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Research paper

Spillovers effect of gas price on macroeconomic indicators: A GVAR approach

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ABSTRACT

The demand for natural gas as a transitional fuel has been increasing steadily due to global energy transitions. However, the high concentration of natural gas sources among a few producers and the dependence of many consuming economies raises questions about the macroeconomic impact of gas price shocks. Therefore, this study utilizes the global vector autoregressive (GVAR) approach to estimate the spillover effects of natural gas price shocks on key macroeconomic indicators. To enhance the GVAR data vintage, we have incorporated Iran and Russia in 24 countries and updated data till 2020. Our empirical analysis reveals that inflation responds positively to gas price hikes in major gas-consuming countries. Moreover, real GDP responds positively to increased gas prices in resource-rich countries such as Iran and Russia but negatively in other countries. Additionally, an augmentation of resource rents fosters GDP for Iran and Russia. Our findings highlight several policy implications that account for gas price shocks. Therefore, policymakers should consider the spillover effects of gas price shocks and their impact on inflation and real GDP. Moreover, resource-rich countries like Iran and Russia should optimize resource rents to foster economic growth.

1. Introduction

Natural gas is currently in high demand globally as transitional energy, as efforts to mitigate climate change necessitate reducing the use of high-carbon content fossil fuels. According to the Energy Information Administration (EIA), natural gas is an ideal transitional energy source because it is 50% cleaner than coal and around 30% cleaner than liquid fuel. Countries that use natural gas in their economies can see significant reductions in greenhouse gas emissions, ranging from 45%–55%, compared to those that rely on non-transitional fossil fuels. Many emerging and developed economies, particularly in Europe, heavily rely on gas energy, as their machinery and domestic heating appliances are designed to use it. However, transitioning away from natural gas may prove unfeasible in the short to medium term due to these dependencies. A major supply-side shock could lead to adverse demand-side shocks and cross-country spillovers on macroeconomic outcomes. The macroeconomic effects of such an energy shock could be immediate, direct, or indirect, affecting utility bills, commodity prices, and energy-intensive sectors. One of the significant challenges of such shocks is their spillover impact on the labour market and employment rate. Industries often reduce their labour force or revise their employment structure in response to the economic downturn brought on by high energy prices. The recent Russia–Ukraine crisis has exposed the vulnerability of economies to energy costs. In Germany, for example, some industries have had to reduce their production level or even shut down entirely due to a gas shortage. Therefore, a comprehensive and well-thought-out strategy for transitioning away from natural gas is necessary to mitigate the risks of supply-side shocks and ensure a smooth and sustainable transition to cleaner energy sources. Given this backdrop, we aim to measure the spillover effects of gas prices on the selected macroeconomic indicators.

While an increase in energy prices can be viewed as a fiscal boon for gas-exporting countries, it is essential to note the potential negative impact on macroeconomic indices and political and economic development. Research by Hamilton (1983) has established a strong link between economic recessions and rising crude oil prices, indicating the influence of oil price shocks on

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macroeconomic indicators. Oil and natural gas prices are considered the same commodity as suggested by existing studies (see Ramberg and Parsons, 2012; Serletis and Rangel-Ruiz, 2004), thus, presuming that the two components share the same dependence and functional role. As all levels of government are required to maintain a stable fiscal policy and budget, exogenous shocks such as energy price increases can significantly disrupt fiscal architecture's performance and effectiveness, resulting in budget overstretching through borrowing.

Governments must maintain stable fiscal policies and adhere to budget limitations, and this study's novelty is to evaluate the spillover effect of natural gas prices on macroeconomic indicators and its transmission effect in mitigating risks related to fiscal sustainability and economic growth. To accomplish this, a Global Vector Autoregression (GVAR) model is used, integrating the major natural gas producers and consumers such as Russia, Iran, China, the United States, and the United Kingdom. Russia and Iran are the focus of the study due to their role as significant suppliers of gas energy to Asia and Europe, with Russia's direct transportation infrastructure to Europe influencing the region's energy sector. While most studies in the existing literature have concentrated on using oil price shocks, assuming that the dependence and functional role of oil and natural gas are the same, this study argues that gas is a transitional energy among other fossil fuels, and the assumption of dependence on oil and gas may not be accurate. Therefore, this study empirically evaluates the spillover effect of gas prices on macroeconomic indicators within the framework of the preceding discussion, providing insights into the potential impact of natural gas price shocks on economies.

Our study makes two significant contributions to the existing literature. Firstly, previous studies have primarily focused on analyzing the impact of oil prices on macroeconomic outcomes, as demonstrated by numerous studies (e.g., Ahmed et al., 2019; Ali Ahmed and Wadud, 2011; An et al., 2014; Ju et al., 2016; Kilian, 2009; Sadath and Acharya, 2021, amongst others). In contrast, we have taken a divergent approach by examining the relationship between natural gas prices and macroeconomic indicators. Secondly, to our knowledge, we have conducted our analysis using the Global Vector Autoregression (GVAR) framework, which has not been explored in previous studies. Furthermore, it is worth highlighting that we have used quarterly data covering the period from 1980 to 2020, which is a more comprehensive data structure than previous studies. Specifically, we have obtained real GDP and inflation data from the International Monetary Fund (IMF), adjusted for seasonal changes, and used it for the GVAR analysis. Additionally, we have extracted and extrapolated data on exchange rates, resource rents to GDP, and short-term and long-term interest rates, which provides a more complete and nuanced understanding of the relationship between gas prices and macroeconomic indicators.

The rest of the paper is organized as follows. The study's theoretical framework is presented in Section 2, in which several mechanisms for the oil and gas effects on the macroeconomic variable are addressed. The Methodology is described in Section 3. Section 4 covers the results and discussion of the GVAR model, notably Generalized Impulse Response Functions (GIRFs)—concluding remarks presented in Section 5.

2. Literature and theoretical framework

The impact of gas prices on macroeconomic variables has been the subject of numerous studies in recent years. While the results of these studies are mixed, there is evidence to suggest that changes in gas prices can have significant effects on economic growth, inflation, consumption, and investment. One study by Hamilton (2009) found that changes in oil prices were highly correlated with fluctuations in US GDP growth, and that increases in oil prices could explain a significant portion of US recessions over the past several decades. Similarly, Kilian and Park (2009) found that oil price shocks could have a significant impact on inflation, and that the effects were particularly pronounced in emerging market economies. Another study by Baumeister and Kilian (2016) examined the effects of oil price shocks on global output, inflation, and trade balances. They found that while oil price shocks had significant effects on global output and inflation, the magnitude of the effects varied widely across countries and regions. In addition to these studies on the impact of oil prices, there has also been research on the effects of natural gas prices on macroeconomic variables. For example, a study by (Gately et al., 2013) found that changes in natural gas prices could have significant effects on US consumer spending, particularly for low-income households that spend a larger share of their income on energy. Similarly, another study by (Sahoo et al., 2014) found that changes in natural gas prices could have significant effects on industrial production and investment in India, with the magnitude of the effects varying across different sectors of the economy. While the impact of gas prices on macroeconomic variables is complex and varies across countries and regions, there is evidence to suggest that changes in gas prices can have significant effects on economic growth, inflation, consumption, and investment. As such, policymakers and analysts should take gas prices into account when making macroeconomic forecasts and policy decisions.

The transmission of energy price to macroeconomic determinants has been studied from a theoretical perspective, as evidenced by the works of Kilian and Murphy (2014) and Hamilton (2014). The Structural Oil Market Model, developed by Kilian and Murphy (2014), describes how changes in oil price can be traced back to distinct structural shocks with diverse economic interpretations. Thus, identifying such shocks is critical for understanding oil market movements and measuring the relationship between oil price and macroeconomic effects (Kilian, 2009). The model links fluctuations in oil price, oil production, oil consumption, and global gross domestic product (GDP) growth to four types of shocks with distinct economic interpretations: oil supply shocks, oil-market-specific demand shocks, storage demand shocks, and global economic growth shocks. The model can also generate conditional oil price estimates compatible with various economic growth scenarios.

While the structural model focuses on broad oil prices, given that energy items such as natural gas have historically been extracted as by-products of oil, it makes logical to assume that the oil market influences natural gas price. Oil price swings have been extensively studied (see Chen et al., 2022; Ahmed et al., 2019; Ali Ahmed and Wadud, 2011; An et al., 2014; Ju et al., 2016; Kilian, 2009; Sadath and Acharya, 2021, amongst others). In comparison, the current study attempted to show a clear link between natural gas shock transmission and macroeconomic factors. We attempt to identify theoretical mechanisms for understanding the impact of changes in natural gas price on macroeconomic indicators, which are noted herewith. First, *Production/revenue effect:* Changes in gas pricing might affect the foreign cash inflow and outflow of a country that exports gas. Specifically, the decline in gas price diminishes a gas-exporting nation's foreign exchange earnings and raises the price of foreign currencies (like dollars). An increase in the dollar price will make exports cheaper and, consequently, increase the exports and production of the gas-exporting countries. *Inflation effect:* The devaluation of national currencies of oil-exporting nations, such as Russia, Mexico, Norway, and Brazil, due to low oil price has been examined (Volkov and Yuhn, 2016). Thus, it can be asserted that a rise in the price of foreign currencies may lead to inflation. As the export of domestic commodities increases, items become increasingly scarce on the market, and their price rise (Grigoli et al., 2019). Inflation can also be affected by changes in exchange rates through the import of intermediate goods, where a rise in the national currency price can increase the price of imported inputs and, in turn, the price of finished goods. Although the indicated channel can also be referred to as cost-push inflation for gas-importing countries, monetary action promoting inflation is possible (Walsh, 2017). It should also be emphasized that countries with strong financial institutions, greater foreign exchange reserves, and a broad export base have less inflationary pressure, according to the studies discussed. *Employment effect:* The fluctuations in oil price can impact the unemployment rate and the employment flows between various economic sectors. Davis and Haltiwanger (2001) revealed that the impact of oil price variations on employment is comparable to that of monetary policy. More so, Herrera and Karaki (2015) examined the effect of natural gas price on job creation and found that when oil price are low, firms in gas-exporting nations face either less revenue or expenditure pressure due to the exchange rate, both of which limit firms' ability to create new jobs or push them to reduce jobs.

Investment effect: The channel describes the impact of oil and gas price fluctuations on macroeconomic indicators in gas-exporting countries through investment. It notes that the greater the investment risk associated with oil price fluctuations, the less appealing it is to participate in that business, resulting in a decline in investment (Kilian and Murphy, 2014). This behavior can be explained if investors are assumed to be risk-averse. *Swing effect:* This channel explains that a decline in oil and gas revenues may cause the government to incur a budget deficit, reducing economic demand. In some resource-rich economies, savings and/or investment funds serve as shock absorbers. Thus, the higher the dependence of the government budget on oil revenues, the more significant the variations in the economy's aggregate demand. To achieve macroeconomic stability, however, a steady and long-term link between government expenditures and income (fiscal sustainability) is crucial (Attar Kashani, 1390: 23). *Habit effect:* In oil- and gas-exporting countries, the relationship between government spending and income is unbalanced. Government spending increases due to increased revenues, but a decline in price results in a budget deficit because government spending does not often decrease. In practice, government expenditure is unrelated to revenue (Karimi Potanlar et al., 2017). *Dutch Disease effect:* According to this channel, in a country with substantial oil and gas exports, the imports of marketable products are more accessible and less expensive, mainly because exports of natural resources offer a substantial foreign currency reserve. This indicates that no indigenous business capabilities are being developed in industries such as manufacturing and agriculture. The Dutch disease describes the condition in which one economic sector is established and powerful (such as natural resources) while others are weak and dependent on exports. *Democracy effect:* In this channel, increasing money from natural resources will make the government independent of the people (and their taxes), hence reducing the likelihood of democracy. However, the empirical findings of Wacziarg (2012) contrast this argument.

3. Methodology

The study uses actual rather than experimental data to run a GVAR model to evaluate the effectiveness of the identified macroeconomic factors and determine the overall impact of their shocks. The methods and data are discussed in the following sub-section.

3.1. Global vector autoregressive approach

GVAR is a set of vectors autoregressive with exogenous variable (VARX) models that incorporate VARX models for several countries. The model has been extensively analyzed by Pesaran et al. (2004), Esfahani et al. (2014), and Mohaddes and Raissi (2019). For *each country* i, $(i = 1, 2, 3, \ldots, N)$, *the VARX* $(1, 1)$ refers to a VAR model that incorporates domestic and foreign variables with a single time lag:

$x_{it} = \Phi_i x_{it-1} + \Lambda_{i0} x^*_{it} + \Lambda_{i1} x^*_{it-1} + u_{it}$

$x_{it} = k * 1$ vector of domestic variables

$x^*_{it} = k * 1$ vector of foreign variables

Where, $x^*_{it} = \sum_{j=0}^{N} \omega_{ij} x_{jt}$.

ω_{ij} is an element in weight matrix ω that shows the connection between two countries i and j (e.g. ω can be a trade matrix and ω_{ij} measures the share of trade between two countries i and j, which will be described later in the model). So $\omega_{ii} = 0$ for country i. And $J = 0, 1, \ldots, N$ are a set of weights such that $\sum_{j=0}^{N} \omega_{ij} = 1$ for country i.

Φ_i, Λ_{i0} and Λ_{i1} are $k * k$ coefficient matrixes for each country i

u_{it} are sectionally weakly correlated.

The trade volume between countries can be used to derive the weights correlating individual VAR models with their foreign partners. However, this is not the only acceptable weight. Financial weight, for instance, is an alternative to trading weights. Notably, global variables are incorporated into VARX models when they exist. The GVAR methodology employed in this paper is heavily based on Dees et al. (2007), and the model estimation follows the GVAR toolbox developed by Smith and Galesi (2014).

3.2. Data and sources

This GVAR model uses quarterly data from the first quarter of 1980 (1980Q1) through the fourth quarter of 2020 (2020Q4). Domestic variables include real GDP, inflation, natural resource rents over GDP, foreign exchange rates, short-term and long-term interest rates, and foreign exchange rates. Similarly, global factors include the price of oil, petroleum consumption, and the price of natural gas. These data are for 26 major trade partners of Iran and Russia, as two primary natural gas producers: Afghanistan, Armenia, Azerbaijan, Brazil, China, France, Germany, India, Iraq, Iran, Italy, Japan, Korea, Malaysia, Netherlands, Oman, Pakistan, Qatar, Russia, Spain, Switzerland, Thailand, Turkey, Emirates, United Kingdom, and the United States. In the following, the variables are explained (See Table 1).

4. Results and discussion

This section examines the impulse responses of GVAR model-derived variables. We address GIRFs, first introduced by Koop et al. (1996) and then extended by Pesaran and Shin (1998). In the following figures, solid lines represent median estimates, and dotted lines represent confidence intervals. These figures were generated using the Bootstrap method.

Oil price Shock

The analysis indicates that a positive gas price shock would result in a rise in oil price. As seen in Fig. 1, oil price increased by approximately 3.5 percent on a relative scale. To explain further, one may argue that oil and gas are production inputs in distinct industries. Due to their great degree of substitutability, their price fluctuates accordingly. In all GIRFs used to assess the effects of gas price shocks on macroeconomic variables, natural gas and oil prices are assumed to move in the same direction simultaneously.

Table 1
Data description and sources.

Variables	Description	Source
Real GDP	Real gross domestic product in millions of dollars	The International Financial Statistics (IFS) of the International Monetary Fund (IMF).
Inflation	Consumer price index	IFS
Resource rents	Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	World Bank, World Development Indicators
Exchange rate	A quarterly average of the nominal bilateral exchange rates vis-a-vis the U.S. dollar (units of foreign currency per U.S. dollar)	IFS
Short-term interest rates	Money market rates data were used as indicators for short-term interest rates.	IFS
Long-term interest rates	Interest rates on government bonds were used as indicators for long-term interest rates.	IFS
Oil price	The average price of different kinds of oil, including Brent used as a proxy for oil price	U.S Energy Information Administration (EIA)
The natural gas price	Gas price index used to make a proxy for the price of all different gas globally.	EIA
Total petroleum consumption	The EIA data for petroleum and other liquid consumption worldwide were used	EIA
Weighted matrices	Time-varying weight matrix based on different trade volumes between countries in different years	IMF's Direction of Trade Statistics (DOTS).

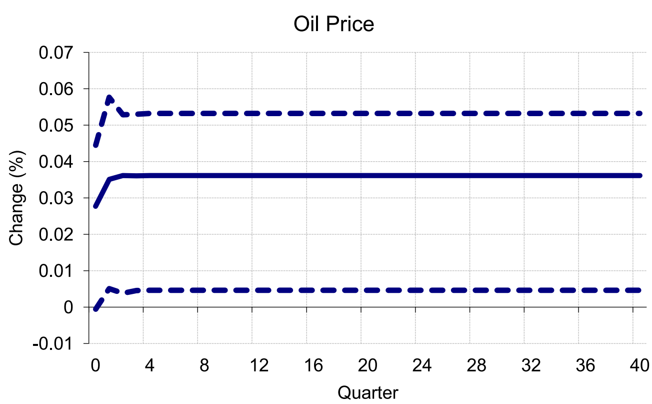

Fig. 1. Response of oil price to a positive gas price shock.

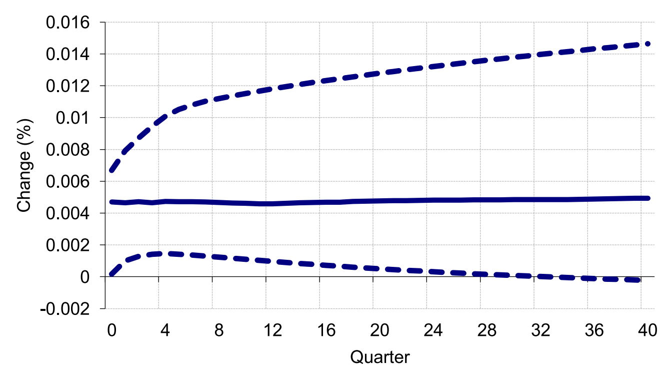

Fig. 2. Response of rents/GDP ratio to a positive gas price shock for Iran.

This would also make it possible to assess the GIRFs using different processes as proposed in the literature on the effects of oil price shocks.

Our analysis establishes the substitutability between crude oil and natural gas, which has implications for the net environmental consequences of using alternative energy resources. Natural gas is considered a capable replacement for crude oil, and its supply is critical in decreasing CO_2 emissions from fossil fuel-consuming countries. However, a significant trade-off appears related to the shift from crude oil to natural gas consumption. As per our results, the natural gas supply boom significantly impacts crude oil price, which implies the supply boom triggers a switch over to natural gas use from oil use in any significant way (Tiwari et al., 2019).

There are technical and economic grounds that explain the correlation, such as price formation rules, contractual arrangements, market structures and liquidity (Villar and Joutz, 2006), the need to hedge huge investment risks in the cultivation of joint oil and gas fields, demand substitutability between oil and gas products, and the competition for the same scarce inputs.

Finally, the covariation of oil and gas price has significant implications. In the final products, oil and gas often substitute when companies compete in the same markets for technical and financial resources for developing non-joint fields. This situation implies that when the oil price spikes, the cost of inputs for gas field development rises, increasing gas price. In addition, oil price can be affected by the rise of oil production (not analyzed here), which relies on a similar technology to natural gas production (Caporin and Fontini, 2017). The same factors affecting the gas industry also influence oil resources, reinforcing their relationship with the partner countries of Russia and Iran. The findings of this study are in line with Romagus (2012), Brigida (2014) and Wolfe and Rosenman (2014).

Resources rents

Figs. 2 (Iran) and 3 (Russia) show impulse responses for the resource rents to the GDP variable. The GIRFs for other countries are listed in Appendix A.1. Here, a positive gas price shock increases the revenue of gas-exporting countries, resulting in higher GDP resource rent. All gas net-exporter countries, including Russia, Qatar, Azerbaijan, and Malaysia, exhibit the same pattern in our model. However, the rents-to-GDP ratio depends on the GDP response to the gas price shock in gas-importing countries. It is further anticipated that a positive gas price shock will increase the cost of manufacturing inputs in gas-importing countries, hence decreasing their GDP.

Generally, rent is a payment made to a factor of production over and beyond what would be required to maintain that factor's current employment. In the case of gas resources, the economic rent (or resource rent) is the "extra" income from gas production, meaning it "exceeds" the returns on investment (capital and labor) that the operator ordinarily earns. Due to the low cost of production or transportation, this income comes into being (in turn, reflecting either geological conditions or location).

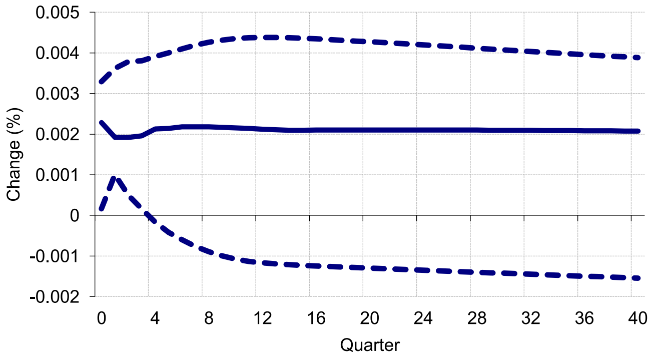

Fig. 3. Response of rents/GDP ratio to a positive gas price shock for Russia.

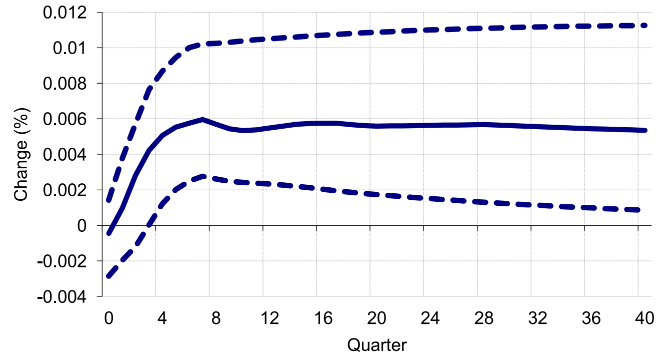

Fig. 5. Response of real GDP to a positive gas price shock for Russia.

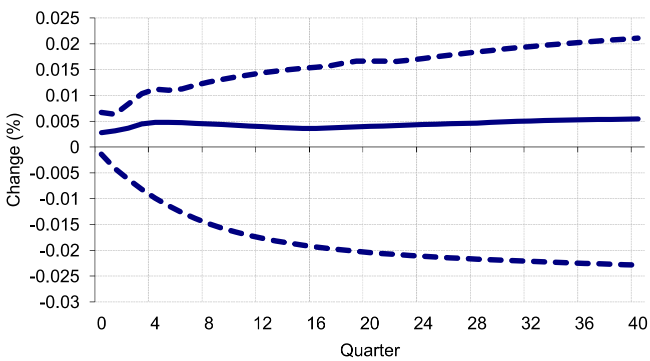

Fig. 4. Response of real GDP to a positive gas price shock for Iran.

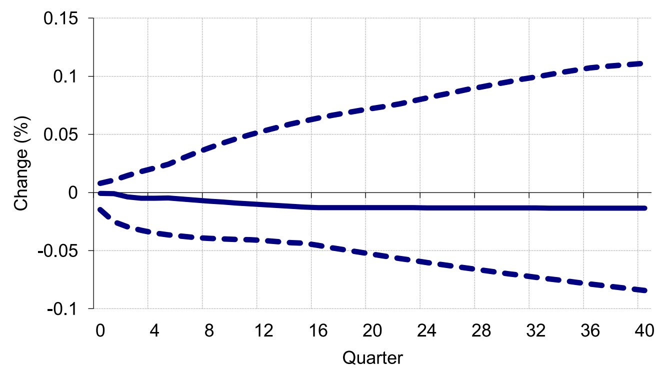

Fig. 6. Response of inflation to a positive gas price shock for Iran.

Most governments strive to collect the majority, if not all, of this resource rent through various strategies, typically through specialized taxes, as they own the land or mineral resources in their jurisdictions (Sagers et al., 1995).

The gas sector in Russia and Iran is an essential source of budget revenue, providing funds for implementing a broad range of government programs, both domestic and foreign (Ciarreta and Nasirov, 2012). It will not be an exaggeration to state that these two economies can earn half of their budget revenues if they collect all taxes from oil and gas resources. In this case, resource pricing policies and their implementation are critical for these two economies that they achieve through the state monopoly in foreign and retail trade (Umbach, 2010). This study's finding relating to the positive response of resource rents to the gas price shock in the case of Russia and Iran is coherent with Kaveshnikov (2010), Müller-Kraenner (2008), Ericson (2009) and Dudlák (2018). These authors highlighted the benefits of oil and gas exports and rent these two countries can acquire from external economies (see Fig. 4).

Real GDP

In all gas-exporting countries, it was observed that the real GDP rises in response to a positive gas price shock. Thus, the negative impact of the production channel described in the literature is dominated by more oil and gas sales. Fig. 5 illustrates the GIRF of Russia's real GDP to price shock. The scenario is a bit different for Iran, where the real GDP improves due to an increase in oil price driven by a positive gas price shock. Appendix A.2 provides a breakdown of the effects on other countries.

Natural gas usage has recently been more popular with benefits, including its relative fuel efficiency, low emissions, rapid building times, and capital costs, notably for the industrial and energy production sectors. This trend is anticipated to continue until 2035 (EIA, 2010). However, this agency also reveals that the government, rather than a market-oriented energy price mechanism, in diverse economies has a limited impact on energy consumption and does not impact economic growth. Like other countries, Iran and Russia have a government-driven system for setting energy price, especially for natural gas. As was already mentioned, the cost of natural gas adversely impacts consumption but has little applicability to Iran's economic expansion in the shorter period (Haidari et al., 2013). Although the natural gas price does not directly affect economic development, its price indirectly impacts economic growth. Notably, these two countries (Russia and Iran) production technology uses a lot of energy. Our study's finding concerning the long-term negative response of real GDP to a gas price shock for Russia and Iran is consistent with Wesseh and Zoumara (2012), who discovers the same outcomes in the case of Liberia. Besides, Haidari et al. (2013) also explored the negative impact of natural gas on the crucial income growth parameter, namely the gross fixed capital formation in the context of Iran.

Inflation

The estimate reveals that the increases in natural gas and crude oil price have resulted in a rise in oil and gas exports. Consequently, the exchange rate per unit of the U.S. dollar decreases. Iran and Russia's impulse responses to inflation are depicted in Figs. 6 and 7, respectively. Three mechanisms effectively determine inflation (as explained in the theoretical literature). For Iran, the mechanism for decreased inflation predominates other adverse effects. However, the net effect on Russia is negative. In addition, increases in inflation vary between countries due to the net effects of distinct mechanisms in each country. All the GIRFs are depicted in Appendix A.3.

Coibion and Gorodnichenko (2015) recently emphasized the significance of accounting for inflation expectations in a series of publications. They precisely argue that (provide convincing

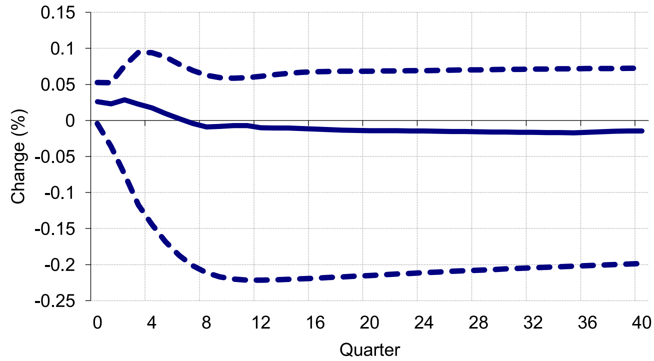

Fig. 7. Response of inflation to a positive gas price shock for Russia.

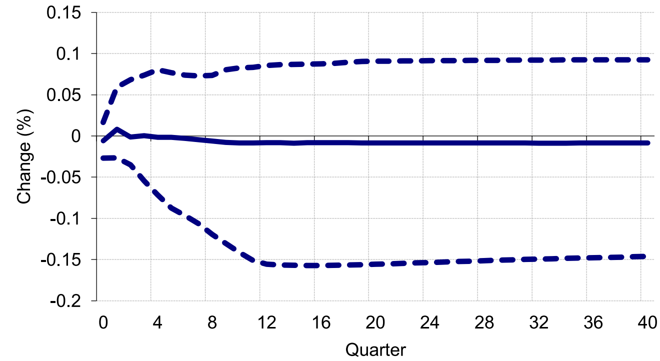

Fig. 9. Response of exchange rate to a positive gas price shock for Russia.

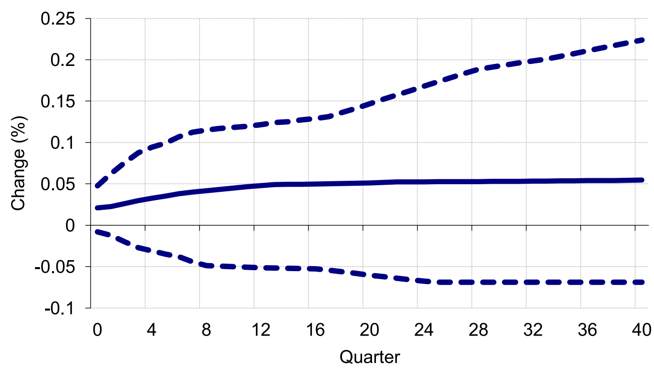

Fig. 8. Response of exchange rate to a positive gas price shock for Iran.

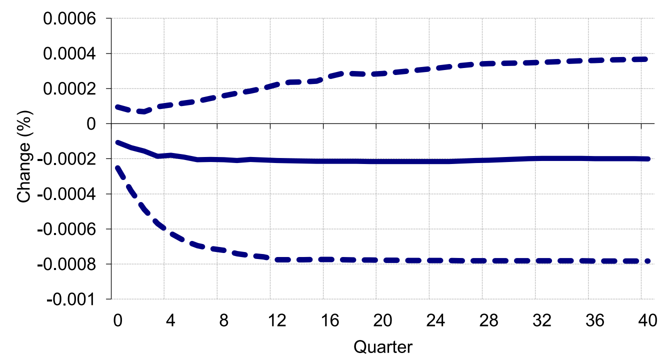

Fig. 10. Response of short-term interest rate to a positive gas price shock for Iran.

evidence) the subsequent rebound in oil price, which raised inflation expectations from 2009 to 2011, can be used to explain the missing disinflation from the financial crisis. The sensitivity of consumers' inflation expectations to changes in gas price is the primary mechanism through which the recovery in oil price enhanced inflation expectations (Coibion and Gorodnichenko, 2015; Hammoudeh and Reboredo, 2018). In this regard, the "frequency hypothesis" illustrates that gas purchases regularly change price, significantly influencing consumers' inflationary expectations. It is one idea of why consumers react unreasonably to changes in gas price, as described by Binder (2018). However, our findings concerned with the response of inflation to a positive gas price shock in Iran and Russia are coherent with Blanchard and Galí (2010), Blanchard and Riggi (2013), and Wong (2015).

Exchange Rates

Figs. 8 and 9 depict the impulse responses of exchange rates for Iran and Russia. Here, there was no significant impact on Russia's exchange rate. Thus, the GIRF is therefore close to zero. However, a positive gas price shock in Iran is followed by an increase in the nominal exchange rate. As the literature describes, this impact can explain a portion of Iran's real GDP growth in response to a positive gas price shock. A positive gas price shock hardly affects the exchange rates of the remaining countries. Appendix A.4 contains the figures.

According to Hartley and Medlock (2014), oil is traded between domestic and international markets, but natural gas is non-traded. The absence of direct arbitrage between the two natural gas markets is less significant if there are many options to switch from crude oil to natural gas. Natural gas price will be significantly impacted by competition with oil, allowing for de facto arbitrage through trade in crude oil. The exchange rate will, however, undoubtedly play a significant and evident influence in deciding the relative price of natural gas to crude oil if the capacity to transfer fuels is restricted in one market.

On the other hand, He et al. (2019) opined that exchange rates are highly dependent on the oil price, and turbulence in the crude oil market could significantly impact the foreign currency market, thus causing exchange rate pressure and even economic instability. Therefore, the monetary authorities must increase or decrease foreign exchange reserves to address the foreign exchange fluctuation. In this context, the prudent Russian monetary authorities help the exchange rates respond positively to gas price shock for Russia and vice versa in the case of Iran (see Fig. 10).

Short-term Interest Rates

In this part, it was observed that a positive gas price shock decreased Russia's short-term interest rate. But none of the major net gas exporters, including Iran, Qatar, Azerbaijan, and Malaysia, responds significantly. The GIRF illustrations are presented in Appendix A.5 (see Fig. 11).

Long-term Interest Rates

GIRFs indicate neither positive nor negative response to long-term interest rates for Iran. In contrast, a positive gas price shock causes Russia's long-term interest rate to fall. Appendix A.6 depicts GIRFs for various countries (see Fig. 12).

According to theoretical analysis, variables of interest rates may impact commodity price in the following two ways. (28–33). *First*, investors earn more interest on their money when they sell resources rather than keeping them in the ground. Moreover, more excellent interest rates could boost the supply of commodities (Frankel and Hardouvelis, 1985). *Second*, commodity supply could also be enhanced since maintaining commodity stocks has higher opportunity costs and lower inventory levels (Anzuini et al., 2012). Another relevant fact is that if the interest rates

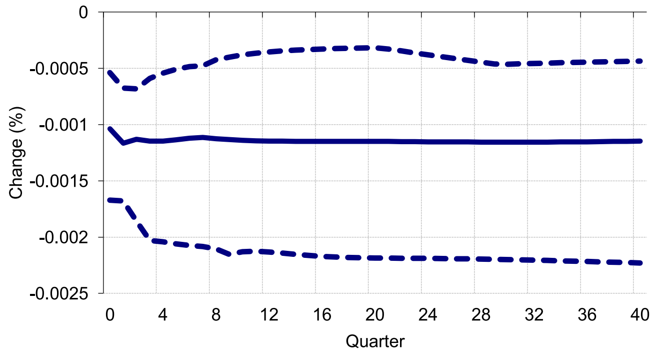

Fig. 11. Response of short-term interest rate to a positive gas price shock for Russia.

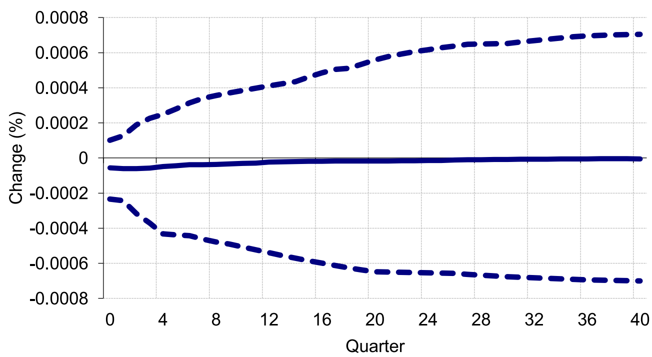

Fig. 12. Response of long-term interest rate to a positive gas price shock for Iran.

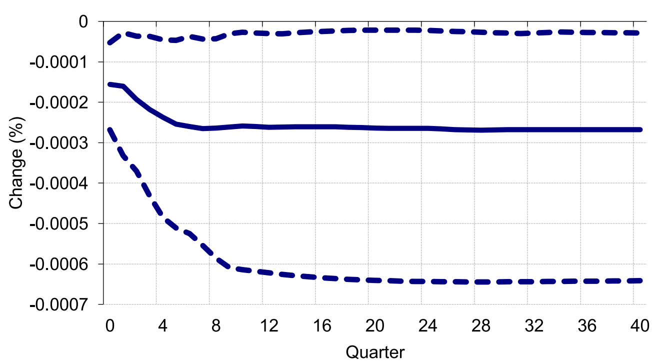

Fig. 13. Response of long-term interest rate to a positive gas price shock for Russia.

are high, traders will flee the commodity markets as alternative investments provide better rewards with lower risk (treasury bills) (Schmidt et al., 2019). Finally, the theoretical conclusion is that higher interest rates lower commodity prices, and energy commodities in particular (most research concentrate on oil and gas) tend to be supported by empirical investigations (Arango et al., 2012; Frankel, 2014). This statement aligns with our research findings concerning the negative response of long-term interest rates to a positive gas price shock for Iran and Russia (see Fig. 13).

5. Conclusion and policy implication

Our study aimed to investigate the spillover effects of gas prices on various macroeconomic indicators. To achieve this objective, we utilized an empirical GVAR model that incorporated data from 25 countries and quarterly observations spanning from 1980 to 2020. In addition, we analyzed the GIRFs of several macroeconomic indicators, including oil price, rents to GDP, real GDP, inflation, exchange rate, short-term interest rate, and long-term interest rate.

Our findings revealed that oil prices responded positively to gas price shocks. Furthermore, the ratio of rents to GDP increased for gas and oil-exporting countries and certain gas-importing countries. Additionally, major gas-exporting countries experienced an increase in real GDP following a gas price shock, including oil-exporting countries such as Iran. However, country-specific responses to inflation varied, with nearly negative responses observed in net natural gas exporting countries, indicating that various mechanisms offset each other. Gas-exporting countries' short-term interest rate responses were insignificant, while long-term interest rate responses were negative for Russia and close to zero for Iran. Our results highlight the importance of gas pricing, particularly natural gas, and how it can impact the macroeconomic framework. Additionally, we found that the effects of gas price shocks can be as detrimental as those of oil price shocks, particularly for gas-importing countries, although energy-exporting countries may benefit.

Given the significance of gas in industrial processes and domestic consumption, policymakers may consider implementing domestic policy frameworks that help absorb distortions to the macroeconomic determinants of the exchange rate, inflation, and GDP. Our study underscores the need for policymakers to evaluate the impact of gas price distortions, as failing to consider them while planning and implementing policies could be unproductive. Our empirical findings suggest that countries impacted by gas price shocks can benefit from implementing macroeconomic prudential policies to mitigate the effects of these shocks. Therefore, we recommend that policymakers consider implementing policies to enhance macroeconomic resilience and reduce their economies' vulnerability to gas price fluctuations. These policies could include diversifying the energy mix to reduce reliance on gas, increasing investments in renewable energy sources, and implementing energy efficiency measures.

Besides, policymakers could consider establishing strategic energy reserves to provide a buffer against energy supply disruptions. Furthermore, countries could consider implementing policies to increase their economies' competitiveness, including improving infrastructure, investing in human capital, and promoting innovation and entrepreneurship. By improving the overall competitiveness of their economies, countries can better withstand the negative impacts of gas price shocks and other external economic shocks. We recommend that countries affected by gas price shocks take proactive measures to enhance their macroeconomic resilience. By implementing these policies, countries can reduce their vulnerability to gas price fluctuations and better position themselves to weather external economic shocks.

CRediT authorship contribution statement

Seyed Reza Mirnezami: Conceptualization, Methodology, Software, Data curation. **Kazi Sohag:** Visualization, Investigation, Supervision, Software, Validation, Writing – review & editing. **Mohammad Jamour:** Writing – original draft, Software, Validation. **Fazel Moridi-Farimani:** Supervision. **Ahmad Hosseinian:** Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.egyr.2023.05.222.

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