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Energy subsidy reforms and the impacts on firms: Transmission channels and response measures

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I. Introduction

In early 2016, Saudi Arabia announced a significant reduction in fossil fuel subsidies (FFS) as a way to compensate shrinking government revenues – and the associated fiscal pressures – due to low oil prices. As subsidies were removed across a range of fuel types, the subsequent price hikes hit consumers and certain industrial sectors to varying degrees. Gasoline prices increased by about 50 per cent, which mainly affected drivers (MEES, 2016). A 67 per cent increase in natural gas prices affected electricity generators and industrial sectors. One of the highest price increases was observed for ethane, which rose from \$0.75/MMBTU to \$1.75/MMBTU (an increase of 133 per cent). Ethane is a key input used by the petrochemical sector, a cornerstone of the Saudi economy.

Soon after the price increases, some of the largest petrochemical firms published estimates for the likely impacts on their production costs or on profits (MEES, 2016). For instance, several large petrochemical firms estimated that the adverse impact on profits ranged from 6.5 per cent to 44.1 per cent relative to 2014. While these self-reported figures may not be consistently comparable, they highlight a common political–economic challenge of FFS removal: firms – and in particular large energy-intensive industries – tend to oppose FFS removal and exert their political clout to do so. Thus, concerns about competitiveness and profitability have been an important argument used by political opponents of FFS reform.

However, focusing on energy cost increases alone is likely to yield an incomplete picture of the likely effects of FFS reform on firms. To understand how energy price shocks (induced by FFS removal) affect competitiveness, both direct and indirect transmission channels for energy prices must be considered, as well as firms' ability to respond. The ability to respond depends on various mechanisms that firms may have at their disposal to mitigate (or pass on) price shocks and is thus crucial for estimating the net consequences on firms' profitability and competitiveness.

While the adverse effects of FFS removal are increasingly well understood for households, the existing literature has largely ignored the effect of subsidy reform on firms. We argue that this is a gap in the evidence base that must be addressed, in order to design and deliver FFS reforms more effectively. In particular, attention must be paid to all the transmission channels for price shocks, as well as the available response measures. Only a full evaluation of these aspects can enable policy makers to make an informed assessment of the likely consequences of subsidy removal on economic activity and competitiveness.

In this comment, we outline the most important transmission channels for energy price shocks and the response measures used by firms.

II. Energy price shocks & competitiveness: transmission channels & response measures

FFS removals typically induce energy price shocks (one-off or gradual), which affect firms and households throughout the economy. In the case of households, the literature typically distinguishes between direct and indirect price effects (in other words, the extent to which energy price changes *directly* affect households by increasing the cost of energy consumption, and *indirectly* by increasing the cost of all other consumption). These two channels of transmitting energy price shocks also apply in the case of firms, but in addition, several response measures also play a crucial role in determining the extent to which firms are affected by subsidy removal.

This section conceptualizes and discusses two transmission channels for energy price shocks and four common response measures, as illustrated in Figure 1 (the transmission channels are labelled 1 and 2, the four response measures, a, b, c, and d). Large-scale surveys of firms can help to shed light on most of these aspects and identify potential differences between sectors or regions. In the case of



larger, publicly listed firms, similar analyses can be conducted using firms' balance sheets and accounts; this is of particular relevance when a strategic sector is dominated by a small number of firms which are in a strong political position to oppose reforms.





For the purpose of formal illustration, we define a simple profit function of a hypothetical firm (*i*), which uses energy *E* and other inputs or production factors *F* for producing output Q_i sold at price p^Q . We distinguish between primary inputs (F^{pri}) such as raw materials or labour, and intermediate inputs (F^{int}) produced by other firms. Overall profits (π) are determined by revenues (*R*) and the costs (*C*) of energy and of primary and intermediate factors:

$$\pi_i = R_i - C_i^{ene} - C_i^{pri} - C_i^{int}$$

$$= p^Q Q_i - p^{ene} E_i - p^{pri} F_i^{pri} - p^{int} F_i^{int}$$
(1)

Where p^{ene} is the price of energy, p^{pri} is the price of the primary input, and p^{int} is the price of the intermediary input.

We also define the profit function of a firm producing intermediate inputs F_{int}^{int} using energy:

$$\pi_{int} = R_{int} - C_{int}^{ene}$$

$$= p^{int} F_{int}^{int} - p^{ene} E_{int}$$
(2)

For illustration purposes we assume that the intermediate firm uses energy inputs only.1

To reiterate, note that subscript *i* denotes the analysed firm, subscript *int* denotes the firm producing intermediate inputs, while superscripts denote types of input or output goods.

Two transmission channels: How energy price shocks affect firms

1) Direct channel

The removal of subsidies on specific energy types (such as electricity) will increase the energy input cost of firms. As subsidy removal can affect energy prices instantly, directly transmitted price shocks are typically the first impact felt by firms following subsidy removal. This means that direct price shocks affect firms' energy costs almost instantaneously, unless the price of energy inputs has been hedged.² Such immediate cost shocks cannot be offset by using longer-term measures (such as technological

¹ The inclusion of other input types would not alter the arguments made in this article.

² This is typically the case for large energy-intensive firms (such as airlines), but is not relevant in the context of small and micro enterprises in developing countries.



updates to increase energy efficiency), but require quickly deployable response measures. In practice, energy-intensive industries, such as petrochemicals, cement, steel, manufacturing, or transport, tend to be particularly exposed to subsidy reform-induced price shocks.

The level of a firm's exposure to *direct* energy price shocks depends on the extent to which it relies on energy inputs for generating revenue. This level of exposure can be approximated quantitatively by the share of energy input costs relative to total input costs or revenues. As a reference point, a recent study on manufacturing and mining sectors in Indonesia estimates energy costs to be about 6 per cent of total costs (Rentschler and Kornejew 2016). It should be noted, however, that firms' energy expenditure does not necessarily increase at the same rate as energy prices. The reason for this discrepancy is that firms' reported energy expenditures may include various extra payments to energy suppliers that do not directly depend on energy prices (such payments could include suppliers' labour costs, electricity transmission costs, or service fees). For accuracy, it would thus be preferable to consider physical units of energy inputs as well, though such data may be more difficult to obtain. Moreover, it should be noted that it is important to distinguish between different types of energy inputs, as energy types are typically subsidized at different rates (and some not at all).

More formally, the direct price effect refers to the change in energy costs C_i^{ene} experienced by a firm (*i*) due to a change in the price of energy, and can be expressed as:

direct effect =
$$\frac{\partial C_i^{ene}}{\partial p^{ene}} \Delta p^{ene}$$
. (3)

This expression hence depends on the (energy) price elasticity of the firm's energy costs, and measures the partial equilibrium effect of FFS reform as described by Coady (2006) and Araar and Verme (2012).

2) Indirect channel

Energy prices also affect firms indirectly, as the production costs of intermediate inputs increase. More specifically, firms producing intermediate goods will incur the same direct energy price shocks as other firms. As intermediate firms rely on various response measures (as outlined in Figure 1), they will (at least partially) pass on price increases to other firms by increasing the price of intermediate inputs. In this way energy price shocks can progress through supply chains in the form of price increases of non-energy goods. In practice, firms relying heavily on energy-intensive inputs (inputs consisting of materials, such as steel, with a high embodied energy content) tend to be affected most by indirect price shocks.

Indirect price effects are likely to take longer to fully materialize than direct ones, as price shocks are successively passed down supply chains. Thus, the rate at which any given firm incurs the full indirect price shock depends not least on the number of preceding intermediate production stages. Moreover, firms supplying intermediate goods may choose not to fully pass on energy price increases, but instead rely on other mechanisms to respond to energy price shocks.

The level of a firm's exposure to *indirect* energy price shocks depends, above all, on the energy intensity of its intermediate production inputs. This can be approximated by determining the 'embodied' energy content of a firm's production inputs. There are various databases which offer detailed estimates of the embodied energy content of hundreds of the most common industrial materials (Rentschler et al., 2016). It should be noted, however, that consideration of the geographical origin of materials is crucial, as domestic energy price shocks due to FFS removal are irrelevant for imported materials – no matter their energy intensity. The use of input–output tables, or of CGE models with detailed sectoral disaggregation, can help with disentangling these aspects.

In formal notation, the indirect price effect has two elements:

(i) A change in intermediate input costs C_i^{int} . Note that a change in p^{ene} affects the energy costs C_{int}^{ene} of the firm producing intermediate inputs, which may choose to adjust the sales price p^{int} in response.



(ii) A change in p^{ene} , which will change the disposable income of consumers. This in turn may affect the equilibrium output quantity Q_i , which will affect revenue R_i :

$$indirect\ effect\ =\ \frac{\partial C_i^{int}}{\partial p^{ene}} \Delta p^{ene} + \frac{\partial R_i}{\partial p^{ene}} \Delta p^{ene} \tag{4}$$

By accounting for this indirect effect, the general equilibrium effects of FFS reform can be more accurately reflected.

Four response measures: how firms deal with energy price shocks

The transmission channels discussed above determine the size of the overall cost shock faced by a firm following a subsidy reform. This section discusses four main response measures that firms typically have at their disposal to cope with the overall cost shock. These response measures are not mutually exclusive, and are typically part of a mixed strategy. Three of these – *absorption, substitution, and resource efficiency* – refer to internal responses within firms (see Figure 1); the last response measure – *price pass-on* – can help firms to forward remaining cost shocks down the value chain to other firms or households, and it thus depends *externally* on the price elasticity of demand.

a) Absorption

If profit margins are large enough, firms can absorb energy price shocks by accepting smaller margins. If energy price shocks are fully absorbed into profit margins, firms can continue operations without making any adjustments to technology and production quantities, or to sales prices. In this case, consumption of both the (formerly) subsidized energy type and of all other energy inputs remains constant – in other words, no behavioural response takes place.

The ability of firms to absorb energy price shocks can be approximated by comparing absolute profits with the combined direct and indirect energy price shock. Alternatively, a computation of the ratio of profits and energy expenditures can also indicate a firm's ability to absorb energy price shocks. In the above-referenced example of Saudi Arabia, the 14 largest petrochemical firms had jointly made total net profits of over \$9bn in 2014 (MEES, 2016). It is plausible that reports of such high profits reaffirmed the belief of policy makers that cost increases caused by increased energy prices could be absorbed by these firms.

Formally, cost increases due to energy price hikes are fully absorbed when the following relationship holds:

$$\frac{\partial C_i^{ene}}{\partial p^{ene}} + \frac{\partial C_i^{pri}}{\partial p^{ene}} + \frac{\partial C_i^{int}}{\partial p^{ene}} = -\frac{\partial \pi_i}{\partial p^{ene}}$$
(5)

This equation describes how cost changes (increases) translate uniformly into a change (reduction, hence the minus) in profits, provided that pre-reform profits are positive. For instance, firms may accept a reduction in profits in order to leave sales unchanged (*ceteris paribus*).

b) Substitution

As subsidy reforms typically increase the price of selected energy types (such as electricity and petrol), firms may also respond by substituting these energy types with fuels that have become relatively cheaper. Such inter-fuel substitution can be observed in the form of changing energy shares (in other words, the energy mix) in total energy usage. The absolute quantity of energy consumption may remain constant even if significant inter-fuel substitution takes place.

The ability to substitute energy types is constrained by technological characteristics of production, which can vary significantly across sectors. Since technological changes to production processes require time and investment, substitution is particularly relevant as a medium to long-run response measure. In



addition, inter-fuel substitution depends critically on access to energy and reliability of supply, which can vary significantly across regions. For instance, frequent power outages or a lack of access to the electricity grid in rural regions mean that rural firms may be unable to rely on electricity as a substitute for energy types that are subject to FFS reform.

Using firm surveys, the nature and magnitude of inter-fuel substitutability can be formally characterized and estimated by both own and cross price elasticities, as well as by Uzawa–Allen partial elasticities of substitution (Pindyck, 1979). Moreover, firm surveys frequently collect information on energy access and supply quality, which can shed light on firms' ability to substitute across regions and sectors.

Formally, note that energy costs reflect the mix of different energy types chosen by the firm; in other words, they represent an energy aggregate $E(E_1, E_2, ..., E_n)$. If the (exogenously determined) price of one of these energy types increases, firms can choose to adjust their energy mix by substituting this energy type for another. In the long run, such systematic changes in firms' energy consumption may result in further changes of (non-subsidized) energy prices and employment, for example in the energy sector.

c) Resource efficiency³

Firms may also respond to direct energy cost increases by reducing their overall energy consumption while maintaining the pre-reform level of output; in other words, they increase their energy efficiency. Moreover, increased material efficiency can play a crucial role in responding to indirectly transmitted price shocks which are due to embodied energy in intermediate materials. In fact, because material costs often significantly exceed energy costs – even in energy-intensive manufacturing sectors – the role of material efficiency is of particular importance (Allwood et al. 2011).

Similar to the case of substitution, the ability to increase resource efficiency depends on a variety of factors which include the availability and affordability of modern technology, and support mechanisms for financing and implementing efficiency-increasing measures. Thus, resource efficiency also requires time and investment, and is not a short-term response measure.

Moreover, various indicators exist to enable the measurement of energy or material efficiency, and hence to allow a direct comparison with related sectors in other countries (Bringezu and Schütz, 2010). More complex indicators can require data which are typically not available from standard firm surveys, but a computation of the quantity of output or revenue per unit of energy (or material) input can provide a basic measure for energy (or material) productivity.

Formally, energy productivity can be defined as the marginal product of energy:

$$e = \frac{\partial Q_i}{\partial E_i} \tag{6}$$

And similarly, material productivity can be described as the marginal product of intermediate inputs (which are a function of p^{ene}):

$$m = \frac{\partial Q_i}{\partial F_i^{int}} \tag{7}$$

These equations imply that gains in energy or in material efficiency require an adjustment to the production function determining Q_i – for instance by improving production processes or technology. An efficiency increase occurs when the marginal product before the energy price change is smaller than it is afterwards.

³ 'Resources' comprise both energy and materials.



d) Price pass-on

While the first three response measures describe how firms respond *internally* to direct and indirect energy price shocks, the net impact on firms depends to a large extent on whether price shocks can be passed on to *external* consumers. This response measure is specific to the analysis of firms, and does not feature in the analysis of FFS reform effects on households. In its essence, this channel refers to the extent to which firms can adjust the sales price of their output in response to changing input costs, while maintaining the sales quantity. Even if energy price increases are large, if firms are able to pass through rising energy prices by charging proportionally higher sales prices, the overall adverse effect on the firm may be limited.

Formally, price pass-on can be measured as the change in the sales price p^{Q} in response to a change in the price of energy:

$$\frac{\partial p^Q}{\partial p^{ene}} \tag{8}$$

Note that (technically in equilibrium) the sales price is equal to the consumer's demand price (that is, the customer's 'willingness to pay'). Thus, a firm's ability to adjust its sales price depends on the consumer's demand choice. The ability to pass on price increases depends essentially on the price elasticity of demand; in other words, how likely it is that end users (such as households) and other firms (consumers of intermediate goods) would substitute away from a given firm's product. This in turn can depend on a variety of factors: the degree of competition and the availability and affordability of alternatives. Moreover, the time dimension may also need to be taken into account, as demand elasticities increase over time, due to the inertia of information updates, behaviour changes, and investment decisions. On reviewing the empirical evidence on the pass-through of carbon taxes, Arlinghaus (2015) concludes that, across industries, pass-on rates vary between 0 per cent and over 100 per cent of the price shock – thus highlighting the important role of sector-specific conditions.

III. Implications for the design of FFS reforms

As case studies of past reforms are studied and lessons learnt, the political–economic challenges of subsidy reform are increasingly well documented (Commander 2012; Fattouh and El-Katiri 2015; Strand 2013). However, while the potential adverse impacts of subsidy reform are increasingly well understood for households, research has given far less attention to the potential impacts on firms.

In fact, concerns about competitiveness and profitability have been an important argument used by political opponents of subsidy reform. It has been argued that energy-intensive manufacturing firms in particular experience substantial changes to their cost structures, with adverse implications for profitability (Bazilian and Onyeji 2012). Evidently such effects can have knock-on consequences for jobs, and thus on households.

This comment has outlined the most important transmission channels for energy price shocks, and response measures used by firms. These transmission channels and response measures directly offer policy makers a reference framework for the design of complementary measures that can be used to mitigate the adverse socio-economic consequences of subsidy reforms. For instance, if firms are able to pass on a large share of price shocks to final consumers, policy makers will need to pay particular attention to the indirect (or non-energy) price shocks incurred by households and take adequate measures for compensation and social protection.

Policy makers may also need to consider actions for strengthening firms' ability to substitute towards alternative fuel types, or to increase the efficiency of energy and material usage. Such measures include: technical assistance, information programmes, and financial support for implementing efficiency investments (for example in modern machinery). In addition, the provision of reliable and affordable access to alternative energies (for example through public investments in electrification) can be critical for facilitating and directing inter-fuel substitution.



In some cases – such as the above example of petrochemical firms in Saudi Arabia – policy makers may decide that no major assistance measures are required, as profit margins are large enough to absorb cost shocks and to finance investments in efficiency and substitution. However, especially in competitive markets, profit margins cannot be assumed to be so large; policy makers would thus be required to consider measures to mitigate potential competitiveness losses. It should be recalled here that energy costs are only one (minor) factor among many that determine a firm's or a sector's competitiveness (WEF 2016).

This implies that policy makers have at their disposal a wide range of measures that can outweigh potential competitiveness losses due to energy price increases. Examples of these are: strengthening institutions and administrative capacity, investing in infrastructure and labour productivity, and ensuring a stable business environment through prudent long-term policy strategies.

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