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Short and long run macroeconomic impacts of the 2010 Iranian energy subsidy reform

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Abstract

This paper examines the short and long run effects of the 2010 Iranian energy subsidy reform on macro indicators including GDP and inflation. The subsidy reform, which consists of a simultaneous energy subsidy cut and a cash transfer to households, is not fiscally motivated but instead aims to reduce energy consumption. Using timeseries to analyse the dynamics of the macro variables in response to the subsidy reform elements (energy price increase, and cash transfer), I find that the subsidy reform has a negative effect on the economy in the short-term, and the cash transfer to households does not fully compensate for this adverse effect. These results are robust and consistent across specifications. The strongest channel that transmits the effect of energy price to GDP is value-added of industry and service sectors. The long run analysis rejects the existence of a long-run relationship between the energy subsidy reform and GDP. The findings indicate that the energy subsidy reform does not result in a reduction in energy consumption. These findings challenge the environmental aspect of the fossil fuel subsidy reforms as stand-alone policies without major reforms in the energy efficiency of economic sectors.

JEL: C54, Q48, C22, O53

Keywords

Energy subsidy reform, energy consumption, macroeconomic, GDP, short and long run, Iran.

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Acronyms

ADF	Augmented Dicky-Fuller
ARDL	Auto Regressive Distributed Lags
Fob	Free on board
CBI	Central Bank of Iran
CGE	Computable General Equilibrium
CPI	Consumer Price Index
GDP	Gross Domestic Product
IO	Input-Output
IR	Iranian Rial
IRF	Impulse Response Function
KPSSH	Kwiatkowski-Phillips-Schmidt-Shin
MA	Moving Average
OECD	Organization for Economic Co-operation and Development
SCI	Statistical Centre of Iran
SRCT	Subsidy Removal and Cash Transfer
Toe	Tone of oil equivalent
VAR	Vector Autoregressive

Short and long run macroeconomic impacts of the 2010 Iranian energy subsidy reform[1] [2]

1 Introduction

The history of subsidizing goods dates back to at least the 1940s as a response to the increasing urban demand for a stable supply of goods (Economic Reform working group, n.d.a). In the 1970s, increasing oil price revenues stimulated subsidizing via two channels. First, the government earned more money from oil exports and was able to extend subsidies to a wider range of goods and services. Second, the gap between the fixed energy carriers' domestic price and the international price multiplied. Consequently, the subsidy on energy took a considerable share in public expenditure as such that in 2006 the energy subsidy became nearly 87% of total subsidy and 77% of public expenditure (Economic Reform working group, n.d. a). Subsidies are known to encourage excessive use and even waste. Moreover, the distribution of the energy subsidy does not help inequalities. On average, in 2009, the richest decile of urban and rural households benefitted 5.3 and 14.3 times more than the poorest decile from fuel subsidies, respectively (Deputy of Electricity and Energy, 2010). Meanwhile, subsidy reforms are delicate policies that can be put to an end by social unrest, strikes and riots. These factors motivated the Iranian government to embark on a budget-neutral energy subsidy reform in December 2010. In practice, the energy subsidy reform or Subsidy Removal and Cash Transfer (SRCT), consists of two parts: subsidy removal on the price of energy and a cash transfer to households. As a result, the prices of energy carriers increased several folds (see Appendix 1). Simultaneously, an unconditional universal cash transfer (derived from the subsidy removal) was granted to households. The cash transfer amounted to 405,000 Iranian Rials (IR)[3] per person per month and is being transferred to the bank account of the head of the households on a bi-monthly basis. In principle, the cash transfer was designed to be sufficient to cover the additional costs incurred due to subsidy removal for an average household (Guillaume, Zytek and Farzin, 2011). Hence, the objective of the SRCT was not fiscal consolidation but to restrain energy consumption and to distribute subsidies equally. The cash transfer package and a massive media (state TV, radio, and social media) campaign on the necessity of the energy subsidy reform played a substantial role in the smooth launch of the reform in December 2010.

This article examines the short and long run effects of the energy subsidy reform on the macro economy of Iran by using Vector Autoregressive (VAR) and Autoregressive Distributed Lag (ARDL) models. The majority of research on SRCT

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[1] An earlier version of this paper has been presented in Development Dialogue 2017 and won the 'First prize' for best conference paper. An article based on this chapter has been submitted for peer-review.

[2] I thank Mansoureh Abbasi for providing historical data of energy carriers' prices and consumption, and Dr. Sajjad Faraji Dizaji for his input on this paper.

[3] It was equivalent to nearly 6 percent of GDP per capita, in 2010.

has applied Computable General Equilibrium (CGE) models to provide insights on the working of the entire economy (Eslami et al., 2012; Shahmoradi et al., 2011; Hosseinninasab and Hazeri, 2012). Bearing in mind that the magnitude of the energy price shock after the reform is massive (the average of energy price increased nearly three folds), the outcome of models that rely on ex-ante stylized facts and parameters are plausibly subject to the Lucas critique (1976). This research utilizes methods (VAR and ARDL) that do not need assumptions or ex-ante stylized facts. The value added of this article is therefore the following: First, it distinguishes between short and long run effects, given that short and long -term dynamics and models are not necessarily similar. Specifically, this research uses an unrestricted VAR approach that is well-suited to short-term forecasting and cointegration methods (i.e. ARDL) that are appropriate for long run analysis (Engle and Yoo, 1987; Naka and Tufte, 1997). Forecasting the effect of SRCT is particularly important, since a year after the introduction of SRCT, heavy international sanctions influenced the economy. Second, this research incorporates and compares the elements of the energy subsidy reform (i.e., increase of energy price and cash transfer), individually and also jointly in the form of a synchronized customized innovation. Third, this article discusses the potential channels that transmit the effects of energy price increases and the cash transfer reform to the country's GDP. The analysis of transmission channels provides valuable policy implications concerning different sectors of the economy.

This paper is organized as follows: Section 2 reviews the studies on subsidy reforms in Iran and other developing countries. Section 3 clarifies the research design from theory to practice. Section 4 explored data. Section 5 elaborates the empirical methodology. Section 6 discusses the empirical results within a short- and long-term framework. Finally, section 7 outlines some policy implication.

2 Existing research on the energy subsidy reform

Prior to the introduction of the subsidy reform, the potential effects of the reform were extensively investigated. Table 1 summarises the outcome of these studies. For example, a World Bank (2003) study using an input-output table forecasted that the complete phase out of energy subsidies would increase the inflation rate to 40% and lower welfare. The study also showed that a flat rate compensation to all households would be able to restore welfare losses. Similarly, Jensen and Tarr (2003), examined the impact of a range of reforms (including energy subsidy) on economic growth, with a computable general equilibrium (CGE) model. They argued that the elimination of the energy subsidy and the redistribution of savings from subsidy removal could both stimulate GDP growth and reduce income inequality. Shahmoradi et al. (2011) used a CGE simulation in which energy prices increased up to Persian Gulf fob prices and households, production firms and the government received 60, 30 and 10 percent, respectively, of the savings from the subsidy cut. Contrary to the previous studies, the outcome showed that GDP and household welfare decrease by 2.2 and 5.2 percentage point, respectively. Hence, the compensation schemes mitigate the negative impact but cannot fully offset the

Table 1
Summary of the literature on energy subsidy reforms

Author(s)/ year	Country	Method	Description	Brief result
World bank (2003)	Iran	IO	Complete removal of energy subsidies; flat rate cash transfer to households	Cash transfer neutralizes the negative impact of subsidy removal; improves income distribution
Jensen and Tarr (2003)	Iran	CGE	Energy subsidy removal; redirecting the savings to the economy	Positive impact on GDP (2.1%) and significant reduction in fuel demand
Shahmoradi et al (2011)	Iran	CGE	Elimination of energy subsidies; different rates of cash transfer to households, firms, and government	In the best scenario, GDP and welfare decrease by 2.2 and 5.2 percentage and non-energy price index increases 26%.
Eslami et al. (2012)	Iran	CGE	electricity subsidy removal and redirecting the savings in the form of cash transfer to households	Cash transfer cannot compensate the negative impact of complete elimination of electricity subsidy removal and GDP decreases by 2.5%.
Hosseininasan and Hazeri (2012)	Iran	CGE	Energy subsidy removal and cash transfer to households, firms and government	The more the share of the households and firms, the less the negative impact of the subsidy removal. Yet cash transfer cannot fully compensate the adverse effect.
Farajzadeh and Bakhshoodeh (2015)	Iran	CGE	Energy subsidy removal along with different alternatives of cash transfer	The best option of cash transfer is to divide the saving between households and firms. Still, it causes a decline in GDP.
Gharibnavaz and Waschik (2015)	Iran	CGE	Energy subsidy removal and cash transfer to households	Increase of households' welfare by 45% but consumer price index will be two folds.
Lofgren (1995)	Egypt	CGE	Removing the energy subsidies to reach the intl. price level; different scenarios for spend the saving	In all scenarios the GDP decreases in the range of 1.7 to 3.2%. energy consumption decreases by 6 to 8%.
Abouleinein et al. (2009)	Egypt	CGE	Subsidy removal to level the production cost of fuels; different options of spending the savings	Lowers the growth rate by 1.5% and increase inflation by 12%. Redirecting half of the savings to the poorest two quintiles is the superior option to mitigate the negative impact.
Lin and Jiang (2011)	China	CGE	Elimination of energy subsidies and redirecting the savings to light industries and poor	At least 35% of savings should be redirected to the economy to mitigate the negative impact of the subsidy removal and protect the purchasing power of the poor.
Liu and Li (2011)	China	CGE	Subsidy removal of coal and fuel	Cut of subsidies of coal and fuel causes 0.5 and 3.8 percentage shrinkage of GDP.
Lin and Li (2012)	China/ world	CGE	Unilateral and multilateral removal of fossil fuel subsidies	Unilateral subsidy removal will decline China's economy more than multilateral subsidy removal. Subsidy removal affects the production mode to non-industrial goods.
Breisinger et al. (2012)	Yemen	CGE	Subsidy removal of fuels and redirecting half of the savings to the poor	Cash transfer mitigates the negative impact of subsidy removal for the poor. In long run it has a development effect and poverty reduction due to increase of return to factors including labour.
Solaymani et al. (2014)	Malaysia	CGE	Complete elimination of energy subsidies	It decreases household's consumption by 5.7% from the base scenario. Poverty increases especially in rural areas.

negative impact of subsidy removal. Furthermore, the non-energy price index increases by 26 percent. Similarly, Hoseinninasab and Hazeri (2012) confirmed that cash transfer cannot completely counteract the adverse effect of the subsidy cut. Yet, the greater the share of households and manufacturing firms (compared to government share), the lower the negative impact of the subsidy reform. The authors also pointed out the inflationary impact of the cash transfer. Eslami et al. (2012) examined three alternative scenarios of increases in electricity prices and cash transfer using a CGE model with a 2005 social accounting matrix. They found that cash transfers to households does not offset the negative impact of the complete removal of the electricity subsidy. Farajzadeh and Bakhshoodeh (2015) suggested that the redistribution of subsidy removal between manufacturing firms and households is more beneficial compared to the redistribution of the savings only among the households. The first option corresponds to 15 percent decline in GDP and 10 percent inflation while the latter reduces GDP by 21 percent and increases inflation by 13 percentage points. On the contrary, Gharibnavaz and Waschik (2015) found that SRCT increase the welfare of households by 45 percentage point, on average but doubles the consumer price index. The authors blamed the international sanctions for the declining economy and (partially for) inflation.

Numerous studies on forecasting of the impact of energy subsidy reform, in other countries, have been carried out. Breisinger et al. (2012) used a dynamic CGE model to examine a range of scenarios for fuel subsidy reforms, in Yemen. The results show that gradual rather than abrupt subsidy cuts (within three years) are preferable from a poverty-reduction and growth perspective. Moreover, phasing out the subsidies, using half of the savings for fiscal consolidation, and redistributing the other half directly to at least a third of the poorest populations can alleviate the negative effects on poor households in the short-term and have a positive effect on the economy in the long run. Overall, the authors predicted a decrease of poverty in the long run. The main driver of poverty reduction is the increased return to the factors (including labour productivity), which in turn is driven by increases in economic growth in the long run.

Lin and Jiang (2011) also applied a CGE model in the Chinese context to demonstrate that the elimination of energy subsidies causes a decline in GDP, employment, and households' welfare. However, if at least 35 percent of the savings from subsidy cuts is redirected to the economy again (i.e., through investments in light industry, infrastructure, health, and education), negative impacts are mitigated, and the economy will recover and thrive. The authors advised on implementing effective measures to protect the purchasing power of the poor against the negative impacts of the subsidy cut. Additionally, Liu and Li (2011) found that coal and fuel subsidy removal cause GDP to decline (by 0.5 and 3.8 percentage points, respectively. The authors suggested gradual elimination of the subsidy, first on coal and then on oil so that firms could have enough time to adjust to the changes. Meanwhile, Lin and Li (2012) examined the impact of fossil fuel subsidy removal in China with a multi- region CGE model (i.e., which includes China, Brazil, India, and OECD countries). In one scenario, the authors predicted that different sectors in different countries would be affected when all the regions eliminate the subsidy simultaneously. The industrial outputs of China, Brazil, and India, for instance, would significantly decline while OECD countries would experience slight increases in their outputs. In total, the subsidy removal would cause the world to experience a decline in industrial goods and slight increase in non-industrial outputs, eventually shifting production from industrial to non-industrial goods and inducing a structural change in the world economy. In another scenario, China's unilateral removal of subsidies would cause the Chinese economy to decline while other countries' economies would be better off. Furthermore, subsidy elimination in China would reduce total industrial output and increase non-industrial output globally.

Lofgren (1995) also used a CGE model to analyse the impacts of subsidy elimination in Egypt. The author analysed three scenarios: savings from subsidy removal are directed to: foreign investment (investing in foreign assets), domestic investment, and transfers to households. The results suggest that foreign investments would have strong adverse effects on GDP, household income, consumption, and employment. In short, redirecting savings to foreign investment would have the most contractionary effects. Abouleinein et al. (2009) concur and add that redirecting half of the savings to households could mitigate the negative impact of subsidy elimination on the economy. Moreover, gradual subsidy cut (within 5 years) and cash transfers to the populations belonging to the two poorest quintiles could be more effective compared to universal cash transfer, in terms of distributional impact and economic growth.

Solaymani et al. (2014) also used a CGE model to analyse the Malaysian context and suggested that complete elimination of the subsidies leads to a significant decline in household income and consumption and increases poverty. In particular, rural households that are employed in the agriculture sector are the most adversely affected.

There is therefore a plethora of studies using CGE models to examine the effect of energy subsidy reforms on the economy. Specifically, in the case of Iran, the various studies yield different outcomes. Three out of seven studies forecasted positive or at least a neutral impact of subsidy removal and cash transfer while the other four reject the assumption that redirecting subsidy removal can fully compensate for the reform's adverse effects, although they all agree that cash transfers could mitigate the reform's negative impact.

The use of CGEs is due to the fact that these models incorporate and connect all sectors, therefore providing an overview of the entire economy. However, CGEs are highly dependent on stylized facts based on historical data prior to the introduction of the reform, and therefore are subject to the Lucas critique: "… Given that the structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models. … For issues involving policy evaluation, … for it implies that comparisons of the effects of alternative policy rules using current macro-econometric models are invalid regardless of the performance of these models over the sample period or in ex ante short-term forecasting " (Lucas, 1976:41). This critique is even more salient in the case of the energy subsidy reform in Iran, wherein the price of all energy carriers (i.e., fuels and electricity) increased between 2 to 21 times. With respect to the magnitude of the reform scheme in Iran (characterized by massive change of energy price for all sectors, and an unprecedented universal unconditional cash transfer to households) and with reference to Lucas (1976), it is legitimate to doubt the validity of models that highly rely on ex-ante stylized facts and parameters and to seek the use of an alternative model.

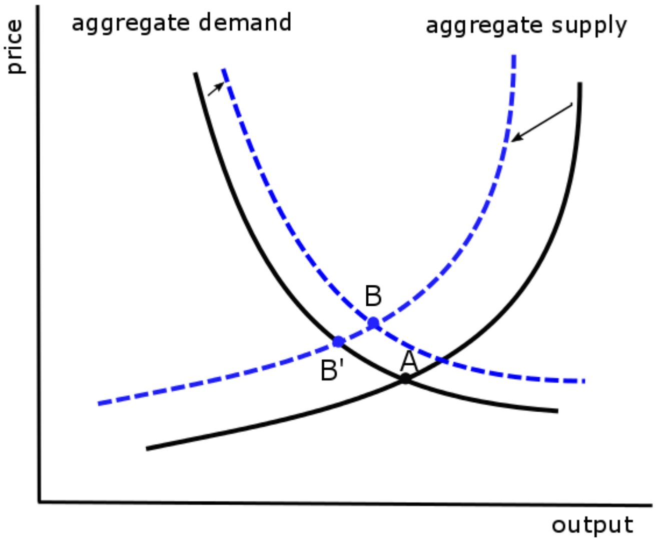
3 Research design

3.1 Theoretical foundation

As discussed earlier, the energy subsidy reform in Iran (SRCT) consists of two simultaneous parts: a subsidy cut (increase in energy price) and a cash transfer to households. Hence, the reform influences both aggregate demand and supply sides. An increase in the price of a basic production input, in this case energy, will shift the aggregate supply curve to the left (see Figure 1). This shift diminishes the output and elevates the general price level (Rasche and Tatom, 1981; Brown and Yucel, 2002; Barro, 2007; Zarepour and Wagner, 2021b).

On the demand side, the subsidy removal and (consequently) energy price increase affects the real budget of households and may induce a contraction on the demand side, i.e., moving backward along the demand curve (Bohi, 1991; Kilian, 2008; Rentschler, Kornejew and Bazilian, 2017; Rentschler and Bazilian, 2017; Zarepour and Wagner, 2021a). On the other hand, cash transfers are likely to have a positive effect on aggregate demand and may shift the demand curve to the right. Therefore, the counterbalance of the impact of the subsidy removal and cash transfer determines the equilibrium position at point B or B' in Figure 1.

Figure 1
Aggregate demand and supply in response to energy subsidy reform



Source: Author's illustration.

3.2 Choice of method

An alternative yet common approach, to examine the effect of a policy on macro indicators, is a Vector Auto Regression (VAR) framework, developed by Sims (1980). Numerous studies have applied the VAR methodology to investigate the impact of a policy/shock on the economy of Iran. (Farzanegan, 2011; Farzanegan and Markwardt, 2009; Dizaji and Van Bergeijk, 2013; Dizaji, 2014; Rafat, 2018; Khoshnevis Yazdi, Homa Salehi and Soheilzad, 2017).

A VAR consists of a set of linear equations of variables in which each variable is in turn explained by its own lagged values, plus current and past values of the other variables. It does not require a particular theory or sets of assumptions, but it can incorporate a wide range of theories (Arora, 2013). Hence, VAR is flexible and is also a powerful forecasting tool (Stock and Watson, 2001), as it can predict short and long run outcomes and does not require assumptions about the exogeneity of variables.

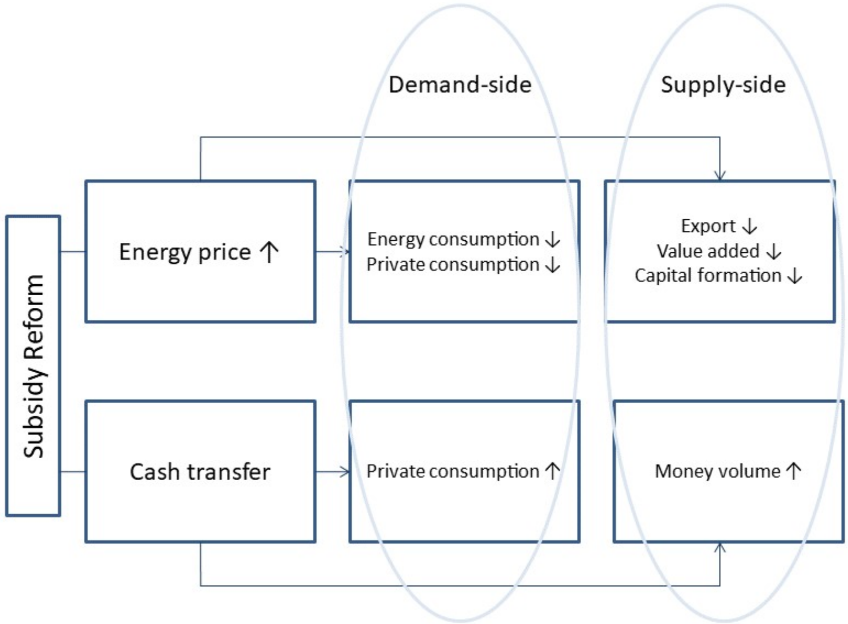
3.3 Conceptualization of the VAR

Inspired by theoretical foundation, Figure 2 visualizes the VAR conceptual framework by demonstrating the channels that connects the elements of the energy subsidy reform to macro indicators. On the supply side, energy price elevation increases the production cost that can affect exports, meaning that more expensive products are less competitive in the international market (Hoseinninasab and Hazeri 2012). Moreover, energy price increases can reduce the value added (if a producer cannot fully transmit the increase in production cost to consumers) (Hope and Singh, 1999; Rentschler, Kornejew and Bazilian, 2017) and cause a decline in capital formation (Atkeson and Kehoe, 1999). As a result, an increase in the energy price reduces output and increases inflation. However, these impacts would be different in the long term when the production firms have enough time to adjust (Bohi, 1991; Hope and Singh, 1999; Rasche and Tatom, 1981; Brown and Yucel, 2002; Barro, 2007).

On the demand side, an increase in energy prices affects aggregate demand via substitution and income effects. An increase in energy prices can reduce energy consumption directly (substitution effect). However, the increase in the general price level due to the increase in energy prices and also the prices of other goods and services (particularly energy-intensive products) results in a decline in real disposable income, lowering purchasing power and consequently diminishing aggregate demand (income effect) .(Rentschler, Kornejew and Bazilian, 2017; Rentschler and Bazilian, 2017; Zarepour and Wagner, 2021b)

The second element of SRCT is the cash transfer to households. The cash transfer enhances purchasing power and subsequently private consumption. The cash transfer is unconditional and universal, and every household receives the same amount regardless of their income level. Private consumption is more likely driven by low- income households since their marginal propensity to consume is higher than the average. On the other hand, cash transfer keeps circulating in the economy and augments money volume that may add to inflation.(Salehi-Isfahani, 2016)

Figure 2
Conceptualization of VAR: impact of the subsidy reform on macroeconomy



Source: Author's illustration.

4 Data

To examine the short and long run effects of the energy subsidy reform on macro indicators, I use a timeseries of the following variables, which were adopted from the time-series databank of Central Bank of Iran[4] (CBI) from 1965 to 2010 (46 observations) (see Table 2 for a description of the variables. Data on the price and consumption of energy carriers are meanwhile collected from the 'Energy Balance Sheet' provided by the Iranian Ministry of Energy.[5]

Energy price *(peng)* is the average price of the main energy carriers including LPG, gasoline, gasoil, kerosene, natural gas, and electricity and it is measured in Ton of oil equivalent (Toe) terms. The conversion of the units to Toe is according to the unit conversion guidelines of the Ministry of Energy. Energy price is used in current Iranian Rials (IRI) to veer away from the tendency of inflation to mask the magnitude of the prices. The main objective of this research is to investigate the effect of the energy subsidy reform (that introduces new sets of (nominal) prices) and to do so it is important to incorporate nominal prices rather than real ones. Investigation of the effect of such reforms based on the nominal energy price (by incorporating nominal energy price in the model) is not uncommon in the literature. (Rasche and Tatom, 1977; Eltony, 2004; Wang and Zhu, 2015; Huntington, 2016). Moreover, as a supplementary analysis, I discuss the effect of the real energy price in the short and long run.

Given that increase of energy price is accompanied by a cash transfer to households, broad definition of money volume or M2 *(mony)* is included in the

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4 See: http://tsd.cbi.ir/Display/Content.aspx accessed by 25-02-2019
5 See: http://pep.moe.gov.ir/accessed by 10-08-2019

models. Increase of energy price directly and indirectly affects the economic sectors particularly industries and service sectors. The value-added of industry and service sectors *(vains)* is the indicator that highlights this link. The energy price increase can potentially be transmitted to capital formation in these economic sectors. Thus, gross capital formation (*capform*) is also included in the model.

Private consumption (*pcon*) is simultaneously affected by increase in energy prices, negatively and by cash transfer, positively. Public consumption (*gcon*) is another potential link that can transmit the effect of energy subsidy reform to GDP. Furthermore, energy price increases can influence the price competitiveness of products in international markets and affect net exports (*expr*). Inflation (*inf*) is a common by-product of the energy subsidy reforms so it is included in the variable list. Finally, energy consumption (*econt*) can potentially be affected by increase in energy prices and also affects other macro indicators including GDP. All variables except inflation rate *(inf)* are in logarithmic form.

Additionally, to take into account the effect of the Islamic revolution in 1979 and Iran-Iraq war during 1980-1988 two dummies are included in the models. These two dummies have also been employed in many recent VAR studies (Farzanegan and Markwardt, 2009; Farzanegan, 2011; Dizaji and Van Bergeijk, 2013).

Table 2
Variables' description

Variables	Name	Unit
Gross Domestic Product (GDP)	*gdp*	Real (1997=100) Million Iranian Rials (IRI) per capita
Value-added of industry/service sectors	*vains*	Real (1997=100) Million Iranian Rials (IRI) per capita
Inflation rate	*inf*	% annual
Capital formation	*capform*	real (1997=100) Million Iranian Rials (IRI) per capita
Public consumption	*gcon*	Real (1997=100) Million Iranian Rials (IRI) per capita
Private consumption	*pcon*	Real (1997=100) Million Iranian Rials (IRI) per capita
Export	*expr*	Real (1997=100) Million Iranian Rials (IRI) per capita
Money volume (M2)	*mony*	Real (1997=100) Million Iranian Rials (IRI) per capita
Energy price (aggregated)	*peng*	Thousands Rilas (IRI) per ton of oil equivalent (Toe)
Energy consumption	*econt*	Ton of oil equivalent (Toe) per capita

5 Modelling and empirical methodology

5.1 Time series econometric issues

One of the issues that need to be addressed with a time series is its stationary status. Augmented Dickey-Fuller, Philips-Perron, and Kwiatkowski-Phillips-Schmidt-Shin are common tests for stationary check. The null hypothesis in Augmented Dickey-Fuller and Phillips-Perron tests is that series have a unit root while the null hypothesis in Kwiatkowski-Phillips-Schmidt-Shin test is that the series is stationary. Table 3 compares the results of various unit root tests based on 5% significance level together with the selected specification. To find the right specification, I first run the test with the most inclusive specification (with intercept and trend included). If the trend appeared to be insignificant, I redo the test without trend. Phillips-Perron tests indicate that all variables are nonstationary I(1). Albeit other tests (ADF and FPE) are not conclusive for half of the variables.

Table 3
Unit root tests comparison

		Augmented Dickey-Fuller	*Philips-Perron*	*KPSSH*
GDP	Result Specification	Nonstationary I(1) Intercept	Nonstationary I(1) Intercept	Nonstationary* Intercept and trend
Energy price	Result Specification	Nonstationary I(1) Intercept and trend	Non stationary I(1) Intercept and trend	Non stationary I(1) Intercept and trend
Money (M2)	Result Specification	Nonstationary I(1) Intercept	Nonstationary I(1) Intercept	Nonstationary I(1) Intercept and trend
Capital formation	Result Specification	Nonstationary* I(1) Intercept	Nonstationary I(1) Intercept	Stationary Intercept and trend
Value-added of Industry and service sectors	Result Specification	Nonstationary I(1) Intercept	Nonstationary I(1) Intercept	Stationary Intercept and trend
Private consumption	Result Specification	Nonstationary I(1) Intercept	Nonstationary I(1) Intercept	Stationary Intercept and trend
Public consumption	Result Specification	Nonstationary* I(1) Intercept	Nonstationary I(1) Intercept and trend	Stationary Intercept
Export	Result Specification	Nonstationary I(1) Intercept	Nonstationary I(1) Intercept	Stationary* Intercept and trend
Inflation rate	Result Specification	Stationary Intercept	Nonstationary* I(1) Intercept and trend	Non stationary I(1) Intercept and trend
Energy consumption	Result Specification	Nonstationary I(1) Intercept and trend	Nonstationary I(1) Intercept and trend	Stationary Intercept and trend

Note: KPSSH: Kwiatkowski-Phillips-Schmidt-Shin; The null hypothesis of Augmented Dickey-Fuller and Philips-Perron tests is that the series has a unit root test. On the contrary, the null hypothesis of KPSSH is that the series is stationary.

All the results are based on 5% statistical significance; * Shows the null hypotheses fails to be rejected at 5% but it is rejected at 10% statistical significance level.

The second issue is to use the variables on level or to differentiate the nonstationary ones to make them stationary. According to Hamilton (1994), the estimated parameters of a VAR in level, using non-stationary variables, are consistent. Even if the VAR in difference is the correct model, still many hypothesis tests based on VAR on level has the same asymptotic distribution as VAR in difference. Moreover, if any seemingly non-stationary variable is differenced while it is stationary, or it has any stationary linear combination as in the cointegrated VAR, then VAR in difference form is mis-specified (Hamilton, 1994; Engle and Yoo, 1987; Khan and Ali, 2003). VAR modeling in levels has better predictive power when variables are mixed, i.e., some variables are stationary and some are not (Khan and Ali, 2003). More importantly, we lose useful information while differencing. In this regard, I use variables at level for the VAR models.

The third issue is the use of unrestricted VAR versus the vector error correction models (VECM), which is the restricted form of the former. Numerous studies have shown that in short horizons, unrestricted VAR is better in forecasting (Engle and Yoo, 1987; Clements and Hendry, 1995; Hoffman and Rasche, 1996; Naka and Tufte, 1997). Since the first part of this research is focused on the short-term impact of the subsidy reform and given the better performance of the unrestricted VAR compared to VECM in the short run forecasting, I opt to use an unrestricted VAR.

5.2 Impulse response functions

An unrestricted VAR is used to investigate the response of macro variables to an innovation in energy price and money volume (liquidity), in the short run. In a VAR framework, all variables are considered to be endogenous, and no prior theoretical restriction is imposed. A VAR consists of a set of linear equations of variables, in which each variable is in turn explained by its own lagged variables, plus current and past values of other variables. The response of one variable to an innovation to another variable(s) in the system is called Impulse Response Function (IRF). The general form of VAR in a form of 'infinite' moving average (MA) can be written as[6]:

$$\boldsymbol{y_t = \varepsilon_t + \Psi_1 \varepsilon_{t-1} + \Psi_2 \varepsilon_{t-2} + \cdots} \qquad \text{(Eq. 1)}$$

This form contains the impulse responses or dynamic multipliers:

$$\boldsymbol{\frac{\partial y_{t+s}}{\partial \varepsilon'_t} = \Psi_s} \qquad \text{(Eq. 2)}$$

The row i, column j element of the Ψ_s matrix represents the response at time $t+s$ of one unit increase in variable j at date t , holding all other innovations constant. (Hamilton, 1994)

The impulse response function can be generalized to simultaneous innovations with different magnitudes by creating a vector, such that each element of it is the magnitude of the impulse. If the first element of the ε_t changes by δ_1 while the second element changes by δ_2 and the nth element by δ_n, then the impulse responses would be:

[6] It is common in the literature to use the MA form of VAR to extract the impulse response functions because the resulted responses are orthogonalized. Nevertheless, one can extract IRFs form an AR form. However, the procedure to make them orthogonalized is complicated. The central point here is that any autoregressive form of order p, AR(P), can be written as MA(∞). For example AR(1) can be written as :

$y_t = \phi_1 y_{t-1} + \epsilon_t$

If we substitute y_{t-1} recursively, we will have an infinite moving average form as MA(∞) (Hamilton 1994): $y_t = \phi_1 y_{t-1} + \epsilon_t = \phi_1(\phi_2 y_{t-2} + \epsilon_{t-1}) + \epsilon_t = \cdots = \sum_{s=0}^{\infty} \phi^i \epsilon_{t-s}$

$$\boldsymbol{\Delta y_{t+s}} = \frac{\partial \boldsymbol{y_{t+s}}}{\partial \boldsymbol{\varepsilon_{1t}}}\boldsymbol{\delta_1} + \frac{\partial \boldsymbol{y_{t+s}}}{\partial \boldsymbol{\varepsilon_{2t}}}\boldsymbol{\delta_2} + \cdots + \frac{\partial \boldsymbol{y_{t+s}}}{\partial \boldsymbol{\varepsilon_{nt}}}\boldsymbol{\delta_n} = \boldsymbol{\Psi_s \delta} \qquad \text{(Eq. 3)}$$

Where

$$\boldsymbol{\delta} = (\boldsymbol{\delta_1}, \boldsymbol{\delta_2}, \dots, \boldsymbol{\delta_n})' \qquad \text{(Eq. 4)}$$

(Hamilton, 1994).

The impulse responses demonstrate the current and future responses of each variable in response to an innovation in the variable of interest. By using IRF, not only is the magnitude of the response observable, but the statistical significance of the response also becomes apparent. When the horizontal zero line in the IRF graphs falls outside the confidence interval (at 5% significance), the null hypothesis (that there is no effect on the variable of interest due to the shock), can be rejected. We can use Eq-3 to construct a simultaneous innovation to two or more variables to simulate the energy subsidy reform that has two elements (increase in energy price and cash transfer).

6 Empirical results

6.1 Short-term analysis: Transmission channels

There are numerous variables from both the supply and demand side that may be affected by the energy subsidy reform and which could eventually also transmit their impact to GDP (see Figure 2 for conceptualization of the VAR). To clarify potential transmission channels, I employ numerous Parsimonious VARs. It is a practical strategy to identify the potential links particularly when the length of the time series is limited. (Christiano, Eichenbaum and Evans, 1996; Jansen, 2003; Dizaji and Van Bergeijk, 2013). Appendix 2 summarizes different criteria for lag order selection in parsimonious VARs. Maximum number of lags was set up to 3. Different criteria suggest different number of lags for models. Akaike criteria has advantages over Schwartz criterion, on theoretical and practical grounds (Burnham and Anderson, 2002; Burnham and Anderson, 2004; Liew, 2004). Thus, I proceed with the number of lags suggested by AIC. Table 4 demonstrates the outcome of parsimonious VARs in response to an innovation in the energy price in Panel A and to money volume (M2) in Panel B, respectively. Each line of this table depicts different specifications of VAR with the sign and significance of the result within a four-year time span. Cholesky decomposition is used to define the impulse. As an example, the first line of the table follows this Cholesky ordering: energy price, value-added of industry and service sectors, capital formation, and GDP. This ordering indicates that a shock to energy price affects the value-added of industry and service sectors, and this in turn alters the capital formation and finally GDP. Accordingly, this VAR states that the increase in energy price has no significant impact in the first year, but it has a diminishing effect on capital formation and GDP, afterward, which becomes significant in year 2 and 3. In this VAR, the intermediate variable is the value-added of industry and service sectors, which also tends to decrease significantly in year 2 and 3. Panel A of Table 4 demonstrates a consistent negative impact on capital formation and GDP in response to an increase of energy price via different transmission channels. Albeit only three of these channels are statistically significant: Value-added, export and inflation. Innovation in energy price has inflationary impact from the first year that becomes significant in year 1 and 2 before it wanes at the end of the time span.

Panel B of Table 4 demonstrates the effect of the second element of the subsidy reform, i.e., cash transfer represented by an innovation to money volume, via parsimonious VARs. An innovation in M2 has an immediate positive effect on all intermediate channels. Albeit this impact is significant only for private and energy consumption, in year 1 and 2. Nevertheless, this positive impact weakly transmits to GDP. Comparing Panel A and B of Table 4 indicates that the negative effect of energy price increase on GDP, from all channels except energy consumption, is statistically significant. While the positive effect of cash transfer on GDP, from all channels, is statistically insignificant. In other words, it is unlikely that unconditional universal cash transfer can overcome the negative impact of the energy price increase. Cholesky ordering (that implies the order of variables) is a suitable method for incorporating the concept of transmission channels to the VARs. The alternative method is generalized impulse responses that do not care for order of variables in the model. It is noteworthy that the results are identical with the application of the generalised impulse method.

Table 4
Effect of energy subsidy reform elements on macro indicators

Panel A: Effect of one SD impulse to energy price

		Intermediate variable				Capital formation				GDP			
VAR no.		Year 1	Year 2	Year 3	Year 4&5	Year 1	Year 2	Year 3	Year 4&5	Year 1	Year 2	Year 3	Year 4&5
1	Value-added	nil	**negative**	**negative**	negative	nil	**negative**	**negative**	negative	nil	**negative**	**negative**	negative
2	Private consumption	negative	negative	negative	negative	nil	**negative**	**negative**	negative	nil	**negative**	**negative**	negative
3	energy consumption	negative	negative	negative	negative	nil	**negative**	**negative**	negative	nil	negative	negative	negative
4	inflation	**positive**	**positive**	positive	nil	nil	**negative**	**negative**	negative	nil	**negative**	**negative**	negative
5	export	nil	negative	**negative**	nil	nil	**negative**	**negative**	negative	nil	**negative**	**negative**	negative
6	public consumption	negative	negative	negative	nil	nil	**negative**	**negative**	nil	nil	**negative**	**negative**	nil

Panel B: Effect of one SD impulse to money volume (M2)

		Intermediate variable				Capital formation				GDP			
VAR no.		Year 1	Year 2	Year 3	Year 4&5	Year 1	Year 2	Year 3	Year 4&5	Year 1	Year 2	Year 3	Year 4&5
7	Value-added	positive	positive	positive	nil	nil	positive	nil	nil	positive	nil	nil	nil
8	private consumption	positive	**positive**	positive	positive	nil	positive	positive	nil	nil	nil	positive	nil
9	energy consumption	**positive**	**positive**	positive	positive	nil	positive	positive	nil	positive	nil	positive	nil
10	inflation	positive	positive	positive	nil	nil	nil	nil	positive	positive	positive	positive	positive
11	export	positive	nil	negative	nil	nil	positive	nil	negative	positive	nil	nil	nil
12	public consumption	positive	positive	positive	positive	nil	positive	positive	positive	nil	negative	positive	positive

Note: Each line represents a VAR model. Significant effects (at 5 % level) effects are in **bold**

6.2 Short-term analysis: Extended VAR

Having numerous VARs not only clarifies the transmission channels of the energy subsidy reform but as shown in Table 4, also demonstrates the robustness of the negative impact of the energy price increase on GDP. Nonetheless, in this step, all variables are put together in an extended VAR for further examination. Extended VAR can address the omitted variable problem that may occur in parsimonious models.

For the extended VARs, the Akaike criteria suggests a maximum lag of 3. Figures 3 and 4 illustrate the response of variables to a one standard deviation impulse in energy price and money volume (M2), respectively. Figure 3 shows that the energy price impulse has a negative impact on value-added of industry and service sectors, private, public and energy consumption, capital formation and GDP. This impact is statistically significant for capital formation in year 1 or 2, and on GDP in year 2. The magnitude is highest in year 2 or 3. On energy consumption, Figure 3 shows that energy price increase has a declining effect on energy consumption, but it is not statistically significant. Figure 3 also confirms the inflationary effect of energy price increase in both years 1 and 2. Moreover, it shows a distinctive cyclical movement of inflation in response to energy price impulse.

Figure 4 demonstrates the response of macro indicators to an impulse involving the second element of the energy subsidy reform, cash transfer, that is represented by a one standard deviation increase in the volume of money. This impulse significantly increases private and public consumption, energy consumption, value-added and export, in the first year, and then it becomes insignificant. The response of this impulse is significantly positive on GDP in year 3. The response of other variables including inflation to this innovation is not statistically significant.

So far, the effect of the energy price increase and cash transfer have been discussed individually. To simulate the energy subsidy reform, we need a customized simultaneous synchronized innovation as a shock to the system. Given the features of the subsidy reform and by utilising Eq-3, the innovation vector is customized with respect to the weights of the shock to energy price and money volume. Recalling that variables in the VAR are in logarithmic form, a 1-unit impulse represents a 1% change in the variable. Therefore, the percentage of the change of the variables of interest due to the subsidy reform is calculated as follows so that the policy can be replicated. Given that cash compensation for the energy subsidy cut is 405,000 IRI per person per month, we have:

Annual money volume per person due to cash transfer= $405{,}000 * 12 = 4.86\ million\ IRI$

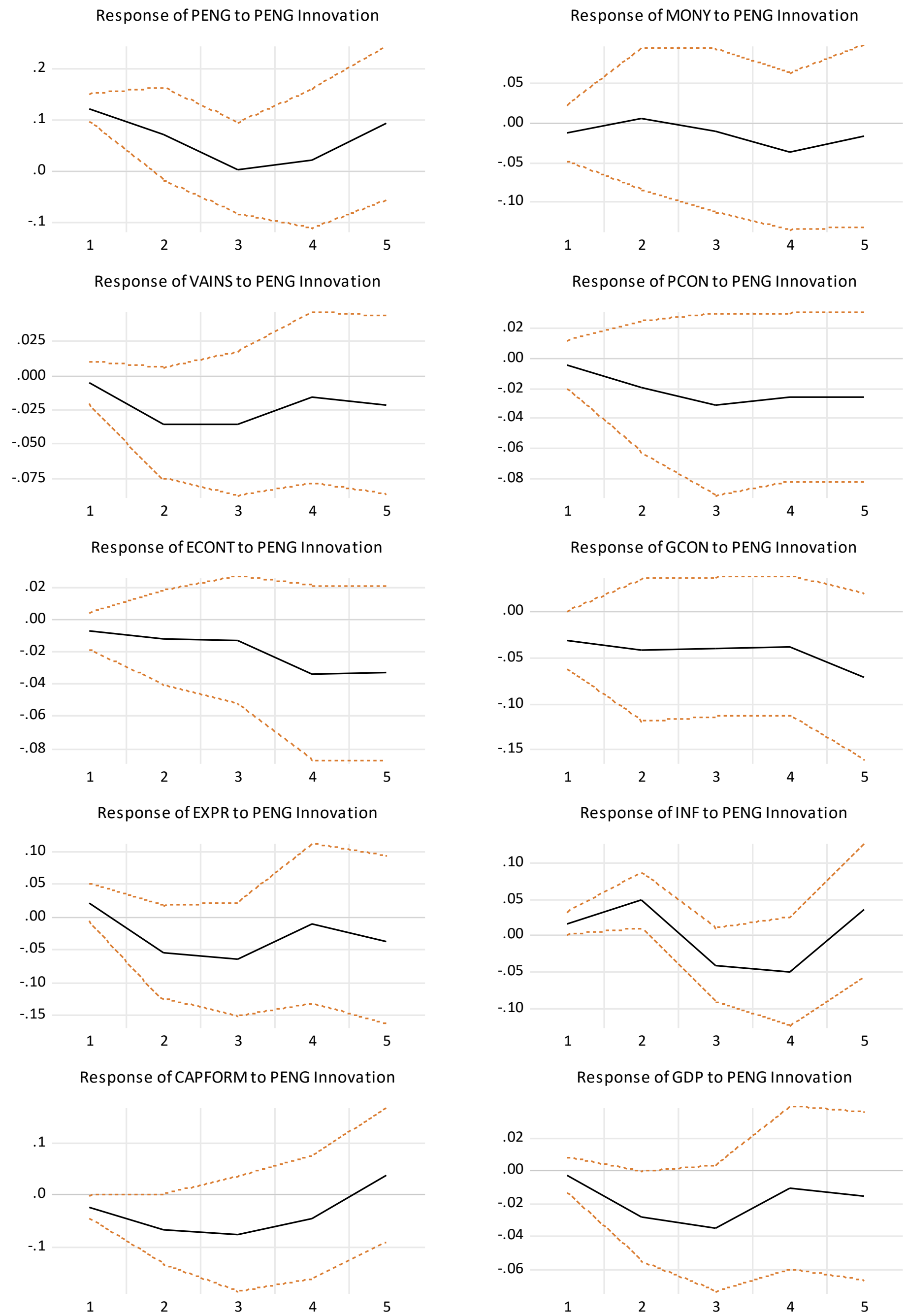
Total per capita money volume in 2011 is 46.97 million IRI, so the change in money volume due to cash transfer (as a part of subsidy reform) is:

$$4.86/46.97 \cong 10\%$$

Vector δ is the customized impulse that can simulate a proportionate shock to the system. The number of the elements in this vector is the same as the number of the endogenous variables in the VAR that is 10.

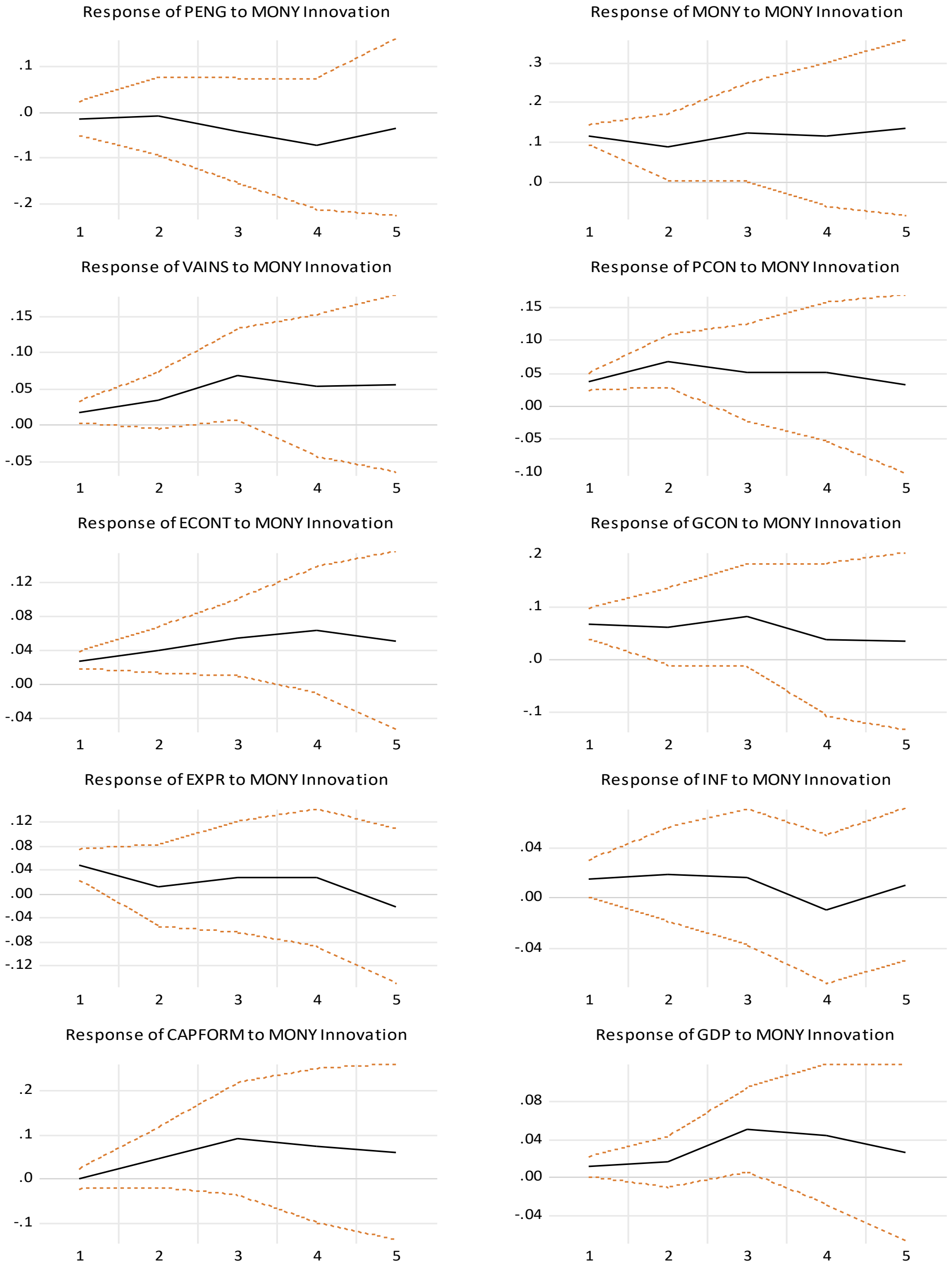
$$\delta = (2.72, 1.0, 0, 0, 0,0,0,0,0,0)'$$

Figure 3
Response to energy price innovation



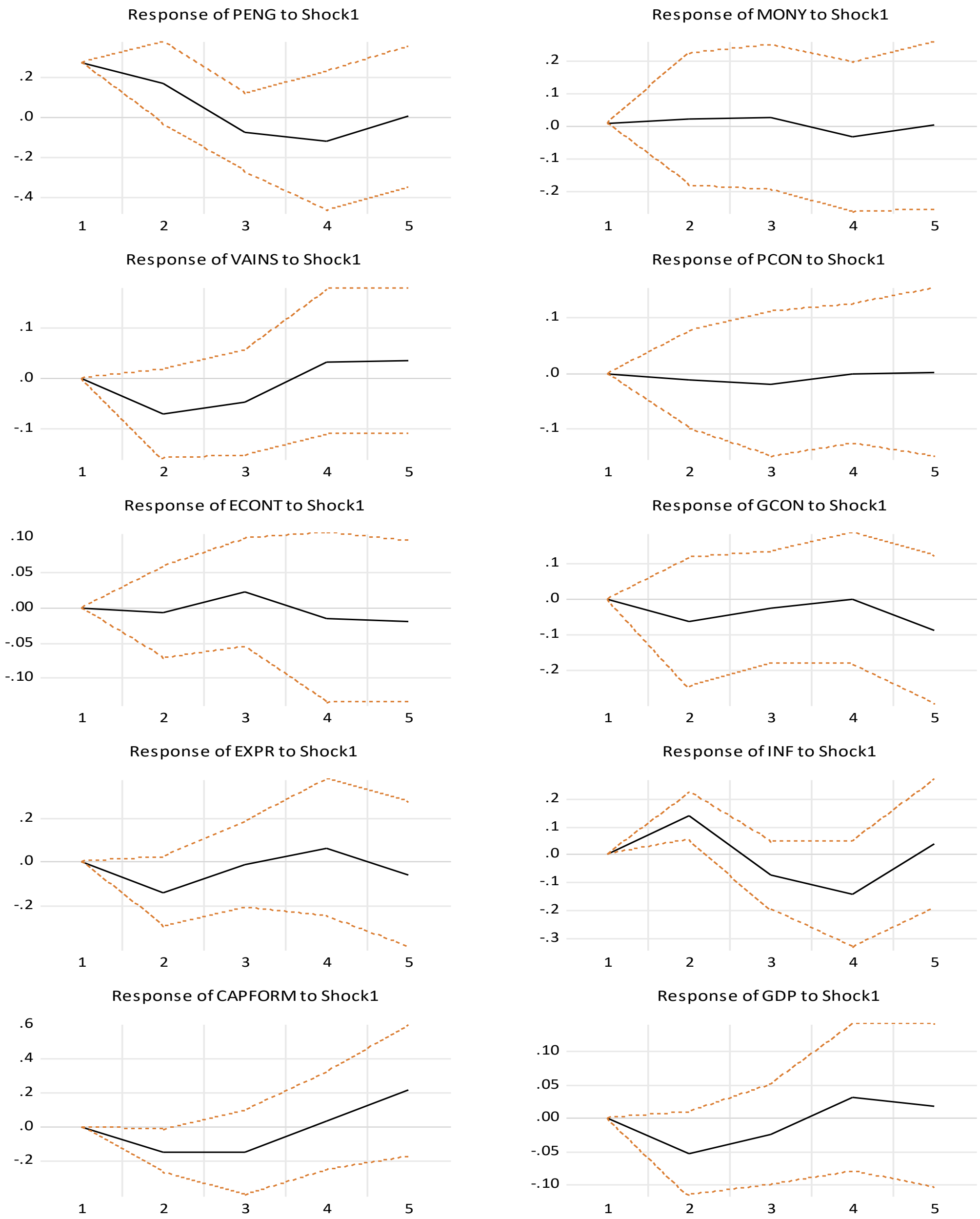
Note: This figure shows the temporal response of macro indicators to a one standard division shock to energy price. The horizontal line shows time (years). The red (dotted) lines show the confidence interval (bands) at 5% significance level

Figure 4
Response to cash transfer innovation



Note: This figure shows the temporal response of macro indicators to a one standard division shock to money volume (M2). The horizontal line shows time (years). The red (dotted) lines show the confidence interval (bands) at 5% significance level.

Figure 5
Response to a synchronized customized innovation
(simulation of the energy subsidy reform)



Note: This figure shows the temporal response of macro indicators to a customized innovation that simulate both elements of the energy subsidy reform simultaneously. The horizontal line shows time (years). The red (dotted) lines show the confidence interval (bands) at 5% significance level.

Figure 5 demonstrates the response of the variables to the customized synchronized shock. In year 2, the negative impact of the energy subsidy reform on value-added of industry and service sectors, capital formation and GDP is approximately 7, 15 and 5 percent, respectively. Albeit this impact, is only statistically significant for capital formation. Energy consumption reduction in response to the simulated energy subsidy reform is trivial (less than 0.7 percent). Figure 5 also shows that inflation increases up to 14 percent in year 2.

In sum, the upshot from the small VARs and the extended VARs with ordinary and customized innovations are comparable and the following may be concluded: i) Energy subsidy reform has substantial adverse effects on value-added of industry and service sectors, on capital formation and GDP, in the short run ii) Energy subsidy reform has a cyclical inflationary effect iii) cash transfer mitigates the negative effect of energy price on private consumption but does not fully offset it and iv) the models do not demonstrate compelling evidence that the energy subsidy reform decreases energy consumption.

A final point, I use nominal energy price throughout the analysis as from a policy evaluation viewpoint, it is more important to identify the effect of the new sets of energy prices on the economy rather than the real prices. Nevertheless, as a supplementary analysis, I use real energy price *(rpeng)* to replicate the results of the extended VARs with the inclusion of real energy price instead. Appendix 3 to 5 demonstrate the response of macro indicators to a one standard error innovation in the real energy price, cash transfer, and simultaneous innovation, respectively. These graphs are comparable with Figures 3 to 5. Value-added, private consumption, capital formation and GDP decline in response to real energy price increase. The dynamics and magnitude of the effect of cash transfer in the VAR with real energy price (Appendix 4) is identical with Figure 4. Appendix 5 shows the customized simultaneous shock to real energy price and cash transfer. Similarly, the dynamics and the magnitude of the impact is comparable to Figure 5. Simultaneous shock has a diminishing impact on the value-added, capital formation and GDP. Decline in GDP reaches trough (approximately 4 percent) in year 3 before recovery begins.

6.3 Variance Decomposition

The analysis of variance decomposition of forecasting errors gives us an idea of the proportion of the forecasting error explained by the variable itself or by other variables. Table 5 demonstrates the variance decomposition of the extended VAR. For value-added, energy consumption and export, the largest proportion of the variation is explained by their own trend. Value-added, in turn, explains a majority of the fluctuation in capital formation and GDP within the 5-year time span. Money volume (M2) explains approximately half of the variation in private consumption and energy consumption.

For inflation, value-added is the major determinant in the first year, but after year 1, energy price explains up to 53% of the fluctuation in inflation (supply-side drivers). The cash transfer can explain no more than 14% of the inflation forecast error. For GDP, energy price accounts for up to 25% of its variation after year 1. Meanwhile, money volume (M2) explains a larger portion of GDP variance after year 3 (up to 33%). For energy consumption, the historical trend of energy consumption and money volume are the major determinants of variation. Energy price has a relatively small portion in the variation of energy consumption - it is no more than 5% but it increases in year 5 to 13%.

These findings confirm the findings of the previous section (impulse response function analysis). It shows the influence of value-added on capital formation and GDP. Energy price influences GDP but its effect diminishes over time. It also reveals that the determinants of inflation variation are more rooted in the supply side (energy price and value-added) and cash transfer and private consumption are less influential.

Table 5
Variance decomposition

Year	Energy price	Money (M2)	Value-added	Private cons.	Energy cons.	Public cons.	Export	Inflation	Capital formation	GDP
Energy price										
1	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	82.88	0.00	0.83	1.79	5.72	4.43	3.69	0.47	0.18	0.02
3	60.28	4.97	2.72	14.85	4.25	3.23	7.11	0.64	1.67	0.28
4	32.54	10.15	17.77	12.08	2.58	3.84	17.87	0.82	2.10	0.25
5	29.24	6.99	12.85	9.54	9.13	13.97	15.87	0.81	1.40	0.20
Money volume (M2)										
1	1.17	98.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.65	74.86	17.21	0.62	5.23	1.03	0.02	0.00	0.36	0.03
3	0.62	77.52	14.77	0.38	4.38	1.77	0.02	0.30	0.22	0.03
4	2.42	76.46	15.33	0.28	3.31	1.78	0.02	0.22	0.17	0.02
5	2.14	77.78	15.15	0.29	2.64	1.60	0.01	0.17	0.19	0.02
Value-added (industry and service)										
1	0.98	10.70	88.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	19.03	18.34	58.94	0.61	1.55	1.01	0.41	0.08	0.02	0.01
3	17.48	39.12	33.20	0.29	0.84	8.60	0.34	0.05	0.09	0.00
4	13.89	42.15	31.88	0.83	1.46	8.37	0.82	0.06	0.47	0.08
5	11.21	39.34	34.48	0.61	1.08	8.00	4.29	0.15	0.75	0.09
Private consumption										
1	0.69	49.55	40.90	8.86	0.00	0.00	0.00	0.00	0.00	0.00
2	3.88	58.26	28.46	4.50	2.33	2.17	0.30	0.01	0.08	0.01
3	8.39	50.16	30.06	3.35	3.01	3.63	0.90	0.25	0.19	0.06
4	8.82	45.19	32.83	2.37	3.33	5.18	1.73	0.19	0.31	0.06
5	9.84	41.47	33.05	2.28	3.58	6.49	2.42	0.30	0.50	0.07
Energy consumption										
1	3.18	49.89	1.80	0.14	44.98	0.00	0.00	0.00	0.00	0.00
2	5.25	66.76	2.43	0.08	19.63	4.14	0.52	1.09	0.07	0.03
3	3.93	58.90	22.20	0.36	7.53	4.08	1.88	0.77	0.26	0.09
4	9.54	56.58	18.66	0.27	5.08	5.66	3.31	0.44	0.38	0.08
5	12.56	53.80	16.15	0.25	4.30	8.26	3.72	0.34	0.54	0.09
Public consumption										
1	8.70	37.61	40.95	0.39	0.44	11.91	0.00	0.00	0.00	0.00
2	15.40	42.99	30.03	0.38	0.53	10.58	0.07	0.01	0.02	0.00
3	14.69	48.77	24.73	0.28	0.37	10.55	0.41	0.10	0.09	0.01
4	14.62	39.27	34.53	0.21	0.84	8.70	1.11	0.12	0.50	0.09
5	21.78	32.04	29.85	0.27	0.81	11.13	3.44	0.11	0.51	0.07
Export										
1	5.76	29.87	3.79	5.15	0.00	1.48	53.95	0.00	0.00	0.00
2	20.57	15.96	1.99	16.36	0.26	4.46	28.69	10.46	1.25	0.01
3	27.15	11.01	16.46	9.77	1.28	3.17	23.89	6.29	0.89	0.08
4	21.00	10.20	16.89	8.59	1.37	2.47	27.76	8.46	3.09	0.18
5	20.65	10.20	18.30	7.23	2.01	6.80	24.73	7.11	2.80	0.16
Inflation										
1	10.28	11.22	38.21	0.06	9.66	22.45	0.33	7.79	0.00	0.00
2	44.49	14.35	17.58	0.06	4.48	11.85	3.51	3.55	0.07	0.07
3	50.78	11.71	15.68	2.74	3.14	8.48	4.50	2.62	0.26	0.08
4	56.99	10.44	13.67	2.08	2.54	8.09	3.87	1.96	0.27	0.09
5	53.02	9.52	15.68	1.63	3.67	9.59	4.99	1.53	0.29	0.09
Capital formation										
1	10.60	0.04	76.90	0.43	0.25	0.01	0.01	9.05	2.72	0.00
2	17.67	5.73	68.40	0.34	4.66	0.61	0.30	1.72	0.57	0.01
3	22.26	17.69	46.54	0.41	2.80	7.62	0.88	1.25	0.53	0.01
4	21.45	22.38	38.16	1.05	2.58	10.84	1.58	1.08	0.80	0.07
5	18.38	22.48	39.59	1.02	2.20	8.60	4.65	1.72	1.27	0.09
GDP										
1	0.43	9.07	86.66	0.96	0.85	0.23	0.66	0.46	0.50	0.17
2	25.46	9.32	55.19	1.35	0.38	5.28	0.49	2.22	0.21	0.09
3	23.72	28.87	32.61	0.53	0.14	11.42	1.64	0.81	0.22	0.05
4	17.47	35.79	29.22	1.01	0.99	9.66	3.54	1.02	1.16	0.13
5	15.61	32.69	28.15	0.83	2.50	11.64	6.24	0.82	1.37	0.16

Note: This table demonstrates the variance decomposition of the forecast errors of the extended VAR.

6.4 Long run analysis: Bounds test

The previous sections discussed the impact of the subsidy reform on macro variables within a short time span, using impulse response functions and variance decomposition within a VAR framework. However, a cointegration analysis is necessary to address the question in the long run.

A cointegrated vector is a linear combination of nonstationary series with stationary residuals. For example, if x_t and y_t are both $I(1)$, and the residuals is stationary $u(t) \sim I(0)$; then, x_t and y_t are cointegrated of order (1,1). The economic interpretation of a cointegrating relationship is that if two or more series are cointegrated, they have a long-run equilibrium relationship and even if the individual series have a stochastic trend (i.e., nonstationary), the combination of the series will move tightly together, and the difference between them will remain stable. (Harris, 1995)

In this regard, if macro variables and particularly GDP move together with energy price and/or money volume (M2) (i.e., if there is a long run relationship between GDP and elements of the subsidy reform), it may be concluded that the subsidy reform has a long-term impact on the economy. Utilizing Auto Regressive Distributed Lag (ARDL) model and Bounds test, we may check for the existence of long-run relationships between energy prices and/or money volume (M2), and important macro indicators. I chose to use the ARDL model and Bounds tests developed by Pesaran and Shin (1998) and Pesaran et al. (2001) because this method is compatible with the mix of I(0) and I(1) variables in the system. Thus, inconclusive unit root tests for some variables are not problematic. Furthermore, in this model, different variables may be assigned with different number of lags. Lastly, it is featured with a post-estimation coefficient diagnostic test (Bounds test) to ensure the (non)existence of a long run relationship at different significance level. Bounds tests consists of two sets of asymptotic critical values that provide a band that covers all possible mix of variables from I(0) to I(1). If the F-statistics falls outside the bounds a conclusive inference can be drawn without needing to know whether the variables are stationary or not. However, if the F-statistics falls between the bounds, the test is inconclusive and the knowledge of degree of integration of variables is necessary to draw any conclusive inference (Pesaran et al., 2001). The basic form of an ARDL regression is presented as:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \cdots + \beta_k y_{t-p} + \alpha_0 x_t + \alpha_1 x_{t-1} + \cdots + \alpha_q x_{t-q} + \varepsilon_t$$

(Eq-5)

where the disturbance term, ε_t, is well-behaved and serially independent.

From Table 3, it is known that none of the variables are I(2), i.e., all the tests show that the variables are either stationary or become stationary after one difference. Thus, the application of the ARDL model is compatible with the dataset at hand. Panel A of Table 6 shows the (non)existence of any relationship between selected macro indicators and energy price. Each row represents a macro indicator as the dependent variable while energy price is the dynamic regressor, i.e., it can take lags. All models include an intercept, a trend and two dummies for Islamic revolution and Iran-Iraq war. The third column, model specification (lag structure) shows the optimal lag structure suggested by the Akaike criteria. The first number shows the number of lags of the dependent variable on the right side of the equation and the rest of the numbers show the number of lags of the dynamic regressors. For example, in the first row the optimal model structure is (2,2) that means 2 lags are assigned to GDP (dependent variable) and 2 lags to energy price (dynamic regressor). The default maximum number of lags is 4. Yet, in case of serial correlation of the residuals[7], the number of lags added up to the number that resolves the serial correlation problem, for a significance level of 5%. In the absence of serial correlation, the Bounds test shows the (non)existence of cointegrated vector in the last column. If the F-statistic of Bounds test (fourth column) is larger than the upper bound, a long run relationship exists. If it is smaller than the lower bound, there is no long run relationship and if it falls between the boundaries, then the test is not conclusive. The critical lower and upper bounds, provided by Pesaran et al. (2001), depend on the number of observations and dependent variables. The critical lower and upper bounds, at the 5% level of significance, for Panel A and B of Table 6 are 7.08 and 7.91, respectively. The F-statistics of the first model, in the first row of Table 6 is 5.348 that is less than the lower critical bound. Therefore, there is no long run association between energy price and GDP. Likewise, no long run relationship exists between energy price and value-added of industry and service sector, private consumption, or energy consumption. However, inflation and energy price move together in long run.

Panel B of Table 6 demonstrates possible long run relationships between macro indicators and cash transfer (represented by money volume (M2)). The critical values are the same as in Panel A. Panel B shows that there is only a long run association between inflation and money volume. Panel C includes both energy price and money volume as dynamic regressors in the model. The critical values here are 5.36 and 6.37 for the lower and upper bounds, respectively. Like the first two panels of Table 6, Panel C shows that there is no long run relationship between the energy subsidy reform elements (i.e., energy price and cash transfer) and GDP, value-added, private consumption, or energy consumption. Nonetheless, energy subsidy reform has a long run inflationary effect. Comparing this result with the outcome of short-term analysis indicate that inflation has a cyclical movement.

Similar to the aforementioned findings, Appendix 6 confirms that there is no long run relationship between real energy price and cash transfer, and the main macro indicators except inflation.

[7] Breusch-Godfrey serial correlation LM test is used.

Table 6
(Non) Existence of long run relationship between energy subsidy reform and main macro indicators

	Dependent variable	Model specification (lag structure)	F-statistics of Bounds test	Long run relationship
Panel A: Energy price	GDP	(2,2)	5.348	No
	Value-added of industry and service	(4,0)	0.211	No
	Private consumption	(2,0)	1.063	No
	Energy consumption	(4,0)	2.519	No
	Inflation	(5,3)	17.378	Yes
Panel B: Money volume	GDP	(2,0)	5.934	No
	Value-added of industry and service	(4,4)	1.313	No
	Private consumption	(6,6)	2.312	No
	Energy consumption	(6,2)	5.886	No
	Inflation	(2,4)	14.174	Yes
Panel C: Energy price and money volume	GDP	(2,2,0)	4.166	No
	Value-added of industry and service	(4,4,4)	0.287	No
	Private consumption	(6,0,6)	1.766	No
	Energy consumption	(4,0,4)	4.986	No
	Inflation	(4,3,3)	10.192	Yes

* Note: All models include an intercept, a trend and two dummies for Islamic revolution and Iran-Iraq war. Exogenous variable(s) in Panel A is energy price, in panel B is money volume and in panel C are both energy price and money volume together.

7 Conclusion and policy implications

This article investigated the short and long run macroeconomic effect of the Iranian energy subsidy reform (SRCT) on macro indicators including GDP and inflation, using annual data covering the period 1965 to 2010. Due to the flexibility that it offers and its powerful performance in forecasting (Stock and Watson, 2001; Charney and Vest, 2003; Arora, 2013), this research applied VAR modelling to forecast the effect of the reform without entanglement with other external circumstances such as embarking international sanctions in 2012. The short-term effect of SRCT on GDP and also the channels that transmit this effect to GDP were examined in this paper through the use of numerous small (parsimonious) and extended unrestricted VARs and the application of Impulse Response Functions (IRFs). The analysis incorporated the elements of SRCT (energy price increase and cash transfer) individually (as a single innovation) and together (in the form of a synchronized customized shock to energy price and money volume (M2)). The long run influence of the energy subsidy reform was addressed by an ARDL model and the computation of Bounds tests.

The results show that the subsidy reform has a consistent negative impact on GDP, capital formation, value-added of industry and service sector and private consumption in the short-term. A majority of the macro indicators reach a trough in year 2 or 3 and thereafter, start to return to their initial levels. Using an ARDL model and Bounds tests, this article found no long-run relationship between the subsidy reform and GDP, value-added of industry and service sectors and private consumption. However, the models show that subsidy reforms do have a long run inflationary impact. The main objective of SRCT is to curb the energy consumption. The findings do not indicate any meaningful reduction in energy consumption in response to the energy subsidy reform. These findings contest the environmental and sustainability aspect of energy reforms as an intrinsic outcome of energy subsidy reforms.

The Iranian context is unique, but the findings of this paper could have relevant implications for future phases of subsidy reform not only in Iran but also in other countries. Energy is a key element in each economy and price changes have a complex impact on the economy. The results showed that redirecting subsidy savings to the economy in the form of an unconditional universal cash transfer to households could not fully mitigate the negative effect on the economy, in the short run. Recovery after year 3 is predicted if no other sizable damaging shock hits the economy, which brings us to the issue of timing. The timing of the reform is crucial to minimize its adverse effects on the entire economy. Ideally, reforms should be launched when the economy is stable, and when no major crisis is foreseen.

Our findings also indicate that value added of industry and service sector is the major channel which transmits the adverse effect of the higher energy price to GDP. The stability of the economy is essential as such industries can recover in due time. Iran initiated the subsidy reform when the country was in the heat of a nuclear dispute with the West. Soon after the reform, hefty international sanctions on oil exports and the Central Bank of Iran paralyzed the economy in 2012. These sanctions influenced the economy and fueled inflation (Katzman, 2014; Hemmati, Niakan and Varahrami, 2018; Pourshahabi and Dahmardeh, 2015). The rapid inflation rate took over the energy price hike and the gap between the local and international energy prices (i.e., the energy subsidy) re-emerged, partially. Poor timing therefore contributed to the reversal of the reform.

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Appendices

Appendix 1
Price of energy carriers before and after the reform

	Before the reform (2010)	After the reform (2011)
Gasoline	4,000	7,000
Gas Oil	165	3,500
Kerosene	165	1,000
Fuel oil (Mazut)	95	2,000
Natural gas	231	992
Electricity	142	335

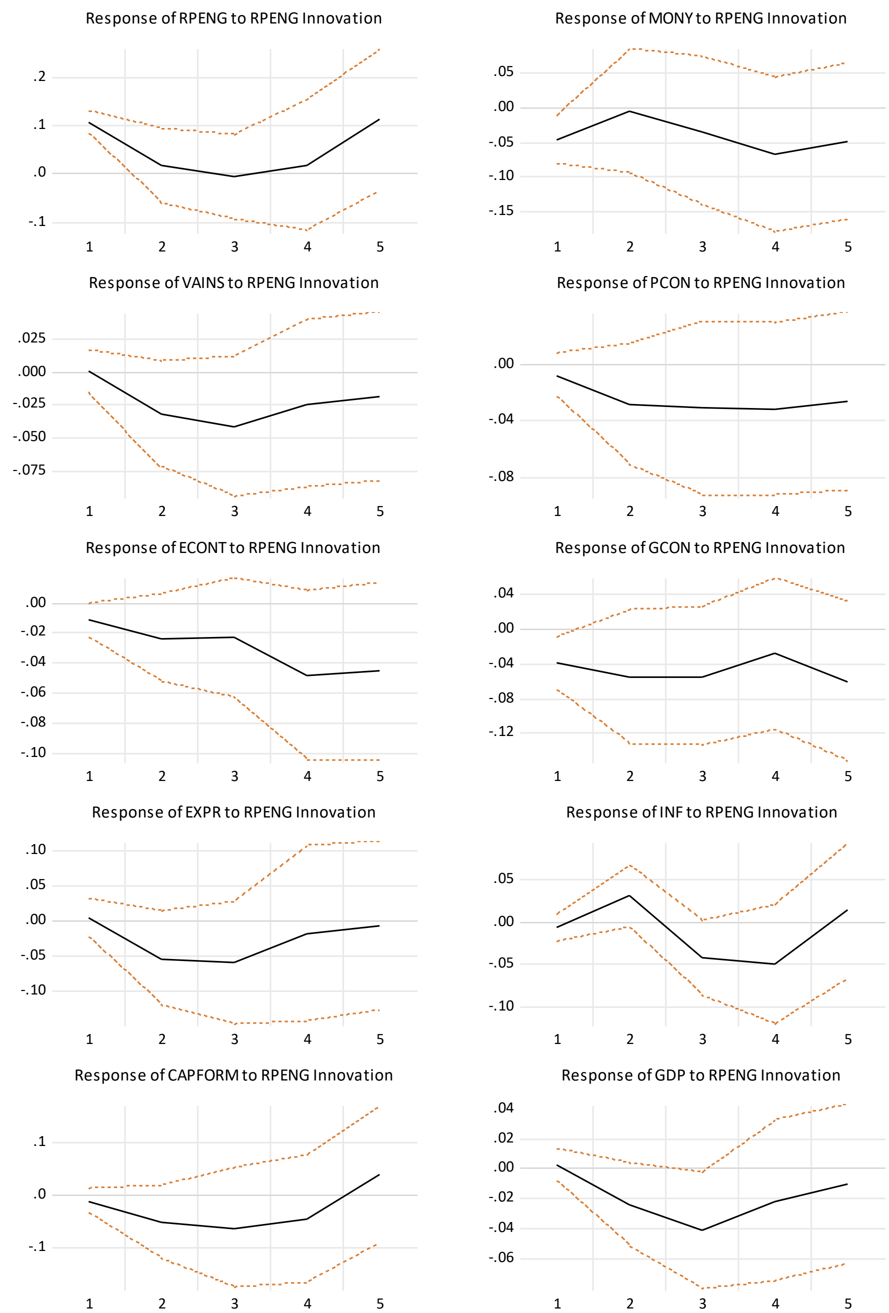
Source: Iranian Ministry of Energy
Note: Prices of fuel are denoted in current Iranian Rials per litre, the price of natural gas and electricity are denoted in current Iranian Rials per cubic meter and per kilowatt hour, respectively.

Appendix 2
Lag criteria for parsimonious VARs- different criteria

VAR no.*	Final prediction Error (FPE)	Akaike information (AIC)	Schwarz information (SC)
1	2	2	1
2	2	2	1
3	2	2	1
4	2	2	1
5	2	2	1
6	3	3	1
7	2	2	1
8	2	2	1
9	2	2	1
10	1	1	1
11	3	3	1
12	3	3	1

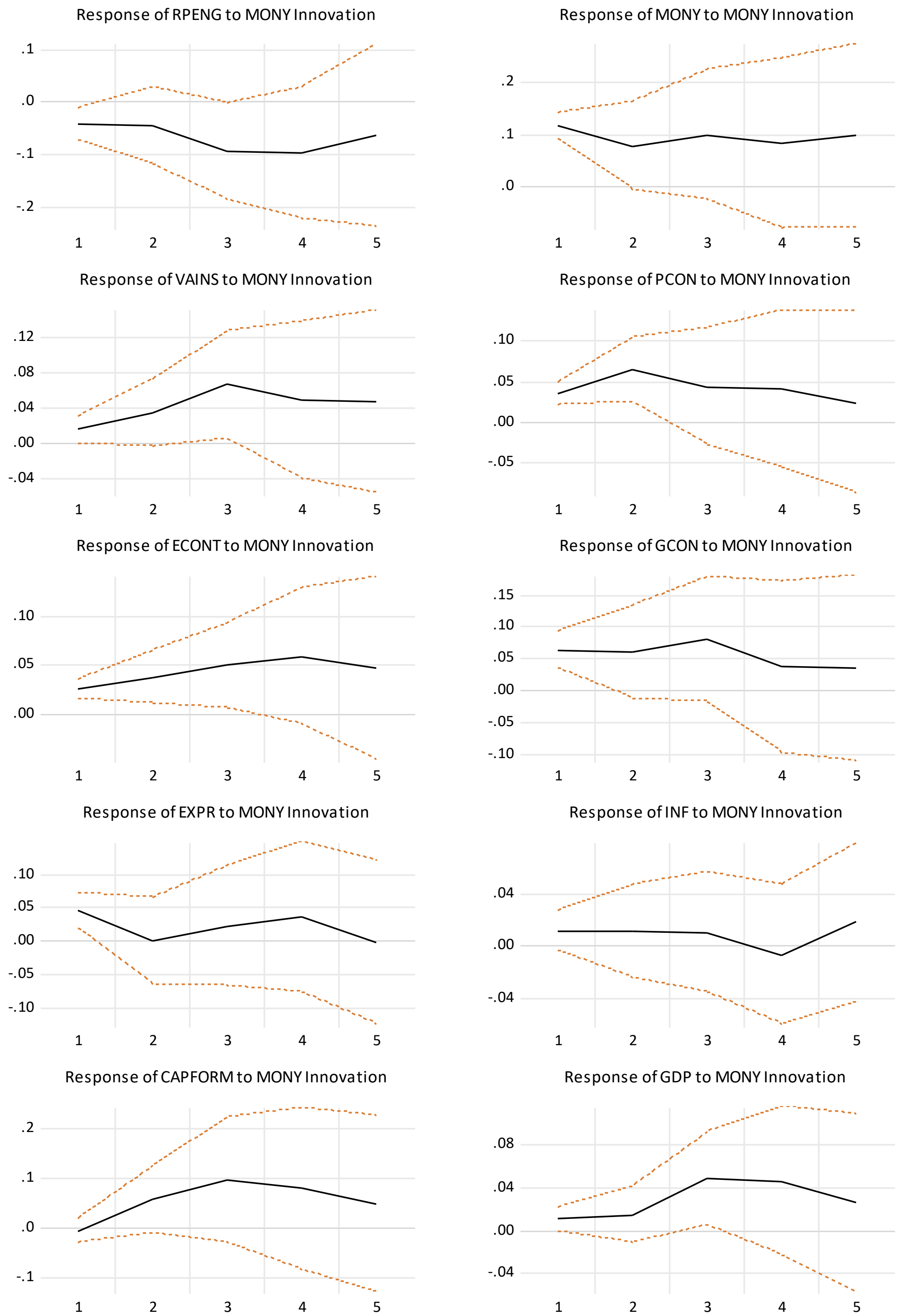
Note: * Var number refers to the number of each VAR reported in each line of Table 5.

Appendix 3
Response to real energy price innovation



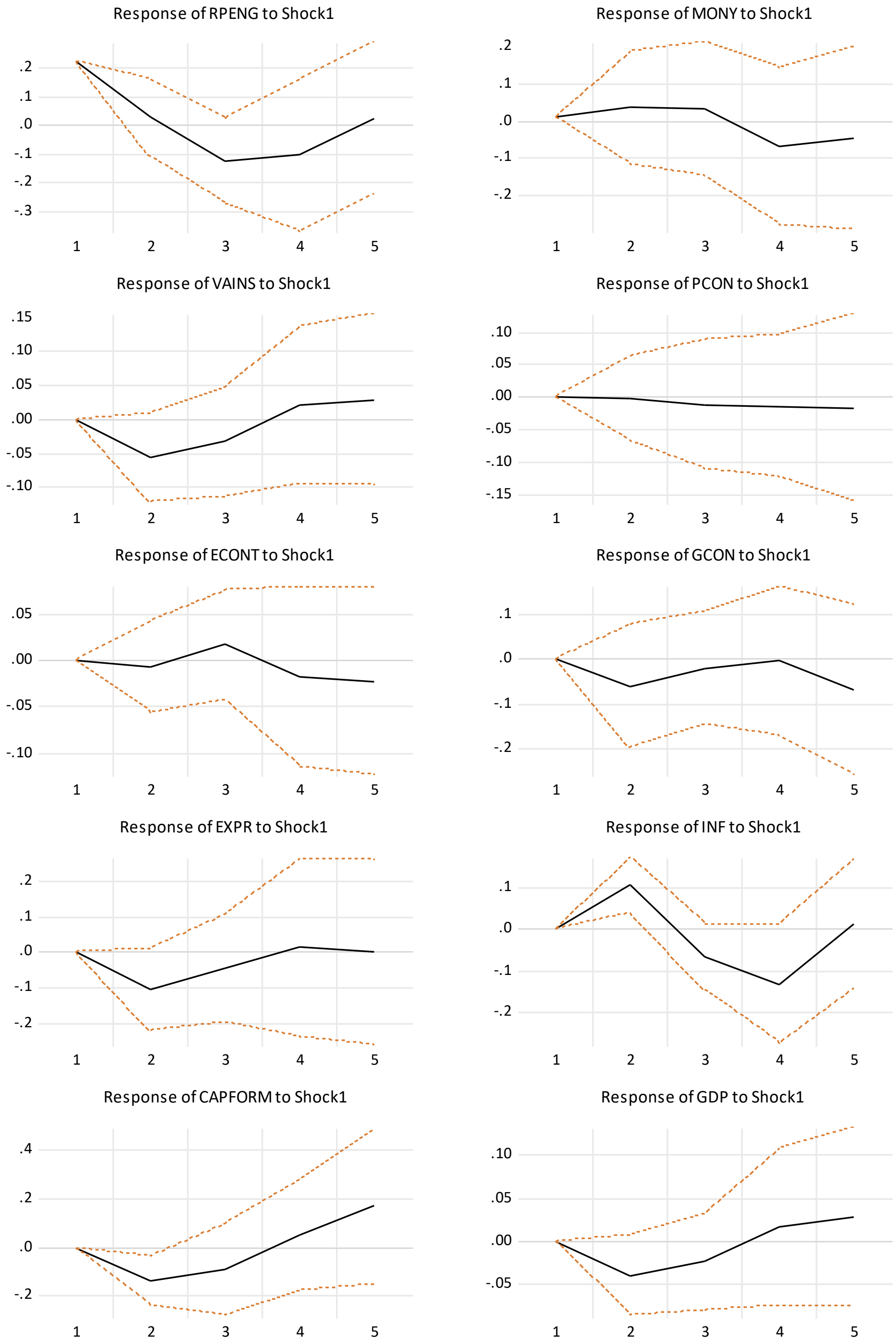
Note: This figure shows the temporal response of macro indicators to a one standard division shock to real energy price. The horizontal line shows time (years). The red (dotted) lines show the confidence interval (bands) at 5% significance level

Appendix 4
Response to cash transfer



Note: This figure shows the temporal response of macro indicators to a one standard division shock to money supply while real energy price is included in the model. The horizontal line shows time (years). The red (dotted) lines show the confidence interval (bands) at 5% significance level

Appendix 5
Response to synchronized customized innovation
(with real energy price and cash transfer)



Note: This figure shows the temporal response of macro indicators to a customized innovation of real energy price and cash transfer. Red (dotted) lines show the confidence interval (bands) at 5% significance level.

Appendix 6
(Non)existence of long run relationship between real energy price and cash transfer, and main macro indicators

Dependent variable	Model specification (lag structure)	F-statistics of bounds test	Long run relationship
GDP	(2,2,0)	2.285	No
Value-added of industry and service	(4,4,4)	0.945	No
Private consumption	(6,3,6)	3.290	No
Energy consumption	(4,2,4)	4.291	No
Inflation	(4,3,3)	9.357	Yes

Note: All models include an intercept, a trend and two dummies for Islamic revolution and Iran-Iraq war. Exogenous variables are both real energy price and money volume (M2) together