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The price and income elasticities of natural gas demand in Azerbaijan: Is there room to export more?

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Natural gas is frequently introduced as a "transitional fuel". Because burning natural gas emits less carbon dioxide emissions than burning either oil or coal. Additionally, the intermittent nature of low-carbon electricity generation creates imperative for using natural gas for power generation. The role of natural gas is currently under scrutiny as climate change transforms into a climate crisis. Meanwhile, share of natural gas in the primary energy consumption of Azerbaijan is 69%, while 94% of the country's electricity is currently being generated in natural gas-fired power plants. In this manner, this paper estimates income and price elasticities of natural gas demand for the Azerbaijan case. In this study, various sets of estimation techniques are utilized. By modeling natural gas demand with different estimation methods, including Autoregressive Distributed Lagged Structural Time Series Modeling, Dynamic Ordinary Least Squares Method, Fully Modified Ordinary Least Squares, Canonical Cointegrating Regression, and General to Specific under Autometrics multi-path search machine learning algorithm, we try to find if there is room for the country to export more. All these utilized estimation methods confirmed the long-run income elasticity to be around 0.8, while the long-run price elasticity is around −0.1. Both estimations provide insights in terms of energy security and electricity security for policymakers during the implementation process of climate, energy, and environmental policy. Findings of this study classify natural as a necessity and normal good for the Azerbaijan case. The main policy implication of this study is that policymakers must enable and facilitate the availability of close renewable substitutes for residential and commercial customers. Estimated elasticities suggest that with rising national income, demand for natural gas will keep increasing, and efficient consumption will not be attainable with increasing prices. In the pursuit of export potential, findings suggest that it is more relevant to free up natural gas allocated from power generation by substituting it with renewable energy sources.

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Introduction

The attractiveness of natural gas for developing countries stems from various features of this fossil fuel. Natural gas is considered a fuel-efficient source of power generation. Burning natural gas emits lower CO2 emissions, has better operational flexibility, and lower capital costs. As Erias and Iglesias (2022) put it, higher climate ambition and increasing renewable energy penetration do not fully undermine the key role of natural gas, at least in power generation. Azerbaijan has rich natural gas resources. The total proven natural gas reserves of Azerbaijan are 2.5 trillion cubic meters, and with the current rate of production, these reserves will be depleted in 96 years (BP, 2022). Furthermore, as IEA (2019) defines it, the country has "one of the highest energy self-sufficiency ratios in the world." As of 2021, the share of natural gas in the primary energy consumption of the country is 69% (BP, 2022). Since coal is not consumed in the country, the declining share of oil in the total energy mix paves the way for a bigger role for natural gas. The growing importance of natural gas in Azerbaijan's economy mainly stems from electricity generation. Almost all oil-fired power plants gradually switched to natural gas. As a result of this transformation in power generation, more than 90% of the country's electricity is currently being generated in natural gas-fired power plants (OECD, 2021).

Furthermore, the energy transition is also a crucial challenge for the Azerbaijan case. Since the country is rich in natural gas resources, on the one hand, the opportunity cost of substituting it with renewables seems very high. On the other hand, how renewable energy resources will replace natural gas in the total energy mix is still a big question mark for policymakers. The Ministry of Energy of the Republic of Azerbaijan targets a share of renewables in the total energy balance of the country to reach 30% by 2030 (MoE, 2022a). Development of 470 MW solar and wind power generation projects has already been started. In total, gradually up until 2030, power generation from renewable energy resources is estimated to be increased by 1500 MW (MoE, 2022a). During this transition period and from 2030 onward, natural gas is estimated to preserve its role as a sustainable energy and electricity source. In a nutshell, natural gas is not only vital for the energy security of the Azerbaijan economy, but it is also crucial for the electricity security of the country.

Geopolitical tensions started with the invasion of Ukraine by Russia and created disruptions in natural gas exports from Russia. It seems, Azerbaijan partially substitutes Russian exports. A pipeline entitled Southern Gas Corridor (SGC) is planned to transport Azerbaijan gas to Europe. The European Commission classified SGC as a Project of Common Interest (PCI) (EC, 2019). Additionally, in July 2022, Azerbaijan and the EU Commission signed a Memorandum of Understanding (MoU) entitled Strategic Partnership in the Field of Energy. And Azerbaijan committed to double the previously announced capacity of SGC and deliver at least 20 bcm of natural gas by 2027 (EC, 2022).

The Strategic Roadmap of the Azerbaijan economy targets high-income country status after 2025. This income increase will generate higher demand for natural gas, and at the same time, the country needs to increase its natural gas exports tremendously by 2027. Overlapping periods of export commitments and national income targets may pose a very striking trade-off or dilemma between domestic consumption and commitments in the export markets.

Modeling natural gas demand will provide insightful implications for renewable energy transition, exporting opportunities, and policymaking related to energy and electricity security. In general, there are not many studies related to the natural gas demand in Azerbaijan. Hasanov et al. (2020) evaluate the role of Azerbaijan's natural gas exports and the Southern Gas Corridor's (SGC) role in the mitigation of the energy security risks of the EU. Considering environmental impacts, Gurbanov (2021) finds that in Azerbaijan's case increase in the share of natural gas in the total energy mix is associated with a decrease in CO2 emissions per capita. That is, during the energy transition period, natural gas can be used as an alternative means of energy supply reducing environmental pollution through carbon emissions. Especially in terms of intermittent renewable energy resources, natural gas becomes a sustainable source of electricity. This important feature of sustainability in the era of accelerating climate change provides big relief for consumers and if there will be any for prosumers.

Considering the above given solid justification, this study contributes to the existing literature firstly by analyzing the relationship between natural gas consumption and economic growth in the case of Azerbaijan. To the best of our knowledge, this kind of broader analysis has not been conducted yet. That kind of disaggregated approach provides better insight into policymaking as well as a holistic understanding of scholarly discussions. The primary reason for this gap in the literature was partially about not having enough sample size to employ estimation techniques adopted in the current study. Additionally, regulated natural gas prices for the Azerbaijan case are not readily available. Since natural gas prices are not fully and publicly available data, we collected this data from various sources of archives. It is another merit of our paper to be mentioned. To the best of our knowledge, by collecting price data, this paper will be unique in estimating the price elasticity of natural gas demand for the Azerbaijan case. Also, first time in its flagship report, IEA (2022e) questions the "transitional fuel" status of natural gas. That is, in terms of policymaking, it is an urgent matter to have a better understanding of the income and price elasticities of natural gas demand. This research study intends to shed additional light on the remaining potential of another fossil fuel for policymaking by providing further evidence. The use of the Structural Time Series Modeling (STSM) and Autometrics multi-path search machine learning algorithms in this study provides additional statistical superiority for the current study.

The remainder of the paper is structured as follows: Next section will provide additional and detailed background information together with practical insights on the importance of natural gas in Azerbaijan's economy. Section "Literature review" provides a review of the related literature. Section "Econometric methodology and used specification" derives the model specification, and data used for empirical estimations are presented in Section "Data". Section "Econometric estimation results and discussions" discusses econometric estimations results. Section "Conclusions and policy implications" concludes the paper and shares the policy implications of the paper.

Importance of natural gas in the total energy mix of Azerbaijan

Natural gas is the most important fuel in the high fossil fuel-dominated energy mix of Azerbaijan. Demand for natural gas has increased rapidly over the years, not only at the household level but also at the industrial level. In comparison to 2000, total primary energy consumption rose by around 40% and reached 183 TWh (terawatt-hour) in 2021 (SSCRA, 2021a). Starting from 2000, natural gas has surpassed oil consumption and dominated the energy mix of the country. Oil consumption experienced a sharp decrease of 30 TWh from 2000 to 2001 (47 TWh in 2001). Between 2001–2021 oil consumption was around 50 TWh, with the lowest level of 40 TWh in 2010 and 2011 (SSCRA, 2021a). In contrast to oil consumption, a gradual and stable increase in gas consumption has been observed between 2000–2021. Compared to 2000, gas consumption increased 2.4 times and peaked in 2021 at 127 TWh (SSCRA, 2021b). Also, the share of natural gas in primary energy consumption has risen gradually over the years and accounted for 69% of total primary energy consumption in 2021, while the share of oil was around 28%. It is obviously seen that country's energy mix is highly fossil fuels dependent, and renewable sources play an insignificant role in primary energy consumption (BP Statistical Review of World Energy, 2022).

The natural gas market has a monopolistic structure in Azerbaijan, and state-owned Azerigaz Closed Joint-Stock Company (CJSC) is responsible for the transmission, distribution, and selling of natural gas to the end-users; it sells more than 50% of its gas to households. Starting from January 1, 2021, according to the decision of the Cabinet of Ministers, the purchase of natural gas from gas producers in the domestic market of the Republic of Azerbaijan, organization of its transportation and sale to domestic distributors and consumers is entrusted to the State Contract Corporation of the Republic of Azerbaijan—Azerkontrakt OJSC. Meanwhile, Azerkontrakt Open Joint-Stock Company (OJSC) is the responsible body that organizes the sale of gas to Azerigaz CJSC and other strategic enterprises (such as the main electricity producer—Azerenergy OJSC) (Cabinet of Ministers, 2020).

Figure 1 shows the breakdown of the natural gas consumption by sector in the whole country. As is seen in Fig. 1, the final consumption of natural gas has grown steadily over time at the household and industrial level and compared to 2007; households consumed 60% more in 2021 (around 4000 mcm, that is 4 bcm). For the industry, the growth for the same period is approximately 32%, and industrial consumption in 2021 was slightly over 900 mcm.

In the broader definition, if natural gas used for power generation is also included, the total supply in 2021 will be 13,126 mcm (13.1 bcm, billion cubic meters), whereas total consumption has been 12,413 mcm (12.4 bcm). That is the total loss in the distribution equaled 713 mcm. After hitting its peak in 2009 and 2010 with 12% (around 1200 mcm), the volume of losses has started decreasing gradually over time and reached around 700 mcm or 5% of the total in 2021. Also, it should be noted that Azerbaijan's electricity transmission and distribution networks have a loss rate of 9.7% (OECD, 2021).

As Fig. 1 indicates, the household sector is the largest consumer of natural gas, with a 70% share of the total, followed by industry with 7%. Also, as Fig. 2 shows, transformation input represents the volume of natural gas allocated for electricity generation, heating systems, and internal use of the energy sector. Figure 2 presents the upward trend in natural gas consumption for electricity and heating production purposes. Compared to 2007, power stations and central and district heating systems consumed 35% more, with 6581 mcm. Since no coal is used in the total energy consumption, the declining share of oil in the total energy mix paves the way for a bigger role for natural gas, and electricity generation is the main factor behind the significant consumption growth of natural gas. Note that almost all oil-fired power plants switched to natural gas, and as a result of this transformation in power generation, 94% of the country's electricity is currently being generated in natural gas-fired power plants (MoE, 2021).

In the Azerbaijan energy market, natural gas prices (tariffs) are not determined as a result of the interaction between supply and demand forces. Tariffs are regulated by the Tariff (price) Council of the Republic of Azerbaijan. From 2007 to 2016, tariffs for the industry remained unchanged and doubled after the approval of the new tariffs in December 2016. End-user tariffs for the industry remained nearly stable from 2016 until November 2021 and have experienced an increase of 10% since then (Tariff Council, 2021). After the denomination of the currency, new residential tariffs have been applied since January 2007 and doubled after July 2009, and remained the same until the approval of new differential tariffs in December 2016. Unlike non-household tariffs, household average tariffs have fluctuated from time to time due to prices and differential limits changes and went up nearly 20% in 2021 compared to 2020. According to the new tariffs, which were adopted in November 2021, tariffs for annual consumption up to 1200 m^3 increased by 20% (Tariff Council, 2009, 2016, 2021).

For an in-depth and closer look, Table 1 shows the energy consumption of households and industry, and construction over the years. Note that in that table, consumption for energy transformation purposes (such as electricity and heating production, etc.) has been provided separately to provide a broader picture of the corporate consumers' response to the price increase more accurately. "Households" consumption declined 10% after the price increase of 2009 July. But we can see even more savings by households in 2012 and 2013 without any price changes. "Households" consumption restored its 2008 level before a decline of 11% following new differential tariffs of 2016, December.

Changes in differential tariff limits for households in May 2019 can be an explanatory factor behind a significant consumption growth of 9% and 14% in 2019 and 2020, respectively since these changes lowered average tariffs for households. Differential tariffs worked like that; annual consumption up to 1700 m^3 was priced at 100AZN/1000 m^3 and once annual consumption exceeded

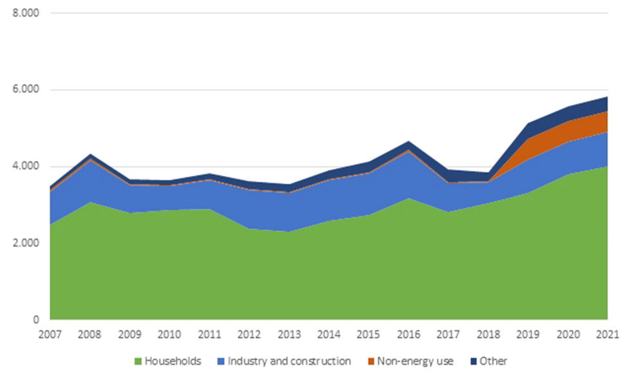

Fig. 1 Natural gas consumption by sector (mcm, million cubic meters). Source: Authors' calculations based on the data of The State Statistical Committee of the Republic of Azerbaijan (SSCRA), (2022) "other" refers to forestry, fishery, transportation, commercial and public services, etc.

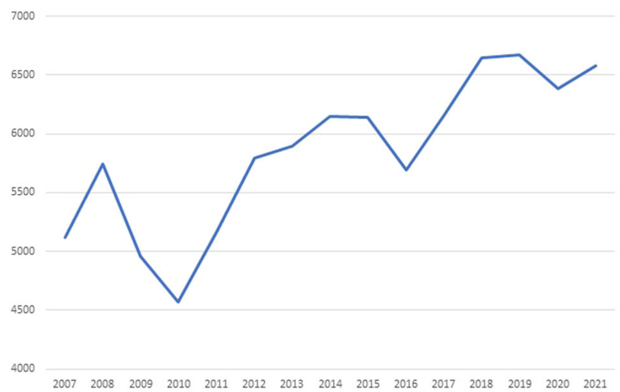

Fig. 2 Natural gas consumption for power generation, heating, and internal use of the energy sector (mcm, million cubic meters). Source: Authors' calculations based on the data of The State Statistical Committee of the Republic of Azerbaijan (SSCRA), (2022).

Table 1 Annual natural gas consumption and exports (mcm).

Years	Transformation input	Natural gas Exports	Households	Industry and Construction
2007	5118	1824	2482	860
2008	5742	5260	3084	1069
2009	4959	5867	2798	703
2010	4567	6187	2878	610
2011	5166	6817	2907	741
2012	5798	6617	2389	986
2013	5900	7308	2307	993
2014	6149	8093	2576	1059
2015	6142	8145	2751	1074
2016	5696	8049	3187	1208
2017	6158	8857	2827	750
2018	6644	9912	3055	530
2019	6669	11,833	3317	878
2020	6383	13,840	3786	854
2021	6581	19,078	4005	911

Source: SSCRA, (2022).

1700 m^3 price doubled to 200 AZN/1000 m^3. Here AZN stands for the national currency of Azerbaijan, manat. The exchange rate of 1 US dollar (USD) in terms of manat currently is 1.7. These tariffs are valid from December 2016 till May 2019. From May 2019 to July 2021, the 1700 m^3 limit increased, and it was replaced by 2200 m^3) (Tariff Council, 2019). Above mentioned consumption increases in 2019 and 2020 took place after this price decrease.

Despite a stable price, consumption of industry and construction also declined by 30% in 2009 and stepped into the stage of a gradual increase until 2016. Following the peak of 1207 mcm, industry and construction consumption went down significantly in 2017 (around 38%) after the price increase in December 2016. This tremendous increase was mainly because of the tremendous price increase during the last 10 years, and the percentage magnitude of the increase was 100. Put differently, since early 2007, industrial consumers paid 100 AZN for 1000 m^3, and this price prevailed up until 2017. In 2017, tariffs were increased to 200 AZN for 1000 m^3 consumption. The price of natural gas was increased also in November 2021.

The descriptive analysis of the relationship between natural gas consumption and prices suggests that changes in consumption patterns may have been impacted by temporary factors, which disappear in the long run. For example, a notable decline in household consumption from 2011 to 2012 and in industry and construction consumption from 2008 to 2009 took place without any price increase. The latter one was because of the global financial crisis, which created ripple effects for the Azerbaijan economy and stalled industrial production and construction. Moreover, even though significant price increases took place, consumption kept growing in 2021 and 2022. Since close substitutes are not readily available to replace natural gas as an energy source, especially for households, natural gas demand tends to be less responsive to changes in price. In this manner, the current study investigates the magnitude of the price elasticity for natural gas demand. Also, in the short run, because of various reasons, household demand may fluctuate, and it seems, in the long run, it follows a steady trend.

Also, as Table 1 depicts clearly, between 2007–2021, Azerbaijan's natural gas exports increased almost ten times. In 2007, Azerbaijan's natural gas export was 1824 mcm (1.8 bcm). By 2021, the export figure reached 19,078 mcm (19 bcm). Hasanov et al. (2020) suggest that deterioration in self-sufficiency in the

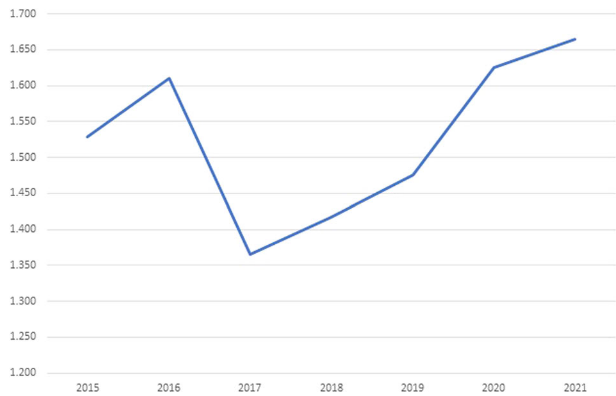

Fig. 3 Natural gas consumption per household, cubic meters. Source: Authors' calculations based on SOCAR, Azerigaz CJSC, and The State Statistical Committee of the Republic of Azerbaijan data.

EU will increase the share of imports in total consumption from 75% to 88% during the period spans from 2017 to 2040. Azerbaijan's natural gas exports are almost the mirror image of this self-sufficiency deterioration in the EU natural gas consumption. Azerbaijan exported 8.2 bcm of gas to Europe in 2021. Strikingly, within the first 9 months of 2022, natural gas exports of Azerbaijan to EU countries totaled 8.3 bcm (MoE, 2022b). More importantly, IEA (2022d) estimates that, in the 2023–2024 period, European countries will face a 30 bcm supply-demand gap for refilling gas storage in 2023. As mentioned in the previous section, Azerbaijan committed to increasing its natural gas exports to the EU to 20 bcm during the upcoming 5 years.

To eliminate the consumption stemming from the entrance of new households into the market and to see the effects of price changes more accurately, Fig. 3 presents consumption per household over the years. Consumption per household plunged dramatically in 2017 by 15% (from 1610 to 1366 m^3), probably due to new tariffs adopted in December 2016. The price increase was more than 100%. Starting from 2018, households have increased their consumption gradually and returned to their 2016 levels in 2020 before reaching a peak of 1665 m^3 in 2021. That is, household consumption was quite responsive to the striking price increase, which was effective by January 1, 2017, and then returned to the same level as the price increase melted down with the rising overall price level.

It is plausible to conclude that households responded to price changes immediately by reducing their consumption in 2017. Household natural gas saving effects of the price changes have disappeared over the years, and despite price increases in 2021, they have not reduced their consumption. On the contrary, household lifestyles have become more energy intensive. Even though price increases can lead to lower consumption for some periods, this process might not create serious room for export for a long period since households and industries return to their consumption habits quickly.

Additionally, gasification is another driving factor of upward trends in the natural gas consumption of households. By October 1, 2016, the number of customers who have access to natural gas had been slightly over 1.9 million. By late 2020, this number reached 2.3 million (Azerigaz CJSC, 2016, 2020). A steady increase in the number of new customers is one driving factor behind increasing natural gas consumption. The gasification level amounted to 40% in 2004, 90% in 2013, and 96% in 2022 (Azerigaz CJSC, 2022). Despite growth in the number of residential customers, electricity consumed by households is 20% less than the 2007 level since people shifted from electricity to natural gas for heating purposes. Put differently, households with access to electricity, but not natural gas, consume electricity for heating.

Azerbaijan also prioritizes Sustainable Development Goals (SDG) to overcome its major development challenges. Among others, SDG 9 is about promoting sustainable industrialization. Also, as a resource-rich country, Azerbaijan strongly needs economic and export diversification. Manufacturing value-added per capita, in terms of constant values, improved slightly from 2007 to 2021, from 248 USD to 337 USD (UNIDO, 2022). Industry and construction jointly make up 7% of total natural gas consumption in the country. Promoting sustainable industrialization along with SDG 9 requires the manufacturing sector of Azerbaijan to move into the decarbonization process in terms of energy consumption. In this manner, subsidized fossil fuel price is also a big policy challenge for the Azerbaijan case. IMF (2021) estimates that 6.8 percent of global GDP or 5.9 trillion USD (191 countries) is allocated for explicit and implicit fossil fuel subsidies in 2020 (IMF, 2021). At the global level, 47% of natural gas in 2020 was priced at least 50% below its true cost IMF (2021). In Azerbaijan's case, this kind of subsidy depicts a striking picture. Since November 2021, the wholesale price of natural gas for distributors in Azerbaijan has hovered around 70 USD/thousand cubic meters, retail price for the industry is around 130 USD/thousand cubic meters (Tariff Council, 2022). For example, as of November 22, 2022, Europe's benchmark Dutch front-month gas was priced at slightly over 1300 USD/thousand cubic meters (Bloomberg, 2022). This striking contrast shows the challenge of eliminating subsidized natural gas prices.

Literature review

Literature considering the price and income elasticities of natural gas demand for resource-rich countries is not a broadly studied topic. There are several studies to mention which shed some light on the above-mentioned relationship: For the Nigerian case, Galadima and Aminu (2019) use Structural VAR (SVAR) and impulse responses to show that one unit shock to the real GDP induces a change in natural gas consumption by 0.03% and 0.04%, in the short and long run, respectively.

Galadima and Aminu (2020) shed light on the natural gas–economic growth nexus for a resource-rich country, Nigeria. Galadima and Aminu (2020) explore the statistical superiority between linear and nonlinear techniques, and they come up with the conclusion that, for the Nigerian case, natural gas consumption and economic growth series follow a nonlinear trend process. They also conclude that energy conservation policies reducing natural gas consumption would dampen economic growth. Galadima and Aminu (2020) discuss that natural gas is the greenest fossil fuel, and it will help economies to establish a green economy. A brief summary of studies modeling natural gas demand is given in Table 2.

Javid et al. (2022), by STSM approach, model natural gas demand for Pakistan. As the value of income elasticity of demand has been less than unity for industry and residential sectors, 0.62 and 0.45, respectively, they classified natural gas as a necessity. The price elasticity of natural gas for industry and residential consumption is estimated as −0.19 and −0.13, respectively. It explains the inelastic nature of natural gas demand in the Pakistan case. OECD-Europe's case as a net energy importer is also interesting. The natural gas demand specification using the STSM approach finds long-term income and price elasticities for OECD-Europe as 1.19 and −0.16 (Dilaver et al. 2014). Dilaver et al. (2014) conclude that the energy consumption of households increased significantly, and they adopted more energy-intensive lifestyles. Besides, with FMOLS and DOLS estimates Bilgili (2013) concludes that, for 8 OECD countries, natural gas is a normal superior good and its demand is unit elastic or slightly more than unit elasticity. Dong et al. (2019) estimate income and price elasticities of natural gas demand for China's 30 provinces covering the period from 1999–2015. Their study finds that the price elasticity of natural gas demand is 1.11 and statistically insignificant for the period of 1999–2009. In addition, they found statistically significant and positive price elasticity of natural gas demand, which is 0.35 for the data period from 2010 to 2015. Dong et al. (2019) conclude that the income elasticity of natural gas demand in China is in the range of 1.23–1.27. Their finding reveals that natural gas demand is income elastic, and the main reason behind this outcome is the rising economic level in the country. For China's case, Zhang et al. (2018), estimates price and income elasticity for five different sectors of the economy. Among others, specifically for the residents' sector, they estimate own-price inelastic demand with a −0.22 coefficient, for both the short and long run. To save space, a broad picture of their findings is given in Table 2. They conclude that, since coal is an inferior good, by rising income levels, Chinese consumers increase the quality of their life, by consuming more natural gas. By adopting the feasible generalized least squares (FGLS) approach, Yu et al. (2014) estimate the natural gas demand function and find price inelastic and income-elastic natural gas consumption for 62 Chinese cities. With the ARDL bounds testing approach, Farag and Zaki (2021) found that the long-run income elasticity of natural gas demand by households is statistically significant with a negative sign for the Egypt case. They concluded that households consider natural gas as an inferior good since Solar Water heater (SWH) use will increase with rising incomes. For the household sector, the price elasticity shows elastic demand with a value of −1.29. They interpret this result as the availability of close substitutes in the long run coming with technological advancement. For the 44 countries, Burke and Yang (2016) find an average long-run price and income elasticity of demand around −1.25 and +1 and higher, respectively. Their interpretation is that, for the countries which have below-cost natural gas prices, subsidy reform can generate significant impacts. That is elastic demand heralds that subsidy reform might bring sizeable reductions in natural gas consumption and emissions. In their study, the interpretation of long-run income elasticity is that, once economies keep growing, the share of natural gas in the total energy mix increases as well. Gautam and Paudel (2018) estimated long-run price elasticities of natural gas demand for the Northeastern United States. The geographical coverage of the sample is selected considering distinctive features of the Northeastern US, like extreme weather and intensive economic activity relative to other US regions. For the long-run relationship, they found inelastic demand for residential, commercial, and industrial sectors. In their estimation, we can single out households as demand is highly inelastic for households. Very inelastic household demand for natural gas stems from the lack of availability of close substitutes imposes little flexibility for the residential sector.

Erias and Iglesias (2022) estimate income elasticity for the natural gas demand for 25 European countries and find that elasticity for the short run and the long run have been 0.09 and 0.14, respectively. They explain relatively lower elasticity values compared to those of previous studies by relating lower values with the positive impact of energy efficiency policies and a more updated database. As is seen in Table 2, they found inelastic natural gas demand both in the short and long run. Considering price inelastic gas demand, Erias and Iglesias (2022) call for caution in implementing price-based tools to tackle climate change. They suggest that that kind of regulatory measures on natural gas demand can encourage more polluting fuel consumption. Alberini et al. (2020) find price inelastic natural gas demand in Ukraine case. They relate −0.16 price elasticity with

Table 2 Summary for selected previous studies on price and income elasticities of natural gas demand.

Author	Country	Period	Method	Income Elasticity	Price Elasticity
Erias and Iglesias (2022)	25 European Countries	2005–2020	ARDL	LR: 0.14 SR: 0.09	LR: from −0.181 to −0.143 SR: from −0.047 to −0.021
Javid et al. (2022)	Pakistan	1972–2019	STSM	LR: 0.62; 0.45	LR: −0.19; −0.13
Farag and Zaki (2021)	Egypt	1983–2015	ARDL	LR: −0.65; SR: 0.14	LR: 0.36; SR: −0.15
Alberini et al. (2020)	Ukraine	2013–2017	2SLS	NA	SR:−0.16
Dong et al. (2019)	China	1999–2009; 2010–2015	CCEMG	1.23; 1.27	1.11 (IS); 0.35 (S)
Gautam and Paudel. (2018)	United States	1997–2016	Augmented Mean Group (AMG)	NA	LR: −0.14; −0.2; −0.28
Zhang et al. (2018)	China	1992–2011	ARDL	From 2.05 to 4.34	LR: from −0.22 to 5.73 SR: from −0.20 to 3.09
Burke and Yang (2016)	Sample of 44 countries	1978–2011	Cross Section, Pooled OLS	LR: 1	LR: −1.25
Dilaver et al. (2014)	OECD-Europe	1978–2011	STSM	LR: 1.19	LR: −0.16
Bilgili (2013)	8 OECD countries	1979–2006	Panel DOLS and FMOLS	LR: 1.032 and 1.393	LR: from −0.345 to −1.292
Yu et al.	China	2006–2009	FGLS	1.235	−0.779
Wadud et al. (2011)	Bangladesh	1981–2008	Dynamic econometric model	LR: 1.47 SR: 0.33	−0.25 to 0.15 (IS)

LR long run, *SR* short run, *NA* not available, *CCEMG* the panel common correlated effects mean group estimator, *S* statistically significant, *IS* statistically insignificant, *ARDL* Autoregressive Distributed Lagged estimation approach, *DOLS* Dynamic Ordinary Least Squares Method, *FMOLS* Fully Modified Ordinary Least Squares.

the limited substitution opportunities. For the Bangladesh case, Wadud et al. (2011) find long-run income elastic natural gas demand and conclude that larger than unity income elasticity is regular for developing countries.

Considering a comprehensive summary of existing literature and analyzing the income and price elasticity of natural gas, we can conclude that elasticities vary from country to country, even across the regions within one country. As seen in the contrast between the findings of Dilaver et al. (2014) and Erias and Iglesias (2022) working with the same sample, the recent dataset may estimate a lower income elasticity. In a nutshell, natural gas demand depicts diverse features in different geographies, time frames, and market structures. In this manner, the Azerbaijan case, with the most recent dataset and state-controlled natural gas market will shed additional light on the policymaking to tackle climate change as well as scholarly initiatives conducting research studies related to all resource-rich and natural gas-dependent countries.

Econometric methodology and used specification

The unit-root properties of variables are exercised via the Augmented Dickey-Fuller (Dickey and Fuller, 1981, ADF) and Philips-Perron (Philips and Perron, 1988, PP) unit root tests. For assessing the existence of the long-run relationship between the variables, we utilize the Engle and Granger (1987) and the Bounds Testing Approach to Autoregressive Distributed Lagged (ARDLBT, Pesaran et al., 2001; Pesaran and Shin, 1999) cointegration tests. For estimating the relationships between the variables, we have utilized a set of estimation techniques for robust results. Namely, we have used the General to Specific (Gets) modeling approach (see Hendry and Doornik, 2014; Doornik and Hendry, 2018, among others), the Bounds Testing Approach to Autoregressive Distributed Lagged models (ARDLBT, Pesaran et al. 2001; Pesaran and Shin 1999), the Structural Time Series Modeling (STSM) approach (Harvey, 1989), the Fully Modified Ordinary Least Squares (FMOLS) method (Phillips and Hansen, 1990), the Dynamic Ordinary Least Squares (DOLS) method (Saikkonen, 1992; and Stock and Watson, 1993), and the Canonical Cointegration Regression (CCR) (Park, 1992) method.

This study uses a conventional energy demand specification, where demand is modeled as a function of its own price and income. The unobserved components are modeled via stochastic trends (Dilaver et al. 2014) or saturation dummies (Hendry and Doornik, 2014). Mathematically the model to be estimated could be expressed as follow:

$$ngas_t = \alpha_0 + \alpha_1 income_t + \alpha_2 price_t + unobserved\ components + u_t \quad (1)$$

Here ngas is natural gas demand, income is countries income level, and the price is the price of natural gas. Unobserved components incorporate variables that have an impact on natural gas consumption but are not directly observable, or hard to find a relevant proxy. Examples of unobserved components might be technological improvements, capital stock or its utilization rate, etc.

Data

This section describes the used variables and their sources. This study has been developed using annual data for the period of 1993–2021. Natural gas consumption stands for the final consumed natural gas, in cubic meters. It is retrieved from Natural gas data, BP Statistical Review of World Energy (2022). Natural gas consumption data was converted to per capita terms using the population data. Population data is taken from World Bank Development Indicators (WB, 2022b). Income is proxied with GDP per capita, constant 2015 US$. This data is sourced from the World Bank database (WB, 2022a). Natural gas price data is weighted, real price data. It is calculated using two main elements of overall natural gas consumption, namely the residential and

Table 3 Descriptive statistics of the variables.

	Mean	Standard Deviation	Coefficient of Variation, %	Minimum	Maximum
Ngas	1050.11	265.51	25.28	644.54	2029.46
income	3427.60	1796.01	52.39	1102.45	5505.98
Price	0.34	1.36	400	0.20	7.66

Source: Authors' calculation based on WB (2022a), SSCRA (2021a).

industrial "sectors" shares. These two sectors comprise around 77% of the overall final consumption of natural gas demand in 2021 (SSCRA, 2021a). Natural gas price data is not fully available data for the public. Nominal natural gas prices are collected from publicly available data starting from 2007. And that kind of public data is not readily available. It is scattered in many different resolutions. Before that, retail natural gas prices are collected from archives. Natural gas retail price is not determined as a result of the interaction of supply and demand forces. Prices are regulated by the Tariff (price) Council of the Azerbaijan Republic. Nominal natural gas prices are converted to real values using the consumer price index (CPI). CPI data was taken from the World Bank database (WB, 2022a) and rebased to 2015. The descriptive statistics of the used variables are presented in Table 3.

The graphs of natural gas consumption weighted real natural gas prices, and real per capita GDP are depicted in Figs. 4–6.

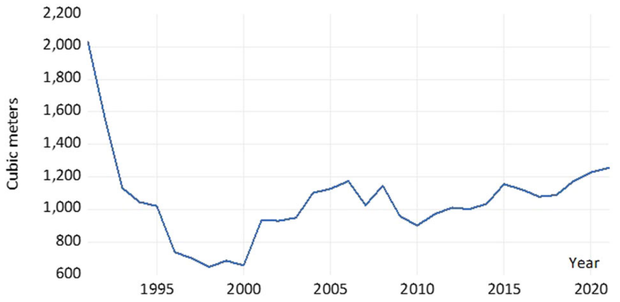

Fig. 4 Natural gas consumption, per capita, cubic meters. Source: "authors" calculation based on BP Statistical Review of World Energy (2022) data.

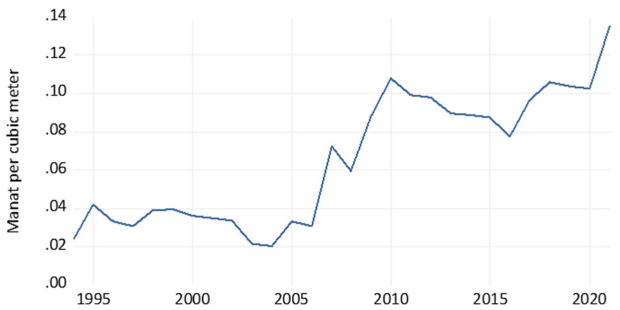

Fig. 5 Weighted real natural gas price, manats per cubic meter. Source: "authors" calculation based on the Tariff (price) Council of the Azerbaijan Republic data.

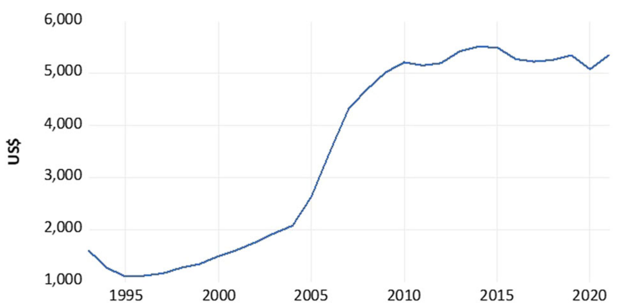

Fig. 6 Real GDP per capita, constant 2015 US dollars. Source: "authors" calculation based on World Bank data.

Econometric estimation results and discussions

The ADF and PP unit root tests are employed initially in the empirical estimate process to examine the variables' unit-root features. Table 4 displays the results of the ADF and PP.

The results of the ADF and PP tests revealed that all variables are I(1), which means that they are stationary at the first difference. Therefore, the unit root test concluded that all the variables were to be integrated in the first order. This allows testing the variables for sharing a common long-run trend. We use the Engle and Granger, as well as the Bounds Testing cointegration tests, to find out if there is a long-term cointegration relationship between the variables. The results of cointegration analyses are shown in Table 5.

The critical values of the Z-statistics and Tau-statistics of the Engle–Granger are bigger than the respective critical values, which means that the null hypothesis of "no cointegration" can be rejected in favor of the alternative hypothesis of cointegration. Moreover, the null hypothesis of "no cointegration" is rejected if the calculated F statistic of the Bounds cointegration test is bigger than the critical values for the upper bound. Therefore, both conducted cointegration tests found that a cointegration relationship exists. After concluding the existence of the cointegration relationship between the variables of interest, in the next step, the long-run relationships are handled using the techniques mentioned in the Methodology section. The long-run estimation results are provided in Table 6. Additionally, the detailed estimation results from all used methods are given in Appendix A. As the table shows, all used estimation techniques produced quite similar results. The signs of the coefficients of income and price variables are in line with the theoretical expectation, being positive for income and negative for price.

The diagnostic test results from the Gets approach are presented in Table 7. We do not report diagnostics results for other techniques to save space, but they can be provided upon request. All the diagnostic test results are in favor of the obtained models.

All utilized estimation methods concluded the long-run income elasticity to be around 0.8, while the long-run price elasticity was around −0.1. Only DOLS found it to be slightly different, namely around −0.2. Based on the outcomes of empirical estimations, the income elasticity of natural gas demand is positive (about 0.8) and statistically significant. It implies that a 1% rise in income results, on average, in a 0.8% rise in natural gas demand, in the long run. It is also important that the income elasticity of demand is smaller than one. Based on the data in Table 6, it can be inferred that natural gas is a normal good that is yet seen as a necessity for Azerbaijan.

Additionally, the price elasticity of natural gas demand is negative (around −0.1) and statistically significant. It means that a 1% rise in price reduces natural gas demand by 0.1%. As a consequence, the price of natural gas demand for Azerbaijan is inelastic. In other words, the decline in the quantity demanded of natural gas is not as great as the rise in price. According to estimation results, we can classify natural gas as a necessity good in the case of Azerbaijan. This is supported by the fact that

Table 4 Unit root test results.

	Variable	The ADF test			The PP test			
		ngas	income	price	ngas		income	price
Level	intercept	−1.790		−1.319	−0.148	−2.492	−0.525	−0.148
	Trend& intercept	−2.622		−2.357	−1.909	−2.623	−2.597	−1.909
First difference	intercept	−4.640***		−2.689*	−150.34***	−4.855***	−2.683*	−150.34***

Two is used as a maximum lag, and the optimal lag number is chosen based on the Schwarz criterion; "***" and "*" stand for rejection of null hypothesis at 1%, 5%, and 10% significance level, respectively.

Table 5 Cointegration tests' results.

Bounds test				Engle–Granger	
F-statistics = 34.51	Critical value			Tau-statistics	−4.127 (0.04)
	10%	2.915	3.695		
	5%	3.538	4.428	Z-statistics	−21.949 (0.03)
	1%	5.155	6.265		

p-values are in parenthesis. The null hypothesis for both tests is the non-existence of cointegration.

Table 6 Long-run estimation results.

Variable	Gets	ARDL	STSM	DOLS	FMOLS	CCR
Income	0.791*	0.816*	0.772*	0.730*	0.794*	0.779*
Price	−0.110*	−0.118*	−0.100*	−0.161*	−0.093**	−0.088[a]

In Gets, the optimal lag is chosen based on the Autometrics machine learning algorithm and the number of diagnostic tests, while for the ARDL BT and DOLS, it is determined based on the Schwarz criterion. In STSM, the maximum lag is set to 2, and the optimal lag is chosen based on the Schwarz criterion and the number of diagnostic tests.
Source: Estimation results.
"*" and "**" stand for rejection of null hypothesis at 1% and 10% significance levels, respectively.
[a]it is significant at 14% significance; in Gets, ARDL BT, and DOLS approaches, maximum lag is set to 2.

Table 7 Diagnostic test results for the Gets approach.

AR 1–2 test:	F(2,19) = 0.549 [0.586]	R ∧2 = 0.956
ARCH 1–1 test:	F(1,27) = 0.892 [0.353]	Adj.R ∧2 = 0.942
Normality test:	Chi ∧2(2) = 0.424 [0.809]	
Hetero test:	F(12,16) = 1.895 [0.116]	
RESET23 test:	F(2,19) = 1.941 [0.171]	

AR autocorrelation test (Godfrey, 1978), *ARCH* autoregressive conditional heteroscedasticity test (Engle, 1982), *Normality test* Doornik and Hansen (1994) normality test, *Hetero test* heteroscedasticity test (White, 1980), *RESET23* Regression Specification Test (Ramsey, 1969). *p*-values are in brackets.

natural gas is less expensive than alternatives and that approximately more than 90% of electric power is generated from natural gas in Azerbaijan (IEA, 2022c). As can be seen from the literature review, there are no studies investigating the elasticity of natural gas demand in the case of Azerbaijan. Therefore, we cannot compare our obtained income and price elasticities of natural gas demand with the results of previous studies. As a result of empirical estimation, the price elasticity (−0.1) of natural gas demand is close to zero, and the income elasticity (0.8) is close to one, which can be considered a relevant result for a resource-rich, developing country like Azerbaijan.

The found long-run price elasticity of natural gas demand for Azerbaijan case, in terms of sign and magnitude of the elasticity, is in line with previous studies such as Erias and Iglesias (2022), Javid et al. (2022), Gautam and Paudel (2018) and Dilaver et al. (2014) find for the country and country groups. In all these studies, the magnitude of the price elasticity hovers around - 0.2, that is implying high price inelastic demand in the long run.

Conclusions and policy implications

Modeling income and price impacts of natural gas demand, this study investigates the potential room for natural gas exports in the case of Azerbaijan. All utilized estimation methods concluded that the long-run income elasticity is around 0.8, while the long-run price elasticity is around −0.1. It means, in the long run, all other circumstances being the same, a 1% increase in income, on average, increases per capita natural gas consumption by 0.8%. In a similar vein, a 1% increase in price, on average, decreases per capita natural gas consumption by 0.1%. Put differently, we can classify natural as a necessity and normal good for the Azerbaijan case.

The first insight that can be generated from the above-mentioned price inelastic natural gas demand is that, in the short run, it may be unattainable for policymakers to have efficient consumption by increasing the natural gas prices in Azerbaijan. Since close substitutes are not readily available for residential and industrial consumers, very inelastic natural gas demand is the most likely outcome. The findings of this study suggest that since natural gas demand is price inelastic for the Azerbaijan case, increasing natural gas prices may be detrimental to industrial growth and household welfare. Highly price inelastic demand means that natural gas is perceived as a necessity, and increasing natural gas prices will not bring about a further considerable decrease in consumption. Whereas in the long run, a gradual increase in historically subsidized natural gas prices may create additional room for higher exports and increasing revenue for the government. Also, one should keep in mind that it would be challenging for policymakers to increase prices for households and industries. Increasing natural gas prices for the industry sector may dampen the competitiveness of the sector and impede economic diversification in the country. Then, it would be a prudent approach to switch to renewable energy sources for power generation with an increasing trend. Natural gas used power generation much exceeds the volume of household and industrial consumption combined. Allocating decreasing volume of natural gas for electricity production by substituting it with renewable sources, would create a two-fold benefit for the Azerbaijan economy; decarbonization of electricity production and maintaining electricity security.

Long-run income elasticity estimated in this study suggests that, by increasing income, natural gas demand will keep increasing, and its additional factor will be limiting export options of the country. Azerbaijan's goal of becoming a high-income country after 2025, will generate additional demand for natural gas. Since the income elasticity of natural gas demand is estimated to have a positive sign, it means natural gas is a normal good, and with increasing national income, demand for natural gas will increase too. Azerbaijan to be a high-income country after 2025, which means that 2021 GDP per capita is supposed to be increased from the current 5384 USD (World Bank, 2022c) to 13205 USD. As of July 2022, World Bank classification for high-income countries starts from 13,205 USD (World Bank, 2022d). As it is quite an ambitious national goal, income elasticity estimated in this study implies increasing demand for natural gas. Precisely expressing, to be a high-income country, Azerbaijan's GDP per capita needs to be increased by 145%. Since the income elasticity of demand is estimated to be 0.8%, then national gas demand will increase 116% correspondingly. Total natural gas consumption by 2021, has been 12.4 bcm. When the country moves into high-income status, assuming the current consumption trajectory, demand will be 26.8 bcm. In this manner, the estimated income elasticity in this study sheds light on the potential of exports.

Considering the above-given explanations, in terms of policy suggestions, we conclude that natural gas allocated for power generation should be the main focus of policymaking and creating room for exports. By 6.5 bcm consumption, the power sector is consuming the biggest part of the domestic consumption and generates 94% of electricity. In this manner, electricity and energy security has a very close definition for the Azerbaijan case. Moving power generation away from gas-fired power plants not only provides electricity security but also brings about energy security. With the accelerating climate change-related natural disasters, electricity and energy security require growing attention from policymakers. For example, the largest gas exporter of sub-Saharan Africa, Nigeria, with the biggest proven reserves has natural gas supply disruptions because of climate change-related flooding. Nigeria could have earned record profits and missed this opportunity in 2022 (WSJ, 2022a). A similar approach holds for the Netherlands: Groningen Field, one of the world's biggest natural-gas reserves, needs to halt production since natural gas production-related earthquakes damaged Dutch villages (WSJ, 2022b).

As existing literature shows, increasing natural gas dependence further will not provide environmental sustainability. Since sustainability is the primary merit of renewable energy sources, policymakers should accelerate the energy transition away from fossil fuels, including natural gas. As Gurbanov (2021) concludes, only increasing the share of natural gas in the total energy mix will make Azerbaijan's commitment to reduce greenhouse gas emissions (GHG) by 35% in 2030 unattainable. Also, as stated in the specific SDG indicator 8.4, sustainable economic growth implies a decoupling between economic growth and environmental degradation (UN, 2017). Since burning natural gas still emits CO2, sticking to natural gas, in the long run, might not ensure sustainability in terms of environmental protection. In the scenario of sticking only to natural gas, the price and income elasticities of demand estimated in this study reveal that it will exacerbate environmental deterioration. If decreasing natural gas consumption overlaps with increasing renewable energy consumption, the country will also be able to attain environmental sustainability. This kind of desirable decarbonized development path is also in line with the above-mentioned indicator, namely, SDG 8.4.

Furthermore, in terms of global environmental sustainability, IMF (2022) finds that relative to 2022, on a global scale, emissions need to be 25% less in 2030. It is a requirement to avert catastrophic climate disruptions. If relevant measures are not taken in 2022, fossil fuel exporting countries might face a considerable loss in their GDP. That is, among others, fossil fuel exporting countries are considered most vulnerable to the changes in climate, which is expected to come with global inaction during the next 7 years. Also, in the fossil-fuel exporting countries, macroeconomic costs, in terms of inflation and economic growth, will be relatively higher if the decarbonizing of electricity generation is delayed further. A slower transition away from fossil fuel-based power generation will require higher measures later on, like adopting larger GHG tax increases (IMF, 2022). IMF's most recent calibration model, entitled Global Macroeconomic Model for the Energy Transition (GMMET), together with the findings of the current study, suggest that Azerbaijani policymakers also can implement the proper measures immediately and incur costs of the energy transition, since as long as it is within the manageable magnitudes. Since sharp increases in carbon prices and taxes may increase the cost for industry and consumers, as time passes, it will be a more challenging option for policymakers. At this stage, carbon prices and tax revenues may be fully or partially rebated to households and firms to provide certain financial relief. In this manner, from now on, carbon tax, methane tax, and emissions trading system could be the main discussion topics for the Azerbaijan case.

Since natural gas is not fully capable of providing environmental and energy sustainability, it paves the way for estimating the elasticity of substitution between renewables and natural gas in electricity generation. It could be the topic of future study. The Stated Policies Scenario (STEPS) estimated by IEA (2022e) shows the trajectory of fossil fuel demand by considering current policy settings. It was the first time that IEA questioned the role of natural gas as a "transitional fuel." With the STEPS, IEA (2022e) finds that global demand for natural gas will increase less than 5% between 2021 and 2030 and then remain flat up until 2050. IEA (2022e) suggests that downward revision will mainly stem from a faster switch to clean energy. If Azerbaijan lags behind its peers in adopting renewable energy sources, it may find itself in a very undesirable macroeconomic equilibrium. For example, Nigeria, with decreasing export revenues, may find it difficult to finance fuel subsidies, totaling more than 9 billion USD in 2022, and service its 103 billion USD public debt (WSJ, 2022a).

One should keep in mind that, as every research study has, our paper also has several limitations. Our study with its single equation approach provides partial equilibrium in modeling natural gas demand. In future studies, macroeconomic models like DSGE (Dynamic stochastic general equilibrium) and macroeconometric models can provide additional insights on this topic. In this approach, alternative driving forces for natural gas demand could also be considered.

Data availability

These datasets were derived from the following public-domain resources: https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf. https://data.worldbank.org/indicator/NY.GDP.PCAP.KD?locations=AZ. https://data.worldbank.org/indicator/SP.POP.TOTL?locations=AZ.

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Conceptualization: SG; Data acquisition: SG, JIM, and SNM; Methodologies: SG, JIM, and SM; Analysis: SG, JIM, and SM; First-draft preparation: SG, JIM, SM, and SNM; Final draft preparation: SG; Proofreading: SG and JIM; Project supervision: SG and JIM; Interpretation of data for the work: SG, JIM, SM, SNM; Final approval of the version to be published: SG, JIM, SM, and SNM.

Competing interests

The authors declare no competing interests.

Additional information

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