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The demand for natural gas in the Northeastern United States

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This paper examines the demand for natural gas in the residential, commercial, and industrial sectors of the Northeastern United States, comprising nine states and using annual state-level panel data over the period between 1997 and 2016. It applies panel unit root and cointegration tests, and then estimates the parameters using five alternative estimators: dynamic fixed effects (DFE), mean group (MG), pooled mean group (PMG), common correlated effect mean group (CCEMG), and augmented mean group (AMG). The panel unit root and cointegration tests show that the series are I (1), and cointegrated. The estimated results show that the long run own price elasticities for natural gas in residential, commercial, and industrial sectors are −0.14, −0.29, and −0.28, respectively. The cross price elasticities of fuel oil for natural gas demand in residential, commercial, and industrial sectors are 0.19, 0.52, and 0.24, respectively. The long run natural gas demand is not affected by income in all three sectors. The heating degree days (HDD) have significant positive effects on demand for natural gas in all three sectors.

1. Introduction

The demand for natural gas in the residential, commercial, and industrial sectors of the Northeastern United States over the period 1997–2016 is the main focus of this study. Dilaver et al. [1] and Erdogdu [2] in European cases show that the demand for natural gas could be price elastic or inelastic, whereas it is generally income elastic. However, an increase in income or economic growth may not necessarily cause an energy consumption increase, as evidenced by Ajmi et al. [3]. Nick and Thoenes [4] find temperature and supply shocks influence the price of natural gas. Although the demand for natural gas was previously studied for the Northeastern U.S. by Beierlein et al. [5]; using the data from 1967 to 1977, much has changed regarding the factors affecting natural gas demand, which makes it imperative that we look at this issue again. Additionally, Beierlein et al. did not account for unit roots and cointegration among variables. In time series panel data, the possibility of unit roots and cointegration are serious concerns, and without addressing those, regression results could be spurious. Therefore, we use the most appropriate techniques, proposed by Pesaran [6]; Maddala and Wu [7]; Neal [8]; and Persyn and Westerlund [9]; for testing the panel unit root and cointegration tests. Furthermore, we use dynamic fixed effects (DFE), mean group (MG), pooled mean group (PMG), augmented mean group (AMG), and common correlated effect mean group (CCEMG) for the parameter estimation.

Unique regional factors are often lost due to aggregation in data. The importance of regional effects on energy consumption and cost has been noted by several authors [10]; [11]; [5]; [12]; and [13]. The Northeastern U.S. is a unique study area for natural gas demand estimation due to its extreme weather, the presence of more economic activities than in other regions of the U.S., income variations, and practices in energy use, especially the wide range of consumers use heating oil as a substitute heating fuel.[1] Regarding natural gas production, Pennsylvania alone produces around 20% of the total U.S. production, according to recent EIA reports.[2] More

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[1] EIA report available at: https://www.eia.gov/tools/faqs/faq.php?id=46andt=8.
[2] Ranking of energy consumption per capita available at: https://www.eia.gov/state/rankings/.

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interestingly, overall energy consumption per capita in the Northeastern U.S. is among the lowest compared to other states, as stated by the most recent EIA report. However, the average number of HDD in this region is above the national average (see footnote).[3]

Intuitively, people use more energy to stay warm during colder days. Considine [14] shows the responsiveness of energy demand to the deviation in heating degree days (HDD) in the short run. Harold et al. [15] evaluate the determinants of natural gas demand in Ireland using household level data. Estimated results using a random effects model reveal that weather variation is the most influential factor on daily natural gas consumption by households. The previous study of the Northeastern U.S. natural gas demand did not include the impact of HDD, although HDD are an important determinant of the natural gas demand estimation process. This paper uses the latest model specification techniques and estimates the parameters using the most recently available data from 1997 to 2016. Additionally, it includes HDD to capture the short run impact of natural gas demand, because an immediate adjustment in natural gas demand is directly related to temperature variation at the current moment. Conversely, the short run natural gas price is influenced by temperature and supply shocks [4]. This study makes a number of contributions to the literature by extending the sample period, accounting for an additional variable, adopting the latest model specification methods, and using more efficient estimation techniques.

Paul et al. [16] use a partial adjustment model of electricity demand for the U.S. and estimate a fixed effects model paying particular attention to regional, seasonal, and sectoral variations. The estimated results reveal that consumption is price inelastic in the short run but price elastic in the long run, though varying by region, season, sector, and customer classes. Alberini et al. [17] investigate the demand for electricity and natural gas in households/dwellings in the 50 largest metropolitan areas in the United States with data over the period from 1997 to 2007 and find a strong household response to energy prices, both in the short run and the long run. Additionally, they report that the price elasticity of electricity demand declines with income, but the magnitude of the effect is small. Dagher [18] examines the natural gas demand function for the United States using an autoregressive distributive lag model. He finds the demand response to price and income to be lower even in the long run than has been suggested by previous studies. Regarding the energy demand and economic growth nexus, increased energy consumption is found to cause economic growth, but the reverse causality is not true based on U.S. data analysis, which is consistent with previous findings [3]; [19]; [20]; and [21]. Joutz and Trost [22] examine the consumer responses to natural gas for all regions of the United States using the ordinary least square (OLS), fixed effect (FE) dummy, and likelihood dominance criterion (LDC), using monthly data provided by NGA member companies. These aforementioned studies do not incorporate the case of nonstationarity, which is an important concern in the panel data specification.

Lee and Lee [23] investigate the demand for electricity and total energy in OECD countries with data over the period 1978–2004 using the panel unit root test and cointegration test. They find the total energy demand to be price and income inelastic. Liu [24] examines own-price and cross-price elasticities of demand for natural gas in the residential, commercial, and industrial sectors in the U.S. Department of Energy classified regions using the simultaneous equation model with data from 1967 to 1978; Liu excludes the year 1973 due to the effects of the oil embargo. He finds that the demand for natural gas is much more price elastic in the long run than in the short run and that industrial sector natural gas use is less price sensitive. Furthermore, he finds significant interregional and intersectoral variations among the elasticities estimated. Blázquez et al. [25] examine the residential demand for electricity for 47 Spanish provinces using data from 2000 to 2008 with a dynamic partial adjustment approach. They pay particular attention to the influence of price, income, and weather. They find short run and long run elasticities to be negative but less than one, as expected and consistent with the previous studies. Fouquet [26] evaluates the price and income elasticities of energy demand in the United Kingdom over the last two hundred years. The findings indicate that the income elasticities have followed an inverse U-shaped curve, and price elasticities have followed a U-shaped curve. Indeed, these trends are found to be affected by energy and technological transition, leading to demand boost. Meier et al. [27] estimate Engel spending curves using static and dynamic models for a panel dataset comprising over 77,000 observations for the period 1991–2007 in the UK. They find U-shaped income elasticities that are less than unity, suggesting that energy services are a necessity for households.

Burke and Yang [28] estimate the price and income elasticities of natural gas demand in 44 countries, including OECD countries, using the data from 1978 to 2011. Estimated results using the single equation model and an instrumental equation indicate that the long run price and income elasticities are −1.25 and greater than one, respectively. They further reveal that at an aggregated level natural gas use is more price sensitive. Zhang et al. [29] estimate sectoral demand for natural gas demand in China using an autoregessive distribution lag model with data over the period between 1992 and 2012. Estimated results show that the own-price elasticity of natural gas demand in the residential sector is 0.223 (both the long run and short elasticities are same) and income elasticity is 2.051. Zhang et al. also find the substitutability between natural gas and liquefied petroleum oil. Income elasticity for the industrial sector is 2.30, which is similar to that of the residential sector. However, the own price elasticity in the industrial sectors is less than unity, but positively signed, which is a completely different result from that found in most of the existing literature. The reason mentioned is due to the government-controlled pricing, in which low prices lead to market distortion and resource mismatch, resulting in a natural gas market disequilibrium. Schulte and Heindl [30] estimate price and expenditure elasticities for the residential energy demand in Germany using official expenditure data over the period from 1993 to 2008. Estimated results using a quadratic expenditure system show that the own price elasticity of space heating is −0.50, and the expenditure elasticity of space heating is 0.41. They also indicate a behavioral response to energy price is weaker for low income households and stronger for higher income households.

The U.S. Energy Information Administration (EIA)[4] reports that in 2009, of the total 114 million households in the United States, approximately eight million used heating oil. Out of those eight million heating oil users, approximately 6.4 million (80%) were in

[3] The United States Environmental Protection Agency (EPA) report of 2016 shows that the U.S. average heating degree days from 1990 to onward range between 4000 and 4500. However, it is in a declining trend. Historical averages for HDD and CDD for the U.S. can be obtained from an EIA report (2012) as well. The Northeastern U.S. region has an average of HDD above 5000 for the period of the past 30 years, as reported by Northeast Regional Climate Center. These reports are accessible from the following sites: https://www.epa.gov/sites/production/files/2016-08/documents/print_heating-cooling-2016.pdf) http://www.nrcc.cornell.edu/wxstation/comparative/comparative.html#) https://www.eia.gov/todayinenergy/detail.php?id=8810).

[4] U.S. Energy Information Administration Report (http://www.eia.gov/energyexplained/index.cfm?page=heating_oil_use).