Environmental Impacts of Phasing out Energy Subsidies

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ABSTRACT

Here, we investigate the environmental impacts of removing these subsidies in terms of emission of air pollutants. The paper employs a multi-pollutant, multi-fuel and multi-sector Computable General Equilibrium (CGE) model calibrated using 2001 Energy Micro Consistent Matrix (EMCM) of Iranian Ministry of Energy. We consider the possibility of pollutant substitution, which may change the pollutants mix and cause new environmental problems. Our findings suggest that pollutant substitution may happen if a policy causes extreme changes in relative energy prices. The magnitude of this substitution depends on energy substitution elasticities as well as sectoral activity level changes, energy share parameters, and emission factors. For the Iran case, we found that CO and CH emissions would increase after rising in energy prices.

KEYWORDS

Air Pollution; Fossil Fuels; Energy Subsidy; Government Intervention; Carbon Dioxide; Emissions.

INTRODUCTION

The oil exporting countries tend to highly subsidize the domestic use of energy by setting prices much lower than international markets. Here, we investigate the environmental impacts of removing these subsidies in terms of emission of air pollutants. A cut in subsidies or an increase in energy prices may reduce environmental emissions via two channels. It may decrease the fossil fuel consumption and hence cause emission reduction. On the other hand, it can encourage energy-saving technology improvement for firms and households as a result of the increase in costs. These changes in fossil fuel demand and energy use technology will affect the emission level.

Energy pricing policy can be an effective tool in reducing air pollutants. It was estimated that phasing out fossil fuel subsidies by 2020, would cut the expected growth in carbon-dioxide emissions by 2 gigatons (IEA and OCSE 2010). Herein, Iran is ranked 10th by annual CO2 emission in the world and 1st in the MENA (Middle East North Africa). Along with G-20 leaders' commitment to "rationalize and phase out inefficient fossil fuel subsidies that encourage wasteful consumption", Iran is also taking a key step toward reforming energy subsidies and increasing the prices. In early 2010, a law outlining far-reaching subsidy reform was enacted in Iran and is started by 2010 December. The subsidy reform law calls for gradual implementation of market-based energy pricing and the replacement of subsidies by targeted cash assistance to lower income groups.

Policy makers expect that phasing out energy subsidies in Iran will reduce annual emission of air pollutants. The policy includes a significant increase in energy prices. Prices of electricity, gasoline, kerosene, natural gas, gasoil, and crude oil are going to increase extremely. This increase ranges from 140% to 800% as shown in Table 1. However, as the relative prices are going to change in this policy, the economic theory estimates a substitution between energy commodities. This will result in increased consumption of relatively cheaper energy goods. In other words, we expect production and consumption technologies to changes towards more consumption of electricity and gasoline which face a lower increase in prices. As the emission factor differs for every pollutant for each energy commodity, it may increase the emission of some pollutants. We may call this effect as "reverse emission effect" of energy price increase policy. The reverse emission effect may reduce the benefits of the energy price increase.

Table 1. Change in energy prices due to removing energy subsidies*

Energy commodities	Price change
Liquid Gas	2797%
Gas Oil	809%
Kerosene	809%
Fuel Oil	784%
Natural Gas	600%
Electricity	227%
Gasoline	140%

* Energy pris are highly regulated and determined anually through legislation.

Environmental economists suggest that energy taxes may improve environmental quality, stimulate technological innovation and enhance energy security. Also, the so called "double dividend hypothesis" indicates that tax revenues from environmental or green taxes can be used to cut other taxes (Bento and Parry 1999; Bovenberg 1999; Metcalf 1999). While the double dividend hypothesis talks about carbon taxes, the reverse emission effect is about relative energy prices (when the policy focus is not carbon emission). With the existence of the reverse emission effect, both revenues and environmental gains may fall. The revenue of the policy depends on the levels of the price increase and the quantity demanded. However, producers and households will try to reduce the cost shock by shifting toward cheaper ways of providing energy. This shift will decline the demand for more revenue-making energy commodities and increases the demand for less revenue-making energy goods. This can result in a decline in the expected revenue of energy policy. On the other hand, the emission factor changes across energy goods. Hence, by shifting from one energy to another it is expected that the pollutants emission composition may change.

Here, we quantify the impacts of the proposed Iranian policy on environmental emissions. We apply a computable general equilibrium (CGE) model which consists of seven energy goods including electricity, natural gas, liquid gas, gasoline, kerosene, fuel, gasoil. We consider seven pollutants including CO, CO2, SO2, SO3, CH, SPM, NOx (Manzour and Haqiqi 2012). The model is calibrated based on a Micro Consistent Matrix of 2001 from the Ministry of Energy (Manzoor, Shahmoradi, and Haqiqi 2012). The matrix also illustrates emission factors for Iranian production sectors and households.

Emission factors differ across sectors. They differ also across energy goods. We also assume different scenarios of energy layer elasticity of substitution which describe different technology changes in our sensitivity analysis.

METHOD

To measure the "reverse emission effect" we need a comprehensive computational framework. The pervasive role of energy in the economy and the numerous ways in which energy subsidies can distort resource allocations imply the necessity of a general equilibrium approach. Within all applied models the mathematical properties of the general equilibrium model provide a rich and powerful foundation for much of modern microeconomic theory and policy analysis. Despite many benefits of CGE modeling, its complexity requires more time to calibrate and more effort to develop. There are several global/regional CGE models for evaluating energy policy (Burniaux and Truong 2002; Lee 2002; 2008; Andrew and Peters 2013; Peters 2016; McDougall and Golub 2009; Truong, Kemfert, and Burniaux 2007) as well as for projecting emissions (Hertel et al. 2009; Birur, Hertel, and Tyner 2007; Beckman, Hertel, and Tyner 2011; Böhringer and Rutherford 2000; Böhringer, Löschel, and Rutherford 2006; Böhringer and Rutherford 2010; Böhringer and Welsch 2004). Regarding single country models, there are a few CGE exercises concerning Iran but they rarely address the emissions. One early study is the World Bank study on all kind of reforms (including trade, tariff, and non-tariff barriers and subsidies) in Iran (Jensen and Tarr 2003). The World Bank study shows a decrease in fossil fuels wasteful consumption in Iran. But it includes nothing about environmental effects and emissions of the pollutant. There are several independent CGE studies regarding policy evaluation without looking at emissions (Khiabani 2008; Mortazavi Kakhaki, Haqiqi, and Mahdavi Adeli 2013; Haqiqi, Shahi, and Ismaili 2017; Sajadifar, Khiabani, and Arakelyan 2012). The ministry of finance employs a CGE model for energy price reform (Shahmoradi, Haqiqi, and Zahedi 2011) without looking at emissions. The CGE model of Monetary and Banking Research Institute also used for energy policy evaluation (Bahador and Haqiqi 2016; Haqiqi and Bahalou Horeh 2013). There is also another CGE model from IMPS (Institute For Management And Planning Studies) applied for energy policies (Haqiqi and Bahaloo Horeh 2015; Davood Manzoor and Haqiqi 2016) which do not consider environmental emissions. Here we use the CGE model from Ministry of energy which has been well validated and documented (Manzoor, Shahmoradi, and Haqiqi 2012; Haqiqi, Manzoor, and Aghababaei 2013; Haqiqi and Manzoor 2013; D. Manzoor and Haqiqi 2012) and is appropriate for this study.

THE MODEL ASSUMPTIONS

The current model includes 18 production sectors, rural and urban households, the government, imports, and exports. The market clearance, income balance, and zero profit conditions for each sector are satisfied. Production is modeled by a series of nested CES production functions. There are four producing categories in our study: coal, crude oil and gas sectors; end-use energy sectors; energy intensive sectors; and other sectors. A set of nested constant elasticity of substitution (CES) functions characterizes the use of inputs in the production of goods and services. Production exhibits constant returns to scale. Goods are produced with capital (K), labor (L), energy (E), and material (M) or briefly in KLEM structure. In other words, outputs in each sector are produced using aggregate non-energy intermediate goods, aggregate energy input, and primary inputs (labor and capital). The nested structure of the production and the aggregator functions is depicted by nested CES functions. A set of constant elasticity of transformation (CET) functions characterizes the differentiation of production among production for domestic and export markets. Regarding imports, nested CES functions characterize the choice between imported and domestic varieties of the same good.

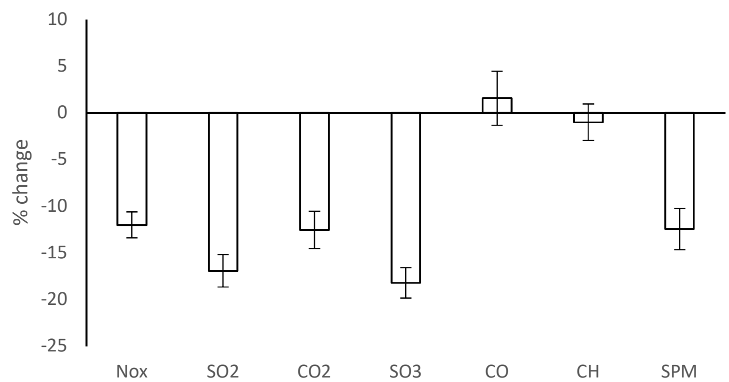
In the labor market, we assume perfect labor mobility between sectors which we expect to happen in the long run. It lets the labor to move to the sectors which offer higher wages. We also expect wage flexibility in real terms. It means the nominal wages may decrease or increase less than general price levels. Iran has a managed foreign exchange market, but in the long run, the market forces are dominant. Hence, we model import and export forces in the foreign exchange market. As the energy and oil have an important share in Iranian export, we expect foreign exchange fluctuations after energy price shock. We expect import increase due to domestic price rise. So the demand for foreign exchange increases. Also, we expect a fall in domestic energy consumption and hence increase in energy export. But as the non-energy export may decrease due to cost shock the overall export may decline or not.

The choice of elasticities of substitution is important in our CGE analysis. The magnitude of reverse emission effect is determined by the substitution elasticities, as the substitution between energy goods depends on the elasticity of substitution between them. Usually, one would choose these elasticities based on the literature and previous studies. In our case, though, we could not follow this common method. As we have already mentioned, this study is one of the first of its kind in Iran. On the benchmark replication of the model, we assume substitution elasticity in fossil fuel layer as 0.2. The substitution between electricity and fossil fuel layer is 0.1. A Cobb-Douglass function shows the value-added layer and the substitution between labor and capital. The import elasticity of substitution is assumed to be 3 while the export elasticity of transformation is 1. We also consider different scenarios of technology change. The more the substitution elasticity is, the more is the technology change. Hence the substitution elasticity parameters are used to show the scenarios of technology changes. For substitution between fossil fuels we consider six scenarios of 0, 0.1, 0.2, 0.3, 0.4 and 0.5. The same is considered for substitution between electricity and fossil fuels.

As we mentioned the energy prices are controlled by the government in Iran. For many years the energy prices had been set below international prices. For our policy analysis, we assume 6 steps increase in energy prices toward FOB prices. In the scenario, the price of liquid gas in all 6 steps increases by 2797% with respect to the benchmark price. This huge increase illustrates the gap between domestic and FOB prices. Price gap for other prices is less than liquid gas. Kerosene and gas oil price go up by 809%. Crude oil and natural gas price increase by 784% and 600% respectively. And the least increase in prices happens for electricity and gasoline by 227% and 140%. As on the counterfactual scenario, the price of gasoline will increase 140% but the price of liquid gas is going to increase about 2797%, these differences increase the possibility of "reverse emission effect" after the policy.

RESULTS

The findings suggest that by an increase in energy prices, the emission of most pollutants would decrease except for CO and CH. For these two, depending on the technology changes after the policy, their emission may decline or not. This means considering these increases in energy prices "reverse emission effect" exists.



After the counterfactual scenarios of price increase, in the case of NOx the annual emission declines between 10.05% and 14.78%. The SO2 emission also will be reduced between 14% and 20%. The more the possibility of substitution the more decline in the emissions. The CO emission may change between -3.85% and +6.74%. For the CH the results are between-4.22% and +2.26%. The more the possibility of substitution the more increase in the CO and CH emission. The decline in CO2 emission will be between 9% and 16% percent depending on how production technology changes. Finally, SO3 emission declines between 15.6% and 21.2%. And SPM emission will be reduced by 2.8% to 16%.

CONCLUSION

The idea of this paper is to introduce the "reverse emission effect". Reverse emission effect indicates that if the relative prices of energy change extremely, some pollutant emissions may increase instead of decrease. Our findings suggest that reverse emission effect may happen for the Iranian policy of energy price increase. We analyzed the policy using a Computable General Equilibrium model. As on the scenario, the price of gasoline would increase 140% and the price of liquid gas increased about 2797%, the "reverse emission effect" was more likely to happen. As expected, we found that CO and CH emission would increase due to the energy price policy in Iran. We found that the magnitude of this effect depends on energy substitution elasticity.

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