



How Do Firms Adjust Their Capital Structure in Response to a Sudden Geopolitical Shock? Evidence from the Russian Invasion of Ukraine

Tobias Baur

Dissertation written under the supervision of professor Jörg Stahl.

Dissertation submitted in partial fulfilment of requirements for the MSc in Finance, at
the Universidade Católica Portuguesa, 24 May 2026.

How Do Firms Adjust Their Capital Structure in Response to a Sudden Geopolitical Shock? Evidence from the Russian Invasion of Ukraine

by Tobias Baur

Abstract

This thesis examines how firms adjust their capital structure in response to a sudden geopolitical shock, using the Russian invasion of Ukraine in February 2022 as the empirical setting. Drawing on quarterly Compustat data on roughly 9,400 publicly listed non-financial firms in Western Europe and the United States between 2020 and 2023, the analysis applies a difference-in-differences design that combines cross-industry variation in energy intensity with cross-regional variation in shock exposure. European energy-intensive firms increased their leverage by approximately 4.5 percentage points relative to control firms after 2022Q1, a roughly 15 percent shift relative to the pre-shock mean, while cash holdings remained essentially unchanged. The corresponding U.S. estimates are uniformly weaker, supporting an interpretation centred on the European-specific energy supply channel. The pattern indicates that European firms absorbed the cost shock primarily through external borrowing while preserving liquidity buffers, with implications for corporate financial management, lender risk exposures, and the design of policy support during crises.

Keywords: Capital structure, Leverage, Corporate financing, Geopolitical risk, Energy price shock, Russia-Ukraine war, Difference-in-differences

Como Ajustam as Empresas a Sua Estrutura de Capital em Resposta a um Choque Geopolítico Súbito? Evidência da Invasão Russa da Ucrânia

por Tobias Baur

Resumo

Esta dissertação analisa como as empresas ajustam a sua estrutura de capital em resposta a um choque geopolítico súbito, utilizando a invasão russa da Ucrânia em fevereiro de 2022 como contexto empírico. Com base em dados trimestrais da Compustat referentes a aproximadamente 9.400 empresas não financeiras cotadas em bolsa na Europa Ocidental e nos Estados Unidos entre 2020 e 2023, a análise aplica um desenho de diferenças-em-diferenças que combina a variação entre indústrias na intensidade energética com a variação inter-regional na exposição ao choque. As empresas europeias intensivas em energia aumentaram a sua alavancagem em aproximadamente 4,5 pontos percentuais relativamente às empresas de controlo após o primeiro trimestre de 2022, uma variação de cerca de 15 por cento face à média pré-choque, enquanto as disponibilidades de caixa permaneceram essencialmente inalteradas. As estimativas correspondentes para os Estados Unidos são uniformemente mais fracas, sustentando uma interpretação centrada no canal de oferta de energia específico ao contexto europeu. O padrão indica que as empresas europeias absorveram o choque de custos sobretudo através de financiamento externo, preservando simultaneamente as suas reservas de liquidez, com implicações para a gestão financeira empresarial, para a exposição ao risco por parte dos credores e para a conceção de medidas de apoio durante crises.

Palavras-chave: Estrutura de capital, Alavancagem, Financiamento empresarial, Risco geopolítico, Choque de preços da energia, Guerra Rússia-Ucrânia, Diferenças-em-diferenças

List of Contents

ABSTRACT	I
RESUMO.....	II
LIST OF CONTENTS.....	III
LIST OF TABLES.....	IV
LIST OF FIGURES.....	IV
1. INTRODUCTION.....	1
2. LITERATURE REVIEW.....	4
3. EMPIRICAL STRATEGY.....	7
A. IDENTIFICATION STRATEGY	7
B. DATA AND VARIABLES.....	8
C. DESCRIPTIVE STATISTICS	12
D. METHODOLOGY.....	18
4. RESULTS.....	20
A. WESTERN EUROPE.....	20
B. UNITED STATES.....	22
C. FULL SAMPLE AND CROSS-REGIONAL DISCUSSION.....	23
D. LIMITATIONS	25
E. DISCUSSION.....	27
5. CONCLUSION.....	28
REFERENCES	31

List of Tables

TABLE 1: SUMMARY STATISTICS – FULL SAMPLE	12
TABLE 2: SUMMARY STATISTICS – BY REGION	15
TABLE 3: SUMMARY STATISTICS – BY TREATMENT STATUS	16
TABLE 4: DIFFERENCE-IN-DIFFERENCES ESTIMATES – WESTERN EUROPE	20
TABLE 5: DIFFERENCE-IN-DIFFERENCES ESTIMATES – UNITED STATES	22
TABLE 6: DIFFERENCE-IN-DIFFERENCES ESTIMATES – FULL SAMPLE	23

List of Figures

FIGURE 1: CAPITAL STRUCTURE DYNAMICS – BY TREATMENT STATUS (FULL SAMPLE)	13
FIGURE 2: LEVERAGE DYNAMICS – BY REGION	18
FIGURE 3: DIFFERENCE-IN-DIFFERENCES ESTIMATES - BY OUTCOME AND SAMPLE	24

1. Introduction

On February 24th, 2022, Russia invaded Ukraine. The conflict produced an immediate and far-reaching disruption of European energy markets. In the years preceding the war, Russia had supplied roughly 40 percent of European natural gas (International Energy Agency, 2022). Thus, the abrupt deterioration of this relationship translated into a sustained and unprecedented increase in wholesale energy prices. The Dutch Title Transfer Facility, the European reference benchmark for natural gas, rose from around 70 euros per megawatt-hour at the start of 2022 to a peak above 300 euros in late August, far above the 5 to 35 euros that had characterised the market over the previous ten years (Council of the European Union, 2025). Industrial electricity prices followed a similar trajectory. By the autumn of 2022, European producers, especially in energy-intensive industries, faced significantly increased input costs that had almost no relation to the conditions under which their operations had been planned. Hence, several companies announced production cuts or temporary closures (European Central Bank, 2023).

How firms absorb a cost shock of this magnitude is a fundamental question for corporate finance. Energy is not merely an input that can be substituted on short notice. For many firms it is the irreplaceable physical condition under which the production process takes place. When the price of that condition multiples within a few months, firms face an immediate problem: operating cash flows fall, sometimes sharply, while the obligations encoded in their balance sheets (e.g. debt service, supplier payments, payroll, capital commitments) remain largely unchanged. The question is not whether firms must respond, but along which margin. They can pass costs through to customers, where competitive conditions allow. They can cut production, eroding revenues but preserving cash. They can defer or cancel investment. They can reduce dividends or skip share repurchases. They can issue new equity, draw down cash reserves, or seek additional debt financing. Each of these channels has different consequences for the firm itself, for its workforce and customers, for its lenders, and for the broader economy.

This thesis examines one specific channel of this response, the capital structure. Did European firms in energy-intensive sectors adjust their leverage, cash holdings, and debt maturity structure in the wake of the energy shock, and if so, how? The question is narrower than the broader query of how firms cope with energy crises, but it is also more tractable. Capital structure variables are observable at quarterly frequency for the population of listed firms, the timing of the shock is unambiguous, and the cross-sectional variation in industry exposure to energy costs provides a credible source of identifying variation. The underlying question is,

however, anything but narrow. The capital structure literature has, for long, debated how firms choose between debt and equity, between long-term and short-term financing, between holding cash and paying it out. Most of this debate has unfolded in normal times, where firms make these decisions in the slow, target-seeking manner that Leary and Roberts (2005) document so persuasively. Major shocks, such as wars, financial crises and pandemics, offer a sharply different testing ground. They reveal which margins firms turn to first when the routines of normal corporate finance no longer apply.

Beyond its academic relevance, the question matters for three reasons. The first is that the energy shock following the Russian invasion extended well beyond a temporary market disruption and affected the cost structure of European industry more durably. Sectors that had built their production processes around the assumption of stable and competitively priced Russian gas (German chemical manufacturers being a prominent example) faced input costs that no longer aligned with the conditions under which their operations had been planned. How these firms financed the resulting adjustment is informative about which margins of corporate behaviour absorb large external shocks. Capital structure variables, in this setting, document the financial dimension of a broader industrial adjustment.

The second consideration is that the question speaks directly to the role of the financial system as a shock absorber. If European firms turned to credit markets to bridge the cost shock, like drawing on revolving facilities, negotiating new bank loans, or accessing public capital markets, then the banking system and bond markets effectively absorbed a substantial share of the energy shock on behalf of the real economy. Whether this absorption capacity proved adequate, and whether it was distributed evenly across firms and countries, has consequences for how policymakers think about credit market resilience under future stress. Concerns about credit conditions in early 2023, including the failure of Credit Suisse and the broader U.S. regional banking turbulence, are reminders that financial intermediation cannot always be taken for granted in the aftermath of a major shock.

The third and perhaps most pressing consideration is that energy supply shocks of this kind are still actual. The closure of the Strait of Hormuz in early 2026, following the outbreak of military conflict between Iran and the U.S.–Israel coalition, has produced a second European energy crisis with notable parallels to the situation in 2022. With the suspension of Qatari LNG shipments and historically low European gas storage levels, European wholesale gas prices rose about 35 percent by late April 2026, and European producers have once again been forced to

absorb sharply higher input costs (U.S. Energy Information Administration, 2026). Whether the financing patterns observed after February 2022 are repeating themselves now is an open question, but the recurrence of energy supply shocks underscores that the lessons drawn from the Ukraine episode are not merely retrospective. Geopolitical disruptions to energy supply have become, for the foreseeable future, a regular rather than an exceptional feature of the European corporate environment. Therefore, understanding how firms financed their way through the first shock provides a baseline against which to interpret the second.

The empirical analysis examines how energy-intensive firms in Western Europe adjusted their capital structure in the eight quarters following the Russian invasion. Using quarterly Compustat data on roughly 9,400 publicly listed non-financial firms from Western Europe and the United States between 2020 and 2023, the analysis applies a difference-in-differences design that exploits two sources of variation. The first is cross-industry variation in energy exposure: firms in chemicals, paper, and primary metals (sectors classified as energy-intensive based on Eurostat data on industrial energy consumption) are compared to firms in less energy-dependent industries. The second is cross-regional variation in shock intensity: U.S. firms, whose energy market was largely unaffected by the European gas disruptions because of high domestic oil production and alternative supply channels, serve as a comparison group that allows the European-specific energy channel to be isolated from broader global trends. The comparison yields four headline findings. European energy-intensive firms increased their leverage by approximately 4.5 percentage points relative to control firms after 2022Q1 – a roughly 15 percent shift relative to the pre-shock mean. Their net leverage rose by an even larger margin, while their cash holdings remained essentially unchanged. The short-term debt share rose modestly. The corresponding U.S. estimates are uniformly weaker, with leverage increasing only marginally and most other outcomes statistically indistinguishable from zero.

Taken together, the results describe a specific adjustment pattern, as European energy-intensive firms absorbed the cost shock by increasing external borrowing while preserving their liquid asset positions. Cash buffers were maintained, presumably as insurance against the possibility that the energy crisis would persist or escalate. Debt accounted for the bulk of the adjustment, and the speed at which leverage rose (substantially faster than the gradual capital structure dynamics typically documented in the literature) points to the role of pre-existing credit facilities rather than new debt issuance. The implication is that the capacity to absorb the energy shock through the financial system was, in practice, the capacity to draw on borrowing arrangements that firms had built up before the shock arrived.

The findings carry several practical implications. For corporate financial managers in energy-exposed sectors, the results underline the importance of maintaining unused borrowing capacity and committed credit facilities as a buffer against shocks that cannot be predicted. To the extent that the observed leverage adjustment was accommodated through pre-arranged credit lines, firms without comparable access would probably have faced harder choices between investment cuts, equity issuance, or operational retrenchment. For lenders and credit market participants, the speed and scale of the adjustment imply that European banks bore a substantial share of the corporate response, with consequences for their own balance sheets and risk exposures that warrant attention. For policymakers, the picture is more nuanced. The fact that energy-intensive firms could absorb the shock through the credit channel suggests that European banking and bond markets functioned reasonably well under stress – a reassuring counterpoint to concerns about credit market disruption during the early months of the crisis (European Central Bank, 2022). At the same time, the estimated leverage increase represents a real cost to the affected firms, who entered the post-crisis period with weaker balance sheets and higher refinancing burdens. Policy measures designed to support energy-intensive industries, including the European Commission's REPowerEU framework and various national subsidy programmes, belong to this picture. They likely reduced the magnitude of the leverage adjustment that would otherwise have been required, even if a complete attribution would require firm-level data on subsidy receipts.

The remainder of the thesis is structured as follows. Section 2 reviews the related literature, locating the present analysis within work on geopolitical risk, energy shocks, and the corporate response to crises. Section 3 develops the empirical strategy, covering the identification logic, the data and variables, descriptive statistics, and the estimating equation. Section 4 presents the results, organised by region – first Western Europe, then the United States, then the full sample and cross-regional comparison – before turning to the limitations of the analysis and a broader discussion of the findings. Section 5 concludes and outlines directions for future research, including how the design developed here could be applied to the second European energy crisis now unfolding around the Strait of Hormuz.

2. Literature Review

Geopolitical developments have long shaped firm behaviour and financial market outcomes, though the precise channels through which they operate remain contested. At the aggregate level, Caldara and Iacoviello (2022) construct a broad index of geopolitical risk and show that

rising tensions are followed by declines in investment and asset prices. Effects that are not uniform across industries, since some sectors carry substantially greater exposure to geopolitical disruptions than others. At the firm level, Hassan et al. (2019) use earnings call transcripts to measure political risk directly and find that firms facing elevated exposure respond by cutting hiring and investment. The implication is that political uncertainty does not merely alter expectations in financial markets but prompts tangible operational adjustments.

Discrete geopolitical events tend to generate particularly sharp responses. Brune et al. (2015) document that war-related episodes trigger significant reactions in global equity markets, consistent with the idea that armed conflicts force rapid reassessments of firm risk and future profitability. Similar dynamics emerge around political turning points more broadly. Wagner et al. (2018) analyse cross-sectional stock price reactions to the 2016 U.S. presidential election and find that differences in firm-level sensitivity to expected tax and trade policy account for much of the variation in returns. In a European context, Breinlich et al. (2018) show that the Brexit referendum produced sizeable valuation effects concentrated among firms with strong trade linkages. What these episodes share is a pattern of heterogeneous impact, meaning the same shock hits firms differently depending on their economic exposure, and that variation tends to map onto observable firm and industry characteristics.

The COVID-19 crisis reinforced this pattern while adding an important dimension. Ramelli and Wagner (2020) find that the shock affected industries very differently, and that within industries, firms with weak balance sheets (low cash holdings or high leverage) fared substantially worse than their peers. This points to capital structure not just as an outcome of external shocks but as a determinant of corporate resilience to them.

One underappreciated transmission channel through which geopolitical conflicts affect firms is the energy market. Supply disruptions and price volatility alter cost structures in ways that are highly uneven across industries, depending on how energy-intensive their production processes are. Ready (2018) finds that oil price shocks generate heterogeneous firm-level effects, with the most pronounced negative consequences falling on consumer-oriented sectors such as retail and consumer durables. The mechanism he identifies runs primarily through reduced household disposable income rather than through direct cost increases, which helps explain why the impact is not simply proportional to a firm's direct energy use. Hamilton (2003) provides the macroeconomic backdrop, documenting that sharp oil price increases are reliably associated with broader economic downturns. The Fukushima disaster offers a more contained

but instructive example of how energy shocks propagate differently across sectors. Ferstl et al. (2012) find substantial valuation divergence across energy-related industries following the accident, while Betzer et al. (2013) show that for German firms specifically, the relevant shock was not Fukushima itself but the regulatory response, namely, the sudden reversal of German nuclear policy – underscoring that policy-induced energy disruptions can have effects as significant as the physical supply shocks that trigger them. Taken together, this evidence motivates using industry-level energy intensity as the key source of variation in exposure to the economic consequences of geopolitical conflict.

How firms respond financially to such disruptions is a separate but related question. Bloom (2009) shows that uncertainty shocks cause firms to pause investment and hiring, generating temporary contractions in activity. The mechanism is well-established, but what matters more for the present study is how firms manage their balance sheets under stress. Duchin et al. (2010) find that during the global financial crisis, investment fell most sharply among firms with limited internal liquidity, suggesting that financial constraints amplify the real effects of adverse shocks. Almeida et al. (2004) show that financially constrained firms systematically accumulate cash as a precautionary buffer, which implies that firms actively reshape their balance sheets in response to heightened uncertainty – not just their investment programmes. On the liability side, Leary and Roberts (2005) document that firms adjust toward target leverage only gradually, reflecting adjustment costs and financial frictions that slow the rebalancing process. Together, these findings suggest that the financial response to large external shocks operates through multiple margins: firms may reduce leverage, build liquidity, or both, and the adjustment is likely to be gradual rather than immediate.

Against this background, the Russian invasion of Ukraine presents a compelling setting. The event combined an abrupt escalation in geopolitical uncertainty with severe disruptions in European energy markets, creating differential pressure on firms depending on their industry's energy dependence. Unlike the short-horizon event studies that dominate the geopolitical risk literature, this study focuses on the medium-term balance-sheet response – how firms adjusted their capital structure in the quarters following the shock. By exploiting cross-industry variation in energy intensity within a difference-in-differences framework comparing EU and U.S. firms, the analysis aims to identify a causal channel linking geopolitical energy shocks to corporate financing decisions, and to extend the existing literature beyond valuation effects toward the real financial adjustments that such crises set in motion.

3. Empirical Strategy

A. Identification Strategy

The identification strategy rests on a difference-in-differences design that exploits two sources of variation generated by the Russian invasion of Ukraine in February 2022: cross-industry differences in energy intensity and cross-regional differences in exposure to the resulting energy shock.

The war caused an abrupt deterioration in European energy markets. Because EU economies had built up substantial dependence on Russian natural gas over the preceding decades, the conflict translated into a sharp increase in energy prices and supply uncertainty that had no comparable domestic equivalent in the United States. This regional asymmetry is central to the identification logic: U.S. firms operating in the same industries faced the same global uncertainty but were largely insulated from the acute energy supply disruptions that hit European producers. By comparing EU and U.S. firms within the same sectors, the design uses U.S. firms as a counterfactual for how EU firms would have evolved in the absence of the war-induced energy shock.

Within this regional comparison, the treatment is defined at the industry level. Firms in energy-intensive sectors – specifically Paper (SIC 26), Chemicals (SIC 28), and Primary Metals (SIC 33) – face structurally higher exposure to energy input costs and are therefore more directly affected by energy price increases than firms in less energy-dependent industries (further specified in section 3.B. *Data and Variables*). The treatment indicator equals one for firms in these sectors and zero otherwise. The post-period begins in 2022Q1, coinciding with the outbreak of the war, while the pre-period covers 2020Q1 through 2021Q4. The sample excludes financial firms and utilities throughout, following standard practice in the capital structure literature (Frank and Goyal, 2009; Rajan and Zingales, 1995).

The identifying assumption is that, absent the war, financing outcomes of energy-intensive and non-energy-intensive firms would have followed parallel trends across both regions (see Figure 1). This assumption is plausible to the extent that the treatment classification is based on stable, structural industry characteristics that predate the shock and are unlikely to be correlated with firm-level financing decisions in a systematic way. The regional comparison reinforces this: any global macroeconomic developments affecting all firms simultaneously – such as pandemic-related recovery dynamics or broader monetary policy shifts – are differenced out by

the EU-U.S. comparison, leaving variation that is more plausibly attributable to the war-specific energy channel.

Two potential threats to identification deserve acknowledgment. First, the pre-invasion period overlaps with the COVID-19 recovery, which itself generated differential effects across industries and regions. To the extent that recovery trajectories differed between energy-intensive and non-energy-intensive firms, pre-period trends may not be fully parallel. Second, the U.S. energy sector underwent its own structural changes during the sample period, which could affect the comparability of U.S. firms as a control group for certain industries. These concerns motivate the inclusion of firm fixed effects, quarter fixed effects, and time-varying firm-level controls – absorbing unobserved firm heterogeneity and common time shocks while isolating the differential response of treated firms in the post-invasion period.

B. Data and Variables

Quarterly firm-level accounting data are retrieved from Compustat North America and Compustat Global, accessed via WRDS. The sample covers publicly listed non-financial firms headquartered in the United States and eighteen Western European OECD countries, including the United Kingdom and Switzerland. Restricting the comparison to advanced economies helps ensure reasonable comparability in financial reporting standards, institutional environments, and capital market access, all of which could otherwise confound cross-regional differences in financing behaviour.

The observation window reaches from 2020Q1 through 2023Q4, yielding sixteen quarters and a balanced split between the pre- and post-invasion periods. Financial firms (SIC 6000-6999) are excluded because leverage decisions in that sector are part of the business model and are governed by regulatory capital requirements rather than the economic trade-offs that motivate capital structure theory. Utility firms (SIC 4900-4999) are excluded for a related reason: sector-specific price regulation and long-term supply contracts tend to insulate utilities from market-based energy price movements, which would attenuate precisely the transmission channel this study aims to identify. Where multiple observations exist for the same firm-quarter (arising from different reporting formats in Compustat) the observation with the fewest missing values across core accounting variables is retained. After these filters, the dataset contains 114,715 firm-quarter observations covering 9,431 unique firms, of which 4,835 are headquartered in Europe and 4,596 in the United States.

The primary outcome variable is leverage, defined as total debt scaled by total assets, where total debt is the sum of short-term debt (*dlcq*) and long-term debt (*dlttq*). Scaling by assets rather than by equity follows the convention established in the capital structure literature (Frank and Goyal, 2009; Rajan and Zingales, 1995), and avoids the volatility of book equity that can complicate cross-firm comparisons. Three complementary balance-sheet measures are examined alongside leverage. Net leverage is constructed as total debt minus cash and cash equivalents (*cheq*), scaled by total assets. This measure is informative because firms can respond to a shock by raising new debt while holding the proceeds as cash rather than deploying them. Gross leverage would record this as a rise in indebtedness, whereas net leverage offsets the additional debt against the additional cash and so captures the change in net indebtedness. The cash-to-assets ratio is defined as cash and cash equivalents divided by total assets, and isolates the asset side of the same adjustment. A change in cash holdings without a corresponding change in debt would indicate a precautionary or operational response that does not show up in leverage. The short-term debt share is defined as short-term debt over total debt and is computed only for firm-quarters with strictly positive total debt. This variable captures the maturity composition of borrowing, which can shift independently of the overall debt level if firms reach for revolving credit facilities, overdraft lines, or short-term bank loans rather than long-term bond issuance. Together, the four outcomes describe the main margins along which a firm might adjust its balance sheet in response to a shock, namely, reducing or expanding gross debt, accumulating or depleting liquidity buffers, and shifting the maturity structure of its borrowings.

The choice of control variables follows standard practice in the capital structure literature (Frank and Goyal, 2009; Rajan and Zingales, 1995). Firm size is measured as the natural logarithm of total assets, since larger firms typically have broader access to credit markets and lower agency costs of debt. Profitability is operating income before depreciation (*oibdpq*) scaled by total assets, capturing the firm's ability to generate internal funds. The pecking order theory predicts a negative relationship between profitability and leverage, while the trade-off view predicts the opposite. Asset tangibility is net property, plant, and equipment (*ppentq*) scaled by total assets, and reflects the availability of collateral, which lowers the cost of debt financing and tends to be associated with higher leverage. Quarterly sales growth is computed as the percentage change in quarterly sales (*saleq*) relative to the previous quarter, and proxies for investment opportunities and demand conditions, both of which influence external financing needs. All controls enter the regressions with a one-period lag, which mitigates simultaneity

concerns by ensuring that the regressors reflect the firm's pre-decision financial position rather than outcomes that may themselves be influenced by the shock.

Treatment is assigned at the industry level using two-digit SIC codes. Firms in three sectors are classified as energy-intensive: Paper (SIC 26), Chemicals (SIC 28), and Primary Metals (SIC 33). The selection draws on Eurostat data on industrial energy consumption in the EU, which consistently identifies these sectors among the largest industrial energy users (Eurostat, 2023), and aligns with the standard classification used in EU energy policy, including the Commission's framework for the EU Emissions Trading System (European Commission, 2024). The common feature of these industries is that energy enters production as a structural condition rather than a discretionary input: chemical reactors, blast furnaces, and paper dryers require continuous and large-scale energy throughput, and substitution toward less energy-intensive technologies is feasible only over a horizon longer than the period studied here. An unexpected change in energy prices therefore feeds through directly to operating costs, with limited scope for short-run adjustment. Across the three sectors, Chemicals accounts for the large majority of treated observations.

The composition of SIC 28 deserves a brief comment, since the code groups pharmaceutical firms (SIC 283x) together with industrial chemical producers, and these firms account for a substantial share of SIC 28 observations in the Compustat sample. The conventional measure of energy intensity, the share of energy in gross production value, stood at roughly one percent for German pharmaceuticals in 2019, compared to 3.5 percent in chemicals and 5.3 percent in non-metallic minerals (Schumacher, 2022). By this metric alone, pharmaceutical firms would not appear to belong in an energy-intensive treatment group. The measure, however, captures only the direct cost share and misses two channels through which the sector is materially exposed to energy supply disruptions. First, the pharmaceutical industry's energy mix (in Germany) has shifted markedly toward natural gas in the past decade, with the gas share reaching approximately 40 percent by 2019 (Schumacher, 2022), so that production becomes vulnerable to supply interruptions even if the overall cost share is modest. Second, most pharmaceutical precursors and active ingredients are sourced from the chemical industry (Francas et al., 2022), which itself faced severe production curtailments during the crisis. The exposure was recognised by industry participants themselves, with Medicines for Europe warning EU energy and health ministers in September 2022 that several producers might be unable to continue manufacturing under a gas rationing scenario (Euro News, 2022). Taken together, the direct gas dependence and the upstream linkage to a sector at the centre of the

energy crisis make pharmaceutical firms a substantively appropriate part of the treatment group. The firm fixed effects absorb static differences between pharmaceutical and industrial chemical firms in cash holdings and leverage, while the estimated coefficients should be interpreted as the response of the broader SIC 28 sector rather than a narrowly defined set of heavy chemical manufacturers.

All continuous variables are winsorised at the 1st and 99th percentiles to limit the influence of extreme observations. The final dataset forms an unbalanced panel, reflecting variation in firm coverage across quarters.

C. Descriptive Statistics

Table 1 reports summary statistics for the full sample of 114,715 firm-quarter observations over the period 2020Q1 to 2023Q4. The mean leverage ratio of 0.338 exceeds the median of 0.251, indicating a right-skewed distribution, in which a subset of firms carries substantially higher debt relative to assets. Net leverage averages only 0.097, and the gap between gross and net leverage reflects sizeable cash holdings across the sample. The median net leverage of 0.111 is positive, so more than half of all firms carry net debt, but the negative 25th percentile (-0.149) shows that roughly a quarter of the sample holds more cash than total debt. This pattern is consistent with the well-documented tendency of smaller and growth-oriented firms to maintain large cash buffers as a precautionary motive (Opler et al., 1999).

Cash ratios confirm this picture: the average firm holds about 24.2% of its assets in cash, though the distribution is again skewed. The median of 0.134 sits well below the mean, pulled upward by cash-rich firms concentrated in sectors like technology and pharmaceuticals. The short-term debt share averages 0.280, with a median of 0.194, suggesting that most firms rely predominantly on long-term debt financing. The interquartile range from 0.070 to 0.400, however, reveals considerable heterogeneity in maturity structure across the sample.

TABLE 1: SUMMARY STATISTICS – FULL SAMPLE

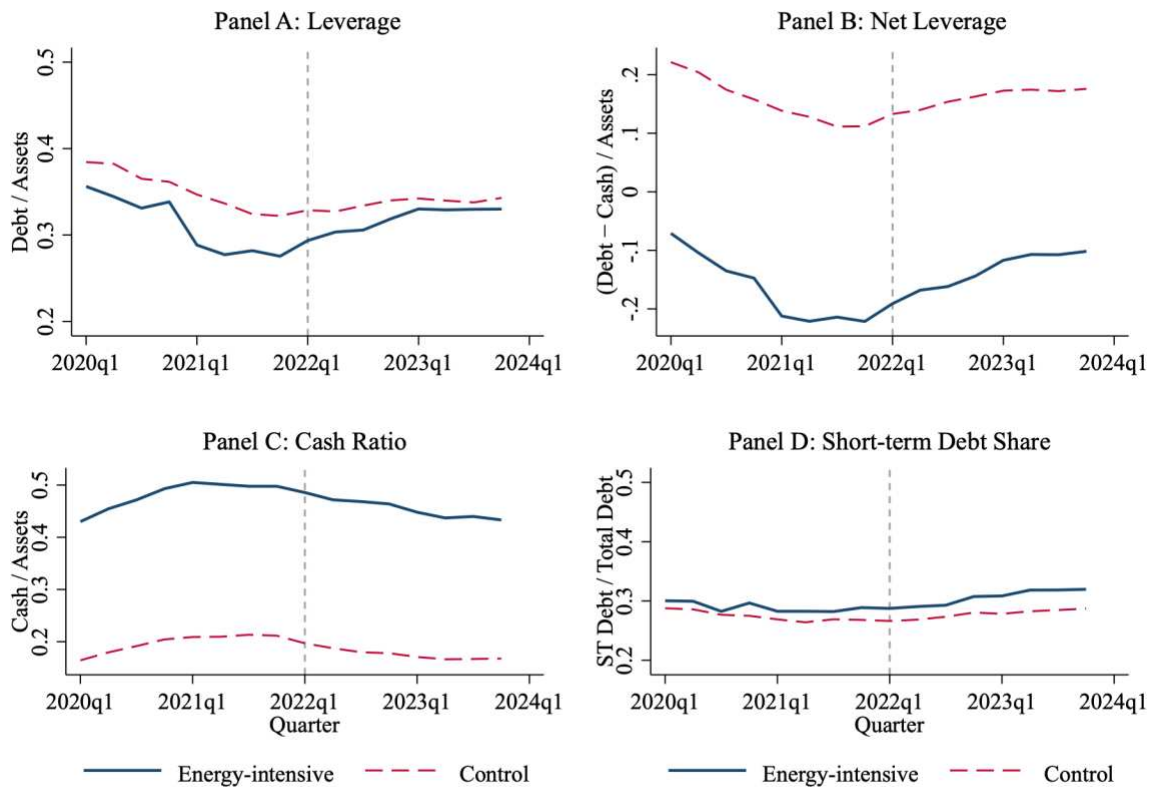
	N	mean	sd	p25	p50	p75
<i>Panel A: Capital Structure Variables</i>						
Leverage	114,715	0.338	0.459	0.097	0.251	0.418
Net Leverage	114,562	0.097	0.561	-0.149	0.111	0.311
Cash Ratio	114,562	0.242	0.261	0.056	0.134	0.332
Short-term Debt Share	111,782	0.280	0.269	0.070	0.194	0.400
<i>Panel B: Control Variables</i>						
Firm Size	114,715	5.909	2.533	4.128	5.939	7.702
Profitability	111,028	-0.026	0.150	-0.028	0.016	0.033
Tangibility	114,178	0.218	0.217	0.054	0.141	0.316
Sales Growth	91,982	0.098	0.557	-0.044	0.000	0.114

Notes: The sample covers non-financial, non-utility firms from Compustat Quarterly for 2020Q1-2023Q4. Western Europe includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. Financials (SIC 6000-6999), utilities (SIC 4900-4999), and non-classifiable establishments (SIC 99) are excluded. All continuous variables are winsorised at the 1st and 99th percentiles. Variable definitions: Leverage = (short-term debt + long-term debt) / total assets; Net Leverage = (short-term debt + long-term debt – cash and cash equivalents) / total assets; Cash Ratio = cash and cash equivalents / total assets; Short-term Debt Share = short-term debt / total debt, defined only when total debt > 0; Firm Size = natural logarithm of total assets; Profitability = operating income before depreciation / total assets; Tangibility = net property, plant and equipment / total assets; Sales Growth = (current quarter sales – prior quarter sales) / prior quarter sales, defined only when lagged sales > 0.

Turning to the control variables, firm size has a mean of 5.909 and a standard deviation of 2.533, indicating that the sample spans a broad range from small, listed firms to large multinationals. Mean profitability is slightly negative at -0.026, driven by unprofitable firms in the lower tail. The median of 0.016 indicates that the typical firm does generate positive operating income relative to assets. Tangibility averages 0.218 with a median of 0.141, suggesting that many firms in the sample are asset-light. Sales growth averages 9.8% quarter-on-quarter, though the median of zero and the large standard deviation of 0.557 suggest that this mean is influenced by a few high-growth observations, while the typical firm experienced flat sequential revenue over the sample period.

To complement the cross-sectional summary, Figure 1 traces the quarterly evolution of each capital structure variable over the sample period, separately for energy-intensive and control firms.

FIGURE 1: CAPITAL STRUCTURE DYNAMICS – BY TREATMENT STATUS (FULL SAMPLE)



Notes: This figure plots quarterly sample means of four capital structure variables for energy-intensive firms and control firms over the period 2020Q1-2023Q4. The vertical dashed line marks 2022Q1, the quarter of the Russian invasion of Ukraine.

Panel A shows that both groups entered the sample period on a declining leverage trajectory, consistent with the broader deleveraging trend during the COVID-19 recovery. Energy-intensive firms carry lower average leverage throughout, a pattern that reflects the composition of the treated group rather than lower debt capacity – as discussed below, the presence of cash-rich pharmaceutical and biotechnology firms within SIC 28 depresses the treated group mean. Both series stabilise around 2022 and move in close parallel through the post-invasion period, with no visible divergence at the onset of the war. Panel B tells a complementary story from the net leverage perspective. Control firms maintain positive and relatively stable net leverage of around 0.10 to 0.20, whereas treated firms carry deeply negative net leverage that declines further through 2021 before partially recovering. The gap between the two groups is substantial and persists throughout the sample.

Panel C mirrors Panel B on the asset side. Energy-intensive firms hold between 43 and 50 percent of their assets in cash, compared to roughly 15 to 20 percent for control firms – a difference of nearly 30 percentage points that is stable over time and does not shift around 2022Q1.

Panel D presents a contrast to the other three panels: the short-term debt share is the one dimension along which both groups track closely. Both series fluctuate within a narrow band around 27 to 31 percent, suggesting that debt maturity structure does not differ meaningfully along the treatment margin.

Table 2 breaks down the sample by region, with roughly equal coverage – about 57,200 firm-quarters for Western Europe and 57,500 for the United States.

US firms carry higher leverage on average (0.382 vs. 0.294), and this gap is not driven by outliers: the medians tell a similar story (0.258 vs. 0.247). The considerably larger standard deviation in the US subsample (0.569 vs. 0.305) points to greater dispersion in debt usage. Net leverage, however, is lower for US firms (0.076 vs. 0.118), despite their higher gross leverage. This apparent contradiction is resolved by the cash ratio: US firms hold substantially more cash relative to assets (0.308 vs. 0.176). The higher US cash holdings reflect two patterns in the data. First, the US subsample contains a disproportionately large share of firms in SIC 28 (Chemicals, including pharmaceuticals and biotechnology), 24.1% of US firms versus 10.9% in Europe, a sector characterized by high cash reserves. Second, even within the same industries, US firms consistently hold more cash than their European counterparts, suggesting that compositional differences alone do not fully account for the gap.

TABLE 2: SUMMARY STATISTICS – BY REGION

	(1)				(2)			
	Western Europe				United States			
	N	mean	sd	p50	N	mean	sd	p50
<i>Panel A: Capital Structure Variables</i>								
Leverage	57,221	0.294	0.305	0.247	57,494	0.382	0.569	0.258
Net Leverage	57,068	0.118	0.379	0.128	57,494	0.076	0.695	0.082
Cash Ratio	57,068	0.176	0.182	0.114	57,494	0.308	0.307	0.174
Short-term Debt Share	57,086	0.304	0.240	0.243	54,696	0.255	0.295	0.129
<i>Panel B: Control Variables</i>								
Firm Size	57,221	5.938	2.382	5.800	57,494	5.881	2.675	6.078
Profitability	54,611	0.006	0.075	0.021	56,417	-0.058	0.192	0.007
Tangibility	56,727	0.223	0.208	0.157	57,451	0.212	0.224	0.127
Sales Growth	47,040	0.087	0.491	0.000	44,942	0.110	0.619	0.024

Notes: The sample covers non-financial, non-utility firms from Compustat Quarterly for 2020Q1-2023Q4. Western Europe includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. Financials (SIC 6000-6999), utilities (SIC 4900-4999), and non-classifiable establishments (SIC 99) are excluded. All continuous variables are winsorised at the 1st and 99th percentiles. Variable definitions: Leverage = (short-term debt + long-term debt) / total assets; Net Leverage = (short-term debt + long-term debt – cash and cash equivalents) / total assets; Cash Ratio = cash and cash equivalents / total assets; Short-term Debt Share = short-term debt / total debt, defined only when total debt > 0; Firm Size = natural logarithm of total assets; Profitability = operating income before depreciation / total assets; Tangibility = net property, plant and equipment / total assets; Sales Growth = (current quarter sales – prior quarter sales) / prior quarter sales, defined only when lagged sales > 0.

The short-term debt share is higher among European firms (0.304 vs. 0.255), indicating a greater reliance on shorter-maturity financing. This is relevant for the identification strategy, as firms with a larger share of short-term debt face more frequent refinancing needs and are therefore more immediately exposed to changes in credit market conditions following a shock.

Among the control variables, firm size is comparable across regions in both mean and median, indicating that the two subsamples cover a similar range of the firm size distribution. The most notable difference appears in profitability: European firms report a mean of 0.006 with a median of 0.021, while US firms average -0.058 with a median of 0.007. The negative US mean is driven by a left tail of loss-making firms, concentrated in sectors such as Chemicals (SIC 28), where a large number of early-stage pharmaceutical and biotechnology firms report negative operating income. Tangibility is broadly similar across regions (0.223 vs. 0.212). Sales growth averages slightly higher in the US (0.110 vs. 0.087), though both medians sit at or near zero, and the US distribution exhibits more dispersion (sd 0.619 vs. 0.491).

These cross-regional differences in leverage composition, cash holdings, and profitability underscore the importance of controlling for firm-level characteristics in the regression analysis and of relying on within-firm variation through fixed effects rather than cross-sectional level comparisons.

Table 3 compares the 22,242 firm-quarter observations classified as energy-intensive (SIC 26, 28, 33) with the 92,473 observations in the control group. The treated group accounts for roughly one-fifth of the sample.

TABLE 3: SUMMARY STATISTICS – BY TREATMENT STATUS

		(1)				(2)		
	N	Energy-intensive			N	Control industries		
		mean	sd	p50		mean	sd	p50
<i>Panel A: Capital Structure Variables</i>								
Leverage	22,242	0.314	0.536	0.172	92,473	0.344	0.438	0.266
Net Leverage	22,225	-0.153	0.705	-0.164	92,337	0.158	0.502	0.142
Cash Ratio	22,225	0.469	0.351	0.455	92,337	0.188	0.199	0.117
Short-term Debt Share	20,792	0.297	0.297	0.196	90,990	0.276	0.263	0.193
<i>Panel B: Control Variables</i>								
Firm Size	22,242	5.315	2.453	5.218	92,473	6.052	2.532	6.158
Profitability	21,424	-0.102	0.201	-0.057	89,604	-0.008	0.129	0.019
Tangibility	22,171	0.160	0.177	0.092	92,007	0.232	0.223	0.152
Sales Growth	14,203	0.183	0.892	0.000	77,779	0.083	0.470	0.000

Notes: Energy-intensive industries are defined as SIC codes starting with 26 (Paper), 28 (Chemicals), and 33 (Primary Metals). The sample covers non-financial, non-utility firms from Compustat Quarterly for 2020Q1-2023Q4. Western Europe includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. Financials (SIC 6000-6999), utilities (SIC 4900-4999), and non-classifiable establishments (SIC 99) are excluded. All continuous variables are winsorised at the 1st and 99th percentiles. Variable definitions: Leverage = (short-term debt + long-term debt) / total assets; Net Leverage = (short-term debt + long-term debt – cash and cash equivalents) / total assets; Cash Ratio = cash and cash equivalents / total assets; Short-term Debt Share = short-term debt / total debt, defined only when total debt > 0; Firm Size = natural logarithm of total assets; Profitability = operating income before depreciation / total assets; Tangibility = net property, plant and equipment / total assets; Sales Growth = (current quarter sales – prior quarter sales) / prior quarter sales, defined only when lagged sales > 0.

The capital structure profiles of the two groups differ in ways that may appear counterintuitive at first. Energy-intensive firms report lower average leverage (0.314 vs. 0.344), and the gap widens at the median (0.172 vs. 0.266). More strikingly, average net leverage is deeply negative for treated firms (-0.153 vs. 0.158), with even the median at -0.164. This is driven by an exceptionally high cash ratio among energy-intensive firms: a mean of 0.469 compared to 0.188 for control industries, a difference of nearly 28 percentage points. The pattern is likely attributable to the composition of SIC 28 (Chemicals), the largest treated sector,

which encompasses not only traditional chemical manufacturers but also pharmaceutical and biotechnology firms – a group known for holding large cash reserves to fund R&D pipelines while carrying little debt. The short-term debt share is similar across the two groups (0.297 vs. 0.276), suggesting that debt maturity structure does not differ meaningfully along the treatment margin.

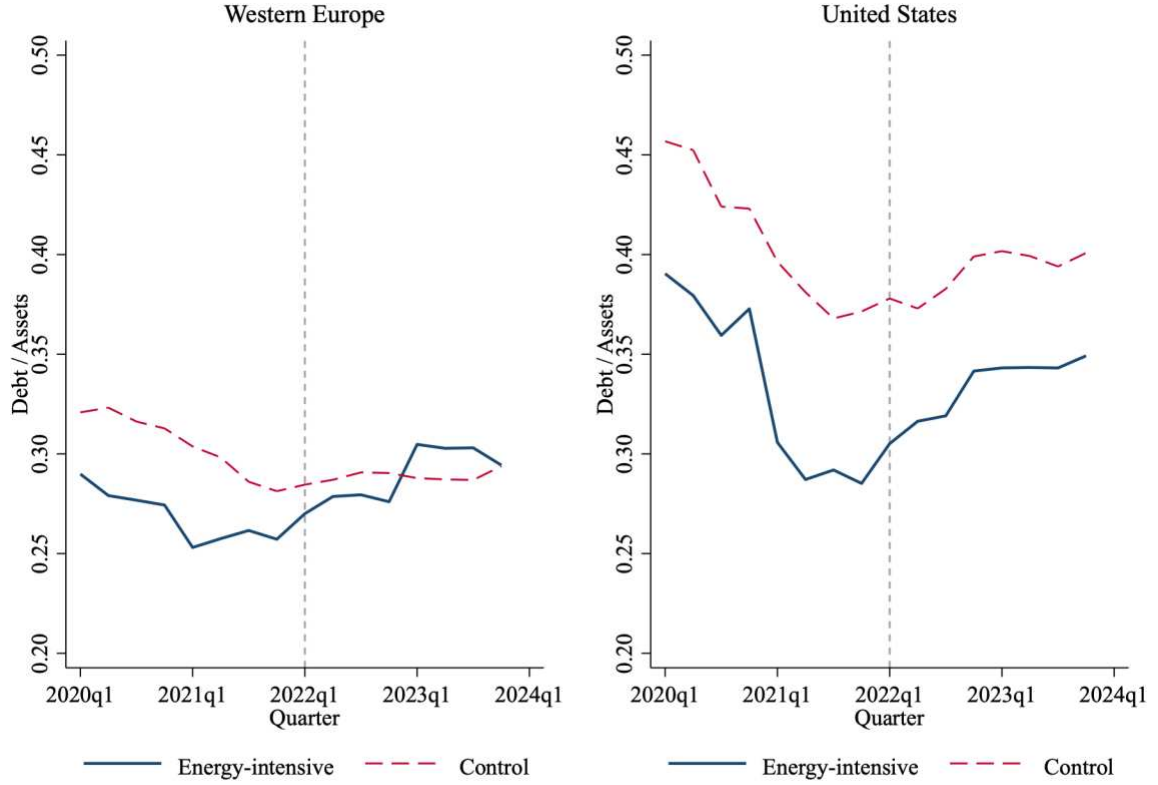
The control variables reinforce the picture of substantial compositional differences. Treated firms are smaller on average (5.315 vs. 6.052 in log assets) and markedly less profitable, with a mean profitability of -0.102 versus -0.008 for control firms. The median treated firm also reports negative operating income (-0.057), while the median control firm is modestly profitable (0.019). Tangibility is lower in the treated group (0.160 vs. 0.232) – again a pattern shaped by the presence of asset-light pharmaceutical firms within SIC 28, rather than what one might expect from traditional heavy industry. Sales growth averages higher among treated firms (0.183 vs. 0.083), though both medians are zero and the treated distribution is far more dispersed (sd 0.892 vs. 0.470), pointing to a few high-growth observations in the tail rather than a systematic difference.

These level differences between treated and control firms are substantial, and they reinforce two points for the empirical design. First, the inclusion of firm fixed effects is essential to absorb time-invariant differences in capital structure that reflect industry composition rather than the energy price shock. Second, the parallel trends assumption must be evaluated carefully, since treated and control firms differ not only in their energy exposure but also in size, profitability, and asset structure – characteristics that may independently affect how firms adjust their financing in response to macroeconomic shocks.

Figure 2 disaggregates the leverage dynamics by region. In Europe (left panel), both groups follow a broadly parallel downward trajectory during the pre-invasion period, with energy-intensive firms consistently below control firms. After 2022Q1, the two series converge as treated firms experience a modest rebound while control firms remain flat. The gap between the groups is relatively narrow throughout, ranging from roughly two to four percentage points. In the United States (right panel), the level difference is more pronounced: control firms carry leverage of around 0.40 to 0.45, while energy-intensive firms fluctuate between 0.25 and 0.35. Both groups exhibit a decline during 2020-2021 followed by a recovery, but the treated group's decline is steeper and the subsequent rebound sharper. The cross-regional comparison highlights two features relevant to the identification strategy. First, the level gap between

treated and control firms is considerably larger in the United States than in Europe, reinforcing the need for firm fixed effects to absorb time-invariant differences. Second, both regions exhibit qualitatively similar pre-invasion dynamics – a shared downward trend that is plausibly attributable to the post-COVID recovery rather than to any anticipation of the energy shock.

FIGURE 2: LEVERAGE DYNAMICS – BY REGION



Notes: This figure plots quarterly sample means of leverage (total debt over total assets) for energy-intensive firms and control firms, separately for Western Europe (left) and the United States (right). The vertical dashed line marks 2022Q1

D. Methodology

As outlined in 3.A. *Identification strategy*, the analysis exploits the interaction of cross-industry variation in energy intensity with the timing of the Russian invasion to estimate the causal effect of the energy shock on corporate capital structure. The baseline difference-in-differences specification takes the following form:

$$Y_{i,t} = \alpha + \beta(HighEnergy_i * Post_t) + \delta X_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

where $Y_{i,t}$ is the capital structure outcome of firm i in quarter t . The coefficient of interest is β , which captures the average differential change in the outcome for energy-intensive firms

relative to control firms following the onset of the war. A positive β on leverage, for instance, would indicate that treated firms increased their debt-to-assets ratio more, or reduced it less, than control firms in the post-invasion period.

The specification includes firm fixed effects μ_i and quarter fixed effects λ_t . Because the treatment indicator $HighEnergy_i$ does not vary over time, it is absorbed by the firm fixed effects; β is therefore identified entirely from within-firm changes across the pre- and post-periods, differenced against the corresponding within-firm changes for control firms. Quarter fixed effects remove any aggregate time-varying shocks common to all firms, including shifts in monetary policy, pandemic-related recovery dynamics, or changes in global credit market conditions. The combination of two-way fixed effects ensures that identification does not rely on cross-sectional level differences between treated and control firms, which, as the descriptive statistics illustrate, are substantial.

$X_{i,t-1}$ is a vector of time-varying firm-level controls, each lagged by one quarter: firm size, profitability, tangibility, and sales growth. Since several of these variables, in particular profitability and sales growth, are plausibly affected by the energy shock itself, controls have been lagged. Using contemporaneous values would risk introducing a bad controls problem (Angrist and Pischke, 2008) where part of the treatment effect is absorbed by a regressor that lies on the causal path between the shock and the outcome. One-quarter lags instead capture the firm's pre-decision financial position, reducing this concern while still accounting for time-varying heterogeneity that the fixed effects alone cannot absorb.

The model estimates the average treatment effect on the treated (ATT), which is, the average differential change in the outcome for energy-intensive firms relative to a covariate-adjusted counterfactual constructed from the control group. The counterfactual accounts for differences in firm characteristics between treated and control firms by conditioning on the control variables, firm fixed effects, and quarter fixed effects.

Standard errors are clustered at the firm level. This accounts for serial correlation in the residuals within a firm's time series, which is a well-known concern in panel settings with a short time dimension relative to the cross-section (Bertrand et al., 2004). Firm-level clustering is conservative for the present application, since the treatment is assigned at the industry level: clustering at the industry level would reduce the number of clusters sharply, which can lead to unreliable inference. Firm-level clustering avoids this small-cluster problem while still allowing for arbitrary within-firm dependence.

The estimation proceeds in three steps. The first specification restricts the sample to European firms and tests whether energy-intensive industries in Europe – the region directly exposed to the gas supply disruption – adjusted their capital structure differently from European control firms. The second specification estimates the same model on U.S. firms only. Because American firms were largely insulated from the European energy supply shock, this serves as a placebo-like benchmark: significant effects in the U.S. subsample would suggest that the results reflect a global trend affecting energy-intensive industries rather than a Europe-specific energy channel. The third specification pools both regions to exploit the full sample. Each specification is estimated for all four dependent variables – leverage, net leverage, the cash-to-assets ratio, and the short-term debt share – to capture the different margins along which firms may adjust their balance sheets.

4. Results

A. Western Europe

Table 4 reports the estimated average treatment effect on the treated (ATT) from the baseline difference-in-differences specification, restricted to firms headquartered in Western European OECD countries. This is the primary test, as European firms were directly exposed to the energy supply disruption following the Russian invasion.

TABLE 4: DIFFERENCE-IN-DIFFERENCES ESTIMATES – WESTERN EUROPE

	Coefficient	Std. Error	t-statistic	p-value
Leverage	0.0447***	(0.0096)	4.669	0.0000
Net Leverage	0.0521***	(0.0117)	4.441	0.0000
Cash Ratio	-0.0064	(0.0047)	-1.370	0.1706
Short-term Debt Share	0.0170*	(0.0090)	1.885	0.0595

Notes: This table reports the estimated average treatment effect on the treated (ATT) of the Russian invasion of Ukraine on four capital structure outcomes for Western European firms. Western Europe includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. Each row corresponds to a separate regression with one of the four dependent variables: leverage (total debt over assets), net leverage ((debt – cash) over assets), the cash ratio (cash over assets), and the short-term debt share (short-term debt over total debt). The reported coefficient captures the differential change in the outcome for energy-intensive firms (SIC 26, 28, 33) relative to control firms after 2022Q1. A positive coefficient indicates a larger increase in the outcome for treated firms following the invasion. N = 41,952 firm-quarter observations on 3,885 firms. All specifications include firm and quarter fixed effects and one-quarter-lagged controls (firm size, profitability, asset tangibility, and quarterly sales growth). Standard errors clustered at the firm level are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

The results indicate a significant increase in leverage among European energy-intensive firms in the post-invasion period. The estimated ATT of 0.0447 ($p < 0.001$) implies that treated firms increased their debt-to-assets ratio by approximately 4.5 percentage points relative to control firms after 2022Q1. Relative to the pre-shock mean leverage of roughly 0.30 among energy-intensive firms, this represents a shift of about 15 percent – a substantial adjustment over a period of less than two years. The pace of the response is itself notable. Leary and Roberts (2005) estimate that firms close only a fraction of the gap between actual and target leverage each year, implying half-lives of several years for capital structure adjustment. That treated firms moved this far this quickly suggests either that the shock generated an immediate funding need that could not be deferred, or that firms drew on existing credit facilities rather than issuing new debt – the latter would explain how an adjustment of this magnitude was feasible within the standard frictions documented in the literature.

The net leverage effect is larger still. The ATT of 0.0521 ($p < 0.001$) indicates that treated firms' net indebtedness (debt minus cash, scaled by assets) rose by more than five percentage points. That the net leverage coefficient exceeds the leverage coefficient, while the cash ratio shows no significant change (ATT = -0.0064, $p = 0.17$), reveals a specific mechanism: energy-intensive firms took on additional debt without simultaneously drawing down their liquid asset holdings. The increase in indebtedness thus reflects new external financing rather than a reallocation from cash to operations. This is consistent with the precautionary motive for cash holdings emphasised by Acharya et al. (2007): firms value liquidity most when uncertainty is elevated, and would be reluctant to deplete cash buffers during an ongoing shock. Maintaining the cash cushion while accessing credit markets preserved financial flexibility against the possibility that the energy crisis would persist or escalate further.

The short-term debt share shows a marginally significant increase of 1.7 percentage points ($p = 0.06$). The direction is economically intuitive and relevant for interpreting the leverage result. Firms facing a sudden cost shock typically prefer shorter-maturity instruments – revolving credit facilities, overdraft lines, or short-term bank loans – over long-term bond issuance, both because the financing need may be transitory and because long-term credit markets tend to tighten for firms with deteriorating profitability. A shift toward short-term debt also supports the interpretation that much of the leverage increase was accommodated through pre-arranged bank credit rather than fresh bond issuance, which would account for the speed of the adjustment.

B. United States

Table 5 presents the same specification estimated on U.S. firms. Because the American energy market was largely insulated from the European gas supply disruption – U.S. natural gas prices remained well below European levels throughout 2022 and 2023, owing to abundant domestic shale production – this subsample serves as a placebo-like benchmark.

TABLE 5: DIFFERENCE-IN-DIFFERENCES ESTIMATES – UNITED STATES

	Coefficient	Std. Error	t-statistic	p-value
Leverage	0.0207*	(0.0114)	1.822	0.0684
Net Leverage	0.0196	(0.0125)	1.571	0.1161
Cash Ratio	-0.0003	(0.0051)	-0.052	0.9586
Short-term Debt Share	0.0116	(0.0082)	1.416	0.1567

Notes: This table reports the estimated ATT for U.S. firms, using the same specification as Table 4. Because the U.S. energy market remained largely insulated from the European gas supply disruption, the U.S. subsample serves as a placebo-like benchmark: under the identification logic, the European-specific energy channel should generate weaker effects here than in the European subsample. Each row reports the coefficient on the treatment indicator from a separate regression with one of the four capital structure outcomes as the dependent variable. N = 40,606 firm-quarter observations on 3,761 firms. All specifications include firm and quarter fixed effects and one-quarter-lagged controls (firm size, profitability, asset tangibility, and quarterly sales growth). Standard errors clustered at the firm level are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

The U.S. estimates are uniformly weaker. Leverage shows a marginally significant increase of 2.1 percentage points ($p = 0.07$), roughly half the magnitude of the European estimate. Net leverage, cash ratio, and the short-term debt share are all statistically insignificant. The pattern aligns with the identification logic: if the capital structure adjustment were driven by a global industry trend unrelated to the European energy channel, one would expect effects of similar magnitude in the United States. Instead, the European coefficients are roughly twice as large and statistically significant at the 1 percent level, while the U.S. estimates are at best marginally significant and economically modest.

That the U.S. leverage coefficient is weakly positive rather than zero likely reflects exposure to factors that, while milder than in Europe, still affected American energy-intensive producers during the sample period. Crude oil prices rose globally in 2022, and U.S. natural gas prices – though low in absolute terms – did spike above their historical range as domestic liquefied natural gas exports to Europe increased. In addition, many U.S. firms in these sectors operate globally, with European subsidiaries and suppliers that transmit part of the European cost shock into consolidated accounts. The key finding, however, is the clear difference in magnitude and

statistical significance between the two subsamples, which supports a Europe-specific interpretation of the main result.

C. Full Sample and Cross-Regional Discussion

Table 6 reports the pooled estimates, which combine both regions to exploit the full sample of 7,646 firms. The pooled leverage ATT of 0.0331 ($p < 0.001$) and the net leverage ATT of 0.0372 ($p < 0.001$) are highly significant and fall between the European and U.S. point estimates, as expected from a weighted average. The short-term debt share is marginally significant at 0.0116 ($p = 0.06$), while the cash ratio remains insignificant.

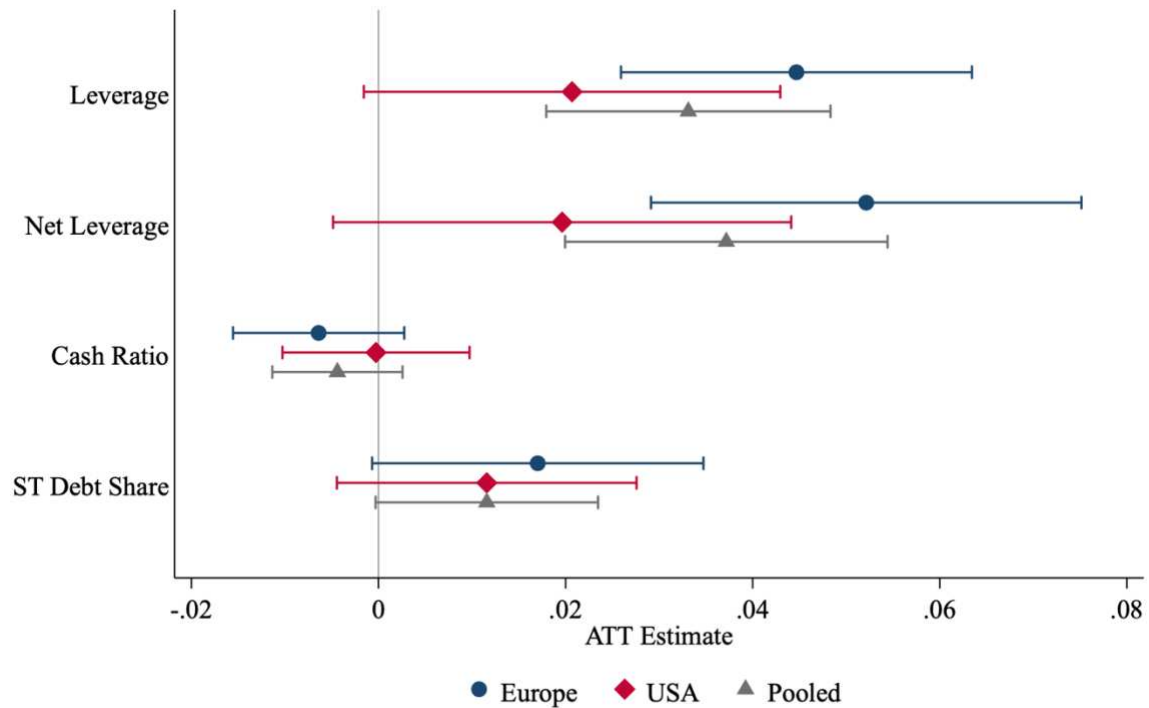
TABLE 6: DIFFERENCE-IN-DIFFERENCES ESTIMATES – FULL SAMPLE

	Coefficient	Std. Error	t-statistic	p-value
Leverage	0.0331***	(0.0077)	4.274	0.0000
Net Leverage	0.0372***	(0.0088)	4.229	0.0000
Cash Ratio	-0.0044	(0.0036)	-1.236	0.2166
Short-term Debt Share	0.0116*	(0.0061)	1.909	0.0563

Notes: This table reports the estimated ATT for the full sample, pooling Western European and U.S. firms in a single specification. The pooled estimates are best understood as a weighted average of the regional effects reported in Tables 4 and 5; they exploit the full statistical power of the sample at the cost of masking regional heterogeneity. Each row reports the coefficient on the treatment indicator from a separate regression with one of the four capital structure outcomes as the dependent variable. $N = 82,557$ firm-quarter observations on 7,646 firms. All specifications include firm and quarter fixed effects and one-quarter-lagged controls (firm size, profitability, asset tangibility, and quarterly sales growth). Standard errors clustered at the firm level are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 3 summarises the regional comparison visually. The coefficient plot confirms two patterns that emerge from the tables. First, for leverage and net leverage, the European point estimates lie consistently to the right of the U.S. estimates, indicating a stronger response among European firms. The confidence intervals overlap, meaning that the difference between the regional coefficients is not itself statistically significant – but the qualitative pattern aligns with the identifying assumption that Europe bore the brunt of the energy supply shock. Second, for the cash ratio and short-term debt share, all three samples cluster near zero, confirming that the adjustment operated primarily through the debt level rather than through cash management or debt maturity.

FIGURE 3: DIFFERENCE-IN-DIFFERENCES ESTIMATES - BY OUTCOME AND SAMPLE



Notes: This figure plots the estimated ATT with 95% confidence intervals for each capital structure outcome, separately for Western Europe (circle), the United States (diamond), and the full sample (triangle). The vertical line marks zero

Taken together, the results reveal that European energy-intensive firms absorbed the cost shock by relying more heavily on external borrowing while keeping their liquid asset positions intact. In principle, firms facing a sharp rise in input costs have several ways to respond. They can cut investment, reduce dividends, issue equity, or run down their cash buffers. What the estimates suggest is that, on average, none of these margins absorbed a meaningful share of the shock in the short run. Instead, debt did the heavy lifting. This is the kind of response the pecking order theory anticipates (Myers and Majluf, 1984): when information asymmetries make external financing costly, firms turn first to internal funds, then to debt, and only reluctantly to equity. As internal cash flows deteriorate under an operating cost shock, debt becomes the natural margin of adjustment, and that is precisely what the data show. The trade-off view sits less comfortably with these findings, since rising distress risk should, under that logic, push firms toward lower rather than higher leverage.

What is perhaps more striking than the direction of the response is its pace. The benchmark in the capital structure literature is one of slow, gradual adjustment. Leary and Roberts (2005) document half-lives measured in years, reflecting the fixed costs of issuance, refinancing, and the broader frictions that make firms reluctant to move far from their current capital structure.

Yet European energy-intensive firms increased their leverage by roughly 4.5 percentage points within six to eight quarters, which is fast by these standards. Two complementary explanations help reconcile this with the standard frictions. The first is that much of the additional borrowing likely came through pre-existing revolving credit facilities rather than new debt issuance. Drawing on committed lines bypasses the most costly elements of capital structure adjustment, and the marginally significant increase in the short-term debt share is consistent with this reading, since revolving facilities typically appear as short-term debt on the balance sheet. The second is that the shock was sharp enough to force firms to move faster than they normally would. When operating cash flows fall sharply, the opportunity cost of waiting rises, and firms act on a timeline that smaller, more routine cost variations would not warrant.

These results also speak to a broader theme in the crisis literature: the role of financial slack in shaping how firms absorb adverse shocks. Ramelli and Wagner (2020) show that during COVID-19, firms with weaker balance sheets (high leverage, limited cash) fared substantially worse than their peers, suggesting that pre-existing financial strength determines resilience. The present findings approach the same mechanism from the other direction. Firms that entered the energy crisis with unused borrowing capacity put that capacity to work, accepting higher leverage as the price of smoothing operations through the shock. In this sense, debt acted as a form of insurance, paid for by drawing on the slack accumulated in better times. Whether firms without such slack – those with already-elevated leverage or constrained credit access – experienced sharper real contractions is a question this study cannot answer directly, but the pattern fits the broader finding that access to financing mitigates the real effects of adverse shocks (Duchin et al., 2010).

D. Limitations

Several features of the analysis warrant explicit acknowledgement before the findings are taken at face value. The most consequential concerns the composition of the treatment group. The SIC system groups pharmaceutical and biotechnology firms (SIC 283x) under the same two-digit code as industrial chemical manufacturers, and these firms account for a substantial share of SIC 28 observations in the Compustat sample. As discussed in the data section, their inclusion is necessary to capture the full extent of gas-dependent production within the sector and to avoid understating the energy channel through supply chain linkages. Static differences in cash holdings and leverage between pharmaceutical and industrial chemical firms are absorbed by the firm fixed effects and pose no concern for identification. What the fixed effects

cannot absorb, however, is differential time variation in balance sheet dynamics across these subgroups. Pharmaceutical and biotech firms followed an unusual cash-and-valuation cycle during 2020 and 2021, driven by post-COVID demand normalisation and shifts in R&D funding conditions, that differed from the trajectory of traditional industrial chemical firms. To the extent that this cycle continued into the post-invasion period, it could mechanically contribute to the estimated treatment effect through a channel unrelated to the energy shock. The estimated coefficients should accordingly be read as the response of the broader SIC 28 sector – pharmaceutical component included – and the magnitude of the European leverage effect may partly reflect the residual unwinding of these idiosyncratic dynamics rather than the energy channel alone.

A related concern is the parallel trends assumption that underpins the difference-in-differences design. Visual inspection of Figure 1 suggests that treated and control firms entered the sample period on a similar declining leverage path during the COVID-19 recovery, and the two series do not visibly diverge in the quarters leading up to the invasion. That said, the post-COVID normalisation did not affect all industries in the same way, and residual differences in recovery timing across sectors could contribute to the estimated treatment effect even if they are not large enough to be visible in the means.

The Compustat sample itself imposes a further limitation. Because the analysis covers only publicly listed firms, the results speak to a segment of the corporate sector that is larger, more established, and has better access to capital markets than the private firm population. If the energy shock affected private firms along different margins – for example, by tightening credit conditions for smaller firms without established banking relationships – the estimated effects would not necessarily generalise to the broader economy. Addressing this question would require survey-based or loan-level data outside the scope of the present analysis.

There is also a more granular issue around the measurement of debt itself. Compustat accounting data show that leverage rose, but they do not distinguish between new debt issuance, drawdowns on existing credit lines, and loan restructurings. The interpretation offered earlier – that firms drew on pre-arranged revolving facilities – is consistent with the speed of the adjustment and with the modest increase in the short-term debt share, but it cannot be directly verified within the available data. A more complete account of the financing channels through which the response operated would require loan-level information.

Finally, the eight-quarter post-period limits what can be said about how persistent the adjustment proved to be. The window itself reflects a deliberate methodological compromise. A symmetric span of eight quarters before and after the shock improves the comparability of pre- and post-treatment dynamics and reduces the risk that unrelated macroeconomic events confound the estimate. Extending the pre-period further back would push the comparison into 2019 and earlier, where the onset of the COVID-19 pandemic generated extraordinary disruptions to corporate balance sheets that bear no clear relation to the energy channel of interest. Extending only the post-period, on the other hand, would create an asymmetric design and bring in unrelated developments after 2023. Within the present window, the estimates capture the immediate balance sheet response to the shock. Whether the additional borrowing observed during 2022 and 2023 was later unwound as European gas prices receded toward pre-invasion levels is a question that future research with longer post-period coverage will be better placed to answer.

E. Discussion

The findings contribute to three strands of the literature. The first is the work on capital structure adjustment dynamics. Existing research, most prominently Leary and Roberts (2005), has documented that firms adjust their leverage only gradually. The present results suggest that their benchmark may understate the speed of adjustment when shocks are sufficiently large and sufficiently abrupt. Within six to eight quarters of the invasion, treated firms moved several percentage points along the leverage dimension – a magnitude and pace inconsistent with the slow, target-seeking behaviour the literature typically describes. The likely reconciliation, that much of the borrowing came through pre-arranged credit lines rather than fresh issuance, points to a margin of capital structure flexibility that is not always central to theoretical models but appears important when firms face acute pressure.

The second strand concerns the corporate finance response to geopolitical and energy shocks. Existing work on the Russia-Ukraine conflict has focused largely on equity market reactions and on aggregate macroeconomic consequences (Boubaker et al., 2022; Bounboua and Yatié, 2022). The present analysis extends this evidence to balance sheet adjustments, demonstrating that the energy channel of geopolitical risk operates not only through reduced firm valuations but also through observable changes in financing structure. The asymmetry between European and U.S. results sharpens this conclusion, since it is the regional dimension of the shock, namely the gas supply disruption concentrated in Europe, that drives the financing

response, rather than a general industry-level exposure to higher commodity prices. This gives empirical content to the notion that geopolitical shocks have differential financial consequences depending on the precise channel through which they propagate.

The third strand is the broader literature on corporate resilience to adverse shocks. Ramelli and Wagner (2020) showed that during the COVID-19 crisis, firms with stronger balance sheets proved more resilient to the shock. The present findings approach the same mechanism from the other side, by showing that firms that entered the energy crisis with available borrowing capacity used it. Debt functioned, in effect, as insurance – purchased through the borrowing capacity accumulated in better times. This complementarity matters for how one thinks about corporate balance sheets in normal periods, since the value of such capacity only becomes visible when shocks arrive.

5. Conclusion

This thesis has examined how firms adjusted their capital structure in response to the energy supply shock triggered by the Russian invasion of Ukraine in February 2022. Using a difference-in-differences design that combines cross-industry variation in energy intensity with the cross-regional contrast between Western Europe and the United States, the analysis identifies a clear and economically meaningful effect: European firms in energy-intensive sectors increased their leverage by roughly 4.5 percentage points relative to control firms in the post-invasion period, while their American counterparts exhibited a weaker and largely insignificant response. The adjustment operated almost exclusively through the debt margin. Cash holdings remained unchanged, the short-term debt share rose only modestly, and the increase in net leverage closely tracked the gross leverage effect. Read together, the estimates describe a specific corporate response to a sudden cost shock. Namely, external borrowing absorbed the bulk of the financial pressure, while liquid asset positions were preserved as a precautionary buffer.

The implications extend beyond academic interest. For corporate financial managers in energy-exposed sectors, the results underline the importance of maintaining unused borrowing capacity and committed credit facilities as a buffer against shocks that cannot be predicted. To the extent that the observed leverage adjustment was accommodated through pre-arranged credit lines, firms without comparable access would presumably have faced harder choices between investment cuts, equity issuance, or operational retrenchment. The analysis also speaks

to lenders and credit market participants. If the speed and scale of the leverage adjustment reflect drawdowns on existing credit facilities, as the patterns in the data suggest, European banks would have absorbed a substantial share of the corporate adjustment, with implications for their own balance sheets and risk exposures that warrant attention. For policymakers, the findings have a more nuanced reading. The fact that (listed) energy-intensive firms could absorb the shock through the credit channel suggests that European banking and bond markets functioned reasonably well under stress – a reassuring counterpoint to concerns about credit market disruption during the early months of the crisis. At the same time, the estimated leverage increase represents a real cost to the affected firms, who entered the post-crisis period with weaker balance sheets and higher refinancing burdens. Policy measures designed to support energy-intensive industries, including the European Commission's REPowerEU framework and various national subsidy programmes, can be understood in this context. They likely reduced the magnitude of the leverage adjustment that would otherwise have been required, even if a complete attribution would require firm-level data on subsidy receipts.

Several avenues remain open for future research. A longer post-period would distinguish between a permanent shift in capital structure and a temporary response to the acute phase of the crisis, while loan-level data could verify the conjecture that revolving credit facilities accommodated the bulk of the adjustment. Extending the analysis to private firms, which have systematically different access to credit markets, would broaden the inference beyond the publicly listed segment covered by Compustat. Greater attention to heterogeneity within the treatment effect by asking which firms adjusted most, and what predicts the size of the response is a further natural step. A particularly timely avenue concerns the recurrence of energy supply shocks of this kind. The closure of the Strait of Hormuz in early 2026 has produced a second European energy crisis with notable parallels to 2022. Whether European firms respond through the same financing channels would help identify which features of the Russian shock were particular to its setting and whether the documented response represents a generalisable feature of how energy-exposed firms manage acute cost shocks.

The Russian invasion of Ukraine was, in the first instance, a geopolitical event with consequences extending well beyond corporate finance. But it also offered a sharp empirical setting for examining how firms adjust their financing under acute and unforeseen external pressure. The evidence presented here suggests that European energy-intensive firms responded by leveraging up while preserving their liquidity – a pattern shaped by the constraints of the moment, the access to credit they had built up over time, and the basic logic of the pecking

order. As the literature on corporate finance under stress continues to develop, the response to this particular shock provides one further data point on how firms behave when the cost environment shifts beneath them faster than capital structure theory typically allows.

References

- Acharya, V. V., Almeida, H., Campello, M., 2007. Is cash negative debt? A hedging perspective on corporate financial policies. *Journal of Financial Intermediation* 16, 515–554. <https://doi.org/10.1016/j.jfi.2007.04.001>
- Almeida, H., Campello, M., Weisbach, M.S., 2004. The cash flow sensitivity of cash. *Journal of Finance*. <https://doi.org/10.1111/j.1540-6261.2004.00679.x>
- Angrist, J.D., Pischke, J.-S., 2008. *Mostly Harmless Econometrics: An Empiricist's Companion*.
- Bertrand, M., Duflo, E., Mullainathan, S., 2004. How Much Should We Trust Differences-In-Differences Estimates? *Q. J. Econ.* 119, 249–275.
- Betzer, A., Doumet, M., Rinne, U., 2013. How policy changes affect shareholder wealth: The case of the Fukushima Dai-ichi nuclear disaster. *Appl. Econ. Lett.* 20, 799–803. <https://doi.org/10.1080/13504851.2012.748172>
- Bloom, N., 2009. The Impact of Uncertainty Shocks. *Econometrica* 77, 623–685. <https://doi.org/10.3982/ecta6248>
- Boubaker, S., Goodell, J.W., Pandey, D.K., Kumari, V., 2022. Heterogeneous impacts of wars on global equity markets: Evidence from the invasion of Ukraine. *Financ. Res. Lett.* 48. <https://doi.org/10.1016/j.frl.2022.102934>
- Boungou, W., Yatié, A., 2022. The impact of the Ukraine–Russia war on world stock market returns. *Econ. Lett.* 215. <https://doi.org/10.1016/j.econlet.2022.110516>
- Breinlich, H., Leromain, E., Novy, D., Sampson, T., Usman, A., 2018. The Economic Effects of Brexit: Evidence from the Stock Market. *Fisc. Stud.* 39, 581–623. <https://doi.org/10.1111/1475-5890.12175>
- Brune, A., Hens, T., Rieger, M.O., Wang, M., 2015. The war puzzle: contradictory effects of international conflicts on stock markets. *Int. Rev. Econ.* 62, 1–21. <https://doi.org/10.1007/s12232-014-0215-7>
- Caldara, D., Iacoviello, M., 2022. Measuring Geopolitical Risk. *American Economic Review* 112, 1194–1225. <https://doi.org/10.1257/aer.20191823>

- Council of the European Union, 2025. A market mechanism to limit excessive gas price spikes - Consilium [WWW Document]. URL <https://www.consilium.europa.eu/en/infographics/a-market-mechanism-to-limit-excessive-gas-price-spikes/> (accessed 5.20.26).
- Duchin, R., Ozbas, O., Sensoy, B.A., 2010. Costly external finance, corporate investment, and the subprime mortgage credit crisis. *J. financ. econ.* 97, 418–435. <https://doi.org/10.1016/j.jfineco.2009.12.008>
- Euro News, 2022. European pharma companies may stop producing some generic drugs amid energy crisis | Euronews [WWW Document]. URL <https://www.euronews.com/health/2022/09/29/european-pharma-companies-may-stop-producing-some-generic-drugs-amid-energy-crisis> (accessed 5.24.26).
- European Central Bank, 2023. Economic Bulletin Issue 1, 2023.
- European Central Bank, 2022. April 2022 euro area bank lending survey [WWW Document]. URL <https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.pr220412~1670a54325.en.html> (accessed 5.24.26).
- European Commission, 2024. Scope of the EU ETS [WWW Document]. URL https://climate.ec.europa.eu/eu-action/carbon-markets/eu-emissions-trading-system-eu-ets/scope-eu-ets_en (accessed 5.20.26).
- Eurostat, 2023. Final energy consumption in industry - detailed statistics [WWW Document]. URL https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Final_energy_consumption_in_industry_-_detailed_statistics (accessed 5.20.26).
- Ferstl, R., Utz, S., Wimmer, M., 2012. The Effect of the Japan 2011 Disaster on Nuclear and Alternative Energy Stocks Worldwide: An Event Study.
- Francas, D., Fritsch, M., Kirchhoff, J., 2022. Resilienz pharmazeutischer Lieferketten.
- Frank, M.Z., Goyal, V.K., 2009. Capital structure decisions: Which factors are reliably important? *Financ. Manage.* 38, 1–37. <https://doi.org/10.1111/j.1755-053X.2009.01026.x>

- Hamilton, J.D., 2003. What is an oil shock? *J. Econom.* 113, 363–398.
- Hassan, T.A., Hollander, S., Van Lent, L., Tahoun, A., 2019. Firm-level political risk: Measurement and effects. *Quarterly Journal of Economics* 134, 2135–2202. <https://doi.org/10.1093/qje/qjz021>
- International Energy Agency, 2022. How Europe can cut natural gas imports from Russia significantly within a year - News - IEA [WWW Document]. URL <https://www.iea.org/news/how-europe-can-cut-natural-gas-imports-from-russia-significantly-within-a-year> (accessed 5.20.26).
- Leary, M.T., Roberts, M.R., 2005. Do firms rebalance their capital structures? *Journal of Finance* 60, 2575–2619. <https://doi.org/10.1111/j.1540-6261.2005.00811.x>
- Myers, S., Majluf, N., 1984. Corporate financing and investment decisions when firms have information that investors do not have. *J. financ. econ.* 13, 187–221.
- Opler, T., Pinkowitz, L., Stulz, R., Williamson, R., 1999. The determinants and implications of corporate cash holdings, *Journal of Financial Economics*.
- Rajan, R.G., Zingales, L., 1995. What Do We Know about Capital Structure? Some Evidence from International Data. *J. Finance* 50, 1421–1460. <https://doi.org/10.1111/j.1540-6261.1995.tb05184.x>
- Ramelli, S., Wagner, A.F., 2020. Feverish stock price reactions to COVID-19. *Review of Corporate Finance Studies* 9, 622–655. <https://doi.org/10.1093/rcfs/cfaa012>
- Ready, R.C., 2018. Oil Prices and the Stock Market*. *Rev. Financ.* 22, 155–176. <https://doi.org/10.1093/rof/rfw071>
- Schumacher, S., 2022. Energiemix der Pharmaindustrie in Deutschland. IW-Kurzbericht (Institut der Deutschen Wirtschaft).
- U.S. Energy Information Administration, 2026. International LNG prices rise amid Strait of Hormuz closure - U.S. Energy Information Administration (EIA) [WWW Document]. URL <https://www.eia.gov/todayinenergy/detail.php?id=67604> (accessed 5.20.26).

Wagner, A.F., Zeckhauser, R.J., Ziegler, A., 2018. Company stock price reactions to the 2016 election shock: Trump, taxes, and trade. *J. financ. econ.* 130, 428–451. <https://doi.org/10.1016/j.jfineco.2018.06.013>