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Working Paper

Excess profit taxes in times of crisis: The example of the inframarginal revenue cap in the EU electricity market

ZEW Discussion Papers, No. 26-012

Provided in Cooperation with:
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Suggested Citation: Nicolay, Katharina; Spix, Julia; Steinbrenner, Daniela (2026) : Excess profit taxes in times of crisis: The example of the inframarginal revenue cap in the EU electricity market, ZEW Discussion Papers, No. 26-012, ZEW - Leibniz-Zentrum für Europäische Wirtschaftsforschung, Mannheim

This Version is available at:
https://hdl.handle.net/10419/340104

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// NO.26-012 | 04/2026

DISCUSSION PAPER

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AND DANIELA STEINBRENNER

Excess Profit Taxes in Times of Crisis: The Example of the Inframarginal Revenue Cap in the EU Electricity Market

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Excess Profit Taxes in Times of Crisis: The Example of the Inframarginal Revenue Cap in the EU Electricity Market

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This version: 20 March 2026

Abstract: We conduct a data-based policy evaluation of the first large-scale, EU-wide excess profit tax, implemented during the 2022 European energy crisis to tax the windfall profits of inframarginal electricity producers. In particular, we evaluate the inherent trade-off of excess profit taxation: the benefits from generating additional tax revenues for crisis mitigation versus the costs of potential distortions to production and investment decisions. On tax revenues, our analysis indicates that the inframarginal revenue cap could cover almost one quarter of the crisis-related government support, although the distribution of tax revenues and thereby the cost coverage is highly uneven across EU Member States. On distortions, we distinguish between impact on long-run investment and short-run production decisions. While we find only a limited negative impact on profitability, which could discourage investment in the long run, we find, using a difference-in-differences design, that electricity producers slightly adapt their short-run production decisions to improve their profitability. Our conclusions help to guide policymakers in future supply shocks. Excess profit taxes only provide a beneficial cost-benefit perspective under specific conditions. Policymakers must carefully time the implementation and accurately identify excess profits. Even with a generous definition of profits, excess profit taxes can be distortionary and, hence, fail to be pure windfall taxes. While retroactive implementation could be an avenue to enhance the cost-benefit profile of excess profit taxes as a crisis measure, it may undermine the credibility and predictability of the tax framework.

JEL: H21, H23, H32, H12

Keywords: Excess profit taxes, windfall profit taxes, inframarginal revenue cap, European electricity crisis, non-distortionary taxation, real effects of taxation

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We thank Zareh Asatryan, Friedrich Heinemann, Barbara Stage, Annalisa Tassi, Johannes Voget, and Nicolas Wölfing for their insightful comments and constructive feedback. We are also grateful for the valuable discussions and suggestions from participants at the Brown Bag Seminar at the Area of Accounting and Taxation of the University of Mannheim and the 2024 ZEW Public Finance Conference. Julia Spix gratefully acknowledges funding from the Graduate School of Economic and Social Sciences of the University of Mannheim.

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1. Introduction

Recent years have witnessed a series of severe supply shocks that caused sudden scarcities with abrupt price increases for energy and other goods. The Covid-19 pandemic, with its widespread supply chain frictions, the halt of Russian gas exports to the West following 2022, and the Iran conflict of 2026 are all examples of shocks that led to sudden sharp price increases imposing a significant and highly salient burden on consumers. In times of supply-side crises marked by rapid price increases, governments face the dual challenge of financing crisis-related expenditures and alleviating the burdens borne by severely affected households and industries. At the same time, there are beneficiaries of crisis such as companies in affected sectors, realizing unexpectedly high profits due to crisis-induced price hikes. These profits may have a windfall character, as windfall profits do not arise from direct and planned actions by a firm but from unanticipated external changes in market conditions that could not have been anticipated when the initial investment decision was made. Taxing these windfall profits therefore appears attractive from both a fiscal and a distributive perspective (Avi-Yonah, 2020; Keen & Slemrod, 2021). Hence, the underlying economic rationale for an excess profit tax is that it taxes windfall profits constituting pure economic rents. Taxing rents should, in principle, raise revenue without distorting operational or marginal investment decisions (Boadway & Bruce, 1984; Devereux & Freeman, 1991).

This paper exploits the first large-scale, European Union (EU)-wide excess profit tax on electricity to analyze its suitability as a policy measure in times of crisis. In particular, we assess the extent to which this excess profit tax can be regarded as a non-distortionary windfall profit tax by analyzing the inherent trade-off of excess profit taxation: raising additional revenues for crisis mitigation while potentially distorting production and investment decisions. Our analysis relies on a rich, comprehensive dataset comprising hourly electricity generation by technology and wholesale price data for all EU Member States. The high frequency and granularity of these data enable a precise assessment of the policy's fiscal capacity and distortionary effects.

During the 2022 energy crisis, the average electricity price in the European day-ahead market soared from 96 EUR/MWh in 2021 to over 200 EUR/MWh[1], severely affecting households and energy-intensive businesses (Çam & Alvarez, 2023). Meanwhile, the production costs of inframarginal power plants, such as renewable or nuclear plants, remained negligible, resulting in substantial increases in profits within the electricity sector. In response to these developments, the EU introduced a temporary excess profit tax – the Cap on Market Revenues (hereafter referred to as the inframarginal revenue cap). Under this measure, market revenue exceeding 180 EUR/MWh generated by certain low-cost and,

[1] For an illustration of the development of day-ahead prices from 2021 to 2023, see Figure 4 in Appendix A.1.

hence, inframarginal power plants in the European electricity market were considered "windfall gains" and subjected to a 100 percent tax rate (Council Regulation (EU) 2022/1854, 2022).[2]

We estimate that total tax revenues from the inframarginal revenue cap amounted to at most EUR 47 billion (bn) across the EU, substantially below initial projections of approximately EUR 117bn. Although these tax revenues, in aggregate, cover 24.3 percent of the costs of government support measures related to the European energy crisis, they are very unevenly distributed across our sample countries. While France and Belgium collected the majority of tax revenues during the peak price period in summer 2022, the remaining EU Member States only raised EUR 16bn, covering just 8.3 percent of the costs of governmental support measures. Regarding potential distortions induced by the inframarginal revenue cap, we find no evidence that the policy negatively affects the recovery of sunk investment costs and thereby distorts future investment behavior in the electricity sector. However, we find distortions in short-run operational decisions. Our difference-in-differences (DiD) results show statistically and economically significant decreases in capacity utilization among electricity production types covered by the inframarginal revenue cap in countries that implemented a 90 percent tax rate rather than a 100 percent tax rate. By strategically withholding inframarginal capacity, electricity producers can induce the dispatch of more expensive marginal plants, thereby increasing wholesale prices and improving their profitability under the inframarginal revenue cap.

Our findings suggest that achieving a balance between generating substantial revenue without causing distortions critically depends on timing, market design, and the persistence of price shocks. For the inframarginal revenue cap, tax revenues would have covered a significantly higher share of the costs of governmental support measures related to the European energy crisis in most EU Member States if tax collection had coincided with the peak of the crisis. In the absence of such timing, fiscal outcomes fell short of expectations. Furthermore, policymakers should identify excess profits precisely and refrain from excessive taxation, where profits result from firms' own actions or investment decisions. We document no distortions in the recovery of investment costs associated with the inframarginal revenue cap due to the generously chosen price caps. In contrast, we identify distortions in electricity generation, which implies that electricity generators did not consider their gains to be pure economic rents. This could be the case as exceptionally high prices had persisted for over a year, making such gains more predictable. More generally, policymakers face a trade-off between capturing windfall revenues and maintaining a predictable and credible tax framework. While retroactive implementation could have

[2] Council Regulation (EU) 2022/1854 was in place between 01.12.2022 to 30.06.2023. Although the Council Regulation stipulates a 100 percent tax rate, most EU Member States implemented a 90 percent tax rate into domestic law, using the security of supply option offered by the directive. Also, the revenue threshold varied across EU Member States. For further information, see Table 7 in Appendix A.2.

increased revenues and mitigated strategic withholding, it may undermine the framework's credibility and predictability.[3]

Our study contributes to the literature on windfall profit taxation and rent-based tax instruments in crisis contexts. While previous contributions predominantly provide historical accounts of windfall profit taxation (Adams, 1920; Arnold, 2014; Billings & Oats, 2014; Haig, 1920; Plehn, 1920) or qualitative assessments of recent policy initiatives (Antón Antón, 2023; Diniz Magalhães & De Lillo, 2023; Ferreira & Santos, 2023), systematic empirical evidence on the fiscal performance and efficiency of modern windfall profit taxes remains scarce. We provide such an evaluation for the EU-wide inframarginal revenue cap introduced during the 2022 energy crisis. Exploiting cross-country variation and detailed hourly generation data, we estimate the revenue potential and distributional implications of the policy, relevant to assess whether it satisfies the main criteria of windfall profit taxation. A key strength of our setting lies in the transparency of the electricity market's centralized price formation, which provides a uniquely clean environment to analyze windfall taxation and derive insights that are informative for the design of future crisis-driven windfall profit taxes.

Our study further relates to the literature on behavioral responses to windfall and sector-specific excise taxes (Dugan & Zubrow, 1954; Lazzari, 2006; Rao, 2018). While recent evidence challenges the presumption that excess profit taxes are inherently non-distortionary, existing analyses primarily focus on extractive industries and medium-run production adjustments. Our analysis adds further evidence against the non-distortionary rent-taxation rationale. We find short-run operational distortions in a more recent setting and demonstrate that production responses can arise even in the very short run to policies enacted as crisis interventions. The renewed debate on windfall profit taxation during the COVID-19 pandemic (Avi-Yonah, 2020) and in the current war contexts[4] further underscores the relevance of understanding the fiscal and efficiency implications of such instruments.

Finally, our paper relates to research on taxation and production incentives in electricity markets (Freire-González & Puig-Ventosa, 2019; Leslie, 2017). Prior work studying environmental or input taxes, find that most taxes are not designed to incentivize substitution toward cleaner energy sources. Consistent with previous evidence, our findings suggest that the specific design of the inframarginal revenue cap

[3] We are aware that there are legal limitations to introduce retrospective taxes. For an example of such legal limitations, see Wissenschaftliche Dienste (2012). Nonetheless, the economic perspective on policy design is a valuable insight for future policy decisions. In the case of the inframarginal revenue cap, a retroactive introduction of the excess profit tax would have ensured the existence of windfall gains and thereby higher tax revenues. Furthermore, our profitability analysis indicates that a retroactive introduction in 2022 would not have harmed investment due to the generous revenue caps in the EU. Moreover, since retroactive taxation does not influence past production decisions, it could have mitigated the risk of capacity withholding.

[4] Taxing excess profits in the military sector are being discussed in several EU Member States: Hungary and Italy discuss defense contributions (Gyori & Komuves, 2024; Kington, 2024). Furthermore, the European Council decided that central securities depositories holding Russian sovereign assets and reserves of more than EUR 1 million will make a financial contribution from their corresponding net profits, which will be used for further military support to Ukraine (Council of the European Union, 2024). Also, in the context of the Iran conflict of 2026, excess profit taxes on fossil fuels are discussed again in Germany (Lorz, 2026).

altered relative production incentives. In particular, it appears to have encouraged increased reliance on generation technologies not subject to the cap, most notably fossil-fuel-based plants.

The remainder of this article is organized as follows: In Section 2, we briefly explain the role of taxes in times of crisis. Section 3 focuses on the functioning of the European electricity market as well as the institutional background of the inframarginal revenue cap and its national implementation in the EU Member States. In Section 4, we discuss the data employed, present our methodology and discuss estimates of tax revenues, investment effects, and distortions to short-run operational decisions. Section 5 concludes.

2. Taxes in times of crisis

The demand for public resources increases in times of crisis along with the associated fiscal burden, underscoring the necessity for stakeholders to contribute their fair share. Consequently, crises of any nature highlight the need for efficient and resilient tax systems that facilitate both public and private investments to foster economic recovery (European Parliament - Committee on Economic and Monetary Affairs, 2023). To restore long-term economic growth and productivity after a crisis, several tax policy measures are recommended. These extend beyond income-based incentives, such as reduced tax rates and exemptions, to include input-based instruments, such as accelerated depreciation, allowances, and tax credits, as well as shifts in the tax mix from direct to indirect taxation (OECD 2021). In the short term, however, temporary and sector-specific excess profit taxes have gained popularity as a policy instrument, primarily justified by the windfall-profit argument (Avi-Yonah & Shanan, 2024).[5]

Windfall profit taxes aim to capture unexpected gains that arise from extraordinary economic circumstances – such as wars, natural disasters, or pandemics – that disproportionately benefit a small number of taxpayers. The key challenge in designing a pure windfall profit tax lies in distinguishing between ordinary and excess profits (Diniz Magalhães & De Lillo, 2023). This distinction is crucial, as excessive taxation of profits that are causally linked to firm's investment decisions or risk-taking may undermine ex ante investment incentives. In practice, two main approaches are used to identify excess profits. The first defines an ordinary return, taxing only the portion of profits that exceed this threshold. The second relies on a reference period prior to the crisis, taxing profits above the average pre-crisis profits. Both approaches, however, face limitations: the definition of a "normal" return is inherently arbitrary and may create scope for strategic behavior or tax avoidance (Avi-Yonah & Shanan, 2024). Depending on the definition of excess profits, taxation can proceed either through a surtax levied on excess profits in addition to the regular corporate tax rate, or via an allowance for corporate capital that exempts a normal return and taxes only excess profits (Hebous et al., 2022; Proposal for a Council

[5] Permanent windfall profit taxes also exist, as do proposals that treat such taxes as a structural alternative to conventional corporate income taxation. For a more detailed discussion, see Avi-Yonah & Shanan (2024) or Hebous et al. (2022).

Directive on Laying down Rules on a Debt-Equity Bias Reduction Allowance and on Limiting the Deductibility of Interest for Corporate Income Tax Purposes, 2022).

According to optimal taxation theory, a tax is considered welfare-optimal if it raises revenue without distorting taxpayers' behavior. This condition is generally satisfied if the consumption of the taxed goods or activities is highly inelastic (Ramsey, 1927). In theory, since excess profits are unexpected, their taxation should neither lead to a deadweight loss nor distort agents' economic planning (Kades, 1999). As a result, windfall profit taxes can serve as an efficient means for raising revenue while maintaining economic viability for corporations and their stakeholders. However, the role of taxation extends beyond mere revenue generation. Pigou (1920) and Mirrelees (1971) emphasize its role in correcting market failures and redistributing income and wealth. To the extent that excess profits reflect economic rents arising from extraordinary economic circumstances, windfall profit taxes can be viewed as corrective tax instruments designed to curb above-normal returns attributed to monopolistic powers. Although these taxes may not directly affect consumer prices or demand, the revenue they generate can be used to mitigate adverse distributional consequences of economic crises (Avi-Yonah & Shanan, 2024).

Based on the above discussion, three key criteria emerge for evaluating excess profit taxes as policy instruments in times of crisis. First, these taxes should generate substantial revenue that can be allocated to mitigate the adverse distributional consequences of the crisis. Second, the distinction between ordinary and excess profits must be sufficiently precise to avoid excessive taxation of returns attributable to companies' investment decisions and risk-taking. Third, the tax design should minimize short-run distortions by preventing strategic behavioral adjustments aimed at circumventing the tax while still benefiting from extraordinary economic circumstances during the crisis.

3. Institutional Background

3.1. Introduction of the inframarginal revenue cap in the EU

Council Regulation (EU) 2022/1854 established a common European framework introducing two types of excess profit taxes applicable from December 2022 to 2023. The commitment to a common regulation had two main objectives. First, it was intended to avoid significant distortions between electricity generators operating in the integrated European electricity market. Second, it aimed to generate additional tax revenue that EU Member States could deploy to finance measures alleviating the burden of high energy prices on households and industry. Specifically, the Council Regulation introduced the Solidarity Contribution and the Cap on Market Revenues (i.e., the inframarginal revenue cap). The Solidarity Contribution imposed a 33 percent tax on excess profits earned by companies that derive at least 75 percent of their turnover from crude oil, natural gas, coal, and refining sectors. The

inframarginal revenue cap imposed a fixed cap on realized market revenues of inframarginal energy generators. Revenues exceeding this cap were subject to taxation.[6]

For our data-driven policy evaluation, we focus on the inframarginal revenue cap, as the transparency of the electricity market provides a uniquely clean environment to analyze excess profit taxation. This transparency is reflected in the granularity of available European electricity data (Nicolay et al., 2023) and in the turnover-based design of the inframarginal revenue cap, which is less susceptible to traditional profit-shifting strategies.

The Council Regulation provided a common implementation framework to avoid a patchwork of unilateral national regulations. According to the European Commission, the inframarginal revenue cap was to apply to generators, intermediaries, designated market participants, and electricity system operators located in a respective EU Member State using one of the technologies listed in Article 7.1 of Council Regulation 2022/1854, with an installed capacity of at least 1 MWh. Covered inframarginal technologies included solar, wind, geothermal, hydropower (without reservoirs), biomass (excluding biomethane), waste, nuclear, lignite, crude petroleum products, and peat. A revenue cap of 180 EUR/MWh was to be set on the realized market revenue of electricity generators for domestically generated electricity across all electricity markets, including the day-ahead, intraday, balancing power markets, and the grid operator's reserve market.[7] Revenues exceeding this cap should be subject to a 100 percent tax. The framework covered domestically produced electricity. All EU Member States that are part of the coupled electricity market were obliged to implement the inframarginal revenue cap from 1 December 2022 to 30 June 2023.[8] One notable exception are EU Member States, which had a comparable measure in place prior to the adoption of the Council Regulation (i.e., Finland, Hungary, Greece, Italy, Portugal, Romania and Spain).[9] These Member States were free to decide whether to introduce the inframarginal revenue cap by aligning their national legislation.

All EU Member States except Malta, Estonia, and Latvia adopted some form of an excess profit tax.[10] Among those with pre-existing measures, however, only Italy adjusted its existing regulations to comply with the Council Regulation. Despite the harmonized implementation framework, the Council Regulation granted EU Member States substantial discretion in key design elements, leading to considerable heterogeneity in the implementation.[11]

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[6] For inframarginal generators, turnover is a good proxy for current profits, as marginal costs for non-fossil fuel-fired electricity generators are typically constant and comparatively low.

[7] However, not all EU Member States included all electricity markets in their national implementation of excess profit taxes. For further information, see Lorne et al. (2024).

[8] Malta and Cyprus are explicitly excluded from the mandatory introduction of excess profit taxes, see Council of the European Union (2022).

[9] Among pre-existing excess profit taxes, those in Romania, Hungary, Spain and Portugal are most similar to the inframarginal revenue cap. For further details, see Table 6 in Appendix A.2 for further details.

[10] For a comprehensive overview, see PwC Netherlands (2022).

[11] For more details on the national implementation and the respective tax laws, see Table 7 in Appendix A.2.

Table 1: Overview of central aspects of the implementations of the inframarginal revenue cap in the EU

	Covered electricity sources												Tax rate	Method	
	Wind	Solar	Geothermal	Hydro	Biomass	Waste	Nuclear	Lignite	Fossil coal	Fossil fuels	Peat	Biogas		Technology-specific	Uniform
Austria	x	x	x	x	x	x		x	x	x	x		90%		x
Belgium	x	x	x	x	x	x	x	x		x	x		100%	x	
Bulgaria	x	x	x	x	x	x	x	x		x	x		90%	x	
Croatia	x	x	x	x	x	x	x	x			x		100%		x
Czech Republic	x	x	x	x	x	x	x	x		x	x		90%	x	
Denmark	x	x	x	x	x	x	x	x		x	x		90%		x
France	x	x	x	x	x	x	x						90%	x	
Germany	x	x	x		x	x	x	x		x	x		90%	x	
Ireland	x	x	x	x	x	x	x	x	x	x	x		100%	x	
Italy	x	x	x	x	x	x	x	x		x	x		100%		x
Lithuania	x	x		x	x	x	x	x		x	x		90%		x
Luxembourg	x	x		x	x	x						x	90%	x	
Netherlands	x	x		x	x	x	x		x			x	90%	x	
Poland	x	x		x	x			x	x				100%	x	
Slovakia	x	x	x	x	x	x	x	x		x	x		90%	x	
Slovenia	x	x	x	x	x	x	x	x		x	x		100%		x
Sweden	x	x	x	x	x	x	x	x		x	x		90%		x

Notes: The table gives an overview of the taxed electricity sources (included in national regulation if marked with an "x"), the tax rate (applicable tax rate marked with an "x"), and the design of the cap (applicable design marked with an "x") of the implemented inframarginal revenue caps following Council Regulation (EU) 2022/1854. Under technology-specific price caps different production technologies have different price caps, whereas uniform caps set one price cap for all production technologies. As most national regulations do not have an official English translation, we machine translate them into English. We are aware that this method can lead to mistranslations, but we are confident that this method provides a sufficient understanding of the policies for our study.

Overall, the set of covered energy sources are comparatively homogeneous across countries (see Table 1). Most EU Member States included the production technologies specified in the Council Regulation without further adaptation to country-specific production technologies. While the Regulation set a general tax rate of 100 percent, most countries opted for the reduced tax rate of 90 percent. Only Belgium, Croatia, Ireland, Italy, Poland, and Slovenia applied the 100 percent tax rate to capture all excess revenues. The main source of variation is the price cap chosen. EU Member States could set stricter price caps or differentiate them according to the underlying energy source (i.e. technology-specific price caps). Technology-specific caps, which were on average stricter than the proposed 180 EUR/MWh, were adopted by most of our countries in our sample. In contrast, among the seven countries that implemented a uniform price cap, only Austria and Slovakia chose a cap below 180 EUR/MWh.

Upon initial examination of the national implementation of the inframarginal revenue cap, it becomes evident that the objective of fostering a unified approach has only partially been achieved. The proposed framework, with its considerable degrees of freedom, has resulted in a patchwork of uncoordinated approaches across Europe. As a consequence, electricity generators across EU Member States experienced disparate impacts from the excess profit tax. However, this heterogeneity generates valuable variation for identifying the revenue effects and distortionary responses to the inframarginal revenue cap.

3.2. Functioning of the European electricity market

Price formation in the European electricity market is governed by a complex institutional framework comprising multiple sequential trading stages, whose essential components are described in the following. Electricity trading involves multiple markets, each tailored to different time horizons leading up to final delivery. These include forward markets, the spot market, and ancillary markets designed to balance supply and demand of electricity in real time. Among these, the day-ahead market is particularly important in price formation. It is the first market exclusively dedicated to participants who are interested in physically buying or selling electricity. As it is organized shortly before delivery and results in a single price per hour, the day-ahead market best reflects the value of electricity during different hours. For this reason, the day-ahead market is often referred to as the reference market for other (electricity) markets (Florence School of Regulation, 2020).

The day-ahead market operates through a sealed-bid multi-unit, uniform price auction, in which electricity for each hour of the following day is auctioned. Generators submit price-volume bids for each hour of the following day, while buyers submit corresponding bids indicating the quantities they are willing to purchase at various prices. The auctioneer aggregates these bids into hourly demand and supply curves, with the market clearing price determined at the intersection of these curves (Agnieszka, 2023). A key feature of this auction process is the merit-order mechanism, which dispatches available generation capacity in increasing order of bid prices. This mechanism should incentivize electricity generators to bid slightly above their marginal costs to increase the likelihood of dispatch (Green, 1999). The market clearing price is set by the price bid of the most expensive plant required to meet demand, known as the marginal plant. This price is then paid to all generators with accepted bids, irrespective of their individual costs (Wolak, 2021).

In practice, flexible but expensive natural gas-fired power plants frequently operate at the margin. Their high marginal costs, therefore, set the market clearing price for many hours of the year (Zakeri et al., 2023). The reduction in European gas supply in 2022 led to a sharp increase in wholesale gas prices, which in turn caused a significant rise in the marginal costs of gas-fired power plants. Under the merit-order mechanism, this resulted in exceptionally high market clearing prices across the European electricity market. While these elevated prices may have been necessary for the continued operation of

gas-fired plants, they simultaneously led to substantial windfall profits for lower-cost generators, so-called "inframarginal plants", whose production cost remained well below the market clearing price.

To maintain grid stability, ensure security of supply, and maximize economic efficiency and cross-zonal trading opportunities, the European electricity market is divided into multiple bidding zones. Most European bidding zones align with national borders. However, some zones span multiple countries, such as Austria, Germany, and Luxembourg, or the Single Electricity Market for the island of Ireland. Others are subnational, as seen in Italy, Norway, or Sweden. Electricity generators and buyers submit bids and offers within their respective bidding zone. National and cross-border electricity flows are efficiently coordinated for the largest part of the internal market by a "market coupling" algorithm that jointly clears interconnected day-ahead markets. In case of price differentials between neighboring bidding zones, the algorithm incorporates cross-border trade bids until either (i) both markets clear at the same price or (ii) the physical interconnector capacities between the zones are fully utilized. Consequently, while market clearing prices remain uniform within each bidding zone, they can vary across zones depending on the level of cross-border trade and interconnector capacities.

3.3. (Potential) distortionary responses to the inframarginal revenue cap

Although the design of the European electricity market ensures relatively efficient operation, residual incentives and opportunities remain under the inframarginal revenue cap to strategically behave to increase profits and to further benefit of the extraordinary economic circumstances during the crisis. One potential channel for market distortions, which may have been exacerbated by the introduction of the inframarginal revenue cap, is the strategic withholding of physical capacity from low-cost plants, driven by differences in inframarginal revenue caps between technology types.

In a competitive market, excess capacity above its short run marginal cost is expected to be sold to achieve a positive contribution margin. In the European electricity market, however, this strategy is not always profit-maximizing due to the unique price formation in bidding zones. Withholding physical capacity can be profitable if a supplier anticipates that a reduction in supply will trigger the dispatch of a more expensive power plant, thereby leading to higher market prices for all inframarginal output remaining in its portfolio. Even small price increases can significantly boost revenues when applied to a large output volume.

The introduction of the inframarginal revenue cap modifies, but does not eliminate, these incentives. Since most EU Member States applied a reduced 90 percent tax rates to excess revenues of inframarginal electricity generation types, suppliers retained a residual share, of at least 10 percent, of any price increase above the cap. To the extent that the marginal plant is not subject to the cap (e.g., gas-fired generation), strategic adjustments in the dispatch of capped versus uncapped technologies may remain privately profitable. Moreover, heterogeneity in cap levels across technologies can create relative incentives to shift generation toward assets facing less stringent constraints.

Strategic capacity withholding is documented, for example, by Joskow and Kahn (2002) in the context of the 2001 California energy crisis and by Patrick and Wolak (2001) in the UK wholesale electricity market during 1991-1995. Subsequent research emphasizes that the likelihood of capacity withholding increases with the pivotality of suppliers and diversified power plants. In particular, suppliers must hold dispatchable assets, such as hydroelectric facilities, biomass, or waste combustion, within their portfolios to exploit inframarginal resources (Bataille et al., 2019). At the same time, forward trading mitigates capacity withholding, as suppliers with forward-sold capacities do not benefit from price increases in the spot markets (Joskow & Kahn, 2002). Forward trading induces generators to bid closer to their actual costs in the day-ahead auction. This, in turn, minimizes the risk of capacity withholding (Green, 1999; Newbery, 1998; Wolak, 2021, amongst many others).

Against this background, the market environment in Europe during 2022, marked by elevated price levels, tight capacity margins, and frequent peak-load conditions, may have preserved scope for limited capacity withholding behavior, even in the presence of inframarginal revenue caps. It is important to note that the caps may not accurately capture excess profits and that they significantly constrain the market's upside potential while leaving the downside risk unchanged. Thus, generators may face altered intertemporal and intra-portfolio incentives, potentially leading to short-run distortions in generation patterns.

4. Data-based policy evaluation

4.1. Data

For our analysis, we rely on a rich and comprehensive dataset new to taxation research. We draw on data from the ENTSO-E Transparency Platform, a primary source of reliable data on the EU electricity market. ENTSO-E, the European Network of Transmission System Operators for Electricity, is responsible for the secure and coordinated operation of the European electricity system and is mandated by the EU to facilitate transparent data exchange with market participants (ENTSO-E, 2026). As a result, the data can be qualified as administrative records and has comprehensive coverage if a bidding zone and year is included in the dataset.

We use hourly data, supplemented by quarter-hourly data where necessary, for 2019, 2021, 2022, and 2023. The core variables include Actual Generation per Production Type (ENTSO-E, 2024a), Cross-Border Physical Flow (ENTSO-E, 2024b), Day-Ahead Price (ENTSO-E, 2024c), and Installed Capacity by Production Type Data (ENTSO-E, 2024d). After merging these data sources, the final dataset comprises approximately 130,000 hourly observations per year across 23 EU Member States. For bidding zones where day-ahead prices are not denominated in euros, we convert values using the annual average exchange rate published on the ECB Data Portal (European Central Bank, 2025, 2026a, 2026b).

Table 2: Descriptive statistics

Panel A: Revenue collection and investment effects

	N	mean	min	p25	p50	p75	max
2023							
Day-ahead price	68,721	95.04	-500.00	60.01	97.36	128.99	348.00
Treated electricity generated	131,400	4136.34	0.00	0.00	915.00	4,035.00	68,646.00
2022							
Day-ahead price	129,945	209.04	-222.36	97.34	192.62	286.13	2987.78
Treated electricity generated	131,400	5,649.28	0.00	742.00	2,289.00	6,003.00	181,759.00
2021							
Day-ahead price	131,361	93.33	-263.31	48.08	69.83	110.79	626.06
Treated electricity generated	131,400	5,972.42	0.00	698.00	1853.00	5,272.00	72,202.00
2019							
Day-ahead price	131,361	41.49	-500.00	34.00	40.00	48.36	365.04
Treated electricity generated	131,400	5,884.70	0.00	590.00	1,728.50	4,709.50	75,037.00

Panel B: Analysis of distortionary responses to the inframarginal revenue cap

	N	mean	min	p25	p50	p75	max
Treatment countries (AT, BG, CZ, DK, LT, NL)							
Day-ahead price	7,056	273.29	0.04	187.44	264.03	335.93	708.58
National capacity utilization	7,056	0.32	0.05	0.17	0.26	0.50	0.65
Imports aggregated	7,056	856.21	0.00	0.00	340.00	1,210.00	5,833.50
Control countries (HR, PL, SI)							
Day-ahead price	3,024	257.34	-50.10	187.44	234.86	300.33	665.01
National capacity utilization	3,024	0.32	0.08	0.18	0.31	0.44	0.77
Imports aggregated	3,024	348.62	0.00	0.00	0.00	799.00	2,050.00

Notes: The table shows descriptive statistics (number of observations, mean, minimum, 25th percentile, median, 75th percentile, maximum) for the variables employed in Sections 4.2, 4.3, and 4.4. Panel A shows the variables applied in Sections 4.2. and 4.3 split by year for 2023, 2022, 2021, and 2019. *Day-ahead price* is the day-head price in hour *t* and *Treated electricity generated* is the sum of electricity generation in MW in hour *t* subject to the inframarginal revenue cap. Panel B shows the variables applied in Section 4.4 split into the treatment (Austria, Bulgaria, the Czech Republic, Denmark, Lithuania, and the Netherlands) and control countries (Croatia, Poland, and Slovenia). *Day-ahead price* is the day-ahead price of hour *t*, *National capacity utilization* is the sum of electricity generated in MW in hour *t* subject to the inframarginal revenue cap divided by the total available production capacity in MW per hour, *Imports aggregated* are electricity imports in MW to our sample countries in hour *t*.

Table 2 presents descriptive statistics for the main variables used in the analysis. Panel A reports descriptive statistics for the revenue collection estimates (Section 4.2) and the analysis of investment effects (Section 4.3). The data show a pronounced increase in wholesale electricity prices between 2019 and 2022, with prices peaking in 2022, while aggregate electricity generation remains comparatively stable over the same period. Panel B provides descriptive statistics for the analysis of distortionary responses to the inframarginal revenue cap (Section 4.4). The treatment and control groups are highly comparable in terms of day-ahead prices. Aggregated imports are zero in most hours for both groups, though occasional spikes reflect periods of intensive cross-border trade. There is also preliminary evidence of slightly lower capacity utilization among generation technologies subject to the inframarginal revenue cap in treated countries compared to control countries.

4.2. Tax revenue estimates

The first evaluation criterion for excess profit taxes as policy instruments in times of crisis is their capacity to generate revenue that can be used to mitigate the adverse effects of the crisis. A key objective of Council Regulation 2022/1854 was to generate substantial tax revenues to fund government support initiatives aimed at mitigating the impact of high energy costs on households and industry. In September 2022, the European Commission projected annual tax revenues of up to EUR 117bn from the policy (European Commission, 2022). Official estimates of these tax revenues are limited. To the best of our knowledge, official figures are available only for Bulgaria (EUR 163 million in December 2022) and Lithuania (EUR 10 million by 9 March 2023) (European Commission, 2023). We therefore estimate ex post tax revenues using production quantity and day-ahead price data for all electricity production types in our dataset that were subject to the excess profit tax within each sample country and period when the policy was actively implemented.

Given our focus on evaluating the newly implemented EU regulation, we incorporate only countries without prior corresponding regulation. We further exclude countries that introduced market-value-based revenue caps.[12] The monthly tax revenue in country *c* for production-type *i* and hour *t* is computed as:

$$Tax\ Revenue_{c,\,I,M} = \sum_{i=1}^{I}\sum_{t=1}^{M} \max\left(Day\ Ahead\ Price_{c,t} - Cap_{c,i}\,, 0\right) * \ MW_{c,i,t} * Tax\ Rate_{c} \qquad (1)$$

If the day-ahead price of a given country and hour exceeds the production-type-specific caps ($Cap_{c,i}$), we multiply the excess amount by the electricity generated (in MW) for the production type in that particular hour and by the tax rate.[13] The total monthly tax revenues per country *c* are aggregated across all production types *I* and hours within each month *M*.

Table 3, Panel A presents our monthly tax revenue estimates for the inframarginal revenue caps implemented in the EU sample countries. Except for France and Belgium, which generated average monthly revenues of EUR 3.3bn and EUR 0.4bn, respectively, monthly tax revenues in other EU Member States are modest, averaging EUR 51 million. The significantly higher tax revenues in France and Belgium can be attributed to two factors. First, both countries implemented the inframarginal revenue cap retroactively (France from 1 July 2022, Belgium from 1 August 2022), thereby capturing

[12] A market-value-based revenue cap has no cap fixed at a specific value but determines the cap based on a formular including the current market price. This is the case in Germany, Lithuania and partly in Poland. Excluding countries with such a market-value-based revenue cap and no prior corresponding regulation, the resulting sample countries are Austria, Belgium, Croatia, Czech Republic, Denmark, France, Ireland, Netherlands, Slovakia, Slovenia, and Sweden.

[13] Note that the inframarginal revenue cap was collected from the price effectively paid for the MWh of electricity. This means that if a lower price than the day-ahead price resulted from a forward contract, this lower price was considered for calculating the tax burden. Therefore, our estimates represent rather an upper bound of the tax revenues collected from the inframarginal revenue cap.

excess revenues during the peak price period in summer 2022. Second, France adopted one of the strictest caps in the EU, which remained binding even after wholesale prices declined sharply in the last week of December 2022 and remained low in 2023.[14]

Our estimates in Table 3 suggest that the tax revenues from the excess profit tax most likely did not result in substantial funds in most countries to finance measures aimed at keeping electricity affordable for households and energy-intensive businesses. Our estimate of the total tax revenues from the inframarginal revenue cap of roughly EUR 47bn is much lower than the EUR 117bn projected by the EU. However, as prices declined significantly after January 2023, the lower amount of tax revenues collected may not be an issue during our observation period, as the reduction in electricity prices simultaneously reduced the need for support measures. But since our sample countries had already implemented measures to mitigate the European electricity crisis between September 2021 and January 2023, the total government expenditures to be covered by the policy are estimated at EUR 192.5bn (Sgaravatti et al., 2023). If we compare this estimated amount of EUR 192.5bn with our total tax revenues, the inframarginal revenue cap could cover almost a quarter of the cost associated with initial government support. Nevertheless, this finding is misleading, as the bulk of estimated revenue stems from the retroactive introduction of inframarginal revenue caps in France and Belgium. Considering only tax revenues from December 2022 to June 2023 yields EUR 16bn, which covers only 8.3 percent of government support expenditures.

To assess the importance of timing in excess profit taxation, Table 3, Panel B presents counterfactual revenue estimates for a hypothetical implementation from May 2022 to November 2022 across all sample countries. Under this scenario, aggregate tax revenues amount to roughly EUR 55bn, compared to EUR 16bn during the actual implementation period. France would still collect the highest tax revenues, averaging EUR 3.4bn per month, but other EU Member States would also have been able to collect substantially higher tax revenues. In this hypothetical scenario, tax revenues would cover up to 28.4 percent of total government support expenditures.[15] The higher tax revenues and the more equal distribution across countries underline the advantage of retroactive tax collection, although even in this scenario tax revenues remain well below the initially announced EUR 117bn.

[14] For an illustration of the development of day-ahead prices in 2022 and 2023, see Figure 4.

[15] The estimated EUR 16bn are less than our initial estimate of EUR 47bn for the actual implementation period, including the French and Belgium retroactive introduction of the inframarginal revenue cap. It should be noted that those figures are not directly comparable as they consider different time periods for tax collections.

Table 3: Total monthly tax revenues of the inframarginal revenue cap by country in the actual and a hypothetical earlier implementation period

Panel A: Estimated monthly tax revenues of the inframarginal revenue cap (in million EUR) in the actual implementation period															
	May 2022	**Jun 2022**	**Jul 2022**	**Aug 2022**	**Sep 2022**	**Oct 2022**	**Nov 2022**	**Dec 2022**	**Jan 2023**	**Feb 2023**	**Mar 2023**	**Apr 2023**	**May 2023**	**Jun 2023**	**Share of government funding (Sep 2021 - Jan 2023) covered by tax revenues**
AT	-	-	0	0	0	0	0	397	70	42	12	7	1	5	2.5%
BE	-	-	0	1,589	1,079	182	317	682	119	71	28	13	1	5	43.5%
CZ	-	-	0	0	0	0	0	877	191	159	102	76	44	65	16.5%
DK	-	-	0	0	0	0	0	177	4	2	0	0	0	0	10.7%
FR	-	-	7,232	8,753	6,633	2,113	2,789	6,236	1,865	1,822	898	613	152	301	42.8%
HR	-	-	0	0	0	0	0	64	3	1	0	0	0	0	3.8%
IE	-	-	0	0	0	0	0	0	2	10	13	0	0	0	0.5%
NL	-	-	0	0	0	0	0	393	36	20	8	3	0	2	1.2%
SE	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
SI	-	-	0	0	0	0	0	143	7	3	0	0	0	0	7.3%
SK	-	-	0	0	0	0	0	236	36	20	4	2	1	1	8.1%
Total	**-**	**-**	**7,232**	**10,342**	**7,712**	**2,295**	**3,106**	**9,205**	**2,333**	**2,149**	**1,067**	**716**	**199**	**380**	**24.3%**

Panel B: Estimated monthly tax revenues of the inframarginal revenue cap (in million EUR) in a hypothetical earlier implementation period															
	May 2022	**Jun 2022**	**Jul 2022**	**Aug 2022**	**Sep 2022**	**Oct 2022**	**Nov 2022**	**Dec 2022**	**Jan 2023**	**Feb 2023**	**Mar 2023**	**Apr 2023**	**May 2023**	**Jun 2023**	**Share of government funding (Sep 2021 - Jan 2023) covered by tax revenues**
AT	200	339	690	1,002	728	163	198	-	-	-	-	-	-	-	15.6%
BE	290	418	861	1,589	1,079	182	317	-	-	-	-	-	-	-	50.4%
CZ	284	464	917	1,592	1,155	283	444	-	-	-	-	-	-	-	55.9%
DK	27	54	151	316	289	28	48	-	-	-	-	-	-	-	53.7%
FR	2,731	3,853	7,232	8,753	6,633	2,113	2,789	-	-	-	-	-	-	-	37.0%
HR	11	22	68	108	76	17	30	-	-	-	-	-	-	-	18.4%
IE	1	2	0	0	0	1	0	-	-	-	-	-	-	-	0.1%
NL	87	174	447	809	601	85	140	-	-	-	-	-	-	-	6.0%
SE	28	76	43	468	324	19	129	-	-	-	-	-	-	-	16.0%
SI	42	86	213	327	231	34	50	-	-	-	-	-	-	-	46.7%
SK	84	132	362	571	344	96	128	-	-	-	-	-	-	-	46.4%
Total	**3,785**	**5,620**	**10,984**	**15,534**	**11,461**	**3,020**	**4,272**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**28.4%**

Notes: The table shows a comparison between the estimated monthly tax revenues (in million EUR) generated by the inframarginal revenue cap as implemented in national law in the actual implementation period (Panel A) and a hypothetical implementation period from 01.05.2022 to 30.11.2022 (Panel B). All numbers are rounded to full million EUR. The share of government funding covered by tax revenues is calculated by dividing the total tax revenues by the aggregated government funding to shield households and firms from the energy crisis between September 2021 and January 2023 by the respective country. The aggregated government funding is taken from Sgaravatti et al. (2023).

Our findings underline that even in a textbook case of excess profits such as a sudden increase in commodity prices due to scarcity (Diniz Magalhães & De Lillo, 2023), a temporary and sector-specific excess profit tax could fail to generate substantial revenue. This shortfall reflects the common pitfall of imposing excess profit taxes only after windfall profits have largely disappeared (Hebous et al., 2022). This is problematic, as the tax still imposes administrative costs without effectively addressing the crisis-induced negative externalities. In the present context, a retroactive implementation would have substantially increased revenue and improved alignment between the tax base and the period of extraordinary rents.

4.3. Impact on firms' potential to recover investment costs

The second evaluation criterion, the absence of distortions to investment decisions, emphasizes the importance of clearly distinguishing between ordinary returns, which are necessary to cover investment and operating costs, and excess profits, which arise from temporary market conditions. If excess profit taxes reduce a taxpayer's profitability by cutting into ordinary profits, it may distort future investment behavior (Chitiga et al., 2012; Grubel & Sydneysmith, 1975). Assessing the inframarginal revenue cap's impact on the profitability of European electricity generators therefore provides a direct test of whether the policy successfully targeted excess profits rather than ordinary returns.

We estimate the short-run profitability of electricity producers under the inframarginal revenue cap and its implications for their ability to recover investment costs. Due to the policy's recent introduction, we do not attempt to analyze potential distortions of future investment behavior. Electricity sector investments tend to be large scale investments, which are planned and executed over years. Observed investment during our sample period is therefore unlikely to incorporate expectations about the inframarginal revenue cap. A full assessment of long-term effects is left for future research.

We employ the concept of Levelized Cost of Energy (LCOE) to assess a firm's profitability and ability to recover its investment cost under the inframarginal revenue cap.[19] The LCOE represents the lifetime cost of a power plant per MWh of electricity. It indicates the average revenue per MWh that a power plant must earn to cover the net present value of its variable costs and initial investment (Millstein et al., 2021). Therefore, the LCOE serves as a proxy for the investment's break-even point (Jansen et al., 2020). If the day-ahead market price net of the LCOE is consistently below this threshold, future

[19] For the methodology applied to calculate the LCOE, see Table 9 in Appendix A.3. We calculate the LCOE for different types of power plants (geothermal, nuclear, hydro, solar, offshore wind, onshore wind) on a country- and year-basis. If data are not available for a particular sample country, we follow IRENA (2023) and take the average LCOE of available EU Member States. We use a variety of sources for the input parameters of our calculation. First, we take the basic assumptions on the lifetime of power plants from IEA et al. (2020) and the interest rate from IRENA (2023). Second, the country-specific technical information on the power plants, namely their system price, fixed annual operating costs, variable annual operating costs, efficiency loss factor and capacity factor are retrieved from IEA et al. (2020), IRENA (2023), and European Commission & Joint Research Centre (2023). Third, all input parameters for the country- and year-specific tax factor are obtained from the IBFD Tax Research Platform (IBFD, 2026).

investment in comparable projects may be constrained. As our study only covers a short time frame compared to the lifetime of a power plant, assessments of the profitability of a plant rely on the assumption that future costs and revenues are highly comparable to those observed in the present.[20] Still, our analysis provides insights of the impact of the inframarginal revenue cap on the firms' profitability and potential to recover investment cost at least in the short-run.

We combine electricity market data from the ENTSO-E Transparency Platform with our tax revenue estimates (Section 4.2) and our LCOE estimates. We restrict the dataset to the production types subject to the inframarginal revenue cap for which we can estimate LCOE – namely, geothermal, nuclear, hydro, solar, offshore wind, and onshore wind. Furthermore, we focus on the same countries as for the revenue estimation.[21] Hourly, production-type-specific profits for a given country in 2019, 2021, 2022, and 2023 are computed as:

$$
\begin{aligned}
(After - Tax)\ Profit_{c,\,i,h,y} \\
&= \left[\left(Day\ Ahead\ Price_{c,h} - LCOE_{c,i,y}\right)\right. \\
&\left. -\ \max\left(Day\ Ahead\ Price_{c,h} - Cap_{c,i}, 0\right) * Tax\ Rate_{c}\right] *\ MW_{c,i,h}
\end{aligned}
\tag{4}
$$

where *c* denotes country, *i* production type, *h* hour, and *y* year. We first deduct the LCOE for electricity production type *i* in country *c* and year *y* from the day-ahead price in country *c* and hour *h* to obtain the residual profit per MWh. We remove all hours where the electricity plants are not activated. The residual profit per MWh is then multiplied by the electricity generated from electricity production type *i* in country *c* and hour *h*. Finally, we deduct the tax burden under the inframarginal revenue cap for electricity production type *i* in country *c,* and hour *h* for the time horizon, where the revenue cap is applicable.[22] Descriptive statistics for our analysis are presented in Table 10 in Appendix A.3 and indicate increasing profitability over the years, driven initially by the recovery from the COVID-19 pandemic and subsequently by the European electricity crisis, followed by a cut in profitability induced by the inframarginal revenue cap.

To assess how changes in profitability affect electricity generators' ability to recover investments cost following the introduction of the inframarginal revenue cap, we conduct t-tests comparing profits in the first six months of 2019, 2021, and 2023. We select these specific years as they allow us to compare a non-crisis setting in 2019, an already increased price setting without any revenue caps in 2021, and a crisis setting with the inframarginal revenue cap in place in 2023. Applying a t-test is a feasible empirical approach in our setting because prices are set in independent auctions, so by definition all of our hourly

[20] Glenk & Reichelstein (2022) note that "stationary" environments are a common assumption in the literature, even though considering non-stationary environments leads to more reliable results. For our purposes, the proxy for profitability derived from a stationary setting is sufficient.

[21] The resulting sample countries are Austria, Belgium, Croatia, the Czech Republic, Denmark, France, Ireland, Netherlands, Slovakia, Slovenia, and Sweden.

[22] The calculation of the tax burden equals the calculation presented in Equation (1) in Section 4.2.

profit estimates are independent of each other. We estimate the t-test with the following specification, with standard errors clustered at the country-level:

$$(After\ Tax)\ Profit_{c,\,i,h,y} = \alpha + \beta_1 * 2021_y + \beta_2 * 2023_y + \epsilon_{c,\,i,h,y} \quad (5)$$

where $Profit_{c,\,i,h,y}$ is our profit estimate calculated as shown in Equation (4). 2021_t and 2023_t are dummy variables, which are one for the years 2021 or 2023, respectively. Accordingly, α depicts the estimates for 2019.

Table 4: T-test comparing the day-ahead prices, profits and after-tax profits based on LCOE from January to June 2019, 2021, 2022, and 2023

	Actual implementation in 2023			Hypothetical implementation in 2022
	(1) Day-Ahead Price	(2) Profit	(3) After-Tax Profit	(4) After-Tax Profit
2019	42.51***	4174.1	4174.1	4174.1
	(33.13)	(0.31)	(0.31)	(0.31)
2021	12.44***	81635.6	81635.6	81635.6
	(3.68)	(1.34)	(1.34)	(1.34)
2022	126.2***			92321.7**
	(4.68)			(2.62)
2023	54.11***	357587.1	243395.9	
	(5.19)	(1.47)	(1.61)	
N	194307	192816	192816	193605

Notes: The table shows the results of a t-test comparing the hourly profits generated from electricity sales in million EUR split by country in the first six months of the years 2019, 2021, 2022, and 2023. The hourly profits for 2019 and 2021 are calculated by deducting country-, production type- and year-specific LCOE from the day-ahead price of a given country and hour to obtain the profit per MWh, which is then multiplied by the electricity generated for the production type in the given country and hour. The after-tax profits for 2022 and 2023 are calculated following Equation (5). We aggregate the profits over all production types in a given country and hour to generate the hourly profits. The data is clustered on the country-level. The t-statistics are shown in parenthesis below the estimates, and the asterisks indicate the following levels of significance: * p<0.10, ** p<0.05, *** p<0.01.

Table 4 shows the results of the t-test. Column (1) confirms the steady price increase in 2021 and 2023 relative to 2019. Column (2) and Column (3) show that both estimates for pre-tax profit and after-tax profit for 2021 and 2023 are not significantly different from those for 2019. The coefficients indicate that the profits have increased over the years, but the effect is not statistically significant. Despite the reduction in after-tax profits in 2023 due to the excess profit tax, we find no evidence of significant losses. Our results suggest that the inframarginal revenue cap did not materially impair the ability to recover investment costs in the short run. Furthermore, Figure 5 in Appendix A.3 confirms that the 2023 coefficients are not driven by a single, especially profitable electricity production type. Coefficients are positive but statistically insignificant across all electricity production types. Moreover, we repeat the t-test in an earlier setting, comparing the first six months of 2019, 2021, and 2022. The after-tax profits in 2022 in Table 4, Column (4) are significantly higher than the profits in 2019. This robustness test underlines that even in a setting where the inframarginal revenue cap would have had a strong binding

effect due to very high prices, there is no evidence of negative profitability and no indication of diminished capacity to recover investments.

Under the inframarginal revenue cap, we find evidence of reduced profitability but no indication that electricity generators' ability to recover their investment costs was compromised. This conclusion would also hold under a retroactive implementation in 2022, when the cap would have been binding due to high day-ahead prices. Our findings suggest that the inframarginal revenue caps applied in EU Member States were indeed set at a level that preserved profits, where a causality between the actions of the recipient and the acquired benefit exists.[23] While this does not preclude attempts to circumvent the tax, it underscores the importance of considering the impact of excess profit taxes on profitability and investment recovery. Ensuring that excess profit taxes do not deter future investments is a key aspect of effective windfall tax design in times of crisis. However, the calibration of an excess profit tax reflects a fundamental trade-off, as tighter caps raise revenues at the cost of greater distortions, while looser caps mitigate distortions but limit revenue generation.

4.4. Distortionary responses to the inframarginal revenue cap

Our third evaluation criterion assesses whether the inframarginal revenue cap induced distortions in the short-run operational decisions of taxpayers. In particular, we examine whether electricity producers engaged in strategic behavior to capitalize on the extraordinary economic conditions during the crisis. Specifically, we investigate whether companies withheld capacity from inframarginal electricity generation types subject to the inframarginal revenue cap to maximize overall revenues and, consequently, enhance their profitability.

For identification, we exploit cross-country heterogeneity in the applicable excess profit tax rate, which ranged from 90 percent to 100 percent. As outlined in Section 3, a 90 percent tax rate preserves the incentive to withhold capacity. We therefore compare countries adopting a 90 percent rate (Austria, Bulgaria, the Czech Republic, Denmark, Lithuania, and the Netherlands) to those implementing a 100 percent rate (Croatia, Poland, and Slovenia). All countries in the estimation sample introduced the cap on 1 December 2022, ensuring common policy timing.[24]

The analysis focuses on the period from November to December 2022. Previous analysis indicates that prices fell significantly in the final week of December 2022 and remained at lower levels in 2023. Consequently, the inframarginal revenue cap only had a strong binding effect in the first three weeks of December 2022, which makes November to December 2022 the most suitable observation period (see

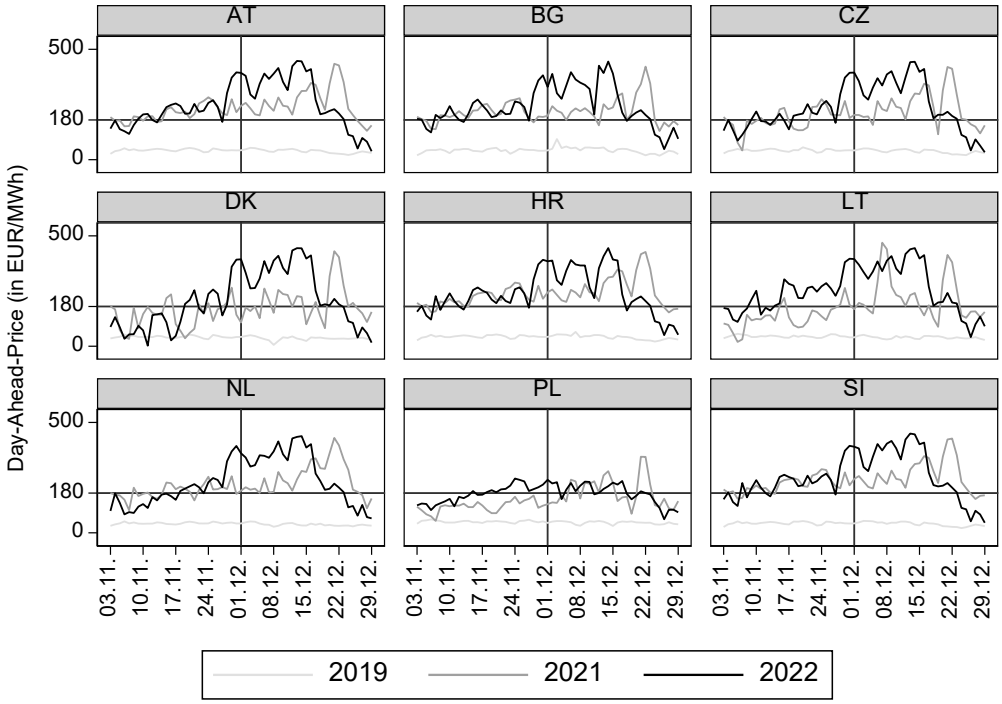
[23] Note that our analysis only looks at six months of the lifetime of a power plant. We cannot predict any future developments in the electricity market and our statements on the ability to recover investments are based on the assumption that the day-ahead prices will be at least comparable to those in 2019.

[24] See Figure 6 in Appendix A.4 for an overview of elimination process, which led to our subsample of EU Member States.

Figure 1). Restricting attention to this narrow window enhances internal validity by concentrating on the period in which behavioral responses were most likely.

The setting satisfies all key assumptions for a DiD design. Anticipation effects are unlikely, as electricity generators had no incentive to alter bidding behavior in daily auctions prior to 1 December 2022, despite the policy announcement in October 2022. The Stable Unit Treatment Value Assumption (SUTVA), specifically the absence of cross-country spillovers, also appears plausible in our context. Capacity utilization in a given country should depend only on its own treatment status. Cross-border electricity imports are small relative to total domestic generation in most hours, limiting potential spillovers. In addition, we observe no evidence of competition for scarce production inputs across borders that could transmit treatment effects across countries (i.e. higher demand in treated countries that cuts the supply in control countries).

Figure 1: Average daily day-ahead prices by country in November and December 2019, 2021, and 2022



Notes: The graphs show the development in average daily day-ahead prices in EUR/MWh by country from 03.11. to 29.12. in 2019 (light grey line), in 2021 (grey line), and in 2022 (black line). The horizontal line marks the benchmark price cap of 180 EUR/MWh as outlined in Council Regulation (EU) 2022/1854 and the vertical line marks the introduction of the inframarginal revenue cap on 01.12.2022.

Moreover, we expect that, in the absence of treatment, electricity markets in treatment and control countries would have evolved similarly, implying that tax rates were not selected based on pre-existing differences in electricity market conditions. Several factors support this assumption. First, the harmonization of the European electricity market, which regulates not only the sale of electricity but also the associated taxes, ensures a level playing field for comparison (Bonn & Reichert, 2019; Council Directive 2003/96/EC, 2003). Second, treatment and control countries exhibit similar electricity

production capacities, averaging approximately 15,000–17,000 MW per hour in 2022, a parity essential for meaningful comparison of market dynamics.[25] Third, both groups experienced a consistent pattern of rising gas prices for non-household consumers, day-ahead prices and non-household electricity consumer prices.[26] Fourth, we observe no relevant confounding policy or supply shocks in our sample countries during the sample period.[27]

Although our setting allows for identification, it also comes with limitations. Our sample countries are not in close geographic proximity, which may reflect that variations in electricity and gas demand could be driven by climate differences, especially for heating purposes in more northern countries. To address this concern, we first compare the average heating degree days in the treatment and control group finding that both groups are on average comparable.[28] Second, we include weather control variables, mitigating the potential impact of climate variations on our results while preserving comparability.[29] Furthermore, in interpreting our results, we emphasize the need to be cautious about their external validity due to the specific setting. Similarly, causal inference should be approached with caution, as it is impossible to control for all confounding factors that may affect electricity production. Nevertheless, our results are undoubtedly very robust and show a clear disruption of the electricity market following the introduction of the inframarginal revenue cap. It can be expected that if market distortions occur in our subsample, they are likely to have occurred in other EU Member States as well.

We measure the impact of the inframarginal revenue cap on hourly capacity utilization of electricity production types subject to the revenue cap using the following DiD specification:

$$Y_{c,d,h} = \alpha_c + \gamma_d + \delta_h + \beta * D_{c,d,h} + \omega * X_{c,d,h} + \epsilon_{c,d,h} \quad (3)$$

where $Y_{c,d,h}$ denotes hourly capacity utilization of all production types subject to the inframarginal revenue cap in country c, day d and hour h. Capacity utilization is measured as realized output (in MW) divided by available installed capacity (in MW) for the covered technologies. Country fixed effect α_c

[25] See Figure 7 Panel B in Appendix A.4 for an overview of the average hourly production capacity and production for the treatment and control group in 2019, 2021, 2022, and 2023.

[26] See Figure 7 Panel A in Appendix A.4 for an overview of the development of average gas prices, day-ahead prices and consumer prices on a semi-annual basis from 2021 to 2023 for the treatment and control group.

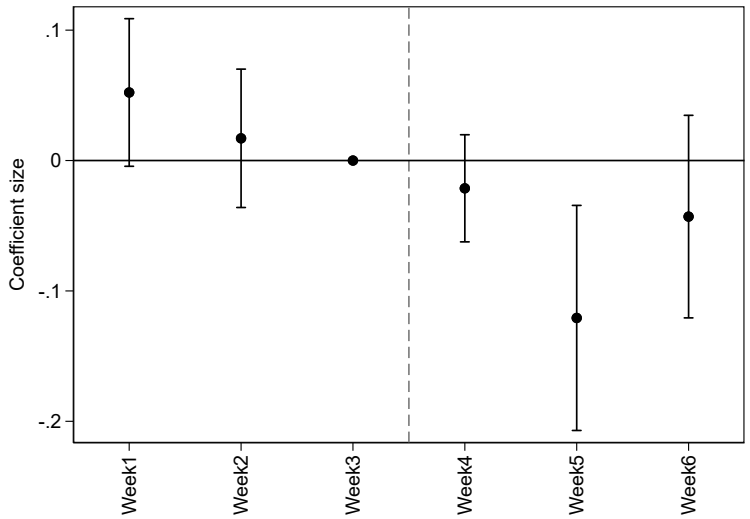
[27] We observe two shocks in Bulgaria and in Lithuania that are not directly related to our setting but could have an influence. First, a Nuclear Power Plant in Bulgaria was shut down due to safety concerns in December 2022 (Kokalova-Gray, 2022). Second, the strengthening of the Lithuania-Latvia gas interconnection was completed in December 2022 (European Commission - Directorate-General for Economic and Financial Affairs, 2023). However, in the robustness tests shown in Figure 10 and Table 11 in Appendix A.4 excluding both countries from the sample the results still hold, underlining that these events do not drive our findings.

[28] See Figure 7 Panel C in Appendix A.4 for an overview of the development of average heating degree days for the treatment and control group from September to December 2022. The Heating degree day (HDD) index is a weather-based technical index designed to describe the need for the heating energy requirements of buildings, whereby higher numbers indicate a higher need for heating.

[29] Due to the high frequency of our electricity market data, we also need high frequency weather data. As this data is not available for all sample countries, we are only able to control for weather effects in a subsample containing data from Austria, Denmark and the Netherlands in the treatment group and Croatia, Poland, and Slovenia in the control group.

absorb time-invariant heterogeneity across bidding zones (e.g. installed capacity), while day (γ_d) and hour fixed effects (δ_h) control for aggregate shocks common to all bidding zones and intraday demand and production fluctuations. $D_{c,d,h}$ is the interaction of *treated country x post-period*. The treatment dummy equals 1 for Austria, Bulgaria, the Czech Republic, Denmark, Lithuania, and the Netherlands and 0 for Croatia, Poland, and Slovenia, while the post-period dummy takes on a value of 1 for the post-period, covering the first three weeks after the implementation (01.12.2022 - 21.12.2022) and 0 for the pre-period (10.11.2022 - 30.11.2022). The coefficient of interest, β, captures the differential change in utilization in countries subject to a 90 percent tax rate relative to 100 percent following policy implementation. The vector of controls $X_{c,d,h}$ includes electricity market control variables such as the day-ahead price in hour *h* in country *c* (*Day-Ahead Price*$_{c,h}$) and the sum of MWhs imported in hour *h* to country *c* (*Total Electricity Imports*$_{c,h}$). Day-ahead prices proxy for current price levels (i.e. the inframarginal rents), while the sum of electricity imports captures substitution possibilities between domestic electricity generation and cross-border supply. Standard errors are clustered at the bidding zone level to account for within-bidding-zone correlation over time.

Figure 2: Event study plot for the analysis of changes in domestic electricity generation



Notes: The figure plots the results of our baseline regression in an event study design. We estimate the specification $Y_{c,d,h} = \alpha_c + \gamma_d + \delta_h + \sum_{j=-3; j\neq-1}^{K=4} \beta_j * D_{c,d,h} + \omega * x_{c,d,h} + \epsilon_{c,,d,h}$. The event study DiD design compares the capacity utilization of all production types subject to inframarginal revenue cap of in Croatia, Poland, and Slovenia (control group) with those in Austria, Bulgaria, the Czech Republic, Denmark, Lithuania, and the Netherlands (treatment group) before and after the introduction of the inframarginal revenue cap on 01.12.2022. The data points are the estimates for β_j. The vector $x_{c,j,d,h}$ includes the day-ahead price in hour *h* in country *c* (*Day-Ahead Price*$_{c,h}$) and the sum of MWhs imported in hour h to country c (*Total Electricity Imports*$_{c,h}$) as electricity market controls. We employ bidding-zone- and day-fixed-effects as well as standard errors clustered by the bidding zone. The confidence bands show the 95% confidence interval.

Subsequently we present the results of our regression analysis. First, we provide support for the identifying assumption of parallel trends of the treatment and control group in absence of treatment. In Figure 2, we plot the results obtained from the event study version of Equation (3) with 95 percent confidence intervals. Consistent with this assumption, we find that the capacity utilization of power

sources subject to a tax rate of 90 percent under the inframarginal revenue cap evolved in parallel to the capacity utilization of power sources subject to a tax rate of 100 percent before the introduction of the policy. We further verify that there is no indication of anticipation effects in Figure 8 in Appendix A.4. In the post-period, the coefficients are in line with our expectation of a decrease in domestic electricity production among production types only taxed by the inframarginal revenue cap at 90 percent instead of 100 percent. The strongest negative coefficients arise in week 2, which is in line with the development of the day-ahead price, which also reached its peak in the second week of December for all sample countries (see Figure 1). Finally, to ensure that we do not measure a general development in electricity generation occurring annually, we conduct a placebo test. The event study plot in Figure 9 in Appendix A.4 shows the result of the event study version of Equation (3) with 95 percent confidence intervals employing data from 2021. We do not observe significant effects comparable to those of 2022, which rules out the possibility that our findings are the result of a general trend.

Table 5: Difference-in-differences results of changes in domestic electricity generation

Full Sample (AT, BG, HR, CZ, DK, LT, NL, PL, SI)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$D_{c,d,h}$	-0.0832**	-0.0832***	-0.0801**	-0.0847***	-0.0628**	-0.0628***	-0.0628**	-0.0628**
	(-2.91)	(-23.00)	(-2.84)	(-3.38)	(-2.30)	(-16.72)	(-2.30)	(-2.30)
Day-Ahead $Price_{c,h}$	0.00005	0.00005***	-0.00003	0.00008				
	(0.37)	(4.52)	(-0.21)	(0.94)				
Total Electricity $Imports_{c,h}$	-0.00006**	-0.00006***	-0.00007**	-0.00006*				
	(-3.21)	(-33.88)	(-2.78)	(-2.18)				
N	10,080	10,080	10,080	10,080	10,080	10,080	10,080	10,080
R-sq	0.751	0.751	0.722	0.264	0.721	0.721	0.691	0.101
Binding-Zone FE	X	X	X		X	X	X	
Date FE	X	X		X	X	X		X
SE Clustered	X		X	X	X		X	X

Notes: The table shows the results of our baseline regression using the specification in Equation (3). The DiD analysis compares the capacity utilization of either production type in the control group (Croatia, Poland, and Slovenia) with those in the treatment group (Austria, Bulgaria, the Czech Republic, Denmark, Lithuania, and the Netherlands) before and after the introduction of the inframarginal revenue cap on 01.12.2022. We employ electricity market controls (*Day-Ahead* $Price_{c,h}$ and *Total Electricity* $Imports_{c,h}$ in columns (1) – (4). We employ bidding-zone-fixed-effects (besides in columns (4) and (8)) and day-fixed-effects (besides in columns (3) and (7)) as well as standard errors clustered by the bidding zone (besides in columns (2) and (6)). The t-statistics are shown in parenthesis below the estimates, and the asterisks indicate the following levels of significance: * p<0.10, ** p<0.05, *** p<0.01

Our main results employing Equation (3) are presented in Table 5. The point estimate of the interaction coefficient is negative and statistically significant independent of the inclusion of control variables, fixed effects, or clustering of the standard errors. Controlling for the day-ahead price mostly does not have a significant impact on our results, whereas electricity imports have a slightly negative impact. To put the magnitude of the baseline effect into perspective, an 8 pp decrease in the hourly capacity utilization of

electricity production types subject to a 90 percent tax rate under the inframarginal revenue cap corresponds to roughly between 3,700 MW in the Netherlands and 290 MW in Lithuania.

The following robustness tests serve to reinforce the conclusion that our findings are attributable to the capacity withholding observed in the electricity auctions. First, we repeat the previous analysis but additionally employ weather control variables. Specifically, we include the average temperature in °C on day d in country c ($Temperature_{c,d}$), the average wind speed in w/s on day d in country c ($Windspeed_{c,d}$), and the average global Radiation in W/m^2 ($GlobalRadiation_{c,d}$), which we obtain from the European Climate Assessment & Dataset (van der Schrier et al., 2024). All weather controls present a country-specific influence on different renewable electricity production types and therefore eliminate climate-specific effects occurring in the sample countries. Unfortunately, this high frequency weather data is only available for a subset of our sample countries, namely Austria, Denmark, and the Netherlands in the treatment group and Poland and Slovenia in the control group.

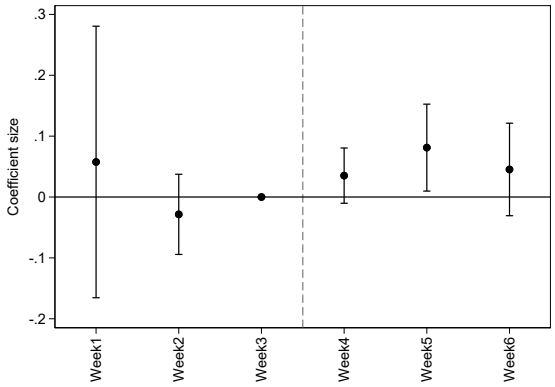
In Figure 10 in Appendix A.4, we again first provide support for the identifying assumption of parallel trends. Also in this specification, we observe that the treatment and control group evolved in parallel before the reform and find a significant reaction to the inframarginal revenue cap. However, the observable parallel trend, the absence of anticipation effects in the pre period as well as the effect of the introduction of the inframarginal revenue cap in the post period in Panel A and Panel B of Figure 10 is more pronounced than in Figure 2 and Figure 8. This could hint at the fact that the results for the full country sample would also be more pronounced if we could control for weather effects in all countries. The corresponding static DiD estimates are presented in Table 11 in Appendix A.4. Comparable to the results in Table 5, we find negative and statistically significant effects independent of the inclusion of control variables, fixed effects, or clustering of the standard errors. The electricity market control variables have an equal impact in terms of size, direction and significance. The weather control variables reveal that the results are mostly influenced by wind speed and less by global radiation or temperature. The biggest difference to Table 5 is the size of the interaction coefficient, which is roughly 6 pp. higher than in Table 5. The change indicated in Table 11 therefore indicates a 14 pp. decrease in the hourly capacity utilization of electricity production types subject to the inframarginal revenue cap, which corresponds to roughly between 6,500 MW in the Netherlands and 500 MW in Lithuania. The discrepancy in the coefficients seems feasible as weather is a significant impact factor in renewable electricity production.

Second, to further verify, what drives our results, we repeat our DiD analysis but replace the overall capacity utilization of electricity sources subject to the inframarginal revenue cap by the capacity utilization of each electricity source on its own. Hereby we focus on the renewable electricity sources in the sample. The results are shown in Figure 11 in Appendix A.4. It becomes evident that our findings are driven by lower capacity utilization of hydropower. This corroborates our findings from Table 5 and indicates that the impact is concentrated in a power generation type where daily production quantity can

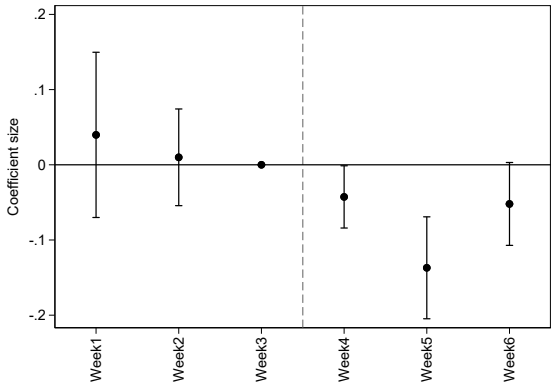
be readily regulated. However, on the contrary, the capacity utilization of waste combustion increases, which could be explained by the fact that waste combustion is less flexible to adapt. Especially when other combustion plants such as gas or coal plants suffer from supply shortages. Overall, the results of our robustness tests align with the concept of capacity withholding, which thus represents the most probable channel behind our results.

Figure 3: Difference-in-differences results - Changes in electricity production of renewable and fossil electricity sources

Panel A: Fossil electricity production types not subject to the inframarginal revenue cap



Panel B: Renewable electricity production types subject to the inframarginal revenue cap



Notes: The figure plots the results of our baseline regression in an event study design. We estimate the specification $Y_{c,d,h} = \alpha_c + \gamma_d + \delta_h + \sum_{j=-3; j\neq-1}^{K=4} \beta_j * D_{c,d,h} + \omega * x_{c,d,h} + \epsilon_{c,,d,h}$. The event study DiD design compares the capacity utilization of all production types subject to inframarginal revenue cap of in Croatia, Poland, and Slovenia (control group) with those in Austria, Bulgaria, the Czech Republic, Denmark, Lithuania, and the Netherlands (treatment group) before and after the introduction of the inframarginal revenue cap on 01.12.2022. The dependent variable is either the capacity utilization of electricity sources not subject to the inframarginal revenue cap (Panel A) or the capacity utilization of taxed renewable electricity sources (Panel B). The data points are the estimates for β_j. The vector $x_{c,j,d,h}$ includes the day-ahead price in hour h in country c (*Day-Ahead Price*$_{c,h}$) and the sum of MWhs imported in hour h to country c (*Total Electricity Imports*$_{c,h}$) as electricity market controls. We employ bidding-zone- and day-fixed-effects as well as standard errors clustered by the bidding zone. The confidence bands show the 95% confidence interval.

Finally, we test whether the decrease in capacity utilization of renewable energy sources subject to the inframarginal revenue cap coincides with an increase in the capacity utilization of fossil energy sources not subject to the inframarginal revenue cap. We repeat the DiD analysis with adapted dependent variables, whereby we consider the capacity utilization of renewable electricity sources and the capacity utilization of fossil electricity sources separately. In Figure 3 we plot the results obtained from the event study version of Equation (3) with 95 percent confidence intervals once for fossil energy sources (Panel A) and once for renewable energy sources (Panel B). We observe in both panels that in the pre-period the capacity utilization of power sources subject to a tax rate of 90 percent evolved in parallel to those subject to a 100 percent tax rate under the inframarginal revenue cap. In the post period we then find a positive significant reaction to the inframarginal revenue cap for fossil electricity sources in Panel A and a significant negative reaction for renewable electricity sources in Panel B in week 2. Table 12 in Appendix A.4 shows the corresponding static Difference-in-Differences estimates. They reveal that both coefficients are significant even though in absolute terms the coefficient for renewable

energy sources is larger than for fossil energy sources. These results indicate that the introduction of the inframarginal revenue cap results in a partial replacement of renewable electricity sources with fossil ones again underlying that capacity withholding is the most probable channel behind our results.

In conclusion, the introduction of the policy appears to distort the utilization of electricity sources subject to the inframarginal revenue cap. The opportunity to capitalize on high electricity market prices incentivizes electricity generators to substitute renewable electricity sources with fossil electricity sources to a small extent. Additionally, this behavioral response may have been reinforced by the fact that exceptionally high prices had persisted for over a year, making such gains more predictable. The taxation of renewable electricity sources at 90 percent and the exclusion of fossil electricity sources thus enables electricity producers to improve their profitability under the policy irrespective of the potential environmental impact of their production decisions. This finding delivers evidence against the non-distortionary rent-taxation rationale often used to justify excess profit taxes. A retroactive implementation of the cap could have mitigated this effect, as past production decisions would have been unaffected by the tax.

5. Conclusion

In this study, we evaluate the inframarginal revenue cap, an excess profit tax introduced in response to the 2022 EU electricity crisis triggered by the Russian invasion of Ukraine. From our analysis, we conclude that the tax revenues generated by the inframarginal revenue cap stayed short of expectations and, with the exception of France and Belgium, have not covered a significant share of the costs connected to the electricity crisis. In terms of distortions, we find no indication of the policy negatively impacting the recovery of investment cost and distorting future investment behavior in the electricity sector. However, in the short period, where due to very high electricity prices the inframarginal revenue cap generated tax revenues, we find indications of short-run operational distortions in the form of capacity withholding and a corresponding statistically significant decrease in capacity utilization of electricity production types covered by the inframarginal revenue cap.

Our findings consequently reveal the following insights on excess profit taxes as a policy instrument in times of crisis. First, these exceptional taxes should generate substantial revenue to help mitigate the crisis's negative externalities. However, in this case, the tax was introduced after windfall profits had largely dissipated, leading to administrative costs without effectively addressing these externalities. This underscores that excess profit taxes are only viable if implemented while windfall profits still exist. In our setting, a retroactive introduction would have ensured this, as electricity prices were exceptionally high across most EU Member States in the summer of 2022. Our revenue estimates for a hypothetical retroactive application indicate that, while the tax would not have fully covered all government support measures, it would have generated significantly higher revenues in most countries than during the actual implementation period.

Second, the distinction between ordinary and excess profits must be accurate to avoid discouraging risky investment. Our analysis finds that while the inframarginal revenue cap reduced profitability, it did not reduce electricity generators' ability to recover investments. This underlines that excess profit taxes in times of crisis only resemble windfall taxes if the definition of excess profits is generous enough to not distort future investment but still tight enough to generate revenues. Given the generous EU caps in 2022, our profitability analysis suggests that a retroactive tax would not have harmed investment, further strengthening the case for its implementation. However, we acknowledge that we cannot estimate the effect of policy uncertainty on investment decisions.

Third, a genuine windfall profit tax would not create short-term distortions in operational decisions of taxpayers. In our setting, we find that the taxation of renewable electricity sources at 90 percent and the exclusion of fossil electricity sources allowed electricity producers to improve their profitability within the policy's framework. This finding is contrary to the non-distortionary rent-taxation rationale often used to justify excess profit taxes and highlights the importance of considering possible policy-induced distortions in advance to prevent the tax from introducing additional negative externalities. Again, a retroactive tax could have mitigated such behavioral distortions, as past production decisions would have remained unaffected, thereby preventing potential capacity withholding.

Given the current debate in times of new supply shocks on introducing excess profit taxes, policymakers should carefully consider the design choices of these taxes, because their design is crucial in ensuring that the tax is a policy tool to raise significant additional revenue without creating distortions.[30] Excess profit taxes are only a viable policy tool to raise significant revenue if the tax is levied timely when the crisis starts and the excess profits arise. The identification of excess profits is a key difficulty in designing a true windfall profit tax. Even with a generous definition of excess profits, any such tax can still have distortionary effects. A possible solution for the issues at hand and thereby an avenue to enhance the impact of excess profit taxes as a crisis measure could be a retroactive implementation,[31] however policymakers face a trade-off between capturing windfall revenues and maintaining a predictable, credible tax framework.

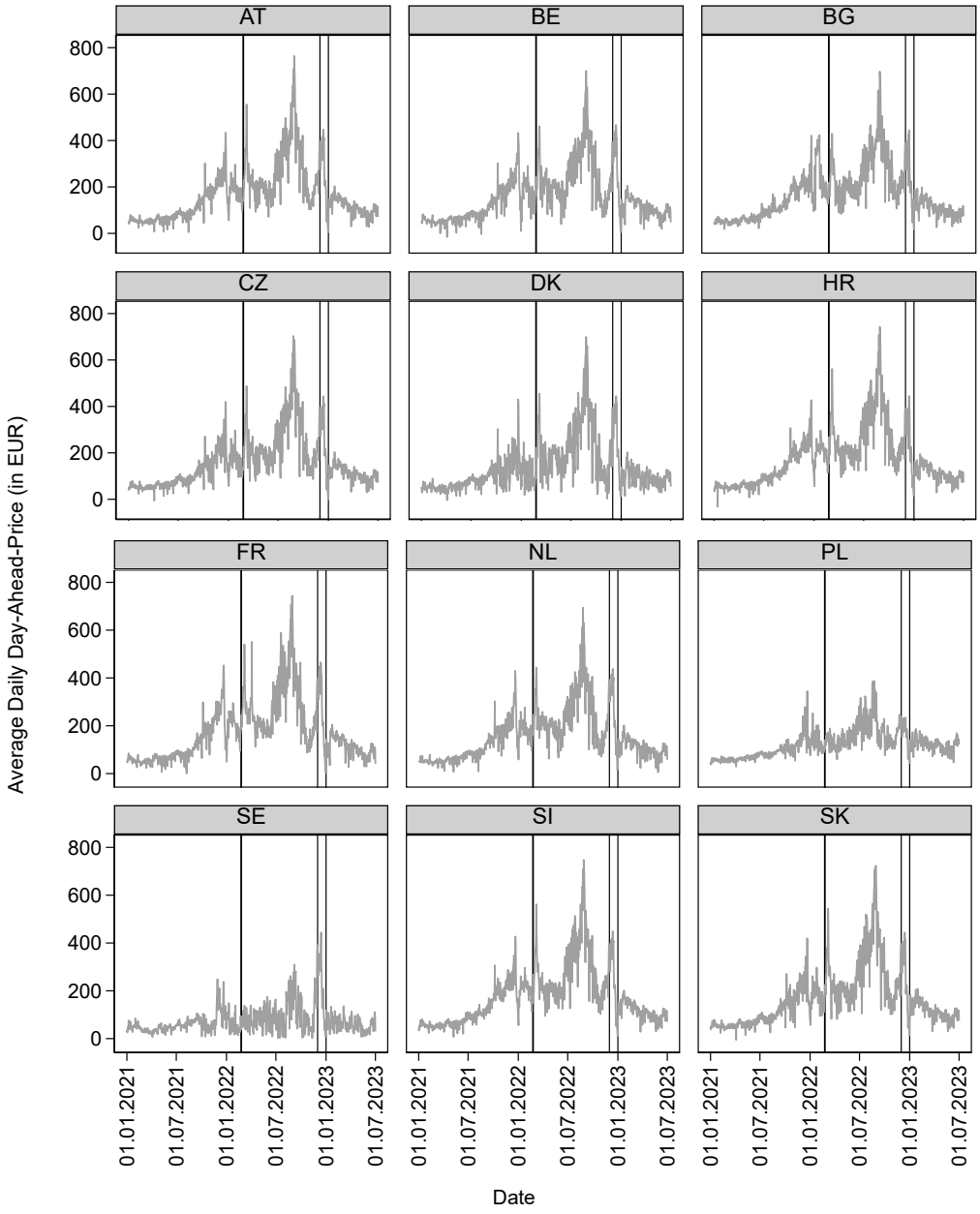
[30] We are aware that there are legal limitations to introduce retrospective taxes. For an example of such legal limitations, see Wissenschaftliche Dienste (2012). Nonetheless, the economic perspective on policy design is a valuable insight for future policy decisions.

[31] Note that our observations are purely financial, which means that we cannot measure, for example, the effect of market uncertainty caused by the inframarginal revenue cap on investment behavior.

6. Appendix

Appendix A.1: Price development in the EU

Figure 4: Average daily day-ahead prices by country from 2021 to 2023



Notes: The graphs show the development in average daily day-ahead prices in EUR/MWh by country from 01.01.2021 to 01.07.2023. The first black line marks the beginning of the invasion of Ukraine through Russia (24.02.2022), the second black line marks the implementation of the inframarginal revenue cap in most EU Member States (01.12.2022), and the last black line marks the beginning of 2023 (01.01.2023).

Appendix A.2: Institutional background

Table 6: Alternative measures implemented in the Member States

Country	Implemented on	Effective as of	Mechanism
Finland	04.01.2023	Tax years 2023 and 2024	30 percent additional tax levied on the net income that exceeds a 10 percent calculative return on equity capital in the tax year.
Hungary	04.06.2022	01.01.2022-01.07.2022	65 percent on the revenue calculated from the amount of electricity fed into the grid less the amount of electricity fed into the grid multiplied by the subsidized price set by MEKH.
Greece	May 2022	October 2021 to June 2022	90 percent retroactive tax on electricity generators' windfall profits from the wholesale electricity prices.
Italy	21.03.2022	October 2021 to April 2022	One-time 25 percent excess profit tax on the production and sale of electricity, methane gas, natural gas, the production, distribution and trade of petroleum products and imports or purchase of the aforementioned products. The tax base is the increase in net-sales reported for VAT purposes above EUR 5,000,000 or 10% compared to the same period of the previous year.
Portugal	14.05.2022	14.06.2022-31.05.2023	Adjustment mechanism targeting marginal fossil power plants established as the difference between 40 EUR/MWh (EUR 5 increase per month until 70 EUR/MWh), and the effective price of the spot market of natural gas each day.
Romania	29.10.2021	01.11.2021-31.03.2022	80 percent if the average selling price of electricity in a month exceeds 450 RON/MWh. (91 EUR/MWh).
Spain	14.05.2022	14.06.2022-31.05.2023	Adjustment mechanism targeting marginal fossil power plants established as the difference between 40 EUR/MWh (EUR 5 increase per month until 70 EUR/MWh), and the effective price of the spot market of natural gas each day.
	31.03.2022	31.03.2022-30.06.2022	Payback mechanism of energy prices above 67 EUR/MWh for the electrical energy generation facilities.

Notes: The table gives an overview of the key elements of the implemented comparable measures to the inframarginal revenue cap in the EU. As most national regulations do not have an official English translation, we machine translate them into English. We are aware that this method can lead to mistranslations, but we are confident that this method provides a sufficient understanding of the policies for our study.
Source: PwC Netherlands (2022) and Fintikakis (2022), in addition to the legal sources establishing the national implementation of the excess profit tax (see Table 8 in Appendix A.2).

Table 7: Implementation of EU Council Regulation 2022/1854 in the EU Member States

Country	Implemented on	Effective as of	Electricity sources targeted	Revenue cap (EUR/MWh)	Tax rate (%)
Austria	13.12.2022	01.12.2022-31.12.2023	Wind, Solar, Geothermal, Hydro, Biomass, Waste, Lignite, Fossil Coal, Fossil Fuels, Peat	140	90
Belgium	16.12.2022	01.08.2022-30.06.2023	Wind, Solar, Geothermal, Hydro, Biomass, Waste, Nuclear, Lignite, Fossil Fuels, Peat	130, besides Gaseous Biomass Fuels/ Waste: 180	100
Bulgaria	30.12.2022	01.12.2022-30.06.2023	Wind, Solar, Geothermal, Hydro, Biomass, Waste, Nuclear, Lignite, Fossil Fuels, Peat	Preferential price determined by the decision of the Commission for Energy and Water Regulation	90
Croatia	29.12.2022	01.12.2022-30.06.2023	Wind, Solar, Geothermal, Hydro, Biomass, Waste, Nuclear, Lignite, Peat	180	100
Czech Republic	30.11.2022	01.12.2022-30.06.2023	Wind, Solar, Geothermal, Hydro, Biomass, Waste, Nuclear, Lignite, Fossil Fuels, Peat	180, besides: Gaseous Biomass: 240; Solid Biomass: 210; Waste: 100; Nuclear: 70; Lignite: 140-230	90
Denmark	02.05.2023	01.12.2022-30.06.2023	Wind, Solar, Geothermal, Hydro, Biomass, Waste, Nuclear, Lignite, Fossil Fuels, Peat	180	90
France	30.12.2022	01.07.2022-31.12.2023	Wind, Solar, Geothermal, Hydro, Biomass, Waste, Nuclear	100, besides: Nuclear: 90; Waste: 145; Biogas: 175; Biomass: 130, Hydro: 80-140	90
Germany	20.12.2022	01.12.2022-30.06.2023	Wind, Solar, Geothermal, Biomass, Waste, Nuclear, Lignite, Fossil Fuels, Peat	Monthly market value as defined in Annex 1 number 3.3. of the renewable energy law + “safety adjustments”	90
Ireland	03.03.2023	01.12.2022-30.06.2023	Wind, Solar, Geothermal, Hydro, Biomass, Waste, Nuclear, Lignite, Fossil Coal, Fossil Fuels, Peat	180, besides: Wind/Solar: 120	100
Italy	29.12.2022	01.12.2022-30.06.2023	Wind, Solar, Geothermal, Hydro, Biomass, Waste, Nuclear, Lignite, Fossil Fuels, Peat	180	100
Lithuania	15.12.2022	01.12.2022-30.06.2023	Wind, Solar, Hydro, Biomass, Waste, Nuclear, Lignite, Fossil Fuels, Peat	Revenue surplus is based on the electricity transaction price for each imbalance settlement period, which is defined Council regulation EU 2019/943	90
Luxembourg	15.03.2023	01.12.2022-31.12.2023	Wind, Solar, Hydro, Biomass, Waste, Biogas	130, besides: Hydro: 100; Biofuels / Biogas: 180	90
Netherlands	30.11.2022	01.12.2022-30.06.2023	Wind, Solar, Hydro, Biomass, Biogas, Waste, Nuclear, Fossil Coal	130, besides; Biomass: 240; Coal: Formula based on coal price (max. 190)	90
Poland	04.11.2022	01.12.2022-30.06.2023	Wind, Solar, Hydro, Biomass, Gas, Lignite, Fossil Coal	Solar: 82; Wind: 68; Hydro: 62; Fossil Fules: Cap is determined based on plant-specific costs, the daily average wholesale price and a 12 EUR/MWh fixed cost payment	100
Slovakia	30.11.2022	01.12.2022-31.12.2024	Wind, Solar, Geothermal, Hydro, Biomass, Waste, Nuclear, Lignite, Fossil Fuels, Peat	Adjustable between 50-250	90

Slovenia	21.11.2022	01.12.2022-31.12.2023	Wind, Solar, Geothermal, Hydro, Biomass, Waste, Nuclear, Lignite, Fossil Fuels, Peat	180	100
Sweden	19.01.2023	01.03.2023-30.06.2023	Wind, Solar, Geothermal, Hydro, Biomass, Waste, Nuclear, Lignite, Fossil Fuels, Peat	172,8 (1957 SEK)	90

Notes: The table gives an overview of the key elements of the implemented Caps on Market Revenues in the EU following Council Regulation (EU) 2022/1854. As most national regulations do not have an official English translation, we machine translate them into English. We are aware that this method can lead to mistranslations, but we are confident that this method provides a sufficient understanding of the policies for our study.
Source: Motylewski, (2022), in addition to the legal sources establishing the national implementation of the inframarginal revenue cap (see Table 8 in Appendix A.2).

Table 8: Sources of law of the national implementations of the inframarginal revenue cap

Country	English title	Original title	Reference
Austria	Federal law on the energy crisis contribution on electricity	Bundesgesetz über den Energiekrisenbeitrag-Strom	-
Belgium	Decision on the model declaration to be submitted by the debtors of the levy introduced under the ceiling on the market income of electricity producers	Décision sur le modèle de déclaration à introduire par les débiteurs du prélèvement instauré dans le cadre du plafond sur les recettes issues du marché des producteurs d'électricité	Decision (B)2511
Bulgaria	Law on the implementation of provisions of the Law on the State Budget of the Republic of Bulgaria for 2022, the Law on the State Public Insurance Budget for 2022 and the Law on the Budget of the National Health Insurance Fund for 2022	Закон за прилагане на разпоредби на Закона за държавния бюджет на Република България за 2022 г., Закона за бюджета на държавното обществено осигуряване за 2022 г. и Закона за бюджета на Националната здравноосигурителна каса за 2022 г	National Assembly No. 104
Croatia	Regulation on the Law on Emergency Inertvention to Resolve High Price Electric Energy	Uredba o Zakonu o hitnoj intervenciji za rješavanje pitanja visokih cijena električne energije	Federal Gazette 156/2022
Czech Republic	Act Amending Act No. 458/2000 Coll., on Business Conditions and Performance of State Administration in Energy Sectors and on Amendments to Certain Acts (Energy Act)	Zákon, kterým se mění zákon č. 458/2000 Sb., o podmínkách podnikání a o výkonu státní správy v energetických odvětvích a o změně některých zákonů (energetický zákon), ve znění pozdějších předpisů	Act No. 365/2022 Coll.
Denmark	Act No. 456 on a ceiling on income from electricity production	Lov no. 456 om et loft over indtægter fra elproduktion	Act No. 456
Finland	The government's proposal to the parliament for legislation on temporary allowances in the electricity and fossil fuel sectors	Hallituksen esitys eduskunnalle sähköalan ja fossiilisten polttoaineiden alan väliaikaisia voittoveroja koskevaksi lainsäädännöksi	HE 320/2022 vp.
France	Law No 2022-1726 of December 30, 2022 on finance for 2023	LOI n° 2022-1726 du 30 décembre 2022 de finances pour 2023	Law No 2022-1726
Germany	Law on the introduction of an electricity price brake	StromPBG - Gesetz zur Einführung einer Strompreisbremse	Federal Law Gazette I p. 2512
Hungary	Government decree 197/2022. (VI. 4.) about extra-profit taxes	197/2022. (VI. 4.) Korm. rendelet az extraprofit adókról	Hungarian Gazette No. 93 of 2022
Ireland	Energy (Windfall Gains in the Energy Sector) Bill 2023	Energy (Windfall Gains in the Energy Sector) Bill 2023	-
Italy	State budget for the financial year 2023 and multi-year budget for the three-year period 2023-2025	Bilancio di previsione dello Stato per l'anno finanziario 2023 e bilancio pluriennale per il triennio 2023-2025	Law No. 197 of 29 December 2022
Lithuania	Law of the Republic of Lithuania No XIV-1680 on the Implementation of Council Regulation (EU) 2022/1854	Lietuvos respublikos įstatymas dėl reglamento (ES) 2022/1854 įgyvendinimo	Law of the Republic of Lithuania No XIV-1680
Luxembourg	Law Project 8175 introducing a cap on excess revenue from the electricity generator market	Projet de loi introduisant un plafond sur les recettes excédentaires issues du marché des producteurs d'électricité	Law Project 8175

Netherlands	Letter No. 361 from the Minister of Climate and Energy and the State Secretary of Finance	Brief Nr. 361 van de Minister voor Klimaat en Energie en de Staatssecretaris van Financien	Letter No. 361
Romania	Law No 259/2021 approving Government Emergency Ordinance No 118/2021 on the establishment of a compensation scheme for the consumption of electricity and natural gas for the 2021-2022 cold season, and supplementing Government Ordinance No 27/1996 on the granting of facilities to persons living or working in certain localities in the Apuseni Mountains and in the "Danube Delta" Biosphere Reserve	Legea nr. 259/2021 pentru aprobarea Ordonanţei de urgenţă a Guvernului nr. 118/2021 privind stabilirea unei scheme de compensare pentru consumul de energie electrică şi gaze naturale pentru sezonul rece 2021-2022, precum şi pentru completarea Ordonanţei Guvernului nr. 27/1996 privind acordarea de facilităţi persoanelor care domiciliază sau lucrează în unele localităţi din Munţii Apuseni şi în Rezervaţia Biosferei "Delta Dunării"	Law No 259/2021
Slovakia	Government proposal which amends Act no. 251/2012 Coll. on energy and on the amendment and supplementation of certain laws as amended and by which certain laws are amended and supplemented	Zákon ktorým sa mení a dopĺňa zákon č. 251/2012 Z. z. o energetike a o zmene a doplnení niektorých zákonov v znení neskorších predpisov a ktorým sa menia a dopĺňajú niektoré zákony	Government Proposal 1328
Slovenia	Law on Measures for Management of Crisis Situations in the Field of Electricty	Zakon o ukrepih za obvladovanje kriznih razmer na področju električne energije	-
Spain	Royal Decree-Law 6/2022, of March 29, adopting urgent measures within the framework of the National Plan of response to the economic and social consequences of the war in Ukraine	Real Decreto-ley 6/2022, de 29 de marzo, por el que se adoptan medidas urgentes en el marco del Plan Nacional de respuesta a las consecuencias económicas y sociales de la guerra en Ucrania.	Official State Bulletin No. 76 of 30 March 2022
Spain	Royal Decree-Law 10/2022 of May 13, establishing a temporary production cost adjustment mechanism for the temporary production cost adjustment mechanism to reduce the price of electricity in the wholesale market	Real Decreto-ley 10/2022, de 13 de mayo, por el que se establece con carácter temporal un mecanismo de ajuste de costes de producción para la reducción del precio de la electricidad en el mercado mayorista	Official State Bulletin No. 115 of 14 May 2022
Sweden	Temporary tax on excess income of certain electricity producers	Tillfällig skatt på vissa elproducenters överintäkter	

Notes: The table gives an overview of the national implementations of EU Council Regulation 2022/1854 in the EU Member States. As most national regulations do not have an official English translation, we machine translate their titles into English. We are aware that this method can lead to mistranslations, but we are confident that this method is sufficient for our study.

Appendix A.3: Impact on firms' potential to recover investment costs

Table 9: Methodology of Levelized Cost of Energy (LCOE)

Formulas			
$$\boldsymbol{LCOE = w + f + c * \Delta}$$			
Variable operating cost (w) $$\frac{\sum_{i=1}^{T} W_i * x^{i-1} * \gamma^i}{\sum_{i=1}^{T} x^{i-1} * \gamma^i}$$	**Fixed Operating Costs (f)** $$\frac{\sum_{i=1}^{T} F_i * \gamma^i}{m * CF * \sum_{i=1}^{T} x^{i-1} * \gamma^i}$$	**Cost of capacity in (c)** $$\frac{SP}{m * CF * \sum_{i=1}^{T} x^{i-1} * \gamma^i}$$	**Tax factor** (Δ) $$\frac{1 - \alpha * \sum_{t=0}^{T^\circ} d_t * \left(\frac{1}{1+r}\right)^t}{1 - \alpha}$$

Variables	
W_i =	Variable operating cost in year i (EUR/kWh)
F_i =	Discounted Annual fixed operating costs (in EUR/kW) over T
SP =	System price (EUR/kWh)
x^{i-1}=	System degradation factor in year i (in %)
γ^i =	Discount factor based on the cost of capital r (in %)
r =	Cost of capital (for our study 3 %)
m =	Number of hours per year (8,760h)
CF =	Capacity factor (in %)
α =	Effective corporate income tax rate (in %)
d_t =	Discounted allowable depreciation charges for income tax purposes over T (in %)

Intuition
The LCOE is a life-cycle concept that includes all the costs a power plant incurs to generate one kilowatt hour (kWh) of electricity. It determines the break-even average hourly revenue that a power plant must achieve to be a zero net present value (NPV) investment. The LCOE consists of three elements. First, the capacity cost is the initial system price contributed over all the hours of energy production that the power plant can deliver over its lifetime. Second, the levelized fixed and variable costs are the net present value of all hourly fixed costs over the lifetime of the power plant divided by its total electricity output. Third, the tax factor quantifies the tax shield resulting from income tax and depreciation.

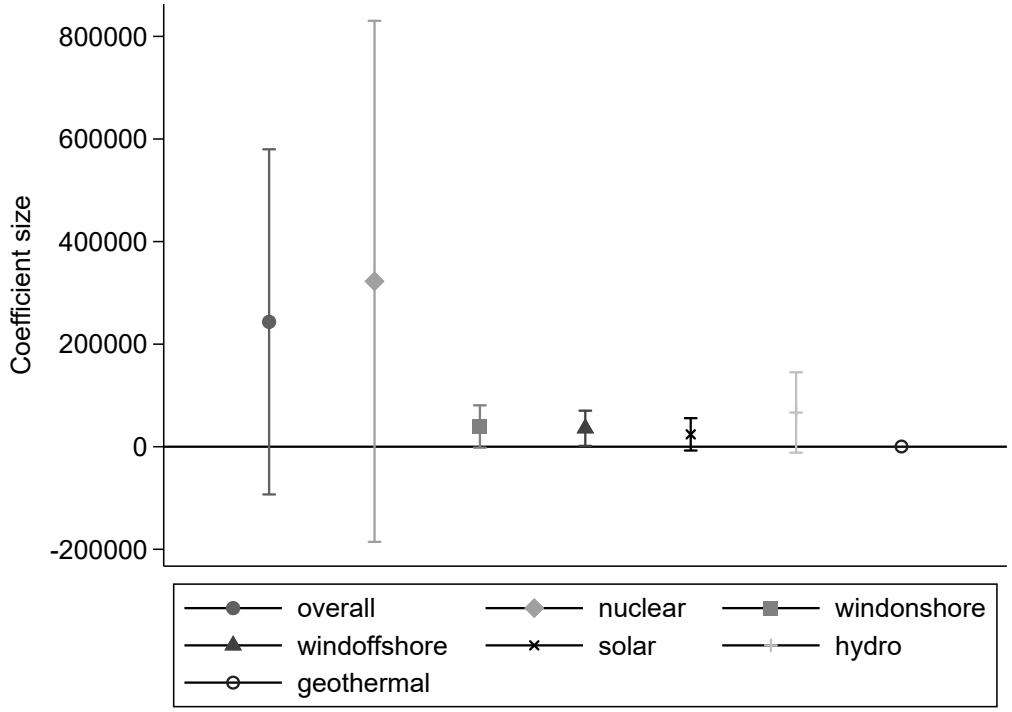
Notes: The table shows the methodology employed to calculate the LCOE in our study. It presents the underlying formulas as well as the variables employed. In addition, it outlines the intuition of the LCOE concept.
Source: Adapted from Comello et al.(2017).

Table 10: Descriptive statistics of hourly profits from electricity sales in 2019, 2021, 2022, and 2023 (in million EUR)

	Year	N	Mean	Min	Median	Max
Day-Ahead Price$_{c,h}$	2019	65,145	42.51	-500	41.91	365.04
	2021	65,145	54.95	-263.31	54.15	500
	2022	64,737	168.69	-222.36	179.9	2987.78
	2023	64,017	96.62	-400	98.72	348
Profit$_{c,i,h,y}$	2019	65,090	0.00	-3.57	0.00	5.25
	2021	64,856	0.09	-4.48	0.01	6.03
	2022	63,659	0.87	-1.98	0.17	129.69
	2023	62,870	0.36	-3.58	0.07	12.53
After-Tax Profit$_{c,i,h,y}$	2019	-	-	-	-	-
	2021	-	-	-	-	-
	2022	63,659	0.10	-0.74	0.04	2.09
	2023	62,870	0.25	-3.58	0.07	3.96

Notes: The table shows descriptive statistics (number of observations, mean, minimum, median, maximum) for the day-ahead price, profit (in million EUR), and after-tax profit (in million EUR) for the hourly electricity generation across production types and countries in the first six months of the years 2019, 2021, 2022, and 2023. The hourly profits for 2019 and 2021 are calculated by deducting the country-, production type-, and year-specific LCOE from the day-ahead price of a given country and hour to obtain the profit per MWh, which is then multiplied by the electricity generated for the production type in the given country and hour. The after-tax profits for 2022 and 2023 are calculated following Equation (4).

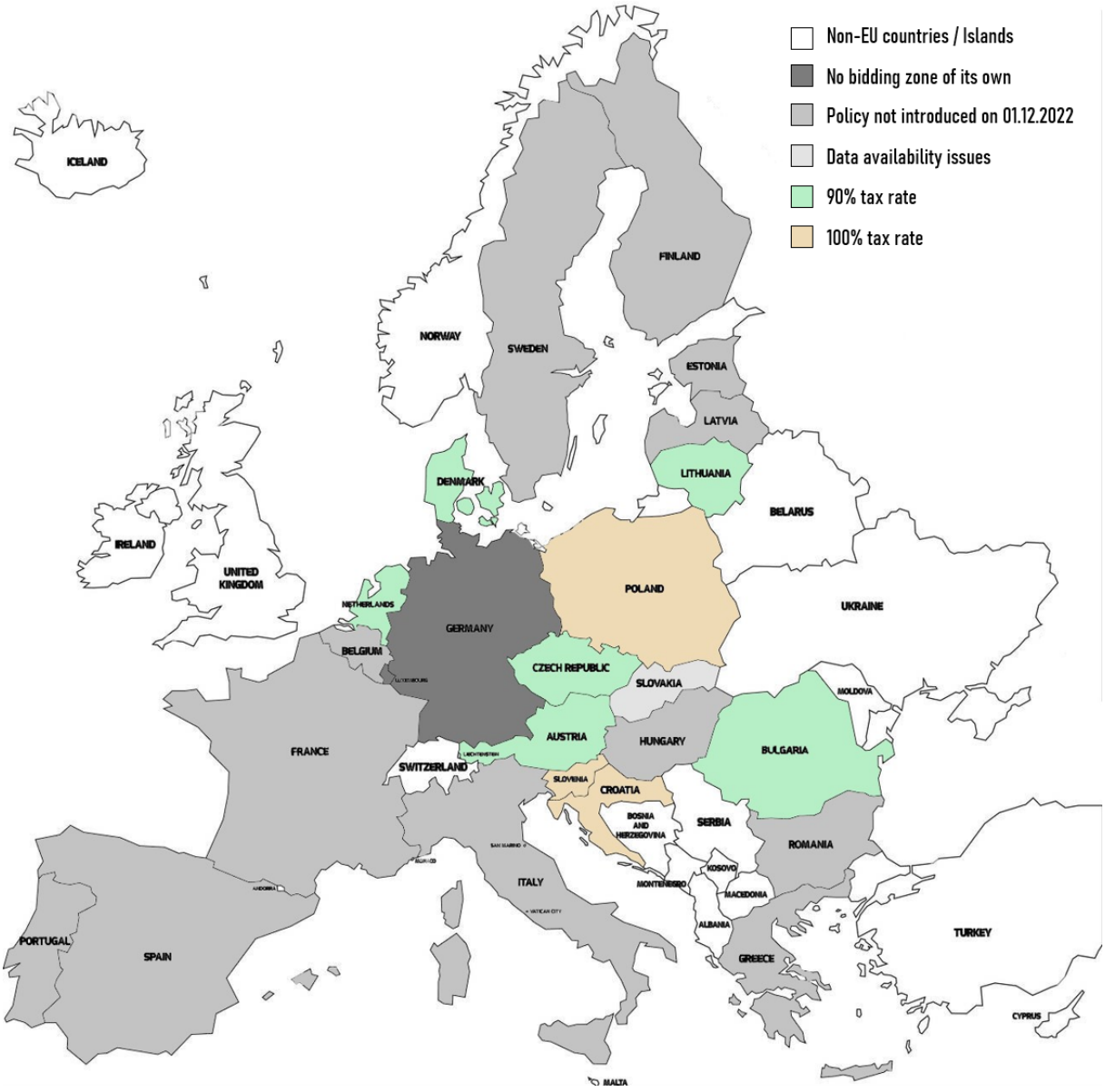
Figure 5: T-test comparing the after-tax profits by production types based on LCOE in January to June in 2019, 2021 and 2023



Notes: The figure shows the results of a t-test comparing the hourly profits generated from electricity sales in million EUR split by generation technology in the years 2019, 2021, and 2023 following Equation (5). The data points are the estimates for β_2 The hourly profits for 2019 and 2021 are calculated by deducting the country-, production type-, and year-specific LCOE from the day-ahead price of a given country and hour to obtain the profit per MWh, which is then multiplied by the electricity generated for the production type in the given country and hour. The profits for 2023 are calculated following Equation (4). The data is clustered on the country-level. The confidence bands show the 95% confidence interval.

Appendix A.4: Distortionary responses to the inframarginal revenue cap

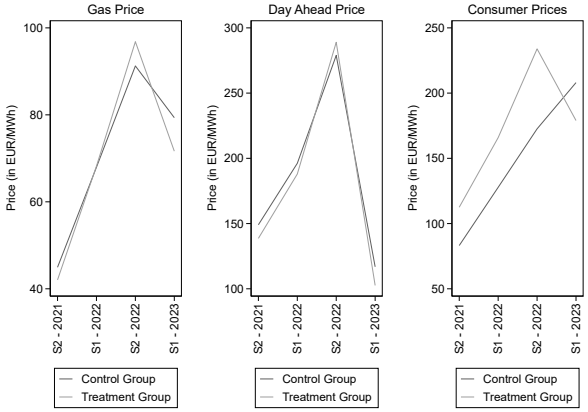
Figure 6: Overview of country sample selection



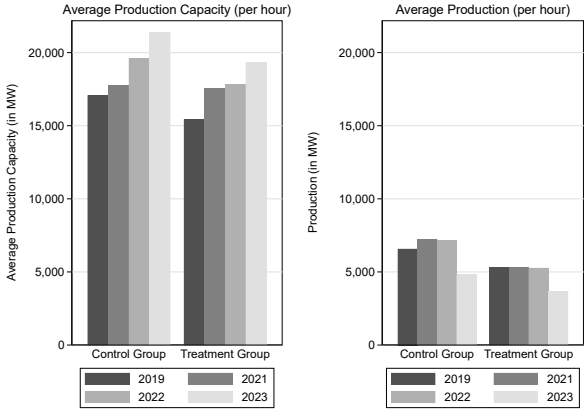
Notes: The map shows the elimination process that leads to our subsample of EU Member States, which allows us to identify market distortions under the inframarginal revenue cap. First, we exclude all non-EU Member States and islands. The electricity market on islands functions differently from that on the mainland, and Cyprus and Malta are explicitly excluded from the inframarginal revenue cap. Germany and Luxembourg only have joint bidding zones with other jurisdictions, which does not allow a clean analysis of these countries. Second, we exclude all countries that did not introduce the police on 01.12.2022. Hungary, Greece, Italy, Portugal, Romania, and Spain introduced alternative inframarginal revenue caps before December 2022, whereas France and Belgium applied their inframarginal revenue caps retrospectively from summer 2022. Finland and Sweden introduced their policies later in 2023, whereas Estonia and Latvia did not introduce an inframarginal revenue cap at all. Finally, we exclude Slovakia from our sample as it lacks data on its electricity production capacity in 2022. The resulting subsample of EU Member States has Austria, Bulgaria, the Czech Republic, Denmark, Lithuania, and the Netherlands as treatment countries (i.e. all introduced the inframarginal revenue cap on 01.12.2022 with a tax rate of 90 percent) and Croatia, Poland, and Slovenia as control countries (i.e. all introduced the inframarginal revenue cap on 01.12.2022 with a tax rate of 100 percent).

Figure 7: Comparability analysis of treatment and control group

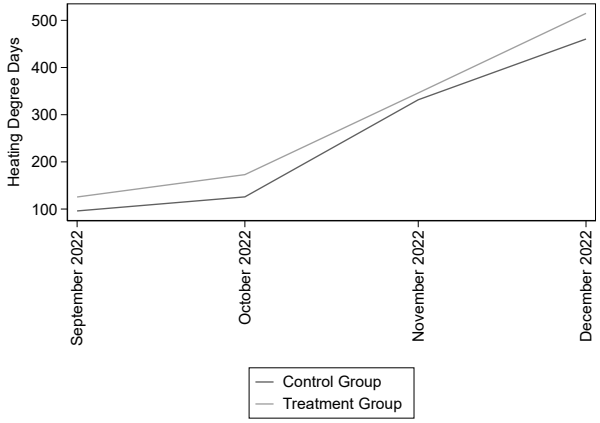
Panel A: Price development in the electricity market for treatment and control group from S2 2021 to S1 2023



Panel B: Average hourly production capacity and production for treatment and control group in 2019, 2021, 2022 and 2023

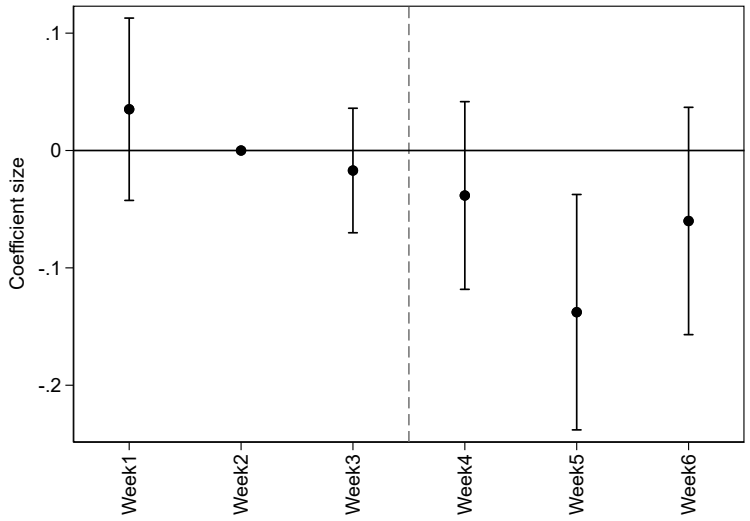


Panel C: Development average heating degree days for the treatment and control group from September to December 2022



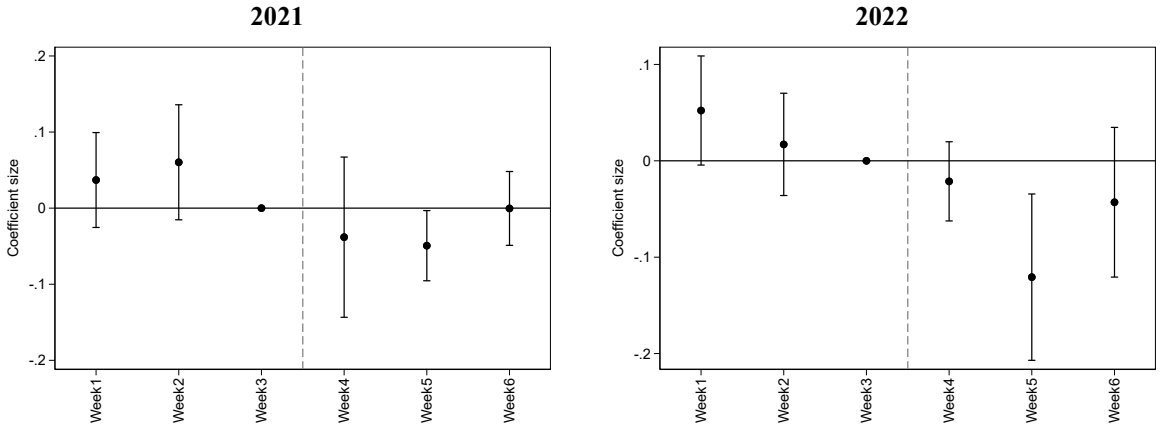
Notes: The graph presents different indicators of the electricity markets of the control group (Croatia, Poland, and Slovenia) and treatment group (Austria, Bulgaria, the Czech Republic, Denmark, Lithuania, and the Netherlands) to ensure comparability of the groups. Panel A shows the price development of average gas prices, day-ahead prices, and consumer prices on a semi-annual basis from 2021 to 2023 for the treatment and control group. The gas prices in EUR/MWh are the natural gas prices for non-household consumers averaged over all consumption bands excluding taxes and levies provided by Eurostat (2025c). The day-ahead prices in EUR/MWh are calculated from the day-ahead price data we obtained from ENTSO-E Transparency Platform (ENTSO-E, 2024c). The consumer prices in EUR/MWh are the electricity prices for non-household consumers averaged over all consumption bands excluding taxes and levies provided by Eurostat (2025b). Panel B shows the average hourly production capacity and production for the treatment and control group. Both figures are calculated from the data we obtained from ENTSO-E Transparency Platform (ENTSO-E, 2024a, 2024d). Panel C shows the development of the heating degree days from September 2022 to December 2022 for the treatment and control group. The heating degree days on a monthly basis provided by Eurostat (2025a). The Heating degree day (HDD) index is a weather-based technical index designed to describe the need for the heating energy requirements of buildings, whereby higher numbers indicate a higher need for heating.

Figure 8: Test for anticipation effects in domestic electricity generation



Notes: The figure plots the results of our baseline regression in an event study design. We estimate the specification $Y_{c,d,h} = \alpha_c + \gamma_d + \delta_h + \sum_{j=-3; j\neq-1}^{K=4} \beta_j * D_{c,d,h} + \omega * x_{c,d,h} + \epsilon_{c,,d,h}$. The event study DiD design compares the capacity utilization of all production types subject to inframarginal revenue cap of in Croatia, Poland and, Slovenia (control group) with those in Austria, Bulgaria, the Czech Republic, Denmark, Lithuania, and the Netherlands (treatment group) before and after the introduction of the inframarginal revenue cap on 01.12.2022. The data points are the estimates for β_j. We include the coefficient of week 2 as the missing period to test for anticipation effects. The vector $x_{c,j,d,h}$ includes the day-ahead price in hour h in country c (*Day-Ahead Price*$_{c,h}$) and the sum of MWhs imported in hour h to country c (*Total Electricity Imports*$_{c,h}$) as electricity market controls. We employ bidding-zone- and day-fixed-effects as well as standard errors clustered by the bidding zone. The confidence bands show the 95% confidence interval.

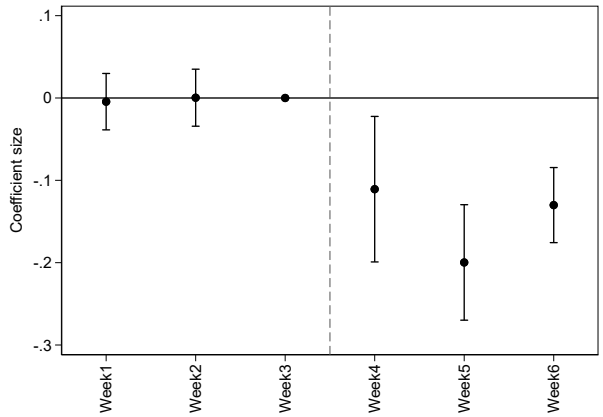
Figure 9: Pseudo-event test of changes in domestic electricity generation



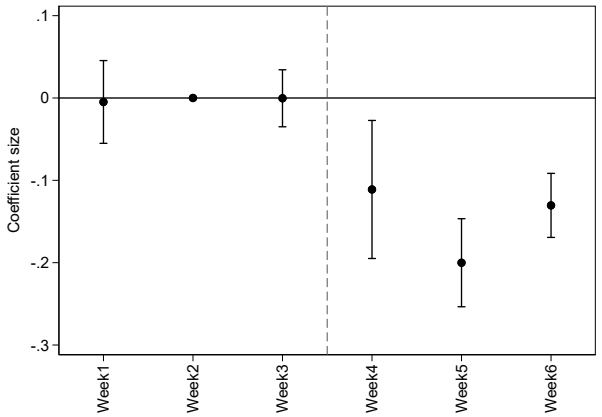
Notes: The graph presents the results of a pseudo-event test for our analysis on changes in the capacity utilization of taxed electricity production types. We estimate the specification $Y_{c,d,h} = \alpha_c + \gamma_d + \delta_h + \sum_{j=-3;j\neq-1}^{K=4} \beta_j * D_{c,d,h} + \omega * x_{c,d,h} + \epsilon_{c,,d,h}$. the event study DiD design compares the capacity utilization of all production types subject to inframarginal revenue cap of in Croatia, Poland and Slovenia (control group) with those in Austria, Bulgaria, the Czech Republic, Denmark, Lithuania, and the Netherlands (treatment group) before and after the introduction of the inframarginal revenue cap on 01.12.2022 For the real event (2022), the event study DiD design compares the capacity utilization of all production types subject to inframarginal revenue cap of in Croatia, Poland and Slovenia (control group) with those in Austria, Bulgaria, the Czech Republic, Denmark, Lithuania and the Netherlands (treatment group) before and after the introduction of the inframarginal revenue cap on 01.12.2022. For the pseudo-event, we repeat both estimations with data from 2021. The data points are the estimates for β_j.The vector $x_{c,j,d,h}$ includes the day-ahead price in hour h in country c (*Day-Ahead Price*$_{c,h}$) and the sum of MWhs imported in hour h to country c (*Total Electricity Imports*$_{c,h}$) as electricity market controls. We employ bidding-zone- and day-fixed-effects as well as standard errors clustered by the bidding zone. The confidence bands show the 95% confidence interval.

Figure 10: Subsample analysis including weather control variables

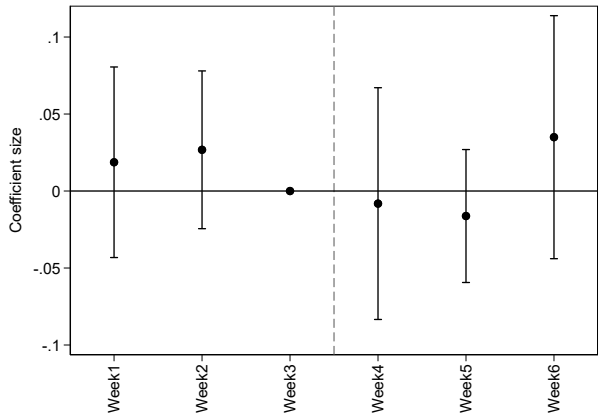
Panel A: Event study plot for the analysis of changes in domestic electricity generation



Panel B: Test for anticipation effects in domestic electricity generation



Panel C: Pseudo-event test of changes in domestic electricity generation



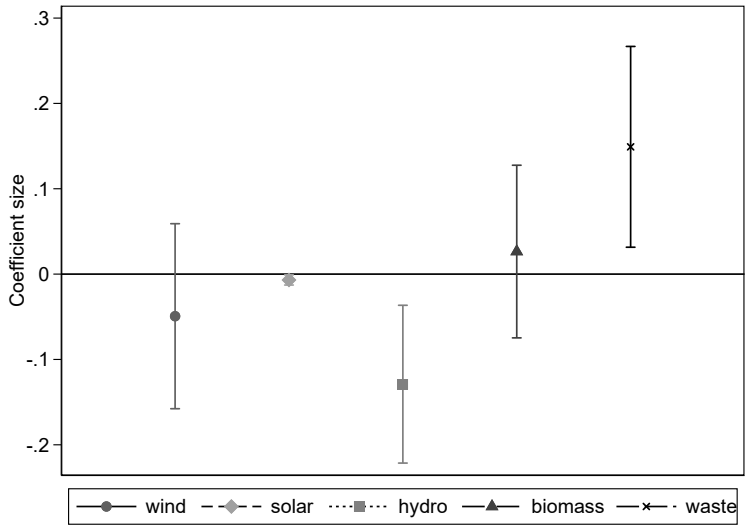
Notes: The graph presents the results of our baseline regression in an event study design (Panel A and Panel B) and a pseudo-event test (Panel C) for our analysis on changes in the capacity utilization of taxed electricity production types. for our analysis on changes in the capacity utilization of taxed electricity production types. We estimate the specification $Y_{c,d,h} = \alpha_c + \gamma_d + \delta_h + \sum_{j=-3;j\neq-1}^{K=4} \beta_j * D_{c,d,h} + \omega * x_{c,d,h} + \mu * z_{c,j,d,h} + \epsilon_{c,,d,h}$. The event study DiD design compares the capacity utilization of all production types subject to inframarginal revenue cap in Poland and Slovenia (control group) with those in Austria, Denmark, and the Netherlands (treatment group) before and after the introduction of the inframarginal revenue cap on 01.12.2022. The data points are the estimates for β_j.The vector $x_{c,j,d,h}$ includes the day-ahead price in hour h in country c (*Day-Ahead Price*$_{c,h}$) and the sum of MWhs imported in hour h to country c (*Total Electricity Imports*$_{c,h}$) as electricity market controls. The vector $z_{c,j,d,h}$ includes the average temperature in °C on day d in country c (*Temperature*$_{c,d}$), the average wind speed in w/s on day d in country c (*Windspeed*$_{c,d}$), and the average global Radiation in W/m^2 (*GlobalRAdiation*$_{c,d}$) as weather controls, which we obtain from the European Climate Assessment & Dataset (van der Schrier et al., 2024). We employ bidding-zone- and day-fixed-effects as well as standard errors clustered by the bidding zone. In Panel A, we present our baseline estimate, in Panel B, we include the coefficient of week 2 as the missing period to test for anticipation effects and in Panel C, we repeat both estimations with data from 2021 as a pseudo-event. The confidence bands show the 95% confidence interval.

Table 11: Difference-in-differences results of changes in domestic electricity generation for subsample analysis including weather control variables

	(1)	(2)	(3)	(4)	(5)	(6)
$D_{c,d,h}$	-0.141***	-0.141***	-0.137***	-0.123***	-0.156***	-0.130***
	(-8.35)	(-26.75)	(-9.53)	(-5.29)	(-8.89)	(-7.40)
Day-Ahead Price$_{c,h}$	0.00006	0.00006***	-0.00005	0.0001	-0.00003	
	(-0.31)	(4.63)	(-0.27)	(0.46)	(-0.18)	
Total Electricity Imports$_{c,h}$	-0.00006**	-0.00006***	-0.00006**	-0.00001	-0.00007**	
	(-3.14)	(-29.51)	(-2.78)	(-1.38)	(-3.86)	
Temperature$_{c,d}$	-0.00245	-0.00245***	-0.00440*	-0.00827		
	(-1.07)	(-3.42)	(-2.38)	(-1.59)		
Windspeed$_{c,d}$	0.00291***	0.00291***	0.00323***	0.00241**		
	(4.63)	(27.82)	(8.68)	(3.53)		
GlobalRadiation$_{c,d}$	0.00061	0.00061***	0.00027	0.00067		
	(1.59)	(7.23)	(0.85)	(1.30)		
N	5,544	5,544	5,544	5,544	5,544	5,544
R-sq	0.680	0.680	0.630	0.546	0.632	0.556
Binding-Zone FE	X	X	X		X	X
Date FE	X	X		X	X	X
SE Clustered	X		X	X	X	X

Notes: The table shows the results of our baseline regression estimating the specification $Y_{c,d,h} = \alpha_c + \gamma_d + \delta_h + \beta * D_{c,d,h} + \omega * x_{c,d,h} + \mu * z_{c,j,d,h} + \epsilon_{c,d,h}$. The DiD analysis compares the capacity utilization of either production type in the control group (Poland and Slovenia) with those in the treatment group (Austria, Denmark, and the Netherlands) before and after the introduction of the inframarginal revenue cap on 01.12.2022. We employ electricity market controls (*Day-Ahead Price*$_{c,h}$ and *Total Electricity Imports*$_{c,h}$) in columns (1) – (5). We additionally employ weather control variable (*Temperature*$_{c,d}$, *Windspeed*$_{c,d}$, and *GlobalRAdiation*$_{c,d}$ in columns (1) – (4), which we obtain from the European Climate Assessment Dataset (van der Schrier et al., 2024). We employ bidding-zone-fixed-effects (besides in column (4)) and day-fixed-effects (besides in column (3)) as well as standard errors clustered by the bidding zone (besides in column (2)). The t-statistics are shown in parenthesis below the estimates, and the asterisks indicate the following levels of significance: * p<0.10, ** p<0.05, *** p<0.01

Figure 11: **Analysis of effect channels for the changes in electricity production**



Notes: The graph shows the results of our baseline regression estimating the specification in Equation (3) broken down by type of electricity production. The DiD analysis compares the capacity utilization of either production type in control group (Croatia, Poland, and Slovenia) with those in the treatment group (Austria, Bulgaria, the Czech Republic, Denmark, Lithuania, and the Netherlands) before and after the introduction of the inframarginal revenue cap on 01.12.2022. The data points are the estimates for β_j. The estimates include control variables for the day-ahead price in hour h in country c ($Day\text{-}Ahead\ Price_{c,h}$) and the sum of MWhs imported in hour h to country c ($Total\ Electricity\ Imports_{c,h}$) as electricity market controls. We employ bidding-zone- and day-fixed-effects as well as standard errors clustered by the bidding zone. The confidence bands show the 95% confidence interval.

Table 12: Difference-in-differences results - Changes in electricity production of renewable and fossil electricity sources

Panel A: Fossil electricity production types not subject to the inframarginal revenue cap

	(1)	(2)	(3)	(4)	(5)
$D_{c,d,h}$	0.0442	0.0442***	0.0385	0.0880*	0.0841
	(0.99)	(10.86)	(0.82)	(2.11)	(1.76)
N	10,080	10,080	10,080	10,080	10,080
R-sq	0.835	0.835	0.823	0.218	0.793
Electricity Market Controls	X	X	X	X	
Binding-Zone FE	X	X	X		X
Date FE	X	X		X	X
SE Clustered	X		X	X	X

Panel B: Renewable electricity production types subject to the inframarginal revenue cap

	(1)	(2)	(3)	(4)	(5)
$D_{c,d,h}$	-0.0924***	-0.0924***	-0.0877**	-0.0750**	-0.0742**
	(-3.26)	(-18.75)	(-3.04)	(-3.15)	(-2.92)
N	10,080	10,080	10,080	10,080	10,080
R-sq	0.525	0.525	0.468	0.166	0.490
Electricity Market Controls	X	X	X	X	
Binding-Zone FE	X	X	X		X
Date FE	X	X		X	X
SE Clustered	X		X	X	X

Notes: The table shows the results of a robustness test using the specification in Equation (3). The dependent variable is either the capacity utilization of electricity sources not subject to the inframarginal revenue cap (Panel A) or the capacity utilization of taxed renewable electricity sources (Panel B). The DiD analysis compares the capacity utilization of either production type in the control group (Croatia, Poland, and Slovenia) with those in the treatment group (Austria, Bulgaria, the Czech Republic, Denmark, Lithuania, and the Netherlands) before and after the introduction of the inframarginal revenue cap on 01.12.2022. We employ electricity market controls (D*ay-Ahead Price*$_{c,h}$ *and Total Electricity Imports*$_{c,h}$) in columns (1) – (4)). We employ bidding-zone-fixed-effects (besides in column (4)) and day-fixed-effects (besides in column (3)) as well as standard errors clustered by the bidding zone (besides in column (2)). The t-statistics are shown in parenthesis below the estimates, and the asterisks indicate the following levels of significance: * p<0.10, ** p<0.05, *** p<0.01.

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