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Lowering Saudi Arabia's fuel consumption and energy system costs without increasing end consumer prices

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ABSTRACT

Using a multi-sector equilibrium model of the Saudi energy system that handles administered prices in a mixed-complementarity formulation, we present results from a set of policy scenarios that lower oil consumption in the country. Some of these scenarios are the solutions to Mathematical Programs subject to Equilibrium Constraints (MPECs) that maximize the net economic gain for the Saudi economy. The policies examined have the potential to generate economic gains exceeding 23 billion USD in 2011, or about 4% of Saudi Arabia's GDP. This economic gain comes mainly from inter-sectoral fuel pricing policies that incent shifting the mix in technologies that generate electricity and produce water from energy intensive technologies to more efficient ones. We show that when complemented by credits for investments in solar and nuclear power generation capacities, a modest increase in the transfer prices of fuels among sectors is sufficient to produce economic gains close to those achieved by deregulating transfer prices. The approach we develop here is an alternative to the classic recommendation of deregulating inter-sectoral fuel prices in situations where the conditions for successful liberalized markets do not exist. It is a template for introducing the notions of incentivizing behavior using prices into countries that rely more on administrative procedures than markets, leading to a deeper understanding of how markets can lead to economic gain.

1. Introduction

This paper outlines an approach that can substantially reduce current fuel consumption and inefficiencies in the Saudi energy system without altering end consumer prices. It contributes to the literature by:

(i) Estimating the potential economic gains that alternative transfer prices of fuels among industrial sectors would generate;
(ii) Illustrating how to design and measure the effects of alternative policies that produce, in countries where conditions for successful liberalized markets do not exist, economic benefits close to those achieved by the classic recommendation of deregulating inter-sectoral fuel prices;
(iii) Providing the first equilibrium model of the Saudi energy system and using a Mathematical Program subject to Equilibrium Constraints (MPEC) to optimize policy parameters given a policy framework.

Our analysis is a counterfactual exercise where we compare current policy versus alternative scenarios for the year 2011.

The standard economic prescription to reduce the inefficiencies associated with low domestic energy prices is to move to prices based on world markets, forcing higher prices on consumers. For this reason, the vast majority of the literature devoted to fuel subsidies deals with the impact of raising consumer prices on economic growth, income and household welfare in countries that devote a substantial portion of their budgets to subsidies (e.g. Clements et al., 2007; Granado and Coady, 2012).

Given the social goal of making energy affordable to the Saudi society, consumer prices are not altered in our analysis. Instead, we examine how to improve economic efficiency through better coordinating decisions in energy intensive sectors of the economy through prices. That low industrial prices for fuels can lead to inefficient investment and operating decisions in the power and water sectors is well-known (e.g. Fattouh and El-Katiri, 2013). However, to the best of our

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knowledge, no one has tried to estimate the costs of current policies or the benefits from altering investment costs or transfer prices for fuels among sectors within the Saudi energy economy.

We estimate these benefits by using the KAPSARC Energy Model (KEM), a multi-sector equilibrium model of the Saudi energy economy that handles administered prices in a mixed-complementarity formulation. This model was developed because Saudi Arabia faces a complex set of energy issues resulting from increasing domestic energy demand which may impact the level of oil exports in the future; constrained production of natural gas relative to the substantial demand driven by low prices; and a domestic energy economy that largely operates with governmentally owned capacities, and transfer prices set by the government and not markets. Domestic oil and gas prices are kept below world prices because low local production costs mean prices can be kept low without incurring accounting losses or explicit transfer payments from the government. Since these prices are passed through to customers of energy-transformation industries, domestic consumers of power, water, and transportation fuels see low prices set by the government.

Because of the market interventions, we have adopted a mixed complementarity formulation instead of using traditional optimization methods. Optimizing producers' plus consumers' surplus results in a solution that can be interpreted as a competitive equilibrium where prices are marginal costs. Mixed complementarity formulations allow for directly describing economic equilibria where prices are not necessarily marginal costs. Greenberg and Murphy (1985) show how to iterate through a sequence of optimizations to have prices different from marginal costs, however formulating the equilibrium as an MCP eliminates the extra programming and is a more general modeling approach.

As the model captures government interventions within Saudi Arabia that also exist in other non-OECD economies, the methodologies we have developed here provide an approach to better estimating the costs of market interventions in many other countries around the world. For example, Darbouche (2013) states that gas prices in the main gas-producing countries in the Middle East and North Africa are capped below both the international prices and the marginal cost of new production. Gas prices vary from 0.8 USD per mmBtu in Kuwait, 0.8–1.50 USD/mmBtu in Oman, 1 USD per mmBtu in Qatar and the UAE to about 0.75 USD per mmBtu in Algeria and 1.25–4 USD per mmBtu in Egypt (Darbouche, 2013). According to Mujeri et al. (2014), Bangladesh sells natural gas and liquid fuels to its electricity sector at prices lower than the supply costs. Commander (2012) estimates that between 2008 and 2010 over half of Asian countries passed on to consumers less than 75% of the increase in international prices for gasoline and diesel fuels. Given the political issues associated with changing controlled prices, the approach we have taken in KEM should help in exploring ways to improve the efficiency of subsidies and lessen their impact.

Saudi Arabia is making massive investments in the energy and water sectors to meet rapid demand growth that is driven by growing population and increasing per-capita real incomes. Since fuel costs are at low administered prices and equipment costs are at the world prices, the Saudi power and water utilities have underinvested in more energy-efficient technologies, which results in economically inefficient outcomes. We examine policies that alter prices to incentivize the investment in an efficient equipment mix and that increase the value added in the energy sector while maintaining current levels of consumer welfare.

The standard recommendation from economic theory is to deregulate transfer prices of fuels and provide lump-sum subsidies. In other words, fuels have to be priced at their marginal values in the economy. However, the marginal values of crude oil and oil products consumed domestically are the export prices, which means that applying the standard remedy involves a huge increase in transfer prices. Energy intensive industries typically require large upfront fixed investments. A big increase in the fuel prices charged to these firms who have internalized a different cost structure by incurring sunk equipment cost may generate too much opposition. It would also compromise the use of prices as a tool for balancing budgets of government-owned organizations. Could the same economic benefits be achieved without such a radical increase in inter-sector transfer prices?

To address this question, in a long-term static framework calibrated on 2011 data, we evaluate several pricing scenarios for inter-sector fuel prices, including the existing policy, prices set to marginal values (as a benchmark for economic efficiency), and alternative fuel-pricing and investment-credit mechanisms that can provide a transition to greater reliance on markets. Some of these scenarios are the solutions to MPECs that maximize the economic gain for the Saudi energy economy.

In the next section we provide an overview of the Saudi energy economy, followed by a literature review and a brief description of the KAPSARC Energy Model. Section 4 explains how we design and implement the policy scenarios studied. Section 5 discusses the resulting economic gains and shifts in the equipment mix, as well as the economic efficiency of introducing investment credits. Section 6 contains the conclusions.

2. Scale and structure of the Saudi energy economy

Classical prescriptions for optimizing the allocation of energy resources in an economy involve price deregulation and market liberalization. However, circumstances do not always support such an approach. For example, the structure of the industry may not allow for sufficient participants to create sustainable competition, the energy industry may comprise too large a share of the economy, or parts of the energy sectors can be government owned. To understand the context for exploring solutions that can provide a transition to full deregulation, we summarize the characteristics of the Saudi energy economy.

The size of the Saudi energy sector, combined with the energy-intensive sectors, is large relative to the domestic economy. In 2011, the sum of the value added by upstream oil and gas production, oil refining, petrochemical production, power generation, cement production, and water production amounted to around 53% of the Saudi GDP.

Primary domestic fuel consumption is still almost exclusively composed of crude oil and natural gas. Thus, the Saudi energy sector is less complex than those of other larger countries. The Saudi government has, however, announced targets for the development of solar and nuclear power generation capacity.

As Fig. 1 shows, the domestic demand for primary energy has doubled between 1996 and 2011. It reached 4.46 million barrels of oil equivalent per day in 2012, representing 35% of the primary energy produced in Saudi Arabia during that year (BP Statistical Review, 2013). This sharp increase in energy demand has been driven by demographic changes, expansion of the export-oriented petrochemical industry, and general economic growth.

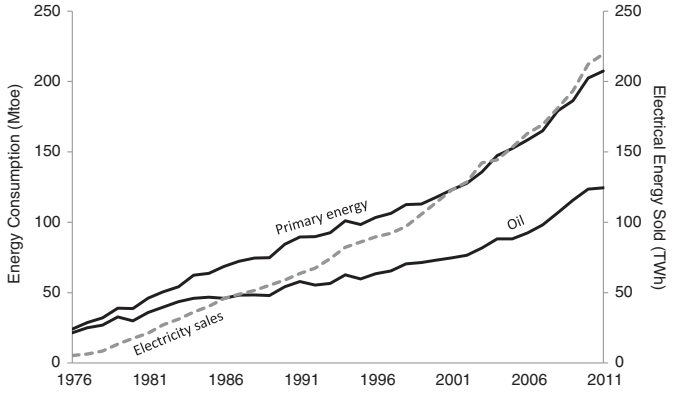

Fig. 1. Domestic demand for oil, primary energy (oil plus natural gas), and electricity (1976-2011). Sources: electricity sales: SAMA (2012); oil and primary energy consumption: BP Statistical Review (2013).