IJEEP
INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY
EJ EconJournals
ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2023, 13(2), 86-91.

EconJournals

The Impact of Natural Gas Prices on Electricity Tariffs in the UK

Mohammad Althaqafi*

Umm Al-Qura University, Saudi Arabia. *Email: mtabed@uqu.edu.sa

Received: 03 November 2022 **Accepted:** 15 February 2023 **DOI:** https://doi.org/10.32479/ijeep.13908

ABSTRACT

The study was conducted to know the impact of natural gas prices on electricity tariffs in the UK. Although the United Kingdom doesn't rely directly on Russian gas supplies, still, we are acutely vulnerable to the energy catastrophe that has resulted from the invasion of Ukraine. The UK is part of the European Union and that is a reason the UK energy tariff and natural gas prices are closely connected to the EU. The literature review will elaborate more on the impact of the natural gas price on electricity tariffs in the UK by using an unrestricted vector autoregressive (VAR) model. The historical data on natural gas prices have been collected from the official government website of the UK and from the of gem website. The sample size was taken annually from January 2010 to August 2020. Our empirical study is close to one study that investigate the nexus between electricity prices and fossil fuel prices in the U.S economy. The results clearly show that natural gas prices and electricity prices in level form were non-stationary, however, when they are initially differentiated, they become stationary and we used pre root test such as augment Dickey Fuller Test and Phillips-Perron. Secondly, in seven power tariffs, we found a substantial bivariate co-integration long term link between electricity tariff and natural gas prices. Thirdly, the unrestricted vector autoregressive model suggested a significant upward (positive) impact of natural gas price on domestic electricity rates in the short run. In the end, the study found the significant positive impact of the natural gas price and electricity prices on commercial rates and on industrial rates.

Keywords: Natural Gas Prices, Electricity Tariff, VAR Model, Co-integration, United Kingdom, Time Series Analysis
SJEL Classifications: Q4, Q41, Q43

1. INTRODUCTION

The United Kingdom is the sixth largest country in terms of economy (Perkins and Syrquin, 1989). As the UK is a market-oriented country its economy is always booming since industrialization (Van Bavel, 2003). The energy sector of the UK is mainly based on fossil fuels (Brockway et al., 2019). Domestic consumption increased by 2.3% or 0.8 mtoe with a 4% increase in electricity and 2% in gas. Electricity is regulated by private organizations and it is a highly restricted market and the barrier to entry is very high. Which means that it has been liberalizing for many years and is not possible to end the market dominance in the price structure (Tamás et al., 2010). The UK is a net importer of natural gas a major source of its energy, with some dependence on supplies from interconnectors from Europe. The domestic production of energy in the UK has declined for nearly two decades now and import bills for natural gas are growing. The UK is a net importer of energy (Acquah-Andoh et al., 2019). Natural gas prices are considered to be the best price for analysis and explaining variables related to the macroeconomics and financial economics and its impact on electricity tariffs in the UK.

The tariff is an amount that charged by customer for their gas and electricity use. There are two type of tariffs fixed and variable. A fixed rate tariff ties in the energy cost for a set amount of time, often a year or over, while variable tariff prices change with the market (Borenstein and Bushnell, 2015; Lewis, 1941). The cost of gas is rising and the UK is facing pricing crises. In the variable tariff the amount is usually high because the supplier adjusted the price per unit (kWh) as market changes. As far as fixed tariff is concerned the prices remain same till your tariff ends (Grubb, 2022; Moore and Boothroyd, 2022).

On the supplier side, suppliers have to buy purchase reserves at huge amount and automatically these prices are going to affect the customer demand price as shown in Figure 1. Suppliers cuts their supply to save the reserve for the emergency situation ant automatically that will create the shortage of natural gas and it will impact the electricity prices (Cherp et al., 2012). The government of the UK sets new energy prices which favor the customer. The Energy Bills Support Scheme provides a £400 non-repayable discount to eligible households to help with their energy bills over winter 2022 to 2023 (Harari et al., 2022).

2. LITERATURE REVIEW

Natural gas, an important ingredient in the global energy market is poised to play an increasingly important role in meeting global energy demand (Mishra, 2012). Natural gas is important in the UK's energy mix (Bahgat, 2006) and gas is mostly used for heating purposes Due to the bad weather and temperature conditions. Total gas consumption in 2020 was 1.3% higher than in 2018 with a 3.3% increase in domestic consumption offset by a 2.0% decrease in non-domestic consumption. Unlike electricity, the domestic sector is the larger consumer, consuming 64% of 2020 total gas consumption in Great Britain (SEGS, 2021).

Natural gas becoming the premium fuel of the world economy. Also, natural gas is the purest and most hydrogen-rich hydrocarbon energy source accessible, having excellent energy conversion efficiency for power production (Economides and Wood, 2009). In the past three decades natural gas has slowly but progressively increased its share of the energy mix (McGlade et al., 2018). Natural gas has the lowest combustion carbon intensity of the three major fossil fuels (IPCC, 2006). Natural gas may be able to play during a transition to a global low-carbon energy system. Climate change policies are a key dynamic that will affect future levels of gas consumption (Bradshaw et al., 2014).

The pioneer studies analyses the relationship between the relationship between natural gas and electricity (Serletis and Herbert, 1999). There were many studies that have been published and most of them find the interaction between the natural gas and electricity prices, for example, (Asche et al., 2006; Bosco et al., 2010; Emery and Liu, 2002; Furió and Chuliá, 2012; Mjelde and Bessler, 2009; Mohammadi, 2009; Muñoz and Dickey, 2009; Nakajima and Hamori, 2012; Woo et al., 2006), among many others. Few of them studied the correlation between electricity and natural gas prices (Emery and Liu, 2002).

The high demand of the gas increases the prices of natural gas and due to this reason there is an adequate shortages of the resources. The extreme case would that there will be no electricity available for the household in the coming days. If the relation with Russia would not become better. The energy gas prices caps also increase and is going to implement from the 1st of October 2022.

3. METHODOLOGY

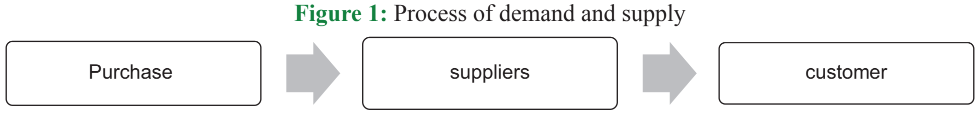
3.1. Research Design

To conduct the research for this study, a research plan was generated to plan out the study. Starting from the primary data collection for the Literature Review, we gathered 18 sources to reference and present a brief review of previous literature. This was followed by the collection of secondary sources like guidelines, reports, datasets, and conference proceedings to support our findings. These sources were then collated and organized to be presented and utilized for the Empirical Analysis, followed by the final analysis that incorporated existing datasets, primary and secondary sources, and the findings of this research. Figure 2 depicts the research design for this study.

3.2. Variable Description

Variables	Definition
g	Natural gas prices
e^{DAC}	This tariff applies to energy services designed solely for domestic use, and it is applied individually to each dwelling, apartment, condominium, or apartment housing that is regarded to have a high consumption
e^{T2_5}	This fee will be applied to the first 50 kWh under the eT2 tariff. Where eT2 is defined. The ordinary service up to a demand of 25 kW Except for services that expressly bind his rate, this rate will apply to all services designed for low voltage energy to any application, with demand up to 25 kilowatts
e^{T2_10}	This fee will be applied to the second 50 kW under the eT2 tariff
e^{T3}	General service for demand exceeding 25 kW. Except for services that expressly bind your rate, this rate will apply to all services designed for low voltage energy to any use with a demand of more than 25 kilowatts
e^{T5}	Street lighting service. This price only applies to the delivery of power for semaphores, decorative lighting, and seasonal lights, as well as streets, squares, parks, and public gardens
e^{T5A}	Street lighting service. Except for the constituencies that determine the rate in T5, this tax only applies to the delivery of energy for the service semaphores, ornamental lighting, and seasonal illumination, streets, squares, parks, and public gardens across the country
e^{T6}	Public service for pumping drinking water or waste. This pricing will apply to the delivery of power for public services such as water or sewage pumping
e^{OM}	Ordinary tariff for ordinary service medium voltage with a demand of less than 100 kW. This pricing will apply to energy-to-any-use services delivered at medium voltage with a lesser demand of 100 kW
e^{HM}	Ordinary tariff for ordinary service medium voltage with a demand of less than 100 kW. This pricing will apply to energy-to-any-use services delivered at medium voltage with a lesser demand of 100 kW
e^{HM}	General service hourly rate medium voltage with a demand of at least 100 kW This pricing will apply to energy-to-any-use services delivered at medium voltage and with a demand of 100 kilowatts or more

Figure 1: Process of demand and supply



e^{HS} General high voltage sub-transmission level hourly rate This tariff will apply to services intended for energy to any purpose, delivered at the high voltage sub-transmission level, and that the characteristics of use of your claim request register for this service, with a 1-year validity

e^{CTCP} Short-run total cost: unit cost variable generation on the marginal plant+variable transmission between the marginal plant and the permittee's interconnection point. In our study, we utilize e e^{CTCPD}, e^{CTCPP}, e^{CTCPA} and e^{CTCPM} to represent the avoided cost in Durango, La Paz, Acapulco, and Mazatlan I, respectively

Natural gas prices and Electricity prices are obtained from the UK government energy statistics and of gem website

4. EMPIRICAL ANALYSIS

This present research was applied research and Vector autoregressive (VAR) model is best to implement because it helps in forecasting and comparison of theoretical model with stimulation technique. The (VAR) approach has been used in this research. It is used to analyses the time series data and macroeconomic analyst. The VAR model used to compare actual data with the time series data. Most of the applied work used pre-tests for unit roots and cointegration before the VAR model implementation. The usage of properties of united roots test and cointegration reduces the uncertainty in the VAR model. These test give the impulse response analysis. The pre-root test used to express all the variables that are including in the VAR model for the specification of VAR model. The problem that faced in this research was the bias of the data because of the persistent nature of the data. The pre-test of the VAR has many limitations that was discussed in the past (Elliott, 1998). In the research it was discussed that how a large size distortion of the cointegration method that arises in system with near unit roots. In conclusion these test is used to reject the null of a unit root test and have a low power to do that when the data is persistent or integrated.

The pre-test unit root test method that has been used in this present study is augmented Dickey-Fuller test and the Phillips-Perron (Phillips and Perron, 1988). We run both the test augmented Dickey-Fuller test and the Phillips-Perron for both the level and the fist difference of our variables. Also we take constant and constant and linear trend for running the augmented Dickey-Fuller test and the Phillips-Perron as shown in Table 1. The Schwarz information criteria determines the lag duration of the enhanced Dickey-Fuller unit root test. The results do not reject the null hypothesis of unit roots at the level, but they do reject the hypothesis in first-difference analysis (Table 2). As a result, we infer that natural gas prices and electricity tariff in the first-differenced form are stationary. It was also discovered that the tariff of electricity and prices of natural gas had a unit root. Once we've determined the unit root behavior of the natural gas price and the various electricity tariffs, we run both bivariate cointegration tests using Phillips and Ouliaris for common stochastic trend. Table 3a and b includes both tau and z-statistics for the bivariate case. Results of the test of Phillips and its indicates that there is a bivariate cointegration relationship between natural gas price and electricity tariff.

Figure 2: Research design

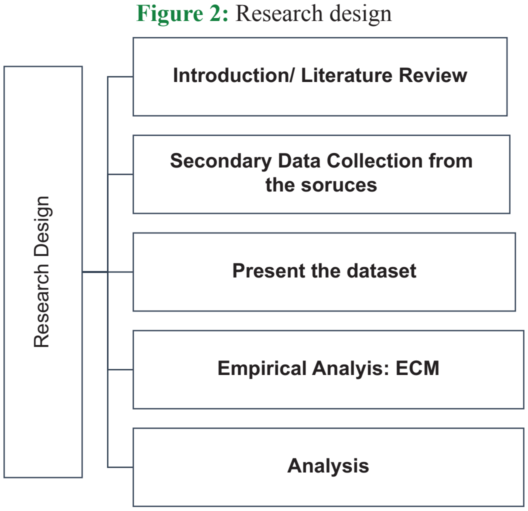


Table 1: Augmented Dickey-Fuller and Phillips-Perron unit root test results

	Augmented Dickey-Fuller		Phillips-Perron	
	Constant	Constant and linear trend	Constant	Constant and linear trend
Original series (in logs)				
$\square$	–2.405	–2.003	–2.044	–1.517
$\square$	–2.265	–3.003	–2.362	–2.852
$\square$	–1.972	–2.007	–2.381	–2.473
$\square^{\square\square\square}$	–2.186	–2.155	–2.012	–1.322
$\square^{\square 2\_5}$	–1.723	–3.486**	–1.802	–2.691
$\square^{\square 2\_10}$	–1.752	–3.488**	–1.801	–2.684
$\square^{\square 3}$	–2.494	–2.312	–2.072	–1.521
$\square^{\square 5}$	–0.463	–5.911*	0.323	–3.688**
$\square^{\square 5\square}$	0.433	–4.856*	–0.001	–3.251***
$\square^{\square 6}$	4.792*	–174.565*	–1.622	–11.091*
$\square^{\square\square}$	–2.494	–2.245	–1.911	–1.250
$\square^{\square\square}$	–2.528	–2.284	–1.915	–1.344
$\square^{\square\square}$	–2.672***	–2.392	–1.957	–1.526
$\square^{\square\square\square\square\_\square}$	–2.439	–2.613	–2.221	–2.135
$\square^{\square\square\square\square\_\square}$	–1.667	–0.623	–3.796*	–3.601**
$\square^{\square\square\square\square\_\square}$	–2.558	–2.577	–2.271	–2.302
$\square^{\square\square\square\square\_\square}$	–2.525	–2.535	–2.122	–2.161
First difference (in logs)				
$\square$	–7.955*	–5.628*	–7.935*	–8.118*
$\square$	–6.915*	–6.885*	–10.195*	–10.142*
$\square$	–10.458*	–10.447*	–10.656*	–10.618*
$\square^{\square\square\square}$	–7.528*	–7.767*	–7.612*	–7.767*
$\square^{\square 2\_5}$	–8.543*	–8.511*	–8.511*	–8.541*
$\square^{\square 2\_10}$	–8.525*	–8.448*	–8.491*	–8.517*
$\square^{\square 3}$	–4.572*	–4.745*	–8.455*	–8.552*
$\square^{\square 5}$	–5.675*	–5.628*	–4.315*	–4.124*
$\square^{\square 5\square}$	–4.047*	–4.032**	–4.145*	–4.125*
$\square^{\square 6}$	–19.14*	–21.957*	–24.161*	–24.025*
$\square^{\square\square}$	–4.321*	–4.571*	–7.957*	–8.105*
$\square^{\square\square}$	–8.033*	–8.142*	–8.036*	–8.145*
$\square^{\square\square}$	–4.554*	–4.609*	–8.661*	–8.738*
$\square^{\square\square\square\square\_\square}$	–5.425*	–5.587*	–9.788*	–9.831*
$\square^{\square\square\square\square\_\square}$	–2.546	–3.221	–10.902*	–10.972*
$\square^{\square\square\square\square\_\square}$	–6.120*	–6.058*	–10.272*	–10.232*
$\square^{\square\square\square\square\_\square}$	–5.839*	–5.169*	–9.552*	–9.535*

*, ** and *** denotes a statistic is significant at the 1%, 5% and 10% level of significance respectively. The lag length of the augmented Dickey-Fuller unit root tests is determined by the Schwarz information criterion. The spectral estimation method of the Phillips-Perron unit root test is the Bartlett kernel with the Newey-West bandwidth. The sample period runs from January 2010 to January 2020

Table 2: Descriptive statistics analyses

Item	Mean	Maximum	Minimum	SD	Skewness	Kurtosis	Jar. Bera
□	1.746	2.116	1.405	0.134	0.276	2.801	1.744
$□^{□□□}$	0.505	0.588	0.363	0.063	−0.642	2.153	1.194
$□^{□2\_5}$	0.406	0.486	0.321	0.044	−0.261	1.794	8.681
$□^{□2\_10}$	0.448	0.487	0.322	0.045	−0.262	1.793	8.693
$□^{□3}$	0.17	0.263	0.062	0.057	−0.102	1.712	8.562
$□^{□5}$	0.348	0.473	0.223	0.071	8.052	1.801	7.257
$□^{□5□}$	0.265	0.392	0.141	0.072	0.001	1.798	7.267
$□^{□6}$	0.142	0.275	0.015	0.072	−0.004	1.814	7.071
$□^{□□}$	0.031	0.154	0.107	0.075	−0.104	1.585	1.028
$□^{□□}$	0.021	0.135	0.115	0.067	−0.107	1.722	8.451
$□^{□□}$	0.068	0.182	0.071	0.075	−0.275	1.706	9.951
$□^{□□□□\_□}$	0.053	0.362	0.282	0.185	−0.072	1.727	6.132
$□^{□□□□\_□}$	0.445	0.677	0.062	0.133	−0.672	3.071	6.774
$□^{□□□□\_□}$	0.065	0.374	0.286	0.192	0.081	1.675	6.682
$□^{□□□□\_□}$	0.064	0.384	0.252	0.188	0.036	1.674	6.601

The sample was taken from January 2010 to January 2020

Table 3a: Phillips-Ouliaris cointegration tests for natural gas

Tau-statistic	Intercept	Intercept and linear trend
$□^{□□□}$	−2.886	−3.009
$□^{□2\_5}$	−2.946	−3.008
$□^{□2\_10}$	−2.946	−3.008
$□^{□3}$	−2.488	−2.976
$□^{□5}$	−3.019	−2.994
$□^{□5A}$	−3.019	−3.034
$□^{□6}$	−3.680**	−3.002
$□^{OM}$	−2.543	−2.951
$□^{HM}$	−2.391	−2.944
$□^{HS}$	−2.379	−2.951
$□^{CTCP\_D}$	−3.205**	−3.657**
$□^{CTCP\_P}$	−2.546	−2.954
$□^{CTCP\_A}$	−2.470	−3.073
$□^{CTCP\_M}$	−2.444	−3.104

Table 3b: Phillips-Ouliaris cointegration tests for natural gas

Z-statistic	Intercept	Intercept and linear trend
$□^{□□□}$	−16.465***	−17.049
$□^{□2\_5}$	−16.529***	−17.012
$□^{□2\_10}$	−16.528***	−17.014
$□^{□3}$	−14.421	−16.790
$□^{□5}$	−17.161***	−16.942
$□^{□5A}$	−17.159***	−17.425
$□^{□6}$	−24.078**	−16.996
$□^{□□}$	−13.022	−16.495
$□^{□□}$	−11.101	−16.513
$□^{□□}$	−10.746	−16.661
$□^{□□□□\_□}$	−17.299**	−23.398**
$□^{□□□□\_P}$	−13.360	−16.607
$□^{□□□□\_A}$	−10.891	−17.530
$□^{□□□□\_M}$	−10.886	−17.985

$$(e^{T2\_5}, e^{T\_10}, e^{T3}, e^{OM}, e^{HM}, e^{HM}, e^{HS} i.e., e^{DAC})$$

The bivariate cointegration results show the existence of a shared trend between natural gas and electricity prices, implying that electricity and natural gas prices should be connected by a long-run connection.

A VAR model was used to investigate the influence of natural gas prices on electricity pricing. We suggest an unconstrained VAR technique, similar to (Cunado and de Gracia, 2014) to investigate the link between natural gas price and electricity tariff. For each of the electricity and natural gas prices, we estimate an unconstrained VAR model. A VAR model of order p with k variables may be written as: y, where the number of lags is concerned, the number of lags is a column vector of all the variables in the model (first difference in crude oil prices, first difference in natural gas prices, and first difference in electricity prices; is a column vector A0 of constant terms; is a matrix of unknown coefficients, and is a column Ai k k t vector of errors with the following properties:

(□□) = 0 ∀□, (□□ □′ □) = Ω □□ □ = □, (□□ □′ □) = 0 □□ □ $\neq t$,…. (1)

Where is the variance-covariance matrix containing non-zero off-diagonal entries The orthogonalized impulse responses of the model variables are derived as a moving average representation of a two-variable VAR with variables arranged in the following order: First log difference of natural gas prices and first log difference of electricity prices. The lag duration is determined by the Akaike information criterion. The dashed lines reflect the 95% confidence intervals for each electricity rate's reaction to natural gas. The generalized impulse response functions of home and commercial electricity rates to the following factors are shown in Figure 3. Figure 4 depicts the relationship between electricity costs (public rates such as e, T5, and T5A) and natural gas prices. In all situations, we find little evidence of a major short-run influence of natural gas prices on public power rates.

The industrial power tariffs are then included in the unconstrained VAR model in the next phase. The generalized impulse response functions of three industrial power rates to natural gas prices are shown in Figure 5. In all situations, we find a strong beneficial influence of natural gas prices on industrial electricity rates. It also discovers evidence of e OM, e HM, and e HS unidirectional short-run causation in the US economy from coal and natural gas prices to electricity prices.

Furthermore, we compare the generalized impulse response functions of four electricity rates (short-run total cost) to natural

Figure 3: Response of electricity prices (domestic and commercial rates) to prices of natural gas

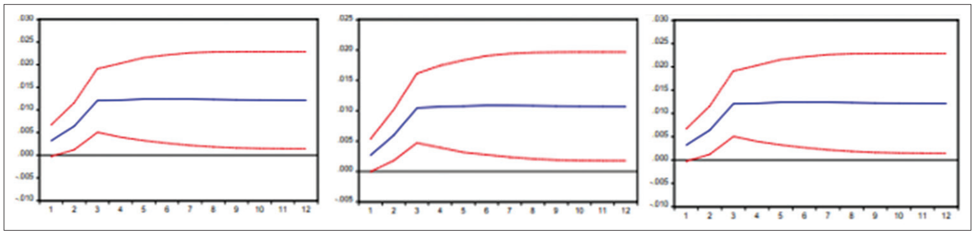


Figure 4: Response of electricity prices (public rates) to prices natural gas

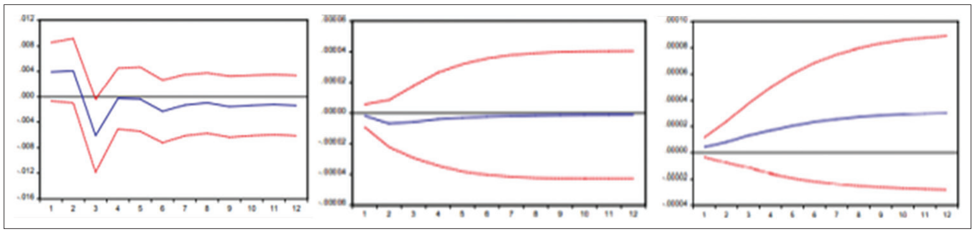


Figure 5: Response of electricity tariff (industrial rates) to prices of natural gas

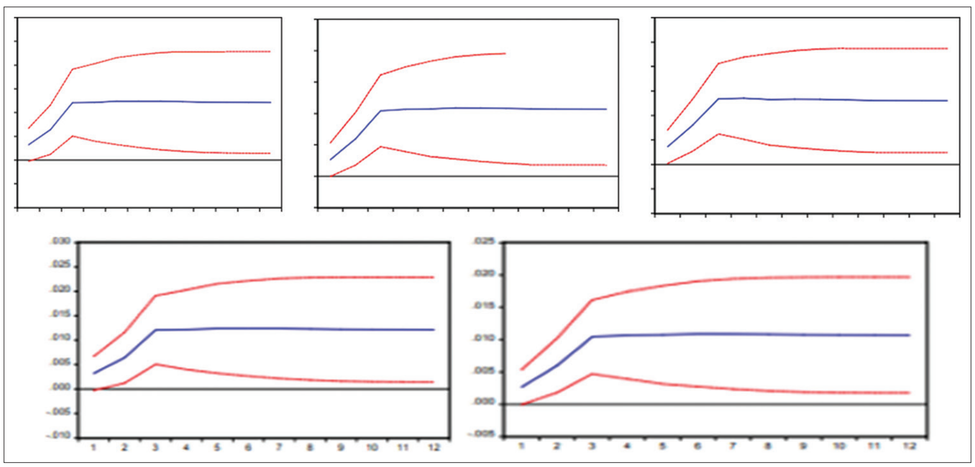
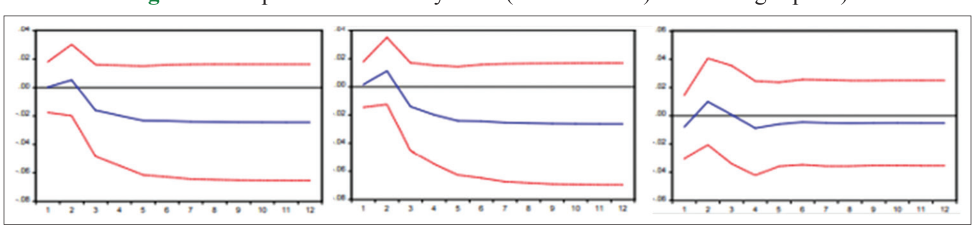


Figure 6: Response of electricity tariff (avoided costs) to natural gas price)



gas prices (Figure 6). The various electrical variables e and do not respond to natural CTCP D, CTCP P, CTCP A, and CTCP M gas prices.

5. RESULTS

The above diagram shows that there are 95% confidence intervals and that is represented through the dash lines and for the response of electricity tariff (domestic and commercial rates) to natural gas.

The above diagram shows that there are 95% confidence intervals and that is represented through the dash lines and for the response of electricity tariff (public rates) to natural gas.

The above diagram shows that there are 95% confidence intervals and that is represented through the dash lines and for the response of electricity tariff (Industrial rate) to natural gas.

The above diagram shows that there are 95% confidence intervals and that is represented through the dash lines and for the response of electricity tariff (avoided cost) to natural gas.

6. CONCLUSION

In the conclusion, the present research finds out the impact of natural gas price on different electricity tariff in the UK economy. In this research we used an unrestricted Vector autoregressive model and the sample size that was taken out to conduct this research was from January 2010 to January 2020 in this research empirical approach has been implement in the economy using alternative electricity tariffs such as domestic, commercial, industrial, public and avoid cost. In this research empirical results have been obtained in detail. In the following research all the natural gas prices and electricity tariff formed non-stationary.

We have get the serval empirical analysis and results. The results clearly show that natural gas prices and electricity prices in level form were non-stationary, however, when they are initially differentiated, they become stationary and we used pre root test such as augment Dickey Fuller Test and Phillips-Perron. Secondly, in seven power tariffs, we found a substantial bivariate co-integration long term link between electricity tariff and natural gas prices. There is an absence of the unified market of energy in the UK. In the past study (Mohammadi, 2009) also mentioned the same evidences has been collected from the US economy and (Bernal et al., 2019) also has same results while they were researching the impact of natural gas on the energy price in the Mexican economy. Thirdly, the unrestricted vector autoregressive model suggested a significant upward (positive) impact of natural gas price on domestic electricity rates in the short run. In the end, the study found the significant positive impact of the natural gas price and electricity prices on commercial rates and on industrial rates.

To summarize the empirical results that has been discussed in the present research present necessary facts in order to comprehend how natural gas price effect UK energy tariff. From the above results, we discover that some power pricing, such as commercial and industrial rates, are tied to crude oil prices in both the short and long run. The UK's energy-intensive industries should keep an eye on the movement of electricity tariffs and natural gas prices. More studies should be conducted to determine the mechanisms to know the natural gas price influence energy pricing.

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