly significant.

The estimates of the impact on exchange-traded volumes in Columns (4) to (6) are in stark contrast. As the estimates throughout all columns illustrate, exchange-traded contract volume, if anything, increases with the onset of war, although the effects are estimated imprecisely. Importantly, notice that the estimates in Table 3 represent net effects on bilateral and exchange-traded contracting. This is because firms may choose to leave both the OTC and exchange-traded markets, or substitute between the two. Indeed, the negative (insignificant) pre-war estimate for bilateral contracting combined with the slightly

Table 3: The impact of the war on OTC and exchange-traded contract volumes.

	Bilateral contracts			Exchange-traded contracts		
	(1)	(2)	(3)	(4)	(5)	(6)
War	-0.866***			0.026		
	(0.222)			(0.294)		
Pre-war increase		-0.337			0.641	
		(0.354)			(0.478)	
Crisis			-0.714***			0.236
			(0.198)			(0.254)
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	48,594	37,291	48,594	48,594	37,291	48,594

Day-of-sample clustered standard errors in parentheses *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

positive (insignificant) pre-war estimate for exchange-traded contracting may indicate that firms substituted away from bilateral contracts ahead of the war and instead relied more on exchange-traded contracts.

To further explore potential substitution patterns, Figure 4 plots the evolution of contract volumes over time. For visibility, we have aggregated daily observations to monthly averages. First, the solid blue line shows the evolution of all contract volume (the sum of bilateral and exchange-traded contract volume). In line with our estimates, Figure 4 shows a moderate decline in contract volume before the war (which is estimated to be insignificant accounting for time and firm fixed effects) and a significant decline after the start of the war.

Looking at the breakdown between exchange-traded contract volume (the dashed green line) and bilateral contract volume (the solid red line), it can be seen that exchange-traded contract volume starts to increase in the autumn of 2021, in parallel with a decline in bilateral contract activity. This pattern suggests that there has indeed been some substitution from OTC contracts to contracts traded on centralized exchanges, although such pre-war changes are only estimated imprecisely as shown in Table 3 above.

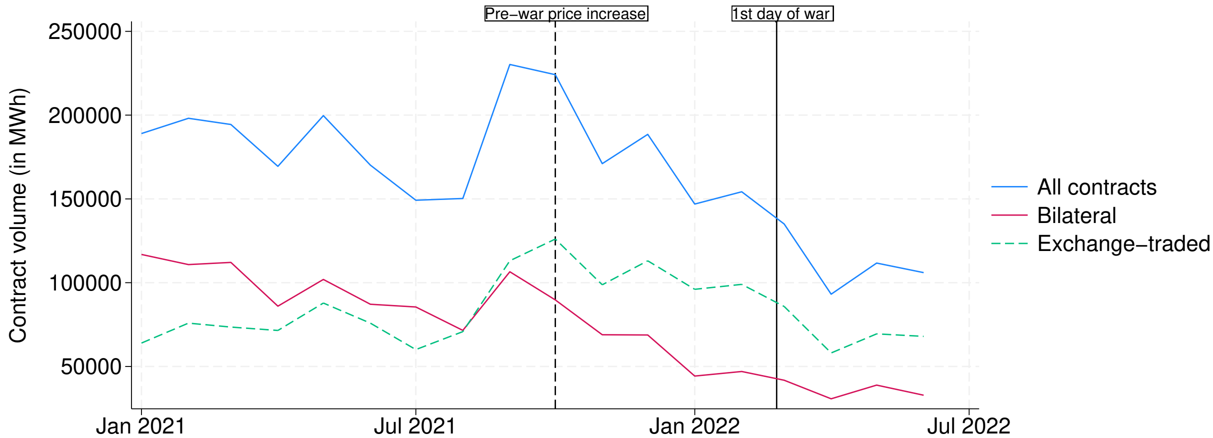

Figure 4: Evolution of traded contract volumes over time.

Taken together, the above findings clearly show that the overall decline in forward trading is largely the result of a collapse of the OTC contract market. This finding is in line with the notion that OTC markets suffer from counter-party risk and adverse selection. This, in turn, leads market participants either to reduce their overall contracting activity or to substitute away from OTC contracts towards trading on centralized exchanges, where the exchange becomes the liable counter-party and where requirements on contract collaterals mitigate adverse selection.

3.3 Firms' net contract positions

The decline in contracting activity documented above suggests that firms may have simultaneously reduced their overall hedging levels and thus become more exposed to high prices and volatility during the crisis. To test this conjecture, we next estimate

$$log(Net\ position)_{it} = \alpha + \beta\, War_t + \gamma\, log(Demand)_t + \delta_i + \upsilon_t + \varepsilon_{it} \tag{2}$$

where $log(Net\ position)_{it}$ is the daily hedging level of firm i, measured by the logartihm of the firm's net contract position at day t. As before, our main estimate of interest is the treatment dummy War_t. We again include firm fixed effects, δ_i, to control for time-invariant differences in firms' propensity to hedge, and month fixed effects, v_t, to control for seasonality in firms' hedging positions. We add a further control, the logarithm of electricity demand in the respective market area on trading day t, which captures that firms' optimal positions typically follow spot market demand patterns.[16]

Table 4: The impact of the war on firm's contract positions.

	Net position			
	(1)	(2)	(3)	(4)
War	0.053***	0.154***		
	(0.009)	(0.009)		
Pre-war			0.072***	
			(0.010)	
Crisis				0.135***
				(0.006)
Demand	0.036	-0.075***	-0.098***	-0.071***
	(0.024)	(0.014)	(0.029)	(0.014)
Firm FE	Yes	Yes	Yes	Yes
Month FE	No	Yes	Yes	Yes
Observations	48,594	48,594	37,291	48,594

Day-of-sample clustered standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Somewhat surprisingly, the results in Column (1) of Table 4 show that firms' net positions on average increased by about 5 percent after the war, or, when controlling for month fixed effects in Column (2), by about 15 percent. Moreover, as shown in Column (3), our estimates suggest the existence of anticipation effects, as firms start to build up significant positions even before the war.[17] In terms of magnitude, the estimate in Column (3) indicates that firms hold about 7 percent higher net positions in the autumn and winter before the war

[16]Hedging levels are typically higher during periods of high demand, see e.g., Bessembinder and Lemmon (2002) and Schwenen and Neuhoff (2024).

[17]The anticipation effects may have been driven by the impact on gas and electricity prices of exceptionally and probably strategically low gas storage levels in the months prior to the outbreak of the war.

than in the "regular" market periods at the beginning of the sample.

Results thus indicate that firms moderately increased their hedging levels before *and* again after the outbreak of the war. Given our earlier findings on the asymmetric impact of the war on OTC and exchange-traded contracts, this increase in positions was largely made possible by centralized exchanges.

4 The role of contract length

In closing, we explore why firms have been able to maintain substantial hedging levels, despite the strong decline in contract market activity. Using information on the contract lengths, we calculate for each firm its forward looking net position. To fix ideas, notice that firms which only buy contracts for delivery in the next month will, at any given time, only have a position (and therefore be hedged) for all the days in that upcoming month. Conversely, firms that buy contracts for delivery several years ahead will have a position (and therefore be hedged) for several years ahead.

The solid blue line in Figure 5 shows the average of this statistic across all firms for January 2021. As can be seen, throughout January 2021, firms on average hold a net position of around 550 MW (in absolute terms) for the next day (the leftmost data point in Figure 5). As plotted, firms roughly maintain this hedging level throughout the next month ahead. Further ahead, i.e., from one month up to one quarter ahead, the average position of the firms begins to decline, until it approaches zero at around three years ahead. This is, firms hedge at maximum up to about three years ahead.

Moreover, Figure 5 shows that at the beginning of 2021 firms were already holding substantial positions for the following year(s) ahead. Moving forward one year, i.e., to one month before the war in January 2022, firms were thus able to capitalise on large contract positions they had already established a year ago. This availability of long-term contracts

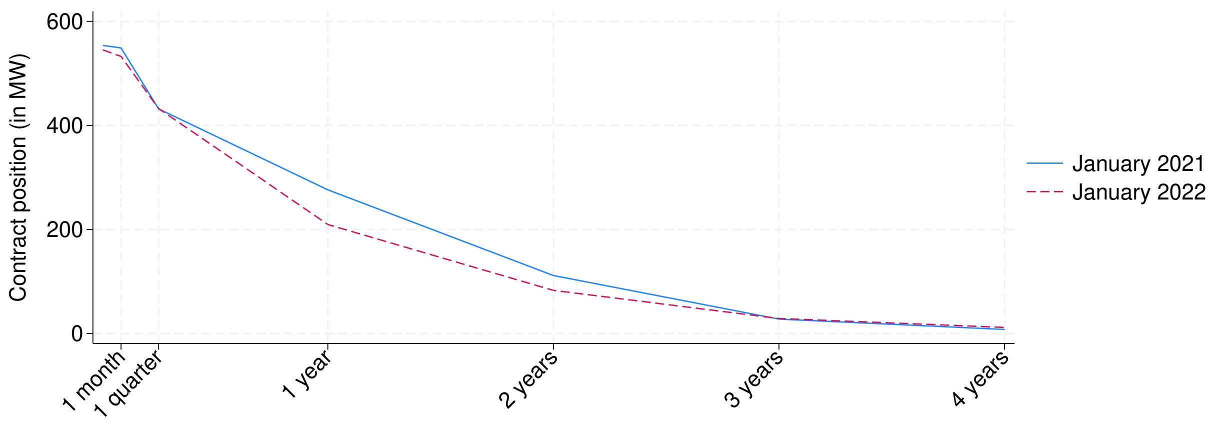

Figure 5: Average forward looking contract positions during January 2021 and 2022.

with maturity far into the future thus allowed firms to take positions well in advance, insulating them from the crisis and contributing to their high overall hedging levels during the initial months of the war.

Finally, as shown by the dip in the dashed red line for January 2022, firms then downward-adjusted this use of year-ahead contracts in January 2022. Thus, while the availability of long-term contracts shielded firms from the crisis, at the same time firms refrained from, or at least postponed, committing to such long-term contracts in the wake of the war.

Notice again that our earlier results indicated that firms' net positions moderately increased during the first month of the war. We have not been able to determine whether the above increase arises from a trade-off whereby firms maintain high positions in the first month of the war by reducing their long-term positions (as indicated by the dip in the red line in Figure 5).[18] However, the data in Figure 5 clearly show that the availability of "long long-term contracts" bolsters the ability of firms to maintain high hedging levels during the war.

[18] For example, firms may finance the purchase of short-term hedges by unwinding their positions for delivery further in the future. An alternative explanation for the observed small increase in net positions is that firms were increasingly speculating to arbitrage the impact of the war.

5 Conclusion

Our paper presents a first and so far rare comprehensive analysis of OTC and exchange-traded long-term contracts in energy markets. Given the importance of long-term contracts in providing firms and entire industries with insurance against economic crises, we conducted our analysis using data surrounding the start of the war in Ukraine in 2022.

We first document that firms make extensive use of long-term contracts—before the war, with roughly equal weights for bilateral contracts and contracts traded on centralized markets, here energy exchanges. We then show that the outbreak of the war led to a significant decline in the overall volume of contracts traded. In terms of magnitude, we find that the contract volumes fall by about 65 percent compared to pre-war levels.

We also show that the war led to a significant shift away from bilateral contracting towards buying and selling contracts on exchanges: OTC market volumes fall by more than 85 percent. In contrast, exchange-based trading experiences a moderate increase, if any. We also find that firms partially substituted OTC markets for exchange-traded contracts during the crisis, which supports the notion that OTC markets are prone to adverse selection as one candidate reason why they were hit hard by the crisis. Despite the collapse in trading activity, the results show that firms' overall hedging level, as measured by their net position in the contract market, increases moderately during the crisis.

Taken together, our results show that the existence of long-term contracts per se does not necessarily protect firms from crises and persistent market shocks. To reap the full benefits of long-term contracts, a variety of forward products, especially for delivery further in the future, and centralized marketplaces, where exchanges act as intermediaries to minimise counter-party risk and mitigate adverse selection problems, are crucial.

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Appendix

A Data and sample description

A.1 Description of firms

Our dataset includes data from 25 large European utilities. We have selected the largest Europan utilities as measured by their market capitalisation in both the S&P 250 and the STOXX 600 index. In addition, we add a number of large public utilities that are not traded on the stock market to provide a more nuanced sample of Europe's leading energy utilities. These unlisted companies are selected according to industry reports. To identify transactions by these 25 companies in ACER's raw data, we search the list of market participants available in the Central European Registry of Market Participants (CEREMP) and selected all entries that matched our list of utilities based on the name of the company. Many of the large utilities have several subsidiaries trading in different national markets (e.g. a Swedish utility appears 33 times in the list of market participants, a large German utility 75 times). In these cases, we attach all entries to the respective global parent company. We then construct firm-market pairs from these 25 companies. For example, if the same Swedish utility traded in both the German and Nordic market areas, we treat these two firms as separate firms, resulting in a total of 89 firm-market pairs. These 89 market-specific firms make up our firm-level panel.

A.2 Data export and preparation

In total, we sample 6,161,505 transactions from January 2019 to July 2022 for the 25 European utilities. We cleaned the data and deleted incomplete, illogical or irrelevant records. In many cases, the reason for deletion was that the information was incorrect (e.g., a contract was traded after the delivery period had expired) or incomplete (e.g., information on the contract volume was missing). We also delete some transactions where we considered the information to be unrealistic, for example because of unrealistically large trading volumes. Following this procedure, we are left with 2,768,874 transactions. We then remove observations for geographic markets that we do not consider for our final analysis. This leaves 2,172,895 transactions. We also exclude from the analysis firms that trade very infrequently. Therefore, we delete firm-market pairs that have less than 50 trades in the period considered for our analysis. This leaves 89 firm-market pairs and 2,170,934 transactions in the final sample.

A.3 Data policy

The views and opinions of the authors expressed herein do not necessarily state or reflect those of ACER. The accuracy of the authors' statistical analysis and the findings they report are not the responsibility of ACER. ACER is not responsible for conclusions or opinions drawn from the data provided. The REMIT data used may not be complete, fully accurate and/or reported in a timely manner. ACER is not responsible for the correctness of the data and for data management, data merging and data collation after provision of the data. ACER shall not be held liable for improper or incorrect use of the data. The data were handled with utmost care, adhering to the REMIT Information Security policy. Before being shared on-premises with the researchers, all data were anonymised, aggregated where pertinent, and any features identifying particular market participants, organised marketplaces and registered reporting mechanisms directly or indirectly were removed. No commercially or privacy-sensitive features of the data were exposed, and the data cannot be linked to specific strategies. The researchers worked at all times under the coverage of comprehensive non-disclosure agreements.