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Urban natural gas demand and factors analysis in China: Perspectives of price and income elasticities

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ABSTRACT

Urban natural gas is becoming the main sector driving China's natural gas consumption growth in recent years. This study explores the impacts of urban natural gas price, wage, socioeconomic determinants, and meteorological conditions on urban natural gas demand in China over 2006–2017. Furthermore, this study also analyzes the potential regional heterogeneity and asymmetry in the impacts of gas price and income on China's urban gas demand. Empirical results reveal that: (1) The increased gas price can significantly reduce the urban gas demand, and the average income level may effectively promote the gas demand, also, a strong switching effect exists between electricity and natural gas in urban China; (2) these impacts are heterogeneous in regions among China, urban natural gas demand is largely affected by the gas price in regions with high-gas-price and by income in regions with low-gas-price; and (3) the impact of gas price on urban gas consumption is consistent in regions with different urban natural gas consumption, while the impact of income is asymmetric. This study further provides several policy implications for improving the urban natural gas industry in China.

1. Introduction

The increasing emission of greenhouse gases, comprising mainly carbon dioxide (CO_2) emissions, has become a global collective problem that needs to be solved (Liu et al., 2021a; Li et al., 2021a; Shuai et al., 2018). However, the burning of fossil fuels, especially coal, is still widely prevalent in China, and is responsible for vast amounts of carbon emissions (Shuai et al., 2017a; Chen et al., 2020a; Li et al., 2021b; Wang et al., 2021a). Given that natural gas is cleaner than other fossil fuels, it has become a widely regarded substitute for dirty fossil fuels and for curbing CO_2 emissions (Apergis and Payne, 2010; Wang and Lin, 2017; Li et al., 2021c; Chen et al., 2020b). Furthermore, China has already taken a series of measures (e.g., market-oriented reform, infrastructure construction, and natural gas price reform) to promote the natural gas industry development in recent decades (Wang et al., 2020; Paltsev and Zhang, 2015). Accordingly, the share of natural gas consumption in primary energy has increased significantly in China, from 2.7% in 2006 to 8.1% in 2019. Moreover, the total natural gas demand in China may reach 600 billion cubic meters (bcm) in 2040, based on the International Energy Agency (IEA, 2017).

China's natural gas consumption is traditionally divided into four sectors: urban natural gas (i.e., households, central heating, gas-powered automobiles, small industrial and commercial businesses, and public welfare businesses), industrial fuel gas (i.e., peak adjustment power plant, and cogeneration), power generation (i.e., metallurgy, special steel, ceramics, glass, and building materials), and chemical industry gas (i.e., methanol, fertilizer, and ammonia) (Liu et al., 2018; Dong et al., 2019). With the guidance of gas utilization policies and the continuing expansion of the penetration rate of natural gas, the share of industrial fuel gas and chemical industry gas has declined, while urban natural gas is becoming the main sector driving the increase of gas demand in China (Liu et al., 2021b; Zhang et al., 2020). Specifically, during 2006–2017, total gas demand nearly quadrupled in China (i.e., from 58.7 bcm to 234.4 bcm), and the share of urban gas consumption of total consumption grew simultaneously (from 41.7% to 53.9%), according to statistics

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from the National Bureau of Statistics (NBS, 2019). However, some major problems still exist in China's urban natural gas market. These include low-income elasticity and nontransparent pricing mechanisms, which have limited the growth of the country's urban gas industry (Wang and Li, 2014; Li, 2015; Rioux et al., 2020). Given that price and income elasticities are two key factors influencing the urban gas market in China, further investigation of its income and price elasticities and other potential determinants is particularly essential. Although numerous studies have explored the elasticities of China's natural gas consumption and its potential determinants, to the best of our knowledge, the study that simultaneously considers the socioeconomic determinants (e.g., price and income elasticities, and others) and meteorological conditions (e.g., temperature) of China's urban gas demand is scarce.

On the other hand, as can be seen from Fig. 1, there are differences in the urban gas price and average wage level in different regions of China. Specifically, urban natural gas prices in south China are generally higher than those in the northwest regions, and the highest price (3.45 yuan/bcm in Guangdong) is more than 2.5 times higher than the lowest price (1.37 yuan/bcm in Xinjiang); the average wage level in the eastern coastal regions is much higher than that in the middle and north regions, and the highest income (131,700 yuan in Beijing) is nearly 2.3 times higher than the lowest income (55,495 yuan in Henan). Furthermore, it is important to study whether there are differences in the impacts of determinants on urban gas demand in different regions of China due to the differences in urban gas price and average wage level. Nevertheless, previous studies often divide China's urban natural gas market into different regions according to location (e.g., western China, central China, and eastern China), which may ignore the significant differences in the urban gas market of different provinces, especially the characteristics of urban gas price and average wage level.

Under these circumstances, this study investigates the socioeconomic determinants (e.g., price and income elasticities, and others) and meteorological conditions (e.g., temperature) of urban gas demand in China by using balanced panel data during 2006–2017. Furthermore, to empirically explore whether the determinants of urban gas demand differ in different regions of China, the 30 provinces in China are re-divided into four regions according to the local urban gas price and average wage level, and the four regions are analyzed separately. Therefore, this paper has the following three contributions: (1) This study explore the impacts of urban gas price, wage, socioeconomic determinants, and meteorological conditions on urban natural gas consumption in China, which not only provides a better understanding of the potential determinants of urban gas demand, but also gains new evidence for China's policymakers to formulate policies to accelerate the urban gas industry growth; (2) considering the differences in the urban gas price and average wage level across each province, this study further investigates the potential regional heterogeneity among the four regions re-divided by urban natural gas price and average wage level, which is particularly essential for exploring the various impacts of the potential determinants on urban natural gas consumption in regions with different levels of urban natural gas price and wage among China; and (3) this study employs the quantile regression to further explore the potential asymmetry of the impacts of urban natural gas price and income on urban gas consumption in regions with various gas consumption levels, which can benefit local governments' policymakers to devise targeted policies to promote urban gas industry development.

The remainder of this paper is organized as follows. Section 2 gives a literature review. Section 3 describes the theoretical framework, model, and data. Section 4 shows the strategies, benchmark results, and robustness test. Section 5 further explores the regional heterogeneous and asymmetric analysis. Section 6 shows the findings and provides policy implications.

2. Literature review

Natural gas demand in the modern era has become the subject of considerable discussion among scholars in the field. Many studies have adopted econometric methods to explore the impacts of potential determinants on gas demand, especially price and wage. This study discusses existing research from the following three aspects: (1) Giving an overview of the relationship between gas demand and price (see Section 2.1); (2) concluding the studies focus on gas demand and income (see Section 2.2); and (3) the nexus between other factors and gas consumption (see Section 2.3).

2.1. Studies on urban gas demand and the price nexus

First, extant studies explore the own-price elasticities of gas consumption in the past decades(i.e., Renou-Maissant, 1999; Chai et al., 2021; Andersen et al., 2011). This study focuses on the impact of gas prices on natural gas demand in the urban sector as the fact that urban gas is becoming the main sector promoting the

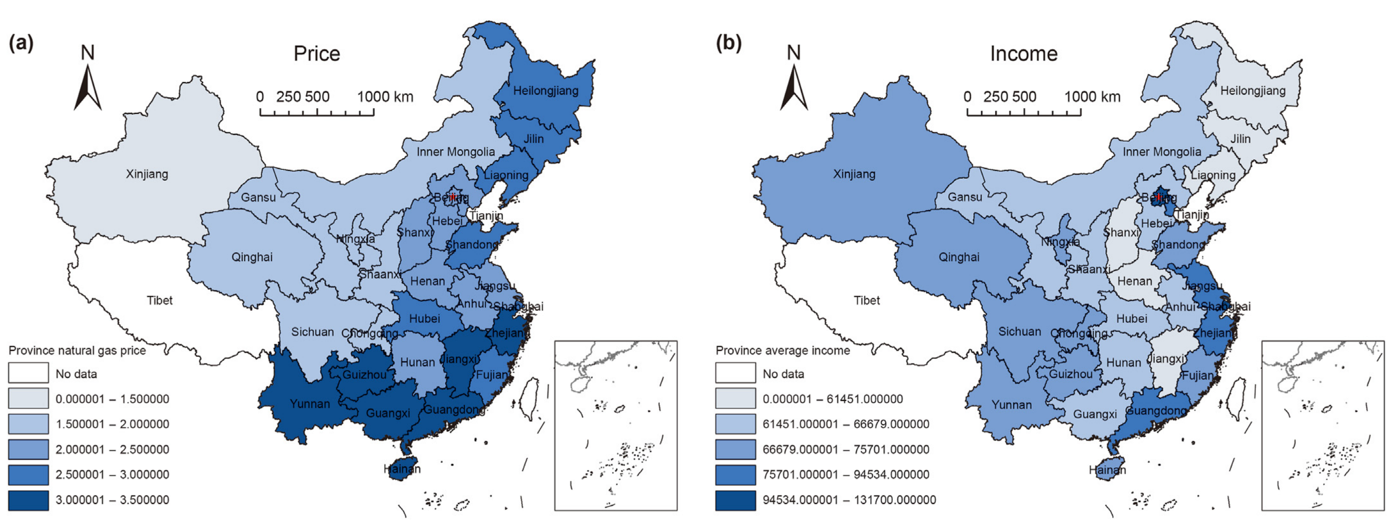

Fig. 1. Spatial characteristics of China's urban natural gas price and average wage in 2017. (a) Urban natural gas price (yuan/m^3); (b) Urban average wage (yuan).

gas demand in China (Zhang et al., 2020). For instance, Alberini and Khymych (2020) use time-series data to explore the residential natural gas demand following energy price changes in the case of Ukraine and conclude that the estimation coefficient of the gas price is significantly negative, about −0.16. A similar conclusion can be found in Yu et al. (2014), who find that the gas price significantly reduces demand in China's residential sector (i.e., −0.895). In contrast to the above findings, Andersen et al. (2011) conclude that natural gas consumption in the European manufacturing industry lacks own-price elasticity. Similar findings can be found in Zhang et al. (2018). In addition, Burns (2021) concludes that residential gas demand in the US is less affected by gas prices. Kostakis et al. (2021) maintain a similar conclusion for the case of the residential sector in Greece. Besides, Liu et al. (2021c) focus on gas demand in the central heating sector of China. Moreover, most existing studies focus on the topic of residential gas demand, while the literature on the impact of price on gas consumption from the urban natural gas sector is limited.

2.2. Studies on natural gas demand and the income nexus

Second, this study aims to explore the impact of income on urban gas demand. Among the existing literature that on energy demand, the average wage or gross domestic product (GDP) per capita is always used to measure the indicator of income level. For instance, Burke and Yang (2016) take GDP per capita as the main indicator to explore income elasticity on national natural gas demand in the case of 44 countries, and find the average long-run income elasticity is higher than +1. Similar findings can be seen in Liddle et al. (2020), and conclude that the elasticity of income on energy demand is generally within [0.6, 0.8], based on panel data of 26 countries during 1996–2014. Furthermore, Tiwari (2014) reports the same results for the and Jiang et al. (2020) for China. In contrast, Burns (2021) concludes that the elasticity of impact of income on residential gas demand is negative in the US. Besides, Kostakis et al. (2021) find that the impact of income on residential gas consumption is elastic in the case of Greece. Furthermore, Wu et al. (2021) explore the nexus between gas demand and economic growth in China. In addition to studies at the national level, there are also many studies on income elasticity in the industrial sector. For instance, Zhang et al. (2018) conclude that income can significantly affect gas demand in the industrial sectors in China.

2.3. Studies on other factors and natural gas demand nexus

Except for the natural gas price and income level, many scholars also take the environment temperature as an important determinant influencing natural gas demand (Izadyar et al., 2015; Soldo et al., 2014; Kostakis et al., 2021), concluding that colder temperatures require more natural gas. Furthermore, some existing literature suggests that the price of alternative energy, such as electricity and liquefied petroleum gas (LPG), may influence gas consumption (Cebula, 2012; Wang et al., 2021b; Wang and Lin, 2014). Besides, the convenience of using natural gas is also an essential determinant influencing the consumption of gas. Consumers in urban China need to be covered by pipeline facilities and the replacement of obsolete energy equipment to use natural gas, which requires equipment replacement costs (Liu et al., 2018). Therefore, many scholars explore the impacts of the convenience of using natural gas (e.g., facilities, urbanization level, and population effect) on natural gas demand (Jiang et al., 2020; Xie et al., 2020; Melikoglu, 2013; Kostakis et al., 2021), and indicating that the improvement of the natural gas convenience level significantly accelerates natural gas consumption.

Other factors influencing natural gas demand include energy intensity (Shuai et al., 2017b), the energy consumption structure (Jiang et al., 2020), and central heating (Liu et al., 2021c) amongst others. However, these determinants are not considered in our model because the study is conducted based on the extended model of production and consumption.

2.4. Literature gaps

Given the above background, analyzing the impact of influencing factors on urban gas demand in China and investigating regional heterogeneity can benefit the country's gas industry development. However, studies systematically analyzing the socioeconomic determinants and meteorological conditions of China's urban gas demand are scarce. Another essential fact is that there exist significant differences among provinces in China. Accordingly, it is essential to re-divide the provinces into regions to study the regional heterogeneity of urban gas demand. Nevertheless, to the best of our knowledge, very few studies explore the regional differences of natural gas consumption according to gas price and income.

3. Theoretical framework, model, and data

3.1. A simple theoretical framework for urban natural gas demand

The extensive literature above shows that various factors influence urban natural gas consumption in China. Yu et al. (2014) developed a model to explore the impact of factors on residential gas demand based on the household production theory proposed by Becker (1965), Muth (1966), and Lancaster (1965). Unlike the chemical industry, the urban natural gas sector does not require the direct use of gas but uses it to produce goods and services (e.g., heating, cooking, and driving) (Liu et al., 2018; Yu et al., 2014). Following previous studies and considering the urban natural gas user as a consumer, and according to the model proposed by Filippini (1999), the function of final energy goods and services (denoted as q) in this study is as follows:

$$q = q(n, e, f) \tag{1}$$

where n is natural gas consumption, e denotes alternative energy consumption, and f represents appliances. The utility function (denoted as u) of this consumer can be defined as follows:

$$u = u(q, s) \tag{2}$$

where q denotes final energy goods and services and s is other goods. There exists a preference for energy goods and services relation (denoted as r), that for all $q \in R_+^n$, $u(q^1) \geq u(q^2)$ if and only if $q^1 \geq q^2$. Hence, the consumer's decision can be transformed as follows (Muellbauer, 1974; Deaton and Muellbauer, 1980).

$$\text{Stage 1: Min } C_q = p^n n + p^e e + p^f f$$
$$s.t.\ q = q(n, e, f) \tag{3}$$

$$\text{Stage 2: Max } u = u(q, s)$$
$$s.t.\ C_q + C_s \leq Income \tag{4}$$

where C_q and C_s stand for the amount spent on q and s, respectively, p^n is natural gas price, p^e is alternative energy price, and p^f is the cost of using equipment to produce final energy goods and services. We can derive optimal cost function C_q^* from Eq. (3) based on the

Lagrangian formula.

$$C_q^* = C_q^*\left(p^n, p^e, p^f; q(n,e,f)\right) \tag{5}$$

The optimal demand function $q*$ can be derived from Eq. (4) and Eq. (5) based on Marshallian demand functions (Marshall, 1890).

$$q^* = q^*\left(p^n, p^e, p^f; Income; r\right) \tag{6}$$

Eventually, substituting Eq. (6) in Eq. (1) yields the demand for urban natural gas q_n as follows:

$$q_n = q_n\left(p^n, p^e, p^f; q^*\left(p^n, p^e, p^f; Income; r\right)\right) = q_n\left(p^n, p^e, p^f; Income; r\right) \tag{7}$$

Known by Eq. (7), gas demand can be defined as a function of final energy goods and services price, income, and preference for final energy goods and services. Therefore, we propose the following Hypothesis:

Hypothesis. Natural gas demand may be negatively correlated with p^n and p^f, and positively correlated with *Income*, p^e, and r.

3.2. Empirical model

Based on the theoretical framework (see Section 3.1.), the urban natural gas demand function in China is defined as Eq. (8) first:

$$\ln q_n = \delta_0 + \delta_1 \ln p^n + \delta_2 \ln Income + \delta_3 \ln p^e + \delta_4 \ln p^f + \delta_5 \ln r + \mu \tag{8}$$

where, given that the alternative energy sources in urban China are mainly electricity, LPG, coal, gasoline, and diesel, this study chooses the electricity price to represent p^e (Yu et al., 2014; Zhang et al., 2018). p^f can be explained by the difficulty obtaining energy sources, such as the penetration rate of urban gas, the urbanization rate, and the gas population ratio. The more difficult it is to obtain energy sources, the smaller the value of p^f, thus the coefficients are expected to be positive. The temperature may influence the r to a large extent, because the lower/higher the temperature, the greater the need for energy goods. There are two peak energy demand periods in southern China (i.e., winter and summer) and one peak in the northern region (i.e., winter) (Zhang et al., 2020). This study chooses heating degree day (*HDD*) to measure the r. Therefore, the urban natural gas demand function in China is generally defined as follows in this study:

$$\begin{aligned} \ln C_{it} = {} & \beta_0 + \beta_1 \ln P_{it} + \beta_2 \ln W_{it} + \beta_3 \ln HDD_{it} + \beta_4 \ln EP_{it} \\ & + \beta_5 \ln PR_{it} + \beta_6 \ln UR_{it} \\ & + \beta_7 \ln NPR_{it} + \mu_{it} \quad i = 1,2,\ldots,\mathrm{N}; t = 1,2,\ldots,\mathrm{T} \end{aligned} \tag{9}$$

where i represents the province and t indicates the year. C represents the urban gas demand, P denotes the price of urban gas, W stands for the average wage. *HDD* is an indicator employed to evaluate the energy demand (e.g., gas, electricity, and coal) used for heating during the cold season, and *EP* is the electricity price. The price of urban gas and electricity in China is highly regulated by the government, which is not a true reflection of the market, so no endogeneity is held to exist in the model (Liu et al., 2018; Yu et al., 2014). *PR* indicates the penetration rate of urban gas, *UR* represents the urbanization rate, and *NPR* denotes the gas population ratio. These three indicators (i.e., *PR*, *UR*, and *NPR*) are used to measure the cost of using equipment to produce final energy goods and services. β_0 is the constant term. μ_{it} is the random error term. The urban gas price in China is set by the government, which largely reduces endogenous problems arising from pricing schemes.

3.3. Data

This paper employs a broad sample of 30 provinces in China (data for Tibet, Hong Kong, Macau, and Taiwan are not available) for the period 2006–2017. It should be noted that there are a few missing data estimated by the linear interpolation. As the core dependent variable, urban natural gas consumption (denoted as C) takes the total urban gas demand in each province to represent. The data of urban natural gas consumption is sourced from NBS (2019). As the main independent variable in this study, the urban natural gas price (denoted as P) is measured by residential gas price (i.e., first stage price if ladder pricing exists). The data of urban natural gas price is collected from National Development and Reform Commission (NDRC, 2020). Furthermore, average wage (W) is measured by the average wage of the employees in urban China, penetration rate (*PR*) is the penetration rate of urban natural gas, urbanization rate (*UR*) is the proportion of the urban population in total population, and gas population ratio (denoted as *NPR*) is the ratio of urban natural gas users to urban LPG users, The data of average wage, penetration rate, urbanization rate, and gas population ratio are sourced from NBS (2019). The electricity price (*EP*) is measured by the industrial and commercial electricity price (i.e., 1–10 kV, and flat period price if time-of-use pricing exists) of the capital city of a province. The data of electricity price is collected from NDRC (2020). *HDD* is measured as follows.

The original temperature data (HDD_{ijt}) are collected from China Ground International Exchange Station Climate Data Daily Value Data Set (V3.0), a product on the National Meteorological Science Data-Sharing Service Platform (CMA, 2019). When the average temperature of a certain day in a year is lower than 18 °C, multiply the difference in degrees between the average temperature of that day and 18 °C by 1 day to get the cumulative value. *HDD* can be defined as follows:

$$HDD_{ijt} = \begin{cases} 0 & \text{if} \quad T_{ijt} \geq 18^\circ C \\ 18 - T_{ijt} & \text{if} \quad T_{ijt} \leq 18^\circ C \end{cases} \quad i = 1,2,\ldots,30; j = 1,2,\ldots,365/366; t = 2006,2007,\ldots,2017 \tag{10}$$

$$HDD_{it} = \sum_{j=1}^{\mathrm{J}} HDD_{ijt} \quad i = 1,2,\ldots,30; j = 1,2,\ldots,365/366; \quad t = 2006,2007,\ldots,2017 \tag{11}$$

where i is province, j is day in each year, and t is year. As can be seen from the formula, the higher the value of *HDD*, the lower the annual temperature of the province.

Moreover, *GDP* denotes economic development, *PD* is the ratio

Table 1
Descriptive statistics of the variables used in this study. (Obs. = 360).

Variable	Variable interpretation (unit)	Mean	Max.	Min.	S. D.
ln*C*	Urban natural gas consumption (100,000,000 m^3)[a]	2.350	5.114	−4.61	1.66
ln*P*	Urban natural gas price (yuan/m^3)[b]	0.825	1.526	0.10	0.30
ln*W*	The average wage of the employees in urban (yuan)[a]	10.60	11.79	9.640	0.45
ln*HDD*	Heating Degree Day (°C·d)[c]	7.565	8.708	3.476	0.87
ln*EP*	Urban electricity price (yuan/KWH)[b]	−0.589	−0.111	−1.23	0.19
ln*PR*	Penetration rate of urban natural gas (%)[a]	4.493	4.735	4.044	0.12
ln*UR*	The proportion of urban population in total population (%)[a]	−0.655	−0.110	−1.29	0.25
ln*NPR*	The ratio of urban natural gas users to urban LPG users (%)[a]	0.302	3.957	−5.19	1.44
ln*GDP*	GDP per capita (10,000 RMB/person)[a]	1.230	2.558	−0.46	0.59
ln*PD*	The ratio of natural gas pipeline length to province area (km/km^2)[a]	0.360	2.081	−4.63	1.04
ln*NR*	The ratio of urban natural gas users to urban population (%)[a]	−1.499	−0.209	−6.21	1.01

Notes: 1) Mean, Max., Min., S. D., and Obs. Denote mean, maximum, minimum, standard deviation, and observations, respectively, and ***2)*** [a] represents data collected from NBS (2019); [b] represents data collected from NDRC (2020); [c] represents data collected from CMA (2019).

of natural gas pipeline length to province area, and *NR* represents the ratio of urban natural gas users to the urban population. The data of *GDP*, *PD*, and *NR* are sourced from NBS (2019). Table 1 reports the interpretation, sources, and statistics of all the variables used in this paper.

4. Estimation strategies and empirical results

To explore the impact of main influencing factors on urban gas consumption in China, the estimation procedures in this paper include six steps. First, we use cross-sectional dependence tests to check whether cross-sectional dependence exists in the panel data (Section 4.1). Second, this study uses the cross-sectionally augmented Im, Pesaran, and Shin (CIPS) panel unit root test to check whether the sequence of variables is stationary (Section 4.2). Third, we use the cointegration test to check the long-term balanced cointegration relationship among indicators (Section 4.3). Fourth, benchmark regression, the feasible generalized least squares (FGLS) model is utilized (Section 4.4). Finally, this study verifies the robustness of the benchmark (Section 4.5).

4.1. Cross-sectional dependence tests

Cross-sectional dependence is one of the most important tests researchers should run before conducting panel regression. The Breusch-Pagan LM test, the Pesaran scaled LM test, and the Pesaran CD test are used. Furthermore, the null Hypothesis of these tests is that there is no cross-sectional dependence. As can be seen from the results shown in Table 2, all the results of the tests reject the null hypothesis, which indicates strong cross-sectional dependence exists.

4.2. Panel stationarity tests

When the sequence of economic variables is non-stationary data, the results of the parameter estimation will produce a certain deviation. In order to avoid false regression, the panel unit root tests are used in this study on the sequence of variables to examine the stationarity characteristics. Notably, the reliability of the first-generation panel unit root tests will be reduced if the cross-sectional dependence exists (Pesaran, 2007). Thus, this study employs the second-generation panel unit root tests proposed by Pesaran (2007) – CIPS tests – which consider the cross-sectional dependence; the results of each variable are shown in Table 3.

Table 2
Results of cross-sectional dependence tests.

Test	Statistics	Prob.
Breusch-Pagan LM	691.13	0.000
Pesaran scaled LM	2.404	0.016
Pesaran CD	3.037	0.002

Table 3
Results of the panel stationarity tests based on CIPS.

Variable	Level		First difference	
	Intercept	Intercept and trend	Intercept	Intercept and trend
ln*C*	−2.623***	−2.822**	−3.302***	−3.576***
ln*P*	−2.812***	−2.651*	−2.936***	−2.845**
ln*W*	−2.072*	−2.176	−2.677***	−2.807**
ln*HDD*	−3.202***	−3.351***	−4.165***	−4.368***
ln*EP*	−2.559***	−2.783**	−3.436***	−3.471***
ln*PR*	−3.262***	−2.779**	−3.204***	−3.294***
ln*UR*	−1.714	−2.241	−2.455***	−2.972***
ln*NPR*	−2.359***	−2.553	−3.143***	−2.974***

Notes: *, **, and *** are significant at the level of 0.1, 0.05, and 0.01, respectively.

The null Hypothesis of the test is that a unit root exists in the sequence. From Table 3, one can see that the original sequence of the *UR* is not stationary both in the two types. Based on this, a common method of converting it to a stationary sequence is the first-order difference. From the results, one can see that the p-values of all variables are higher than 0.05, which indicates that the null hypothesis is rejected (i.e., the first-order difference sequence is stationary).

4.3. Panel cointegration test

This study further examines the long-term balanced cointegration relationship among variables. Notably, the applicability of the traditional cointegration test in panel data is relatively limited. Therefore, this study employs the Kao (1999) and Pedroni (1999) cointegration tests extended based on Engle-Granger's two-step

Table 4
Results of the Kao and Pedroni test for cointegration.

Test	Statistic	P-value
Kao		
Modified Dickey-Fuller t	−1.6394	0.0506
Dickey-Fuller t	−3.2380	0.0006
Augmented Dickey-Fuller t	−4.4634	0.0000
Unadjusted modified Dickey-Fuller t	−1.5716	0.0580
Unadjusted Dickey-Fuller t	−3.2020	0.0007
Pedroni		
Modified Phillips-Perron t	9.8820	0.0000
Phillips-Perron t	−13.8458	0.0000
Augmented Dickey-Fuller t	−12.9683	0.0000

test for panel cointegration tests. The null Hypothesis of the Kao and Pedroni test is that there is no cointegration relationship, and the results are displayed in Table 4. Since p-values of all variables are lower than 0.05 (i.e., the null hypothesis is still strongly rejected), which indicates the long-term balanced cointegration relationship exists among all variables.

4.4. Benchmark regression

This study employs the FGLS model to explore the impacts of factors on urban natural gas demand as the benchmark regression in this paper. The FGLS method can correct heteroscedasticity and sequence correlation problems caused by cross-sectional data, therefore improving the consistency and validity of regression results. Furthermore, this method can effectively deal with complex panel error structures, substitute the residual vectors of individual sections into the cross-section heteroscedasticity covariance matrix, and use generalized least squares (GLS) to obtain parameter estimates. The results of benchmark regression are displayed in Table 5.

The following three conclusions can be drawn based on the estimation results. First, the estimated elasticity coefficient of the *P* is negative and statistically significant at the 1% level, specifically, −1.667. This result bears the expected sign. Price is one of the important determinants directly affecting the use of natural gas by urban gas customers. To be more specific, the higher the own-price (i.e., urban natural gas price), the lower the user's acceptance. Furthermore, the results indicate that a 1% increase in the urban gas price can lead to a 1.667% reduction in total urban gas consumption. The users may reduce the gas demand and increase the consumption of alternative energy which is relatively cheaper when the natural gas price increases. If the gas price increases from 2.385 to 2.6235 yuan, the total urban gas demand will decrease from 126.35 to 105.29 billion m^3 in China. Lin and Li (2020) find that the residential sector is most sensitive to changes in the gas price. Specifically, the impact of price on gas demand in the residential sector is generally confirmed to be negative in previous literature. For instance, Yu et al. (2014) find that the own-price elasticity is −0.895, Zhang et al. (2018) conclude that is −0.223, and Liu et al. (2018) find that is −1.431. In contrast, Zhang et al. (2018) conclude that the impact of natural gas price on demand is significantly positive in the industrial fuel gas sector, specifically, 0.222 in the short run and 0.847 in the long run. One possible reason for that is that the price of urban gas is set by the government, and consumers in the urban sector are sensitive to price, therefore an increase in the urban gas price will reduce the final consumption.

Table 5
Results of the benchmark regression.

Variable	ln*C*
ln*P*	−1.667***
	(−12.34)
ln*W*	0.354***
	(4.01)
ln*HDD*	0.150***
	(3.14)
ln*EP*	2.498***
	(12.47)
ln*PR*	1.741***
	(5.24)
ln*UR*	1.136***
	(7.52)
ln*NPR*	0.409***
	(10.69)
_cons	−6.891***
	(−3.20)
xttest3	22865.34***
Wooldridge	110.258***
Wald chi2	5234.29***
Obs.	360
Province	30

Notes: *, **, and *** are significant at the level of 0.1, 0.05, and 0.01, respectively.

Second, as can be seen from Table 5 that the impact of *W* on urban gas demand is significantly positive at the 1% level, which is in line with our expectations. To be more specific, the estimation results indicate that a 1% increase in average wage can lead to a 0.354% increase in urban natural gas demand in China. Consumers with higher income levels in China will be more inclined to use natural gas. The income elasticity of urban gas consumption is relatively smaller than the own-price elasticity in absolute value. These results are also largely consistent with previous articles. To be more specific, Yu et al. (2014) find that the coefficient of income on natural gas consumption in China's residential sector is 0.222, and Liu et al. (2018) find that the coefficient of income is 0.207. Furthermore, the income elasticity in the urban natural gas sector is much lower than that in the industrial fuel gas sector (i.e., 2.307) concluded by Zhang et al. (2018), one possible explanation is that they use GDP per capita to represent income level, while this study employs the average wage. Furthermore, the natural gas demand is stimulated by regional economic growth in the industrial fuel gas sector, which is stronger than that in the urban natural gas sector, and both of these sectors are rich in income elasticity.

Third, with respect to the control variables (*HDD*, *EP*, *PR*, *UR*, and *NPR*), the coefficient of *HDD* on total urban natural gas demand is positive (i.e., 0.15) and statistically significant; the positive sign is expected because colder weather leads to the use of more energy for space heating, and natural gas has been one of the major resources for heating in China. The elasticity of *EP* is 2.498 and statistically significant, which implies that natural gas demand will increase if the price of electricity increases, and this switching behavior is greatly influenced by the cross-price (i.e., electricity price). This result supports the view that electricity is a good substitute for urban natural gas in China (Zhang et al., 2018). The coefficients of *PR*, *UR*, and *NPR* are all statistically positive, which is in line with our expectations. A 1% rise in the penetration rate of urban gas, urbanization rate, and gas population ratio respectively lead to a 1.741%, 1.136%, and 0.409% rise in the demand for urban natural gas. These results indicate that the improvement of urbanization level and the rapid development of the natural gas industry are important factors promoting urban gas demand. The ratio of LPG users to the urban population declined from 29.3% in 2006 to 15.5% in 2017; in contrast, the ratio of urban natural gas users to the urban population rose from 14.3% in 2006 to 41.7% in 2017. As China's gas industry has developed vigorously and the relevant infrastructure plans have been released (NDRC, 2017), the penetration rate of urban natural gas, urbanization level, and natural gas population will increase accordingly in the foreseeable future (Jane and Huang, 2010).

4.5. Robustness test

To investigate the reliability of the results in Section 4.4, a robustness test was conducted using other indicators to replace several original variables. Some studies use *GDP*, *PD*, and *NR* instead of the *W*, *PR*, and *NPR* to represent the income level of the province, and the availability of natural gas in urban China (Dong et al., 2019; Liu et al., 2018; Zhang et al., 2018). Then we substitute these variables into our model to see whether our results are robust. The robustness test in this study is generally defined as follows:

$$\ln C_{it} = \gamma_0 + \gamma_1 \ln P_{it} + \gamma_2 \ln GDP_{it} + \gamma_3 \ln HDD_{it} + \gamma_4 \ln EP_{it} + \gamma_5 \ln PR_{it} + \gamma_6 \ln UR_{it} + \gamma_7 \ln NPR_{it} + \mu_{it} \tag{12}$$

$$\ln C_{it} = \varphi_0 + \varphi_1 \ln P_{it} + \varphi_2 \ln W_{it} + \varphi_3 \ln HDD_{it} + \varphi_4 \ln EP_{it} + \varphi_5 \ln PD_{it} + \varphi_6 \ln UR_{it} + \varphi_7 \ln NPR_{it} + \mu_{it} \tag{13}$$

$$\ln C_{it} = \omega_0 + \omega_1 \ln P_{it} + \omega_2 \ln W_{it} + \omega_3 \ln HDD_{it} + \omega_4 \ln EP_{it} + \omega_5 \ln PR_{it} + \omega_6 \ln UR_{it} + \omega_7 \ln NR_{it} + \mu_{it} \tag{14}$$

where, *GDP* indicates economic development in China, *PD* is the pipeline density, which is obtained by dividing the length of the pipeline in each province by the area; *NR* denotes the natural gas population density, which is the ratio of urban natural gas users to the urban population in China. The FGLS method is employed to estimate Eq. (12) − (14), and the results are displayed in Columns (1)–(3) of Table 6.

Comparing the empirical results with those in Table 5, one can see that the signs and significance of the estimation results of the determinants in the two tables are consistent, which indicates that the results of the benchmark regression are robust. Furthermore, the price elasticity of natural gas changes from −1.667 to −0.883 when the LPG population is not considered in Column (3), which may be due to each consumer just choosing either gas or LPG because they are so similar. This study makes further estimations by deleting variables separately based on the FGLS estimator to maintain the robustness of the results; the results are shown in Columns (1)–(7) of Table 7. One can see that the signs and significance of all the variables in Table 7 are consistent with the results in Table 5, which indicates that the benchmark results in Table 5 are robust.

Table 6
Results of the robustness test for replacing variables.

Variable	(1)	(2)	(3)
	ln*C*	ln*C*	ln*C*
ln*P*	−1.747***	−1.422***	−0.883***
	(−13.32)	(−10.38)	(−5.61)
ln*W*		0.278***	0.368***
		(3.10)	(4.81)
ln*HDD*	0.0834*	0.221***	0.0805
	(1.77)	(4.35)	(1.43)
ln*EP*	2.281***	2.023***	2.080***
	(11.31)	(10.29)	(10.02)
ln*PR*	1.255***		0.0392
	(3.87)		(0.14)
ln*UR*	0.349	1.515***	0.0593
	(1.60)	(10.81)	(0.43)
ln*NPR*	0.412***	0.223***	
	(12.24)	(5.29)	
ln*GDP*	0.666***		
	(6.29)		
ln*PD*		0.392***	
		(8.71)	
ln*NR*			1.006***
			(17.80)
_cons	−1.823	0.905	1.199
	(−1.13)	(0.86)	(0.75)
xttest3	24479.11***	72361.74***	30250.14***
Wooldridge	103.828***	83.163***	115.828***
Wald chi2	4865.60***	4495.29***	2895.77***
Obs.	360	360	360
Province	30	30	30

Notes: *, **, and *** are significant at the level of 0.1, 0.05, and 0.01, respectively.

5. Further discussions

5.1. Regional heterogeneous analysis

Considering the significant differences in gas prices and incomes levels across regions in China, this study further explores the regional heterogeneity in the impacts of determinants on urban natural gas demand among different regions. In doing so, the 30 provinces are divided into four sub-regions according to the urban natural gas price and average wage. This study calculates the average value of the urban natural gas price and wage for each province in 2013–2017, and then classifies the 30 provinces into four regions according to the median of each average value (see Fig. 2).

Region I is the high-gas-price and high-wage region, which comprises six provinces (Shanghai, Zhejiang, Guangdong, Guizhou, Fujian, and Shandong); Region II is the low-gas-price and high-wage region, which includes nine provinces (Beijing, Tianjin, Jiangsu, Qinghai, Chongqing, Ningxia, Xinjiang, Sichuan, and Inner Mongolia); Region III is the low-gas-price and low-wage region, which comprises six provinces (Shaanxi, Anhui, Gansu, Shanxi, Hebei, and Henan); and Region IV is the high-gas-price and low-wage region, which includes nine provinces (Hainan, Hubei, Yunnan, Hunan, Liaoning, Guangxi, Jilin, Jiangxi, and Heilongjiang). Analysis of the potential determinants across regions is of great significance to adjust energy regulation policies in China; the results are shown in Table 8.

Several key findings can be summarized based on the subpanel results. The price elasticity of urban gas consumption is found to be significant in high-gas-price regions (i.e., Region I and IV); while the income elasticity is found to be significant in the low-gas-price regions (i.e., Region II and III). Specifically, the estimation elastic of natural gas price on urban natural gas demand is −1.444 in Region I and −0.964 in Region IV, and both significant at the 1% level, while the impacts of gas price on urban natural gas demand are positive in Regions II and III. Furthermore, the income elasticity on urban natural gas demand is 1.479 in Region II and 0.832 in Region III, and significant at the 1% level, but the impact of income on urban gas demand is not significant in Regions I and IV. These results show that the gas price is the dominant determinant on urban natural gas consumption in high-gas-price regions; while the natural gas demand is affected largely by income instead of gas price in low-gas-price regions (i.e., Region II and III). Therefore, in the high-gas-price regions, reducing the urban natural gas price is a more feasible method for improving urban gas demand; while it is more effective to improve the local level of economic development and increase per capita income in low-gas-price regions.

Second, the urban natural gas price elasticity, income elasticity, and electricity price in high-wage regions (Region I and II) are relatively higher than that in low-wage regions (Region III and IV), respectively. Specifically, the estimation elastic of gas price on urban gas demand in Region I is −1.444, which is much greater than that in Region IV in absolute value. Besides, the coefficient of wage on urban natural gas demand is 1.479 in Region II, which is higher than that in Region III (i.e., 0.832). Moreover, the consumers in regions with higher income are more sensitive to the natural gas price and income. These results further indicate that compared with the regions with low-wage, it can be more effective to decrease the urban natural gas price and increase the wage levels for improving the urban natural gas demand in regions with high-wage.

Third, the impact of *HDD* on urban natural gas demand is heterogeneous across different regions. To be more specific, provinces with lower temperatures require more natural gas for consumption due to the utilization efficiency in Region IV (i.e., region with high-

Table 7
Results of the robustness test for deleting variables.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln*P*		−1.469***	−1.750***	−1.345***	−1.571***	−2.015***	−2.717***
		(−11.35)	(−13.03)	(−10.11)	(−12.27)	(−14.31)	(−22.50)
ln*W*	−0.0796		0.317***	0.611***	0.405***	0.626***	0.932***
	(−0.85)		(3.74)	(6.80)	(4.52)	(7.24)	(12.14)
ln*HDD*	0.291***	0.130***		−0.00442	0.126**	0.210***	0.266***
	(6.12)	(2.70)		(−0.09)	(2.49)	(4.38)	(5.25)
ln*EP*	1.580***	2.616***	2.284***		2.602***	3.063***	2.969***
	(8.20)	(13.44)	(12.02)		(13.09)	(14.96)	(13.50)
ln*PR*	1.241***	1.349***	1.579***	2.634***		2.484***	3.209***
	(3.49)	(4.02)	(4.96)	(7.29)		(7.46)	(9.64)
ln*UR*	1.541***	1.348***	1.246***	1.644***	1.365***		0.773***
	(9.91)	(9.51)	(8.73)	(11.42)	(9.88)		(5.27)
ln*NPR*	0.640***	0.494***	0.446***	0.424***	0.466***	0.339***	
	(20.44)	(15.96)	(12.43)	(10.98)	(13.62)	(8.84)	
_cons	−2.807	−1.184	−4.620**	−13.88***	0.723	−13.70***	−19.50***
	(−1.35)	(−0.71)	(−2.46)	(−6.20)	(0.65)	(−7.39)	(−10.49)
xttest3	16861***	34711***	18100***	13607***	22848***	6165***	34438***
Wooldridge	110.36***	110.48***	105.85***	112.75***	116.69***	116.66***	102.09***
Wald chi2	2300.3***	5020.0***	5313.3***	4305***	3937.3***	3370.32***	4517.95***
Obs.	360	360	360	360	360	360	360
Province	30	30	30	30	30	30	30

Notes: *, **, and *** are significant at the level of 0.1, 0.05, and 0.01, respectively.

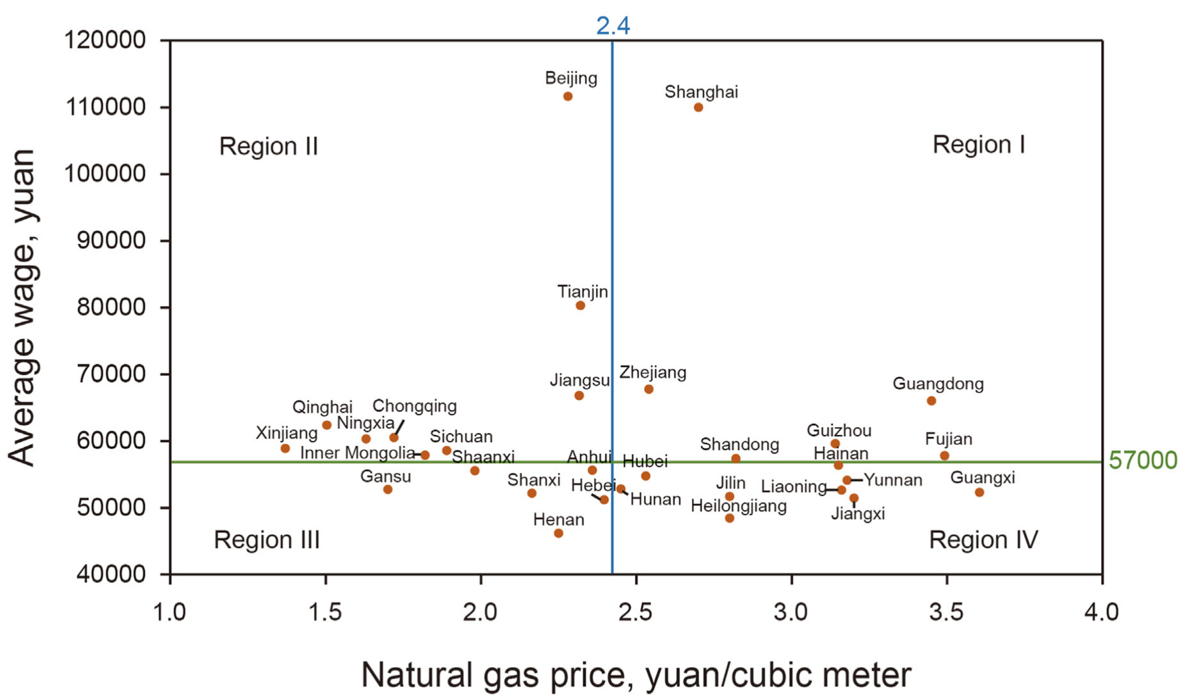

Fig. 2. Regional division based on the natural gas price and average wage. The x-axis represents the average urban natural gas price for each province and y-axis denotes represents the average wage for each province in 2013–2017; the green and blue lines denote the median of each average value.

gas-price and low-wage), but this is not the case for the other three regions. Furthermore, the electricity price elasticity is more flexible in regions with high-wage (i.e., 1.341 in Region I and 1.038 in Region II) than that in regions with low-wage. These results indicate that there exists a strong switching effect between electricity and natural gas in regions with high-gas-price and high-wage in urban China. In addition, the estimation coefficients of *PR*, *UR*, and *NPR* in the four regions are basically in line with the full samples. An interesting finding is that expanding the penetration level of natural gas and increasing the natural gas population will better raise urban natural gas demand in regions with low-wage than that with high-wage, which indicates that the difficulty in obtaining energy sources may discourage consumers with a low income from natural gas consumption. These results may due to the fact that the switch from one kind of energy consumption to another needs to replace the energy equipment, and this replacement requires high cost, which is unacceptable in regions with low-income to some extent.

5.2. Asymmetric analysis

To further clarify the asymmetric characteristics of the relationship of the independent variable and urban gas demand in China, the quantile regression approach is used to further estimate Eq. (9). This study chooses the 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and

Table 8
Results of the regional heterogeneous analysis.

Variable	(1) Region I	(2) Region II	(3) Region III	(4) Region IV
ln*P*	−1.444***	0.690*	0.867*	−0.964***
	(-3.03)	(1.67)	(1.79)	(-2.92)
ln*W*	−0.229	1.479***	0.832***	−0.0679
	(-0.88)	(10.87)	(4.75)	(-0.23)
ln*HDD*	−0.842***	−0.912***	−0.0487	0.177***
	(−3.34)	(−4.57)	(−0.29)	(3.16)
ln*EP*	1.341**	1.038**	0.768*	0.845
	(2.15)	(1.99)	(1.65)	(0.97)
ln*PR*	1.081*	1.891***	−1.282**	2.393**
	(1.89)	(3.32)	(−2.38)	(2.44)
ln*UR*	0.206	−2.224***	0.444	−1.052
	(0.53)	(−5.89)	(0.55)	(−1.38)
ln*NPR*	1.244***	−0.0830**	0.282***	1.049***
	(9.87)	(−1.96)	(3.30)	(6.18)
_cons	9.006	−14.81***	0.0943	−8.741*
	(1.60)	(−5.15)	(0.03)	(−1.69)
xttest3	62619.88***	1674.53***	327.90***	3242.94***
Wooldridge	264.955***	23.497***	8.017**	1008.445***
Wald chi2	934.31***	598.55***	691.82***	414.36***
Obs.	72	108	72	108
Province	6	9	6	9

Notes: *, **, and *** are significant at the level of 0.1, 0.05, and 0.01, respectively.

0.9 percentiles of conditional urban natural gas demand for the estimate, and the results are shown in Table 9. The variation patterns of the independent variable are shown in Fig. 3a–h.

Comparing the results in Table 9 with the results in Table 5, one can see that the signs of all the independent variables are basically consistent. First, the impact of gas price on urban natural gas demand is consistent in regions with different urban natural gas consumption. As can be seen from Fig. 3 and Table 9 that the estimation elastic of natural gas price on urban gas demand is significantly negative in various quantiles, and is higher in regions with lower natural gas demand than the regions with higher gas demand in the absolute value. To be more specific, as the increase of gas consumption (i.e., from the 0.1 to 0.9 quantile), the absolute value of both own-price elasticities gradually decreases from 2.7 to 1.77. Second, the impact of income on urban natural gas demand is asymmetric, specifically, is statistically significant from 0.1 to 0.5 quantiles, but insignificant from 0.6 to 0.9 quantiles. Furthermore, the income elasticity also decreases from 1.18 at the 0.1 quantile to 0.438 at the 0.5 quantile. Third, the estimation results base on the quantile regression also indicates that the urban gas demand is greatly influenced by the penetration rate in regions with low urban natural gas consumption, and is greatly affected by the urbanization level in regions with high urban gas demand.

6. Conclusion and policy implications

Based on the extended model of production and consumption, this study uses balanced panel data on China's 30 provinces covering 2006–2017 to investigate the potential influencing factors of urban natural gas demand. Considering the significant differences in the gas price and average wage level across each province, this study further investigates the potential regional heterogeneity among the four regions re-divided by urban natural gas price and average wage level. This study also employs the quantile regression method to further explore the potential asymmetry of the impacts in regions with different gas consumption levels. The main findings in this paper are as follows:

(1) The natural gas demand in urban China is negatively affected by the natural gas price, and positively affected by income, *HDD*, the electricity price, the penetration rate, the urbanization rate, and the gas population ratio. Furthermore, this study verifies the strong switching effect between gas and electricity in urban China, which is greatly influenced by own-price and cross-price. In addition, higher *HDD* leads to more consumption of urban natural gas, of which the latter has been one of the major resources for heating in urban China.

(2) In regions with high-gas-price (i.e., Regions I and IV), the natural gas price is the dominant indicator that influences urban gas demand; while in regions with low-gas-price (i.e., Regions II and III), urban natural gas demand is affected largely by the average income, but is less responsive to the gas price. Besides, this study finds that regions with higher income (Regions I and II) are more sensitive to gas price and income.

Table 9
Results of the quantile regression.

Variable	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Dependent variable: ln*C*									
	Quantiles								
ln*P*	−2.7***	−2.4***	−2.0***	−1.9***	−2.0***	−2.0***	−1.6***	−1.8***	−1.77***
	(−5.02)	(−8.34)	(−7.09)	(−9.13)	(−8.01)	(−6.37)	(−4.3)	(−3.74)	(−3.83)
ln*W*	1.18***	1.09***	0.58***	0.451**	0.438**	0.286	0.102	−0.193	−0.316
	(4.64)	(4.39)	(2.92)	(2.71)	(1.43)	(0.84)	(0.3)	(−0.6)	(−1.1)
ln*HDD*	0.45***	0.41***	0.32***	0.31***	0.216**	0.083	−0.160	−0.228	−0.577
	(3.38)	(4.88)	(5.69)	(3.67)	(1.96)	(0.5)	(−0.69)	(−0.77)	(−1.37)
ln*EP*	4.27***	3.67***	3.18***	3.22***	3.05***	3.08***	2.38***	2.53***	2.344***
	(7.55)	(10.49)	(8.54)	(7.71)	(7.65)	(6.08)	(4.1)	(5.15)	(3.57)
ln*PR*	4.212**	3.331***	2.717***	2.803***	2.501***	1.934**	0.619	0.126	0.805
	(2.64)	(4.64)	(6.19)	(7.63)	(3.68)	(1.84)	(0.65)	(0.17)	(1.39)
ln*UR*	−0.938*	−0.515	0.265	0.413	0.713**	0.846***	1.206**	2.112***	2.146***
	(−1.86)	(−1.29)	(0.79)	(1.48)	(2.77)	(2.57)	(2.27)	(4.06)	(4.52)
ln*NPR*	0.128	0.155*	0.258***	0.275***	0.299***	0.364***	0.521***	0.520***	0.448***
	(0.88)	(1.55)	(3.87)	(3.51)	(2.47)	(2.62)	(3.69)	(4.62)	(4.23)
_Cons	−29.2***	−24.1***	−15.2***	−13.9***	−11.4***	−5.886	3.514	10.423*	11.550***
	(−4.14)	(−4.97	(−6.75)	(−4.5)	(−1.94)	(−0.76)	(0.48)	(1.68)	(3.09)
R^2	0.6197	0.5854	0.5514	0.5167	0.4818	0.4522	0.4279	0.4212	0.3887
Obs	360	360	360	360	360	360	360	360	360

Notes: *, **, and *** are significant at the level of 0.1, 0.05, and 0.01, respectively.

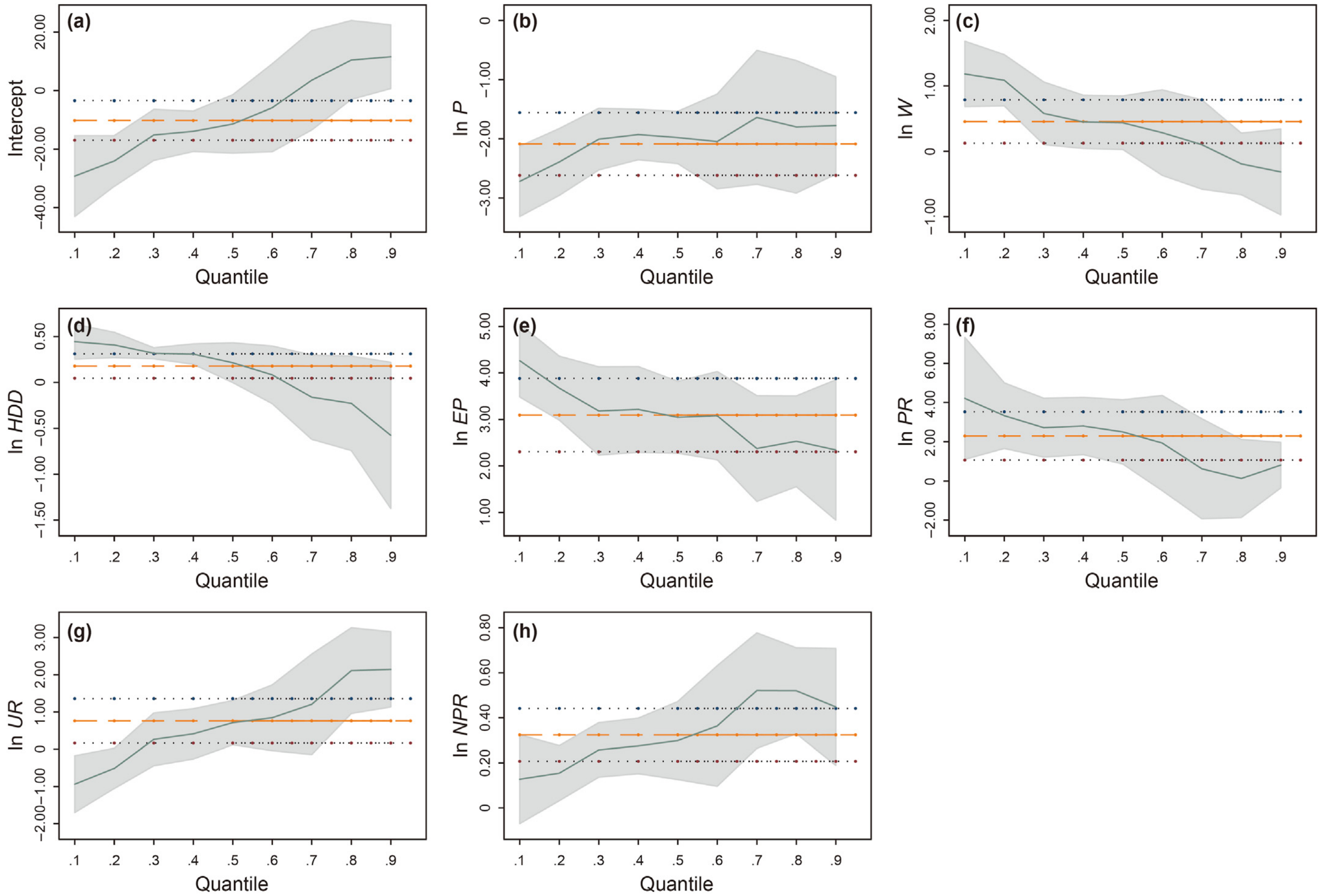

Fig. 3. Change of natural gas demand coefficient based on quantile regression. The x-axis represents the conditional quantiles of urban natural gas consumption and the y-axis denotes the coefficient values of various variables. The orange dotted line indicates the coefficient values of the panel data model with the fixed effect.

(3) These results of the asymmetric analysis indicate that the impact of gas price on urban natural gas demand is consistent in regions with different urban gas demand; while the impact of income on urban gas demand is asymmetric. Specifically, the estimation elastic of income is statistically significant from 0.1 to 0.5 quantiles, but insignificant from 0.6 to 0.9 quantiles. Furthermore, the regions with high gas consumption are less affected by the own-price.

Based on the above findings, several policy implications are suggested:

First, the empirical results indicate that the increase in urban natural gas price can hinder the increase in urban natural gas demand. As the fact that the price of urban gas in China is highly regulated by the government, the negative impact of urban gas prices on gas demand can contribute to natural gas price reform and natural gas production activities. The effective way to promote urban natural gas demand in the region with high-gas-price is to appropriately lower the gas price. On the demand side, raising the gas price may discourage the consumption of urban natural gas directly. While on the supply side, a high gas price will provide an incentive for further gas production and infrastructure improvement, thereby indirectly boosting demand for gas. Furthermore, appropriate wage increases can effectively promote urban natural gas consumption. Besides, it is essential to achieve the coordinated development of urban gas supply and demand. On the one hand, ensuring the supply of natural gas to residents during peak season (i.e., winter) is an important task for the Chinese government's policymakers.

Second, the conclusion of the heterogeneous analysis shows that the local governments should take the urban natural gas price and income level into consideration when designing differentiated policies to improve local natural gas demand. For instance, the key to the energy consumption transition from dirty to clean fuels in regions with low-gas-price is improving the local income level. Furthermore, given that welfare remains unchanged, providing subsidies for urban natural gas consumption might be a better policy instrument to encourage clean energy shifting. Meanwhile, the income level is expected to rise in the next decade in a rapidly developing country like China, which indicates that urban natural gas demand will also increase significantly, especially in the regions with low-gas-price (i.e., Region II and III).

Third, the result of the asymmetric analysis suggests that improving access to clean energy can promote natural gas consumption more effectively compared to cutting the gas price in regions with low urban natural gas demand. Therefore, it is essential to accelerate the construction of infrastructure such as production, transportation, storage, and expand the penetration rate of urban natural gas for improving urban natural gas consumption. Furthermore, in regions with high-gas-consumption, improving the urbanization level and gas population ratio is more effective in further increase the urban natural gas demand.

However, there are still some limitations in this study. One such limitation is that this study provides only preliminary evidence on the impacts of urban gas price, wage, socioeconomic determinants, and meteorological conditions on urban natural gas demand; the internal impact mechanism will be further explored in future research. Another is that it would be interesting to further explore the spatial spillover effects of the urban natural gas price and wage on the urban natural gas demand, which can fill the literature gaps in the analysis of natural gas consumption from the spatial perspective.

Declaration of competing interest

No potential conflict of interest was reported by the authors.

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