The Gas Price Brake Increases Gas Prices: Empirical Evidence*

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Abstract

To help households and firms with exploding natural gas costs in the aftermath of the Ukraine war, a new policy called the "gas price brake" was implemented. Theoretical work has criticized that this policy creates incentives for moral hazard of energy providers to raise per-kWh gas prices. We employ a differences-in-differences approach and analyze data on offered gas contracts from two countries with comparable gas markets, where one country (Germany) has implemented a gas price brake and the other (Austria) has not. Our findings support the theoretical prediction, indicating that the gas price brake led to an increase in per-kWh gas prices in Germany of around 30%.

Keywords: Energy policy, Gas Price Brake, Moral Hazard.

JEL: D04, Q40, Q48, L50.

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1 Introduction

After Russia's invasion of Ukraine in early 2022, Europe was concerned about a significant gas shortage, primarily because of its substantial dependence on gas imports from Russia. This led to a surge in gas prices, putting financial pressure on firms and households alike. As a result, numerous European governments and the EU Commission started considering interventions in the energy market.[1] Many countries implemented policies that implied a reduction of energy taxes or the VAT, or on payments of direct transfers to firms and consumers (Sgaravatti *et al.*, 2023). Any intervention needed, however, to balance financial relief for natural gas consumers with maintaining incentives for energy conservation. In response to this dilemma, the German government rolled out an innovative policy known as the "gas price brake" starting from January 1st, 2023 (EWPBG, 2022), with a substantial budget of up to 200 billion euros being allocated to it. The policy serves two primary objectives: (i) providing financial relief to consumers of natural gas, and (ii) incentivizing consumers to conserve natural gas. It operates through a transfer scheme defined by the following equation:

$$\textit{transfer} = \textit{(contractual per-kWh price} - \textit{guaranteed per-kWh price)} \times \textit{quota.} \tag{1}$$

Here, the "contractual per-kwh price" refers to the consumer's current contractual price per kWh as set by the gas provider, the "guaranteed per-kWh price" refers to a price for natural gas of 12 EUR cent per kWh, and the "quota" is equal to 80% of the consumer's previous-year gas consumption. Thus, the gas price brake refers to a lump-sum transfer that varies in the consumer's current contractual per-kWh gas price.

Theoretical work has shown that the gas price brake achieves its two primary goals—relieving consumers and maintaining savings incentives—but encourages moral hazard by providers of natural gas which raises the fiscal costs of this policy (Dertwinkel-Kalt and Wey, forthcoming). As the transfer increases in the contractual gas price, consumers and gas providers can increase their joint surplus through higher contractual prices. Consumers *prefer* high-price contracts when a surge in gas price raises the transfer by more than it raises the gas bill, a condition that is not unlikely to hold in an energy crisis characterized by sharp price increases and declines in consumption levels. In this case, consumers' and gas providers incentives are aligned in so far as both benefit from higher prices. Altogether, as a response to the gas price brake, it is predicted that gas providers raise gas prices opportunistically.

[1] Sgaravatti *et al.* (2023) provides an overview of national fiscal policy responses to the energy crisis and European Commission (2023a) presents proposals to reform the EU's electricity wholesale market design.

In this paper we empirically investigate whether this holds true. For this, we compare two neighbouring countries with (as we will argue) comparable markets for natural gas, one of which has implemented the gas price brake (Germany) and one of which has not implemented this or a related relief policy (Austria). We empirically analyze the effects of the German gas price brake, and show that this is actually a misnomer, because contrary to its name the gas price brake has actually led to an increase in prices in the German gas retail sector.

As Austria did not implement an energy policy such as the German gas price brake, Austria may serve as a control group for Germany to estimate the effects of the German gas price brake. Domestic supplies in both markets only satisfy between 5 and 10% of total demand, thus both markets are heavily dependent on imported gas (Kühling *et al.*, 2023). Prior to the war, the majority of the imported gas for both countries stemmed from Russia. Currently, for Germany, the majority of gas imports come from Norway, with LNG (liquefied natural gas) also increasing in significance. Austria is still dependent on Russian gas, however, we control for possible confounding effects in our regressions. Wholesale supply markets have become essentially integrated across Continental Europe.[2] Thus, wholesale supply costs are nearly identical for the two countries. Both countries apply "incentive regulation" concerning grid cost, which motivates companies to reduce operating costs, improve service quality, and make efficient investments in the grid infrastructure. In both countries, grid access is similarly regulated either by the *German Bundesnetzagentur* or by the *Austrian E-Control*. Retail prices are not regulated (anymore) and can be set rather freely.[3] The two markets are also similar with respect to market structure. Incumbents, mostly former federal state or municipality controlled monopolies, are still very important for the supply of gas. Moreover, there appears to exist a lot of similarity concerning search costs, switching behavior and generally preferences for stable supply (Kühling *et al.*, 2023). Therefore, economic shocks in gas markets as well as consumer reactions appear to have been quite similar across countries. In the main text we also show that we do not get significant deviations from parallel trends before the gas price brake. Altogether, we argue that a difference-in-difference estimation of gas market outcomes after the introduction of the gas price brake in Germany relative to before its introduction and relative to the Austrian gas retail market

[2]The most important European reference hub index is the Dutch TTF ("Title Transfer Facility"). The most important reference index for Germany is the THE (Trading Hub Europe), the most important trading hub for Austria is Baumgarten with the CEGH (Central European Gas Hub). While there are national specificities in wholesale supply, these two price indexes are—as we show in the main text—nearly perfectly correlated.

[3]Liberalization of gas retail markets happened in Germany in 2005 and in Austria in 2002. For example, retail consumers can freely choose their gas supplier from that year on. The third EU energy package as well as its overhaul in 2019, the "Clean energy for all Europeans package", set the stage for all EU gas retail markets and include rules designed to benefit European energy consumers and protect their rights. They include the right to choose or change suppliers without extra charges, receive information on energy consumption, and quickly and cheaply resolve disputes.

can identify causal effects of the policy intervention.[4]

Our main finding supports the theoretical prediction of a price increase in retail tariffs, indicating that the energy price brake led to an approximately 30% increase in per-kWh gas prices in Germany. This also supports the theoretical implication of our model that the specific design of this relief policy, specifically the fact that the transfer is not restricted by a maximal amount, had a large impact on the economic effects.

Several robustness tests and differential specifications lead us to conclude that this effect is both causal and robust. First, our event study estimates indicates that all pre-treatment monthly indicator variables are insignificant, however all treatment effects become abruptly positive and significant. This is a first indication that the parallel trend assumption appears to hold. Second, we test the sensitivity of our findings against plausible unobserved violations of the parallel trend assumption, using various recent methodological advances in the estimation of event studies. Third, we include control variables in a difference-in-differences framework to control for the VAT tax reduction in Germany that happened in October 2022, for differential gas storage fill levels, differential gas imports from Russia and differential linear trends and also re-estimate our model for alternative outcome variables. In no specification of the difference-in-difference regression do we obtain smaller or insignificant treatment effects. Moreover, we also do not find statistically significant evidence of incomplete pass-through of the VAT reduction.

We proceed as follows. In Section 2 we derive our theoretical prediction, before we discuss our data in Section 3 and provide our main analysis as well as several robustness checks in Section 4. Section 5 concludes.

Related literature. The energy crisis sparked a literature on how to intervene in retail and reform wholesale markets. Batlle *et al.* (2022) discuss regulatory options to tackle the short run problems but more importantly long run scenarios in the wholesale energy, especially electricity, markets. They view a carefully implemented windfall profit tax (actually, an "income tax") to be the least harmful measure in the short run, and "stability options" for longer term solutions. Fabra (2023) recommends in line with the European Commission's proposal (European Commission, 2023b) to maintain short-term electricity markets, fostering long-term Power Purchase Agreements (PPAs) and Contracts-for-Differences (CfDs), as well as permitting member states to regulate retail prices during emergencies. Fabra (2023) suggests

[4]Another interesting aspect may be that the Austrian government from September 2022 on also intensively discussed a gas price brake, and this was demanded even by members of the ruling parties, see e.g. https://energynewsmagazine.at/2022/12/02/strompreisbremse-ja-gaspreisbremse-nein/. The Austrian finance minister, Magnus Brunner, however, did not endorse this idea, and Austria introduced only a related policy for electricity (while Germany introduced "brakes" for both electricity and natural gas). This may count as additional evidence that the two gas markets are quite comparable, having experienced similar economic shocks, and the main difference, starting from January 1, 2023, lies in one country implementing a brake for retail gas prices, while the other does not.

using more CfDs that match the specific needs of power generation technologies. This approach aims to balance efficient resource use with the need to manage risks over time by reacting to immediate price changes and considering future uncertainties.

Our paper also adds to the literature on the economic effects of relief policies in the current energy crisis. Haan and Schinkel (2023) analyze the Dutch price brakes and theorize that these are particularly detrimental increasing upward pricing pressure even compared to the German brakes. The reason is that while in the German ceiling system each household received support on a percentage (80%) of its *own* 2021 consumption, the Dutch brakes apply to an *average* household consumption level of electricity and gas in 2021. The high volumes to which the price ceilings apply have made the majority of Dutch households insensitive to market prices, raising in all probability prices, profits and subsidies. This again shows how, in market interventions, the specific design of the policy matters. We are the first to empirically analyze the price effects of relief policies in the energy crisis systematically.

More generally, our analysis of the effects of the gas price brake contributes to the empirical literature on the effects of energy savings policies (e.g., Reiss and White, 2008; Ito, 2015; Costa and Gerard, 2021; Bertoldi, 2022; Fraser, 2023; He and Tanaka, 2023), and in particular to the body of work that documents energy policies' rebounds or unintended adverse effects (e.g., Fraser, 2023; He and Tanaka, 2023).

2 Predictions

Typical contracts for natural gas are two- or three-part tariff contracts that include a per-kWh price, a fixed price that is independent of consumption, and possibly also a bonus payment for contract signature. For such contracts, Dertwinkel-Kalt and Wey (forthcoming) have shown that the gas price brake gives incentives for energy providers to raise per-kWh gas prices and for gas customers to sign these contracts, and this prediction is quite robust regarding the market structure and the gas contract structure.

The current regulation of the gas price brake requires, however, that the fixed payment reflects costs, and in addition, it virtually eliminated bonus payments (see §4 (1) EWPBG, 2022). Given those restrictions, the German energy suppliers can effectively only set the per-kWh price. When there is no fixed fee or bonus payment via which surplus can be shifted between the consumer and the supplier, consumers do not unequivocally prefer high contractual per-kWh prices. Intuitively, a consumer could benefit from a higher per-kWh price when it increases the transfer by more than the energy bill. Thus, it depends on a consumer's demand curve whether she prefers a high- or a low-price contract. In what follows we follow Dertwinkel-Kalt and Wey (forthcoming) to show this formally.

The gas price brake gives a transfer $T(p)$ defined by

$$T(p) := \max\{(p - s)\alpha\overline{x}, 0\}, \tag{2}$$

where p is the contractual per-kWh price that applies when the transfer scheme is in place, $s > 0$ is the guaranteed per-kWh price, $\overline{x} > 0$ gives a reference energy consumption level, and $\alpha \in (0, 1)$ gives some share of the reference consumption level; we call $\alpha\overline{x}$ the "quota".

Consumer utility from gas consumption x is given by $U(x)$, which is at least twice continuously differentiable over $\mathbb{R}_{\geq 0}$ and which satisfies $U(0) = 0$, $U' := \partial U(x)/\partial x > 0$, and $U'' := \partial^2 U(x)/\partial x^2 < 0$. Let $n \geq 2$ firms face per-kWh costs of c and set a per-kWh price $p \leq \overline{p}$, with $\overline{p} \in (c, k)$ to maximize profits. Consumer surplus from accepting a contract with price p is given by

$$CS(p) := U(x(p)) - px(p) + T(p).$$

How does overall consumer utility, $CS(p)$, depend on p? The effect of a marginal price increase on the consumer's overall utility is, by the envelope theorem, given by

$$\frac{\partial CS(p)}{\partial p} = -x(p) + \frac{\partial T(p)}{\partial p}. \tag{3}$$

Thus, we get

$$\frac{\partial CS(p)}{\partial p} \gtreqqless 0 \Leftrightarrow \frac{\partial T(p)}{\partial p} \gtreqqless x(p) \Leftrightarrow \alpha\overline{x} \gtreqqless x(p). \tag{4}$$

Overall consumer utility can never increase in p without a transfer scheme. However, if there is a transfer scheme, $T(p)$, and a price $\widetilde{p} \in [0, \overline{p})$ for which $\partial CS(p)/\partial p = 0$ holds, then overall utility is increasing in p for all $p > \widetilde{p}$ until $\overline{p}$ is reached. For this to happen, the marginal utility loss from a price increase, $x(p)$, must be smaller than the marginal increase of the transfer, $\partial T(p)/\partial p = \alpha\overline{x}$. This is more likely the larger p (because energy demand $x(p)$ is then relatively low) and the larger the quota $\alpha\overline{x}$. If the quota refers to an arguably relatively high pre-crisis consumption level, whereas $x(p)$ gives the lower demand at the high energy prices in the energy crisis, condition (4) for consumer utility increasing in price is likely to hold.

We now derive the equilibrium under competition. Under competition, $p^* = c$ must hold in the absence of the gas price brake $T(p)$. If this equilibrium prevails with the introduction of $T(p)$, then consumers obtain the entire transfer $T(p^*) > 0$. If, however, the transfer scheme implies that overall consumer utility is increasing in the contractual energy price at p^* (see (4)), then $\overline{p}$ is the unique equilibrium. If, alternatively, overall consumer utility increases not at p^*, but at a higher price in $(p^*, \overline{p}]$, then whether the equilibrium outcome is p^* or $\overline{p}$ depends on the exact shape of $U(x)$. Finally, if overall consumer utility is never increasing in p, then p^* is the unique equilibrium outcome. Consumer utility is always maximized, and firms could make strictly positive profits in the high-price outcome $\overline{p}$.

Proposition (Effects of the gas price brake with linear price under competition)**.**

i) If $\alpha\overline{x} > x(c)$, then $\overline{p}$ constitutes the unique equilibrium energy price.

ii) If $\alpha\overline{x} \leq x(c)$, the equilibrium price is either $p = c$ or $p = \overline{p}$.

Moreover, if $p = c$, then energy consumption is x^*. If $p = \overline{p}$, then demand is reduced to $x(\overline{p}) < x^*$.

This proposition (for a formal proof see Proposition 7 in Dertwinkel-Kalt and Wey, forthcoming) shows that the gas price increases under competition if gas consumption is smaller than the quota. Indeed, a substantial proportion of consumers reduced their gas consumption in 2022 below 80% of the per-crisis consumption (Ruhnau *et al.*, 2023); they find that households on average saved more than 20% until the end of 2022. If gas consumption is, without the price brake, above the quota, then the price brake can still increase the energy price if there is a price level $p \leq \overline{p}$ at which consumer utility increases with price. Clearly, then the introduction of the energy price brake and the resulting price increase must induce an energy consumption level below the quota. We therefore formulate our prediction:

Prediction. *The gas price brake raises the average per-kWh gas price.*

3 Data Overview

Our dataset is constructed from several sources. From *e'net*, a German software and data provider for the electricity industry, we obtained information on the gas tariffs in each of the 7,132 German zip codes. In total we have information on the development of gas tariffs for 843 different German gas retailers which offer 2,415 different tariffs, thus approximately three tariffs per retailer. The data were collected at the first of each month between January 2022 and June 2023, thereby covering the 12 month before the gas price brake came into force and the first six month afterwards. We process the data by building monthly average prices for each gas retailer. For Austria, which serves as our control group, we use information on gas contracts provided by *Durchblicker*, the largest Austrian price comparison platform for electricity and gas tariffs. The *Durchblicker* data are at the grid area (of which there are 18 in Austria) and have been made available at the daily basis. There are 47 gas retailers in Austria which offer in total 147 different gas tariffs (again approximately three different gas tariffs per retailer). Analogously, we also build monthly average prices for each Austrian gas retailer. Additionally, we collected data on wholesale spot and future contracts (TTF and CEGH gas) from Bloomberg, CEGH and the Bundesnetzagentur. Further, we collect data on the filling level of the national gas storage facilities from ENTSO-G (European Network of Transmission System Operators for Gas) as well as data on gas imports – specifically on imports from Russia – from the Bundesnetzagentur and from E-Control. All data are at the month-country level.

The data are summarized in Table I. The summary statistics already indicate a significant increase of per-kWh prices in Germany from an average of 9.5 cent per kWh before the gas price brake came into force to 12 cent per kWh afterwards, while Austrian per-kWh prices even slightly decreased. Similarly, the net total yearly contract prices in Germany have also increased after the gas price brake became effective in Germany, while the total contract price declined in Austria.

Table I: *Summary statistics*

	Germany				Austria			
	Mean	Std.Dev.	Min	Max	Mean	Std.Dev.	Min	Max
Pre-Gas Price Brake								
Per-kWh price	9.54	3.35	4.97	26.63	14.54	5.43	3.88	30.04
Total annual price	1,934	607.2	837.9	5,117	3,013	974	986.6	5,797
Wholesale price	142.5	45.79	94.68	236.6	128.6	44.90	83.08	234.91
Russian gas imports (%)	20.92	20.50	0.00	51.32	56.48	21.06	17.00	81.00
Gas storage fill level (%)	62.97	26.20	25.52	99.36	45.13	27.28	13.89	94.72
LNG	2.40	8.07	0.00	29.55	0.00	0.00	0.00	0.00
Post-Gas Price Brake								
Per-kWh price	11.97	2.73	5.45	25.13	13.12	5.43	4.63	29.00
Total annual price	2,357	503.25	1,080.84	4,623	2,674	969.6	1,101	5,785
Wholesale price	92.45	32.84	32.17	117.6	59.48	27.24	33.65	119.37
Russian gas imports (%)	0.00	0.00	0.00	0.00	59.29	8.62	47.00	74.00
Gas storage fill level	80.89	8.75	64.81	87.38	73.57	6.38	66.76	84.84
LNG	142.63	43.46	113.00	230.07	0.00	0.00	0.00	0.00

Note: This table reports summary statistics of the main variables. All price variables are net of VAT.

Clearly, a causal effect of the gas price brake on prices cannot be derived from these figures before further analyzing the pre-treatment development. The left-hand figure in figure I shows how the monthly (log) net average prices per unit in Germany and Austria developed from January 2022 to May 2023. The gray shaded area represents the introduction of the gas price brake in Germany (but not in Austria) in January 2023. Eyeballing suggests that average (log) net per-kWh prices have evolved quite parallel in Germany and Austria before the introduction of the gas price brake in Germany. The difference in per-kWh prices is fairly stable throughout 2022 with German per-kWh prices being on average approximately 15% lower than Austrian tariffs. The price difference does not appear to have changed significantly between October and December 2022, which suggests that the VAT reduction has essentially been passed on to consumers. While the price difference between German and Austrian gas was relatively stable in the period before the introduction of the gas price brake, the difference has narrowed significantly since the introduction of the gas price brake. This becomes particularly apparent in January 2023, the month of the introduction of the gas price brake, when German gas retail prices kept further increasing, while Austrian gas retail prices already declined.

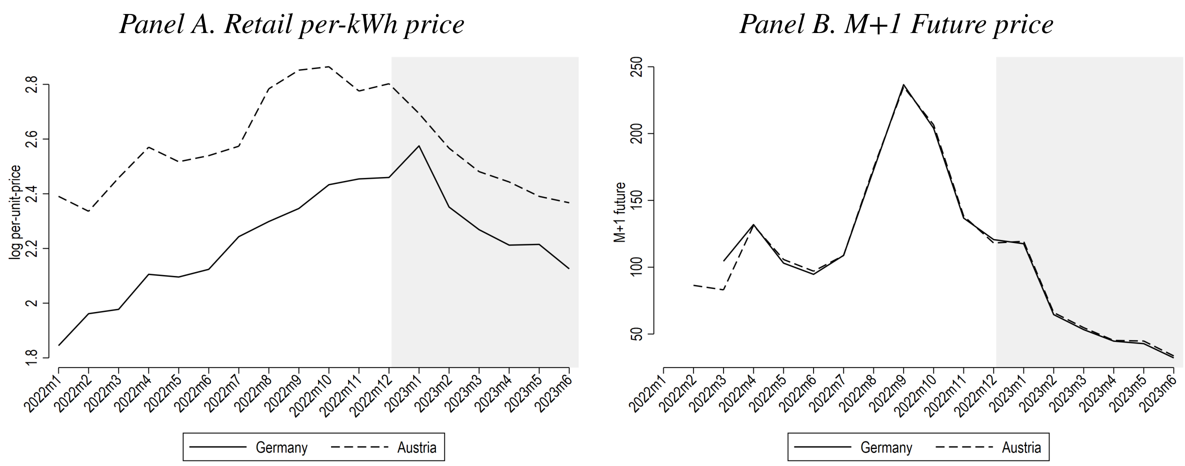


Figure I: *Development of retail and wholesale prices*

The right-hand figure depicts the evolution of one-month-ahead future prices in EUR/MWh, provided by the Bundesnetzagentur for Germany as well as the CEGH for Austria (Central European Gas Hub, which is the main natural gas trading platform for Austria). The futures-prices evolved similarly for suppliers in Austria and in Germany, underlining cost-structure similarity in both countries. The difference in retail per-kWh prices is thus mostly explained by differences in grid fees and energy taxes as well as margins.

4 Empirical Strategy

Our empirical strategy to recover the causal effect the German gas price brake had on gas tariffs relies on a difference-in-differences (DD) approach with Austria serving as the control group. The two main assumptions for a DD design to recover causal relationships, the no-anticipation and the common trends assumption, must be fulfilled. The no-anticipation assumption essentially states that the average causal effect of adopting treatment in a period before the gas price brake is zero. The assumption could fail – for example – if treatment exposure occurs prior to the actual treatment, i.e. if behavior changes due to expectations of future treatment. Two arguments make it, however, unlikely that the no anticipation assumption is violated in our case. First, although the energy price brake (gas and electricity) was proposed already in October 2022, there was a long discussion process on whether and, if so, in what specific form the brakes would be introduced. Moreover, during the whole discussion process in the fall of 2022, EU member states as well as the European Commission raised considerable concerns about the German brakes that they would distort competition in the single market.[5] The formal decision to introduce the energy price brakes was eventually taken by the German Parliament ("Deutscher Bundestag") on the 15th of December, 2022. Thus, it was not clear in the months before January, 2023, whether and if so in what form the brakes would be installed, so that neither suppliers nor consumers had an incentive to react to them before their introduction. The fact that a proposal and its discussion do not guarantee the implementation of an energy policy is evident from the case of the *Gasumlage,*[6] an energy policy proposed and debated prior to the gas price brake until end September 2022. Unlike the gas price brake, which aimed to relieve gas consumers, the *Gasumlage* would have introduced an additional surcharge for gas customers. Despite the discussions, the *Gasumlage* was ultimately cancelled before it could be implemented. Second, even if suppliers or consumers correctly anticipated the eventual introduction and design of the brakes say in October or November 2022, it would not be incentive compatible to either offer or demand higher-price contracts during that period as the relief measures were not set to take effect until January 2023.[7] Furthermore, for providers, offering substantial bonuses to attract consumers into these costly contracts could have been a risky strategy prior to the definitive decision on the gas price brake. The situation with the initially proposed and later cancelled *Gasumlage* could serve as a cautionary example here.

The second assumption, the common trends assumption, essentially states that in the absence of treatment exposure, the average change across post-treatment time periods would be the same in the treatment group and the comparison group. In our case, common trends imply that German gas retail prices would have continued on the same time trend as Austrian gas retail prices if not for the gas price brake. While neither of these two assumptions is fully testable because both depend on unobservable

[5]See e.g. https://www.tagesschau.de/inland/innenpolitik/doppelwumms-101.html.

[6]See https://www.bmwk.de/Redaktion/DE/Downloads/F/faq-gasumlage.pdf.

[7]Another argument may be that similar discussions occurred in Austria at the same time, however, Austria did not introduce a gas price brake. So any anticipation effects may be the same across countries, purged by the DID.

counterfactual prices, the arguments and evidence supplied above appear to validate these assumptions. We in addition provide robustness checks, e.g. the method by Rambachan and Roth (2023), to further probe the credibility of these assumptions in our case.

4.1 Event Study

Following on from *Prediction 1*, we first examine the impact of the German gas price brake on per-kWh gas prices in a non-parametric graphical approach. For prices charged by gas retailer i at calendar month t, we denote the months since the introduction of the gas price brake as r_{it}. We estimate a non-parametric event study regression of the following type:

$$log(p_{it}) = \gamma_i + \gamma_t + \sum_{\tau=-12}^{6} \delta_\tau \cdot I\{r_{it} = \tau, i \in GER\} + \epsilon_{it} \quad (5)$$

Here, $p_{i,t}$ represents the per-kWh price of gas retailer i at calendar month t. The specification includes fixed effects for gas supplier (γ_i) and calendar month (γ_t). We further include relative time to treatment indicator functions and normalize $\tau = -12$, i.e. the first month of our observation period, to zero. ϵ is the idiosyncratic error. Drawing on Bertrand *et al.* (2004), we cluster standard errors at the gas supplier level to allow for an arbitrary correlation of error terms over time within each of the sample's 887 suppliers (843 German and 44 Austrian suppliers).

The regression results from equation 5 are visualized in Figure II which shows the point estimates of the monthly event dummies and the corresponding 95% confidence intervals both before and after the introduction of the gas price brake. While all pre-treatment indicator dummies are insignificant, following the introduction of the gas price brake in Germany, each monthly treatment effect abruptly becomes positive and significant. The treatment effects remains fairly stable at around 0.3 until we reach the end of our observation period in June 2023.

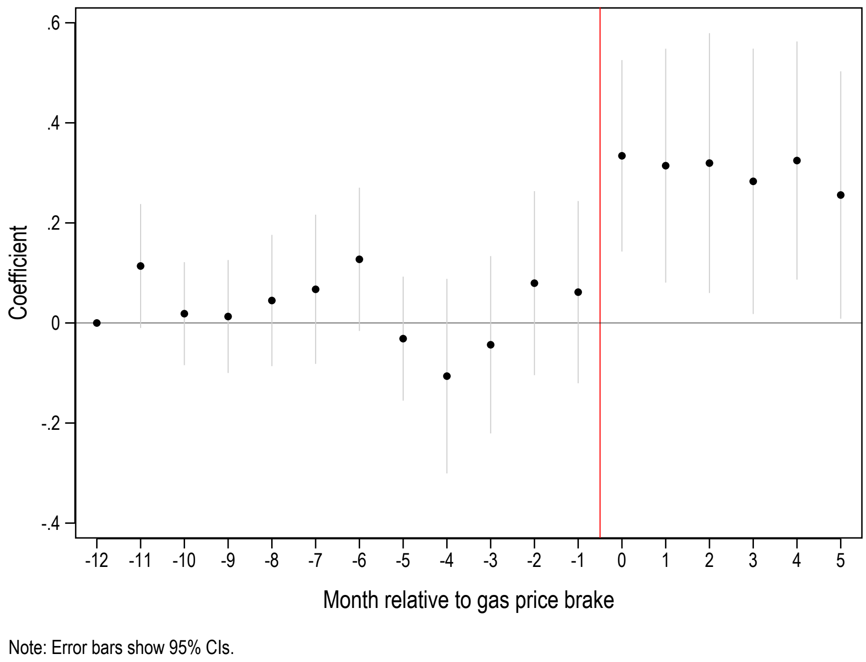


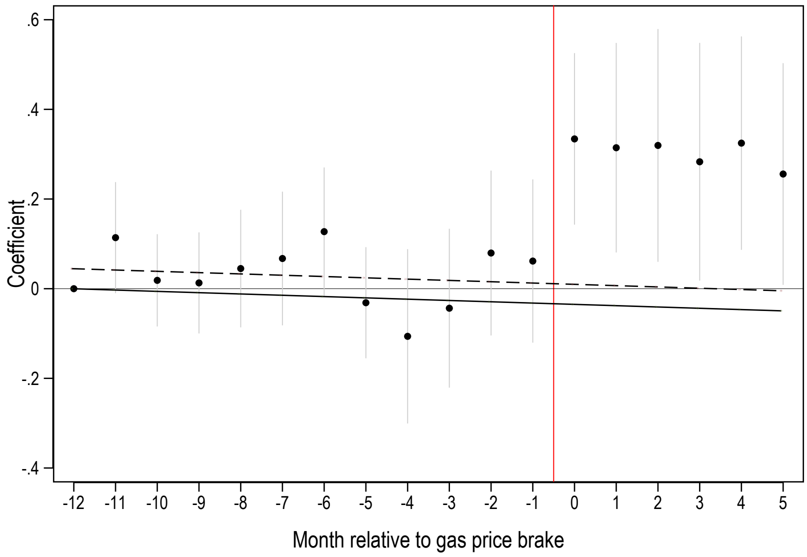
Figure II: *Nonparametric event study*

For the post-treatment period $\tau > 0$, coefficient estimates δ in equation 5 yield causal estimates of the gas price brake's impact on gas tariffs under the assumption that in the absence of treatment exposure German gas retail prices would have continued on the same time trend as Austrian gas retail prices. As all event dummies are insignificant before the introduction of the gas price brake there is some evidence of non-parallel pre-trends suggesting that gas retail prices in Germany would have developed similarly to Austria in the absence of the gas price brake.

4.1.1 Rotated Event Study

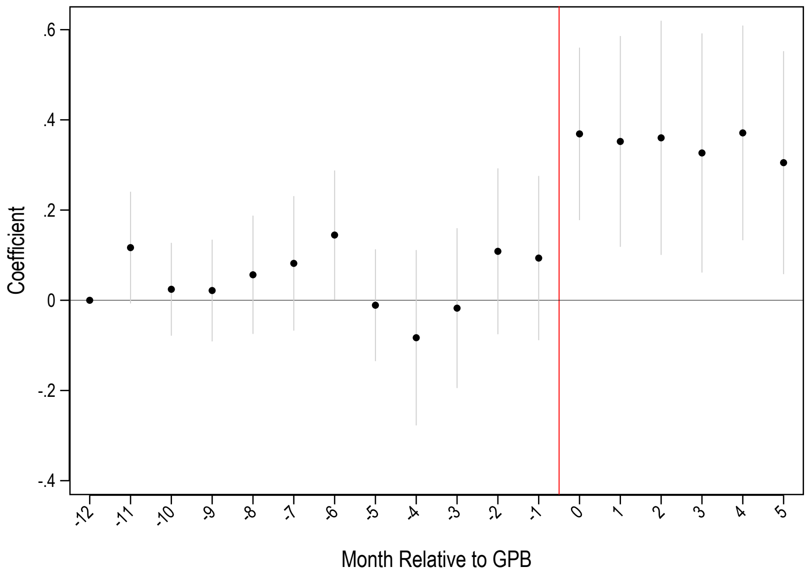
Despite insignificant pre-treatment event dummies there may still be concerns on the validity of the parallel trend assumption (Roth *et al.*, 2023). To further investigate the possibility of differential trends we apply the approach used in Dustmann *et al.* (2022) and Fenizia and Saggio (forthcoming). We first fit a linear trend based on our pre-policy event-study coefficients only and extrapolate it for the post-policy period. For better visualization we shift the pre-trend line vertically so that it intersects the reference period (Panel A of Figure III). We then plot the deviations between the event-study coefficients and this linear trend, thereby visualizing any trend breaks in gas tariffs at the time of the implementation of the gas price brake. Putting it more illustratively, we rotate the event study around the estimated and extrapolated pre-treatment trend. The linear pre-treatment trend is rather flat. Since it tends to go in the opposite direction of the post-event coefficients we estimate an even slightly larger price increase after adjusting for differential pre-trends (Panel B).

Panel A. Event study estimates and linear pre-GPB trend



Note: Error bars show 95% CIs. The dashed black line is an OLS regression line fit to all pre-gas price brake event-study es
vertically shifted to better illustrate the rotation executed in Panel B. Slope: -.003

Panel B. Rotated event study



Note: Error bars show 95% CIs. Coefficients and CIs rotated around the linear trend with slope -.003

Figure III: *Event study estimates adjusted for pre-trend*

4.1.2 Further Addressing Potential Differential Pre-Trends

Next, we test the sensitivity of our findings against plausible violations of the parallel trend assumption, using the recently introduced approach by Rambachan and Roth (2023). We do this by allowing either a deviation from a parametric pre-trend or allowing for a one-period deviation from parallel-trends that is caused by an exogenous shock that is similar in size to pre-treatment shocks. Extrapolating the pre-treatment trend requires to assume that the pre-treatment effect of the confound remains stable post-treatment (see, e.g. Freyaldenhoven *et al.* 2019, Roth *et al.* 2023.)

Smoothness Restriction. In implementing this approach, we define the set of of possible differences in linear trends $\Delta^{SD}(M)$ and allow linear, but also second-degree deviations from the pre-trend. The reduced-form parameter vector β can be decomposed into $\beta = \binom{0}{\tau_{post}} + \binom{\delta_{pre}}{\delta_{post}}$, i.e. a treatment effect τ_{post} and differential trends δ for the pre- and post-period. When correcting for a linear pre-trend, as seen in Figure III, we assume the parametric form $\delta_{pre} = \gamma \cdot t$ and extrapolate this trend into the post-period. In this part of the analysis, we relax this assumption by allowing deviations from this pre-trend by M in each period. This M is then adjusted as part of a sensitivity analysis that allows to find the *maximum deviation* of linear pretrends that still rejects the null-hypothesis of a null-treatment effect.

More formally, we bound the change in slope of the differential trend between Germany and Austria between two periods using the following formula:

$$\Delta^{SD}(M) :\equiv \{\delta : (\delta_{k+1} - \delta_k) - (\delta_k - \delta_{k-1})| \leq M, \forall t\} \tag{6}$$

We estimate M^* such that it is the break-down value for the treatment coefficient for the first period τ_1. Then, M^* represents the upper-bound of a violation of pre-trends that would render τ_1 insignificant on the conventional significance level of 5%. Appendix Figure A.1 shows the confidence intervals of τ_1, under a violation of pre-trends equal to M. Therefore, the break-down value M^* equals 0.09. The estimated pre-trend using pre-treatment coefficients for 2022 equals −0.003. To put this into perspective, for the first treatment coefficient to be not be distinguishable from a diverging trends effect, the estimated time trend not only has to change sign but also become approximately thirty times bigger in January 2023. If we introduce monotonicity restrictions on $\Delta^{SD}(M)$ and allow for only positive slope deviations, we obtain a critical M^*_{MR} value of 0.01. Still, the pre-trend has to reverse sign and become approximately three times as big.

Relative Magnitudes. Another form of sensitivity analysis is to allow for post-treatment shocks that are similar in size to pre-treatment shocks. This sensitivity test is relevant for our setting since there were significant shocks to wholesale prices in European gas markets caused by trade frictions following the Russian invasion in February 2022. Figures I right-side and II do not suggest that these shocks had structurally different effects on either country. Nevertheless, we address this issue by allowing for deviations from parallel trends in post-periods up to M times the maximum deviation from parallel trends in the pre-periods. Formally, as Rambachan and Roth (2023) state it,

$$\Delta^{RM}(M) = \{\delta : \forall t \geq 0, |\delta_{t+1} - \delta_t| \leq M \cdot \max_{s<0} |\delta_{s+1} - \delta_s|\} \tag{7}$$

Again, we look for M^* which represents the maximum scale of the maximum parallel-trends violation in the pre-period which renders the treatment effect τ_1 insignificant. Appendix Figure A.2 plots the confidence sets for different values of M. The value of M^* lies between 1 and 1.2. Considering the size of this critical value, the treatment effect in January 2023 could be explained by a shock similar in size to the one in September 2022. As this shock was truly exceptional in size for the whole of Europe we argue that it is implausible to attribute the observed treatment effect to such an exogenous effect. Thus, even when allowing for external shocks similar in size to the turbulences in summer 2022, we can reject the null hypothesis $\tau_1 = 0$ at the 95% level.

4.2 Average Differences-in-Differences

In the next step we estimate the average treatment effect of the gas price brake in a differences-in-difference (DD) estimation. We iteratively add control variables to the regression to test the sensitivity of our findings. In its richest version the DD regressions model we estimate can be written as follows.

$$\begin{aligned} log(p_{it}) =& \gamma_i + \gamma_t + \beta_1 post_t \cdot GPB_i + \beta_2 trend_{it} \cdot Germany + \beta_3 VAT_{it} \\ &+ \beta_2 Russian\ imports_{it} + \beta_2 storage_{it} + \epsilon_{it} \end{aligned} \tag{8}$$

Here, $post$ is equal to 1 from January 2023 onwards, i.e. when the gas price brake became effective in Germany, and GPB indicating whether a gas retailer is active in Germany and hence is subject to the gas price brake regime.[8] $trend \cdot Germany$ is an interaction term of an integer monthly trend variable and an indicator variable for Germany to control for potentially differential linear developments between the two countries that are unrelated to the gas price brake. VAT is a an indicator variable that is equal

[8]In our set up there is no problem related to staggered adoption since the "Gas Price Brake" was introduced on the same day, January 1st, 2023, for all suppliers of gas, see the recent literature on staggered adoption, e.g. De Chaisemartin and d'Haultfoeuille (2020) or Callaway and Sant'Anna (2021).

to 1 from October 2022 and 0 before for Germany while it remains 0 for Austria throughout the entire observation period. It is included to control for the decrease in VAT in Germany from 19% to 7% that became effective in October 2022 and lasted until the end of our observation period. Since our dependent variable is expressed in net prices, i.e. excluding VAT, an insignificant coefficient on the dummy VAT would imply full pass through of the VAT rate decrease (then gross prices decreased by the VAT decrease and the net price stayed the same). Including the dummy VAT allows us to disentangle the gas price bake effect from the effect of potentially incomplete tax pass-through on net prices. $Russian\, imports$ denotes the share of Russian gas imports in total gas imports of the respective country. One competing hypothesis to a causal interpretation of the gas price brake may be that the two countries differentially fast dissolved from Russian gas imports, and this also differentially affected retail tariffs. For example, if Russian gas is cheaper than e.g. LNG gas (which it is) and Germany dissolved faster than Austria from Russian gas (which it did, see left panel of Figure IV, retail tariffs in Germany may rise relative to Austria.[9] While we have already shown that wholesale prices are nearly identical in the two countries (see Figure I), we control for this possibility in the DD regressions by including the share of Russian gas imports. Finally, we control for gas storage levels, $storage$, which potentially affect retail tariffs.

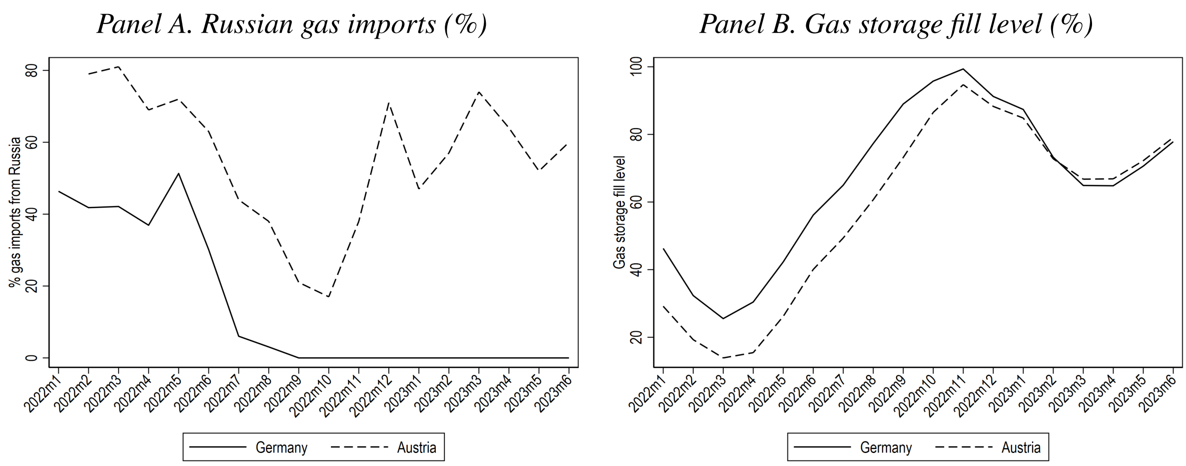


Figure IV: *Development of gas imports from Russia and gas storage fill level*

Table II presents the main results. In panel A the dependent variable is the log of the net per-kWh price, as defined by the data providers, in panel B we adjust the per-kWh price and net out grid costs in both countries, and in panel 3 we take as the dependent variable the log of total annual costs for

[9]On 26 September 2022, a series of underwater explosions and consequent gas leaks occurred on the Nord Stream 1 (NS1) and Nord Stream 2 (NS2) natural gas pipelines, two of 23 gas pipelines between Europe and Russia. Both pipelines were built to transport natural gas from Russia to Germany through the Baltic Sea, and are majority owned by the Russian majority state-owned gas company, Gazprom. After these sabotage attacks, Germany stopped importing Russian gas for good.

gas of a representative household consuming 18,000 kWh. Column 1 including no control variables estimates average treatment effects on the treated of between +29.6% (≈ $(\exp^{(-0.259)} - 1)$) and +32.6% depending on the price variable used. In column 2 we add a trend times Germany interaction variable to the estimations. Trends are never significant or when they are (as in column (4) they obtain a *negative* coefficient. Estimated treatment effects stay positive and significant ranging between +25.7% and +36.2% depending on whether the linear trend is estimated slightly negative or slightly positive.

Table II: *Difference-in-differences models*

	(1)	(2)	(3)	(4)
Panel A: per-kWh price				
Gas price brake	0.276 (0.077)***	0.309 (0.067)***	0.305 (0.066)***	0.315 (0.044)***
Trend × Germany		-0.004 (0.009)	-0.007 (0.010)	-0.016 (0.011)
VAT regime			0.045 (0.058)	0.051 (0.053)
Russian gas imports (%)				-0.002 (0.001)***
Gas storage fill level				0.000 (0.001)
Panel B: Alternative per-kWh price				
Gas price brake	0.282 (0.079)***	0.229 (0.068)***	0.222 (0.067)***	0.351 (0.046)***
Trend × Germany		0.006 (0.009)	0.000 (0.010)	-0.026 (0.012)**
VAT regime			0.074 (0.058)	0.082 (0.054)
Russian gas imports (%)				-0.003 (0.001)***
Gas storage fill level				0.002 (0.001)***
Panel C: Total annual costs for gas				
Gas price brake	0.259 (0.066)***	0.234 (0.060)***	0.230 (0.059)***	0.298 (0.040)***
Trend × Germany		0.003 (0.007)	-0.001 (0.008)	-0.017 (0.009)*
VAT regime			0.044 (0.051)	0.040 (0.048)
Russian gas imports (%)				-0.002 (0.001)***
Gas storage fill level				0.001 (0.001)**
Obs.	9,849	9,849	9,849	9,818

Note: This table reports difference-in-differences estimates of the effect of the gas price brake on various (log) price variables. All models contain fixed effects for calendar month and gas retailer. Standard errors are clustered at the gas retailer level. Significance levels: * < .1, ** < .05, *** < .01.

In column 3 we additionally control for the decrease in the VAT rate in Germany from 1st of October 2022 onwards via introducing a dummy variable, VAT, taking on the value of one from October 2022 onwards for Germany and zero else. As explained above, since we use net prices (excluding VAT) on the left hand side of the regression, an insignificant coefficient would imply full pass through of the VAT rate decrease. In fact, this is what we find in all specifications. More importantly for our purposes, the VAT rate reduction in Germany does not impact our estimates of the average treatment effects of the gas price brake. The same can be said of introducing the additional plausible controls Russian share of imports and gas storage fill levels in the two countries (column 4). In particular, the share of Russian imports attains a negative and significant coefficient in all three specifications, but the effects of the gas price brake remain the same. Thus, while the sources of imported gas differ in the two countries particularly from September, 2022, onwards, when Germany stopped importing gas from Russia but not Austria (see again Figure IV), this does not affect the effects of the gas price brake. Concluding, the gas price brake in Germany is likely to have increased gas retail prices in Germany by approximately 30% relative to Austria.

5 Discussion and Conclusion

In the energy crisis, the German government implemented a gas price brake to protect consumers from surging prices while maintaining savings incentives. Both objectives were achieved with the gas price brake. However, what was not anticipated was that firms might respond to the gas price brake by opportunistically increasing natural gas prices. By now, the Federal Cartel Office in Germany has recognized this issue and initiated 57 investigations against energy providers suspected of exploiting the energy price brake mechanism (Bundeskartellamt, 2023). Our findings support this concern, documenting an approximate 30% increase in natural gas prices due to the gas price brake across all of our empirical specifications.

The reason that a price rise represents the optimal response of firms to the gas price brake can be attributed to the policy's novel feature whereby the transfer increases with the contractual gas price. Energy policies lacking this feature (such as lump-sum transfers or tax cuts) would not have induced such opportunistic firm behavior. It is also insightful to compare the German gas price brake to the energy policy in other countries such as Austria or the Netherlands. These countries implemented price brakes for electricity. The policies include features that mitigate and other features that exacerbates exploitation incentives compared to the German price brake. On the one hand, the quota in Austria and the Netherlands are not household-specific but refer to an average nationwide energy consumption level. This approach exacerbates exploitation incentives as more households (particularly small ones) will consume less than the quota, thus making high-price contracts more attractive for households and this making it more likely for firms to increase prices opportunistically. On the other hand, Austria's policy subsidizes the electricity price up to the quota only with a capped subsidy per kWh. This feature dampens exploitation incentives compared to the German price brake.

Our findings basically show that that firms react to their incentives, and flawed designs of the policies made them unnecessarily expensive for the taxpayer. The problems we point to could be circumvented by helping households via lump sum payments. This would achieve the relief policies' aim of helping households shoulder their energy bills and at the same time not distort pricing incentives of firms. If this policy is not possible for political reasons, households should only be subsidized up to an individual quota (as in Germany), to maintain search and switching incentives. Additionally, the price subsidy per kWh could be capped to mitigate the incentives to raise prices opportunistically.[10] Of course, capped payments would not fully insulate consumers from energy price increases, however, they would improve the trade off with allocative efficiency.

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[10] Such an amendment to the gas price cap was adopted in 2023, but it only applied to large firms (DBAV, 2023). Under this adjustment, the transfer per kWh was limited to a maximum contractual price.

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Appendix

Figure A.1 and A.2 depict the confidence sets for different values of M as defined in equation 6 and 7. The confidence sets were calculated using the R package provided by Rambachan and Roth (2023). The blue confidence intervals represent the authors results of estimating the non-parametric event study defined by equation 5. The critical values M^* can be found at the first intersection of the confidence sets and the x-axis, i.e. the point where the null-hypotheses cannot be rejected anymore at the 95%-level.

Panel A. Without monotonicity restriction *Panel B. With Monotonicity restriction*

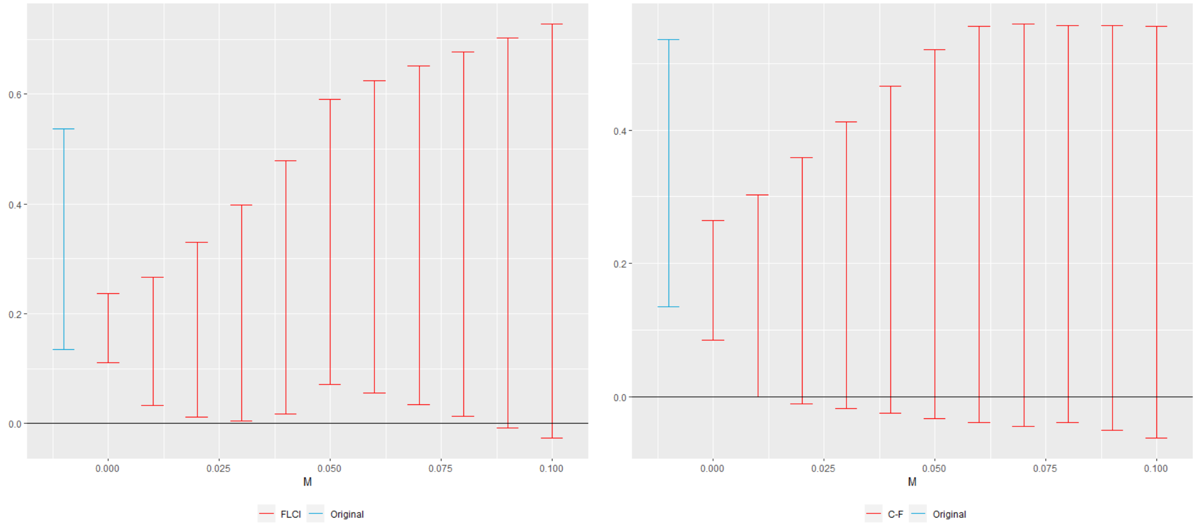

Figure A.1: *Sensitivity estimates based on Rambachan and Roth (2023)*

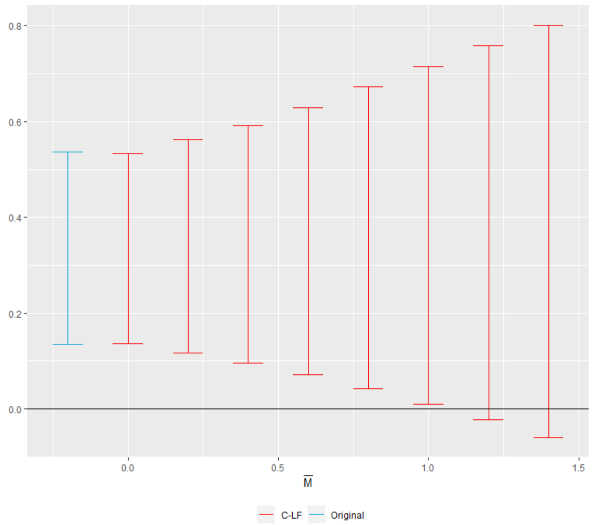

Figure A.2: *Relative Magnitude estimates based on Rambachan and Roth (2023)*