Energy Subsidies, Public Investment and Endogenous Growth

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Abstract

We consider impacts of fossil fuel subsidy reforms on economic growth, focusing mostly on the Middle East and North Africa (MENA) countries. The main empirical result is that a country that initially subsidizes its fossil fuels, and then eliminates or reduces these subsidies, will as a result experience higher economic GDP per capita growth, and higher levels of employment and labor force participation, especially among the young. These effects are strongest in countries whose fuel subsidies are high at the outset, such as in the MENA region. Our model predicts that a 20 cents average increase in the gasoline and diesel prices per liter, through removal of subsidies, increase the GDP per capita growth rate by about 0.48 percent and 0.30 percent, respectively. In the MENA countries, governments' savings from reduced subsidies seem to be earmarked mainly to health expenditures, education expenditures and public investment in infrastructure. These channels appear to be strong contributing factors to higher long-run growth when fuel subsidies are reduced.

1 Introduction

Little work has been done to date to analyze empirically the relationship between energy subsidies and economic growth, and the channels by which such changes in growth rates could take place. This paper seeks to fill this gap. We aim to demonstrate that economies with efficient energy taxation can expect to grow faster than economies with high energy subsidies. We also use a newly collected data set for our empirical work.

Besides studying how the elimination of energy subsidies promotes economic growth in countries that implement enduring energy price reforms, we also determine the economic channels by which such outcome can take place (e.g. are public subsidy expenditures redirected to increased spending on health, infrastructure, and education, so as to subsequently affect growth?).

Energy subsidies are known for example to encourage energy-intensive and capital-intensive production, and discourage employment (World Bank (2014)). There are several reasons to worry about the consequences of energy subsidies. These subsidies can contribute to fiscal insolvency; divert resources away from productive public investment; lead to major distortions in the production structure; encourage wasteful fossil fuel consumption; benefit mostly high income households who constitute a small proportion of the population; and increase fuel consumption to suboptimal levels. The latter critically contributes to global warming and environmental pollution. Such impacts are likely to affect the overall long-run economic performance and economic growth. Petroleum subsidies can thus cause major environmental and economic problems.

In spite of these immense costs and the ineffectiveness of using resources that could be otherwise used in productive public investments and lead to higher economic prosperity, governments are often reluctant to undertake fossil fuel price reforms. The possible reasons could be because of the belief that subsidies alleviate energy poverty. Others have argued that one reason could be lack of information among citizens. That is, citizens can be aware of fuel prices, but they may have inadequate information about the scale of their countries' fossil fuel subsidies and the size of the support they receive from the government. There could be also special interests because only a small percentage of the population or specific economic sectors (certain industries, exports) benefit from fossil fuel subsidies, and not always the poor population (see Kirit Parikh Report (2010) for the case of India). Lobby groups usually support the interest of small, special interest groups (Kitschelt and Wilkinson (2007); Van de Walle (2003); Ogbu (2012); Oosterhuis and Umpfenbach (2014)). It also known that for certain governments it is easier to subsidize fossil fuels, which requires little administration, than to design effective policies and develop institutional capacity to achieve more critical and necessary economic or social objectives (Pritchett and de Weijer (2010), Commander (2012), OECD (2007), Victor (2009), Whitley and van der Burg (2015)). Strand (2016) finds that when politicians expect to stay on power only for a short time, and rely on a small group of persons to be elected, energy subsidies will be high, and public investments in infrastructure low. According to Commander other reasons for having subsidies could be to provide income buffering in response to energy price volatility[1]; to give the population a large share of the natural resources as national patrimony; to target some energy sources for diversification (e.g. subsidizing gas more than diesel to for example decrease carbon emissions); and that national oil companies persuade governments to respond to oil price fluctuations through subsidies and to hide the fiscal burden of subsidies (Cheon et al. (2015)).

There is also analytical work explaining the motives for why governments avoid to eliminate subsidies: i) fear of mass unrest or violence should subsidies be removed (Cox, North, and Weingast (2013); North et al. (2007)); and ii) misaligned electoral institutions that deliver policies to favor only special interest groups instead of the general public (Strand (2013); Armijo, Biersteker, and Lowenthal (1994), Bueno de Mesquita et al. (2004); Keefer (2011)); or allows clientelism (Kirtschelt and Wilkinson (2007)). Commander (2012) in basis of the study by Nikoloski (2011), concludes that the most important motive for providing energy subsidies is to alleviate energy poverty followed by to satisfy special interests of small percentage of the population or specific economic sectors.

The main objective of this paper is to test empirically our simple theoretical model (presented in the Appendix) that predicts that when a governments acquires additional resources from removing energy subsidies to make productive public investment, it will foster higher economic growth by i) promoting entrepreneurship, and higher private investment and employment; and ii) improving efficiency in the allocation of its resources.

Recent work by the International Monetary Fund (2013) indicates that on a "pre-tax" basis[2], subsidies to petroleum products, electricity, natural gas, and coal reached $480 billion in 2011 (0.7

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[1] This has been an important policy for India in which the government has not been allowing a full pass through from oil price shocks to consumer prices following different mechanisms and strategies. The Kirit Parikh Report (2010) explains extensively these strategies followed over several years by the Indian government, and recommends to avoid control of energy prices.

[2] The IMF defines and constructs the "pre-tax" subsidy as the transfer to bridge the gap between domestic and supply cost. Coady et al. (2016) argue that since petroleum products are internationally tradable products, the supply cost

percent of global GDP or 2 percent of global government revenues). It further reports that the costs of subsidies are even higher among oil exporters, which account for about two-thirds of the total. On a "post-tax" basis, subsidies are much higher at $1.9 trillion (2½ percent of global GDP or 8 percent of global government revenues). A prominent feature of energy markets in many countries of the Middle East and North Africa (MENA) region is the existence of energy subsidies, for a range of energy goods including motor fuels, electricity, and natural gas. The World Bank (2014) has indicated that even after reforms, energy subsidies in Egypt, Tunisia and Yemen still account for more than 5 percent of their GDPs. This numbers are even higher for Algeria, Iran, Iraq and Saudi Arabia, more than 10 percent of their GDPs. Reforming energy prices in the MENA region, by letting energy consumers face prices which are higher and closer to their optimal levels, is likely to lead to measurable benefits for these countries.

Most analysis, both theoretical and empirical, of energy pricing reform to date has focused on fiscal and environmental/climate impacts of such reform (e.g. Perry and Small (2005)), and on the effect on household welfare (e.g. Gangopadhyay, et al. (2005); Arze del Granado, et al. (2012); Parry, et al. (2014); Coady, et al. (2015)). We here instead focus on analyzing how fuel taxation will affect economic growth.

Even though the relationship between economic growth and fossil fuel subsidies, is a very important economic policy topic today, but hardly any work exists to shed light on it. The related existing empirical literature concentrates on effects of energy prices or energy consumption on GDP, and not on effects of energy taxes or subsidies which are the core here. Note that subsidies, in contrast to prices, allows us to evaluate price distortions, especially when these subsidies are obtained by comparing the domestic retail price with the prices at the international level.

The study that is closest to our work is the contribution of Bretschger (2015) who presents an endogenous growth model in which energy is a production input. He finds that the effect of higher energy prices on economic growth can be either positive or negative, depending on the degree of input substitution between energy and labor in the consumer good sector. Bretschger tests his model using a balanced panel of 37 countries and 7 5-year periods. Most of these are *developed*

when the petroleum product is imported is equal to the international fob price of the product plus the domestic transport and distribution costs. If the petroleum product is exported, the supply cost is the revenue forgone by not exporting the product, which is then the international fob price minus the cost of transporting the product abroad and domestic distribution costs. The IMF also calculates the post-tax subsidy that includes in addition an estimate of negative externalities from energy consumption, known as the Pigouvian tax. See also Parry and Small (2005) and Clements et al. (2013) for further details.

countries. By contrast, the endogenous growth model that we have in mind analyzes the positive impacts of removing energy subsidies on production efficiency, real profits, employment and economic growth. Also, within the same line of reasoning, public spending on infrastructure and R&D using energy subsidy savings plays roles in enhancing economic growth. We test empirical the following hypothesis: *for a country that initially subsidizes heavily energy consumption, elimination of these subsidies can have positive impacts on its economic growth, and on the channels by which growth is affected.*

In addition, our analysis contrasts Bretschger's (2015) study in two different ways. First, it concentrates on developing countries with special focus on the MENA region. Many countries in this region are among the largest subsidizers of energy consumption. We however also consider other World Bank regions, and the OECD countries. Second, it characterizes countries according to their different fossil fuel policies by using Koplow's (2009) definition of subsidies or "price gap." Many related studies use this price-gap to quantify large deviations in energy prices within a country from world energy competitive prices. For fossil fuel importers, Koplow's price gap is equal to the domestic fuel retail price minus the average U.S. retail price, minus 10 US$ cents per liter. For the fossil fuel exporters, the price gap is equal to the domestic fuel retail price minus the average U.S. retail price, but now minus 20 US$ cents per liter. The price gap is *negative* when fuel is *subsidized*, or *positive* when fuel is *taxed*. As we will show, several countries tax their consumption of fossil fuels, but many subsidize fossil fuels, which means that their domestic fossil fuel prices are too low relative to international prices.[3]

Why to use the price gap approach? There are several reasons: its simplicity, ease of measurement and comparison across countries, and the limited data requirements imposed.[4] This price gap measure is also crucial, not only for the purpose of our study but in general, for quantifying pricing distortions across countries. We should also remark that most studies in the

[3] We attempt to measure subsidies as closed as possible to the IMF's "pre-tax" subsidy (see Footnote 1). Note that the U.S. retail price data includes 10 US$ cents average gasoline or diesel tax, in addition to the costs of transportation and distribution in the U.S. (U.S. Energy Information Administration). To be close to the IMF's pre-tax subsidy, we consider the US prices as the international price and subtract the average taxes of 10 US$ cents to obtain the price gap for the importing countries of petroleum products. The price gap for exporters will subtract not only the 10 US$ cents taxes, but also the costs of transportation and distribution which we approximate to be 10 US$ cents in similar fashion as the IMF estimates its price gap for exporters of the petroleum product. We remark that we do not use the IMF's data on taxes because there are no data before 2003.

[4] Rather than having to analyze hundreds of individual energy-related policies in specific countries, we can focus on comparing the subsidy policies across countries. Note also that often, countries lack the capability or will to provide accurate information on energy-related government activities. See Koplow (2009) for further discussion.

related literature use the US fossil fuel prices as the basis for comparison since the US market is considered as very competitive. See Clements et al. (2013).

Based on our empirical results we draw the following conclusions. *First,* using a *cross-section* approach which considers all the countries in all the World Bank regions, we find that, starting at given levels of average energy subsidy, a 20 US$ cents average increase in the diesel and gasoline price has resulted in an average increase in the GDP per capita growth rate by about 0.28 percent and 0.46 percent, respectively. *Second,* with a *panel* approach for each of the World Bank regions, we find that in most regions, a decrease in fuel (diesel and gasoline) subsidies today leads to increased economic growth in subsequent years. The exceptions are countries in the European and Central Asia (ECA) region, which already have relatively high fuel taxes. Countries like those in MENA, might need to experience immediate reductions in their GDP per capita growth and employment (especially affecting the younger populations) in response to more "correct" (higher) fuel price levels. However, as countries in the MENA region redirect subsidy expenditures toward more productive investments such as infrastructure and other public goods (i.e. health and education), they will in succeeding periods experience higher economic growth and employment. *Third,* our panel analysis shows that there is a significant positive effect from reduced fuel subsidies on employment and labor force participation especially among the young, aged 15 to 25, and higher social and public investments by the government are induced.

The paper is organized as follows. Section 2 presents some stylized facts from the data. Section 3 describes the theoretical background for our empirical analysis by explaining how fuel subsidies affect economic growth. Section 4 contains the econometric modeling while Section 5 includes our empirical results. Section 6 reports the empirical analysis on how fuel subsidy savings of the countries in the MENA region are redirected toward health and infrastructure spending and serve as channels to promote employment and growth. We analyze in Section 7 how these channels affect the relationship between energy subsidies and GPD per capita growth. Section 8 concludes.

2 Data

The data set is on annual basis and has been gathered by the Environment and Energy Team at the Development Research Group of the World Bank (DECEE). The details of the data sources can be found in Appendix A.

Figures 1a, 1b, 2a and 2b display the average diesel and gas *price gaps* (y-axis) as defined by Koplow (2009) [5] and the average changes in these price gaps respectively (x-axis), over the period of 1998 to 2012 for countries in the MENA and ECA regions. The price gap can be *negative* (i.e. fuel is *subsidized*) or *positive* (i.e. fuel is *taxed*).

Figure 1a. Diesel price gap. MENA countries

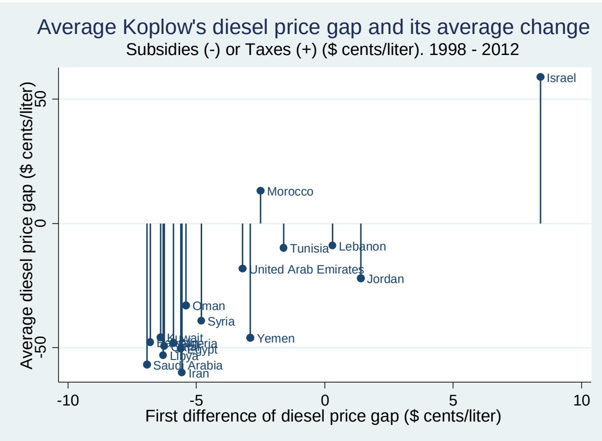
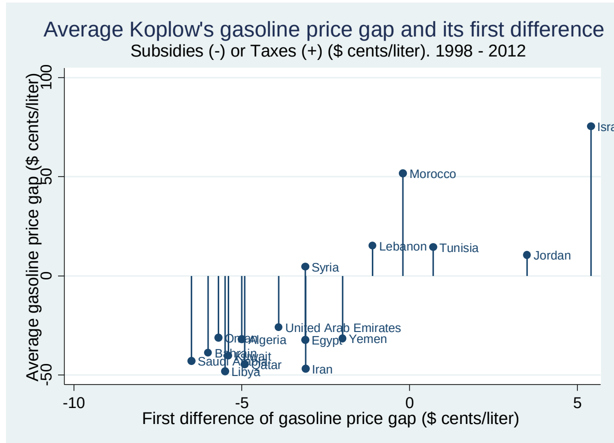


Figure 1b. Gasoline price gap. MENA countries



Notice that a large number of MENA countries have had relatively higher negative price gaps, or *higher average levels* of diesel and gasoline subsidies, than most ECA countries. The noticeable exceptions in ECA are Azerbaijan, Kyrgyzstan, Kazakhstan, Turkmenistan and Uzbekistan, especially with respect to diesel. Moreover, the MENA countries not only have had, over the period of 1998 and 2012, higher levels of fuel subsidies, but these subsidy levels have also become larger over time (i.e. the price gaps have become more negative). The MENA countries have not improved their fuel pricing situation over these years; their situation has instead worsened.

Figure 2a. Diesel price gap. ECA countries

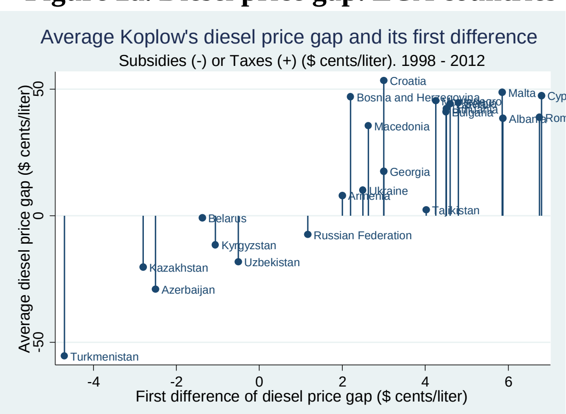
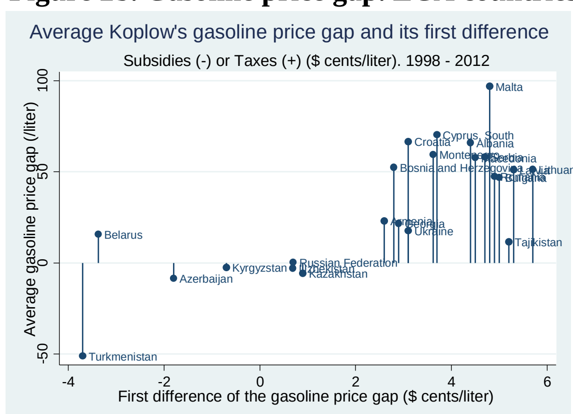


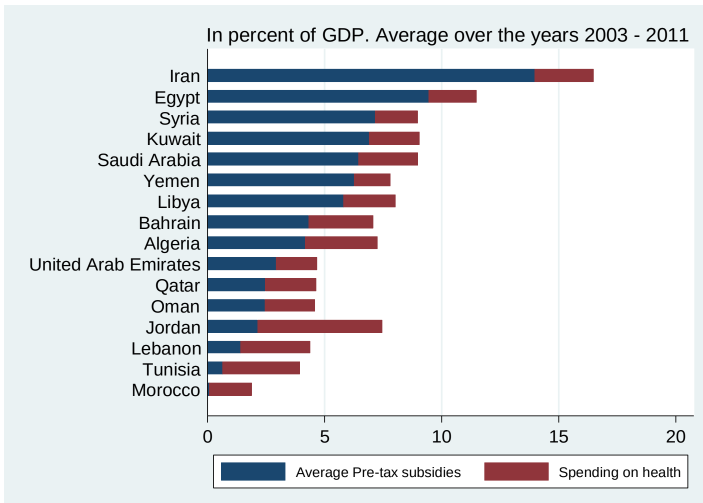
Figure 2b. Gasoline price gap. ECA countries



[5] This is equal to the domestic fuel retail price minus the average U.S. retail price, minus 10 cents per liter for fuel importers (corresponding to the average U.S. tax), and minus an additional 10 cents per liter for fuel exporters.

Figure 3 indicates that the MENA countries have had, on average between 2003 and 2011, higher total expenditures on pre-tax fossil-fuel energy subsidies (to petroleum, electricity, natural gas and coal) than public expenditures on health. The MENA countries will most likely benefit, in terms of higher productive and economic growth, from reducing their fiscal costs due to energy subsidies, and spend more on public goods such as infrastructure, education and health.

Figure 3. MENA Countries. Pre-Tax Subsidies and Spending in Health



Del Granado, et al. (2012) and Manzoor, et al. (2012) in addition stress that in most MENA countries where fuel subsidies are very large, the economy is generally much more energy-intensive, and increases in energy prices triggered by subsidy reform would have a bigger impact here than in economies that have already adapted to high oil prices. Arze del Granado et al. (2012) also indicate that removing fuel subsidies will eliminate price distortions, not only for fuels but also for final goods whose production depends on fuels. The overall allocation of resources would improve; many energy-intensive activities, which enjoy an artificial competitive advantage due to subsidies, would be eliminated; and energy-saving investments would become more profitable.

3 How elimination of energy subsidies can contribute to economic growth: An analytical perspective

Heavy subsidies to energy encourages an excessive energy consumption, exacerbating both the externalities resulting from such consumption, and the allocative inefficiencies among producers.[6] The allocative efficiency reflects the ability of producers to select the "right" combination of inputs

[6] High levels of consumption worsens the negative externalities such as pollution, health problems, traffic congestion, etc. This is well documented in Perry and Small (2005), Clements et.al. (2013) and Perry et.al. (2014).

in light of prevailing input prices (Farrell (1957)). This is a fundamental problem that countries in the MENA region face.

By eliminating energy subsidies, the MENA countries would provide incentives to the private sector to specialize in the production of goods that are more intensive in the use of labor, a factor the region is endowed with in relative abundance. It is also crucial for these countries to foster more entrepreneurship in order to reduce their significant unemployment gap and improve their growth prospects. It is precisely unemployment that has been causing so many economic and social problems in this region.

We provide the details of a small theoretical model of how subsidies affect economic growth in Appendix C. We test below the main prediction of our model:

Elimination of energy subsidies can have positive impacts on economic growth in countries that initially subsidize energy significantly, and implement enduring energy price reforms.

To support our econometric work, we have in mind an endogenous growth model (building on and extending Romer (1986, 1990); Lucas (1988); Bencivenga and Smith (1991); Aghion et al. (2005)). More specifically, we think of an overlapping generations (OLG) model that allows for economic interactions in which the decisions, including energy consumption, made by "younger" generations will affect the "older" generations. This approach also provides a tractable alternative to infinite-horizon representative agent models, and allow us to think of capital formation (and depreciation) as taking place from one generation to the next.

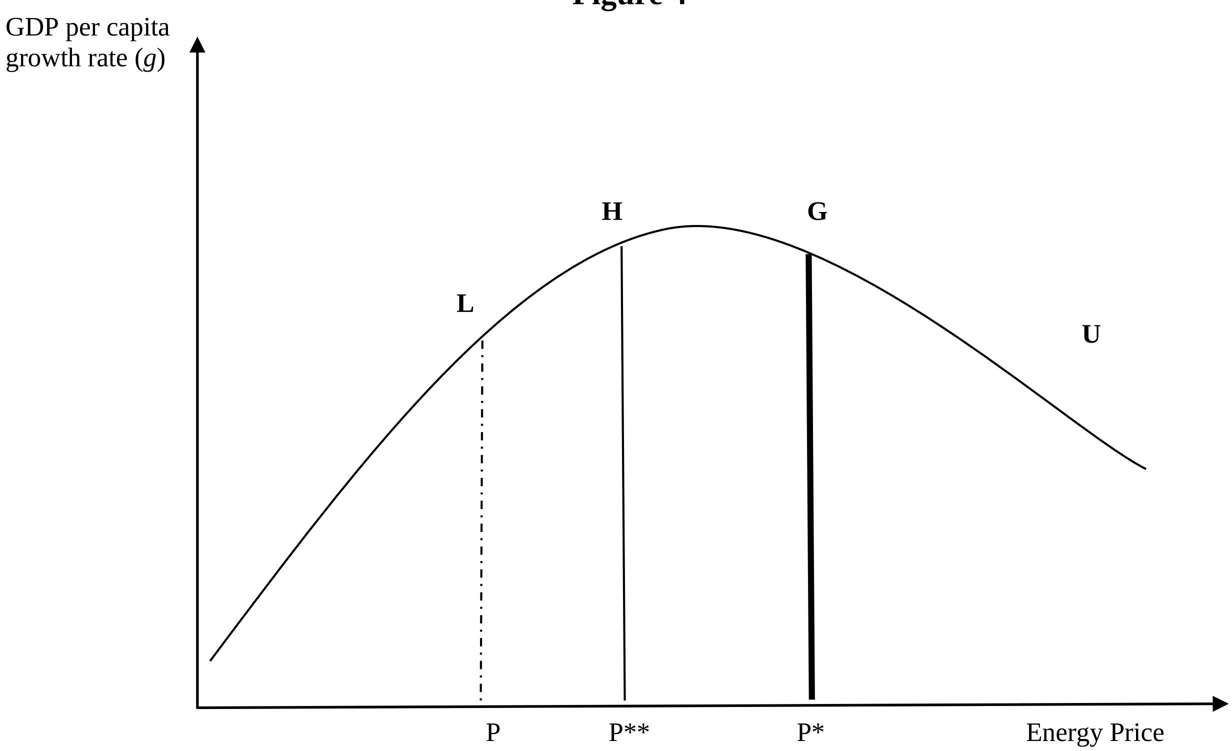
In this context, one can describe how elimination of energy subsidies can stimulate more competitive entrepreneurial activity among future generations, and promote an optimal use of the inputs of production; and thereby achieve higher rates of economic growth. It is crucial to emphasize that these dynamics are better fostered in an environment where the government uses the savings from reduced fuel subsidies to invest in infrastructure, R&D, and public goods.

Reasoning around an endogenous growth model gives a good understanding of the economic forces underlying such higher entrepreneurial activity and efficiency in the allocation of productive inputs when energy subsidies are reduced.

Three important results are obtained from such theoretical framework. *First*, the strongest positive effects on economic growth in response to energy price reform can be expected in countries with high initial energy subsidies. Growth will however decrease if energy taxes rise in an economy that already has high energy taxes. The indirect effects of too high taxes, take place through the reductions in private savings that are one of the main sources of capital formation for future generations. *Second*, removing energy subsidies will enhance allocative efficiency in the use of the inputs of production, to subsequently generate positive spillovers to the economy such as higher employment, productivity and profits. *Third*, it is crucial that the government invests its reserves from fuel subsidy reductions or tax increases, in high-return long-run investments such as infrastructure and R&D in order to increase the economy's productive capacity and give the young generations the adequate incentives to engage in the future in entrepreneurial activities.

Our main results are illustrated in Figure 4, which shows a concave and inverted **U**-shaped curve, illustrating GDP growth per capita as a function of the fossil fuel retail price. When energy prices are *initially very low* relative to a fuel reference price such as **P****, as a result of energy subsidies (as for many MENA countries), my endogenous growth model predicts that the country will experience higher GDP growth as its energy price level rises above **P** and moves closer to **P**** (i.e. subsidies are reduced). This suggests that moving from point **L** to point **H** on the **U-**curve is highly beneficial in terms of economic growth. The indirect effects of this reduction in energy subsidies that induce higher economic growth come through higher entrepreneurial activity; higher efficiency in the allocation of inputs (as explained above); and larger government's long-term investment in infrastructure funded with the savings from reduced subsidies.

Figure 4



Nonetheless, our model also predicts that if the country has *already* relatively high energy prices, the country will face reduced growth when energy prices are increased further relative to **P****, for example to P*. This is probably the situation for many ECA countries today. These countries will move to the right of **H** to **G,** on the **U-**curve**.** This occurs because, as explained above, setting fuel taxes even higher will lead to a substantial decline in *private savings,* and this affects negatively capital formation, and thereafter economic growth, as entrepreneurs will then have fewer resources to transform into capital. To achieve maximal economic growth, an economy should thus, according to our theory, have an appropriate balance between public investment financed from tax revenues, and private savings to avoid the diminishing returns to too high fuel taxes.

Note that our result that higher energy taxes could have diminishing return to economic growth may seem to contradict Hicks' (1932) theory, and Porter's (1991) argument. Hicks's (1932) theory suggests that increases in the costs of a production input should spur innovation to cut down on the use of that input. Porter (1991) argues that environmental policies such as decreasing energy subsidies, will create indirect effects (e.g. changes in the composition of inputs, production process) that induce innovation among firms, which in turn might lead to higher productivity and profitability. Ambec et al. (2011); Koźluk and Zipperer (2014) postulate that *a priori*, it is unclear whether these indirect effects are negative or positive, or how large they are. Ambec et al. (2011) explain that the empirical research on the economic effects of environmental policies is largely inconclusive, and that the results are usually very context-specific and hence can only provide limited general policy conclusions. We remark that our indirect effect of higher energy taxes in an economy where these taxes are *already* high, is through private savings which are crucial for the formation of capital by the entrepreneurs. One could alternatively think that Hicks' and Porter's hypotheses apply better to countries that have *initially* high subsidies. We also here argue that the collected energy taxes or the savings in energy subsidies should be used by the government to invest in infrastructure to obtain the best effect on entrepreneurship and economic growth. The government is here viewed as the most suitable agent to make such investments.

There is also a separate argument put forward by Lucas et al. (1992) who show that stricter environmental regulation (including higher fossil fuel prices) in developed countries might encourage industries to move to developing countries with less strict such regulation. If a country experiences an exodus of firms when fossil fuel prices are increased, this can hardly increase economic growth. A *race to the bottom* scenario might then be at work, if higher fossil fuel prices encourage industries to relocate to countries where fossil fuels are subsidized heavily. As the race to bottom accelerates, our **U**-curve might initially flatten, and then reach a turning point at which lower GDP growth will be experienced.

4. The Empirical Analysis: What do the data tell us about effects of energy subsidies on economic performance?

This section contains the econometric models and the results from estimating these. Our empirical relationships represent our theoretical model which predicts the direct effect that reducing energy subsidies have on economic growth per capita.

We here test the main *hypothesis* of our theoretical model: *a country that initially subsidizes heavily energy consumption, will attain higher levels of economic growth if it eliminates these subsidies*.

This hypothesis addresses the dynamics of economic growth when a country is at a point such as ***L*** in Figure 4. Our empirical strategy also assists us to identify countries that might be experiencing diminishing returns of too high energy taxes as predicted by our theoretical model, and that are in a region around ***G*** in Figure 4.

The indirect effects of reductions in energy subsidies that induce higher economic growth come through higher entrepreneurial activity and employment; and larger government's long-term investment in infrastructure funded with the savings from reduced subsidies.

Our empirical work involves *cross-sectional*, *pooled cross-sectional* and *panel* estimations:

1. *Cross-section* and *pooled cross-section* (with fixed effects) approaches analyze *long-run effects*. With the cross-section analysis, covering the periods from 1998 to 2012 and all countries of the World Bank Regions, we study whether a reduction in subsidies (or increases in fuel price gaps) moves a country toward its optimal steady state potential for economic growth. With the pooled cross-section analysis we attempt to take into account how the effect of fossil fuel subsidies on economic growth could depend on the business cycle[7], and even the financial crisis of 2008. All countries of all the World Bank Regions are also considered with 3 periods of cross-sectional data: i) from 1998 to 2002; ii) from 2003 to 2007; and iii) 2008 to 2012). In all the approaches, it is here required that we obtain, for each country, the mean value

[7] A similar approach was followed by Bretschger (2015).

of the relevant variables for each of the periods of study. We in addition study each of these last three periods separately in order to determine if the estimates are time dependent.

2. A *panel* approach to study *short- and medium-run effects*. This analysis will quantify both the contemporaneous and the two-year-lagged effect of the fuel price gap on economic growth. The analysis here will be done by World Bank region on an annual basis.

All of these approaches are therefore not only technically different, but also give us different perspectives on the relationship between energy subsidies and economic growth.

The empirical analysis again focuses on the relationship between GDP per capita growth and the *price gap* as defined by Koplow (2009). Recall that if *the price gap is positive, there is a tax on this fuel; and a subsidy in the opposite case.*

4.1 Estimation Method

We use the (robust) OLS estimation method for the cross-sectional data, and the System General Method of Moments (GMM) method (Arellano-Bover (1995)/Blundell-Bond (1998)) for the panel data. The GMM corrects for possible endogeneity and non-stationarity of the regressors or explanatory variables. In particular, diesel and gasoline prices are likely to be endogenous, being affected by both demand and supply conditions. Since in a given country, the prices of gasoline and diesel could be highly influenced by the distribution of the different modes of transport (e.g. number of passenger cars, minibuses, passenger light trucks, heavy trucks, etc.), gasoline and diesel prices should be correlated with such distribution in each country. This implies that the intensity of use of different modes of transportation might serve as instruments for fuel price gaps. We also use gasoline (diesel) consumption as an instrument when we consider the diesel (gasoline) price gap as regressor in the growth equation. Thus, any effect that the modes of transportation, and gasoline (diesel) consumption could have on growth, would go through the high correlation between these instruments and the diesel (gasoline) price gap.

All the tables containing the estimates report both the two-step estimates (which yield theoretically robust results, Roodman (2009)). The two-step estimator allows us to obtain the robust Sargan test (i.e. the robust Hansen J-test). This is crucial for testing the validity of the instruments (or overidentifying restrictions). The validity of the model depends also on testing the presence of first- and, in particular, second-order autocorrelation in the error terms. These important statistical diagnostics are presented together with estimated parameters (De Hoyos and Sarafidis (2006). For all our empirical models, the Sargan tests of overidentifying restrictions do not reject the null hypothesis (e.g. of correct model specification and valid overidentifying restrictions) at any reasonable level of significance; hence, it is an indication that the models have valid instruments. Our test results on autocorrelation indicate that we cannot reject the null hypothesis (e.g. the cross section dependence is homogeneous across pairs of cross section units after including time dummy variables). Thus, by including time-dummies in our empirical specification we have removed universal time-related shocks from the error term.

4.2 Cross-Sectional Modeling

The *cross-sectional* approach uses the following simple empirical relation which represents our theoretical result and test our main ***Hypothesis***:

$$GDP_{per\,capita}\ growth_i = \alpha_{1c} + \beta_{1c}(price\ gap)_i + \varphi_{1c}(price\ gap)^2{}_i + \theta_{1c} I_{i,1998} + \eta_{ic}\ . \qquad (1a)$$

GDP per capita $growth_i$ and $(price\ gap)_i$ are measured for each country *i* in *ALL World Bank Regions* from 1998 to 2012. η_{ic} is the error term for the empirical equation (1a).

GDP per capita $growth_i$ and $(price\ gap)_i$ (using Koplow's methodology) are the average for each country *i* in all *World Bank Regions* from 1998 to 2012. This implies that energy price policies are set with a long-term planning horizon of 15 years (from 1998 to 2012). As mentioned, we also considered a *pooled cross sectional* approach.

A sufficiently large positive increase in the price gap indicates that there are net taxes on energy, instead of subsidies. $I_{i,1998}$ represents the initial income for each country in 1998, which serves to quantify the differences in the effect of subsidies on the economic growth across countries, and the conditional convergence effects.

For the *pooled cross-sectional* approach we estimate the following empirical relation taking into account fixed effects. The subscript t denotes each of our three periods.

$$GDP_{per\,capita}\ growth_{it} = \alpha_{1c} + \beta_{1c}(price\ gap)_{it} + \varphi_{1c}(price\ gap)^2{}_{it} + \theta_{1c} I_{i,1998} + \tau_t + c_i + \eta_{it} \qquad (1b)$$

Note that we cannot introduced lags given that we only have 3 5-year periods.

One will fail to reject the main *hypothesis* if β_{1c} is positive and statistically significant in the empirical relationship (1a). This is the case of a country that is close to point ***L*** in Figure 4. The coefficient φ_{1c} accompanying the square of gap prices is expected to be negative if there are diminishing returns to increasing fossil fuel taxes. That is, each additional US$ cent will reduce the positive effect of β_{1c}. Such result will also imply that the relationship between GDP per capita and the fossil fuel price gaps is concave and takes the form of our inverted U curve. Such results are predicted by our endogenous growth model. Therefore, when energy taxes are initially low, or subsidies are high, there is much to gain in terms of additional growth by removing these subsidies. This will however not be the case when energy taxes are initially high, that is, for a country located near ***U*** in Figure 4.

Our empirical specification above can be questioned on the grounds that it does not include several standard variables which according to growth theory are important contributors to explaining economic growth; see Jones (1997), Aghion and Howitt (1999), Doppelhoffer, Sala-i-Martin and Miller (2004), Petrakos, Arvanitidis and Pavleas (2007), Rajan and Subramanian (2008), and Aghion , Boustan, Hoxby and Vandenbussche (2009).[8] Nonetheless, we remark that one of the purposes of our empirical analysis is specifically to answer the following two questions: *first,* do elimination of fossil fuel subsidies spur growth? If the answer is no, there is no need of replicating previous traditional empirical analysis of growth. If the answer is yes, as we here obtain, it becomes important to answer to a *second* issue, are there crucial channels (e.g. employment, education expenditures, infrastructure expenditures, health expenditures which are recognized to contribute to economic growth) by which energy subsidies affect growth? Including in our empirical regressions (cross-sectional and panel analysis) these standard variables together with energy subsidies (i.e. fossil fuel price gap), will not by itself tell us exactly how the reduction/elimination of energy subsidies are related to such standard variables, which can then affect the economy. Fossil fuel subsidies are expected to be related to these standard variables that are known to explain growth, and we corroborate this in the following sections. In addition, entering all these variables in the same regression will create collinearity problems. We here set out to demonstrate that reducing subsidies will lead to higher economic growth, but also i) provide empirical evidence on the channels by which it is possible to achieve growth and ii) document the time path of the effects of eliminating subsidies on these standard variables that are important for growth. We think it is important for policy purposes to show whether governments' savings from reducing energy subsidies are used productively in the economy (for more health and education expenditures), immediately or with delay?), and how this affects employment (does it take time for the reduction of subsidies to have an effect on employment?). These questions cannot be

[8] We have obtained empirical results for the panel modeling (considering each region of the World Bank) in which we include some of these standard variables together with fuel price gap. These can be made available upon request.

addressed by simply including all the standard variables together with the price gap in the growth equation.

4.3 Panel Estimations Modeling

This approach allows an analysis by World Bank Region. Equation (1b) is modified as follows:

$$\begin{aligned} GDP_{per\,capita}\ growth_{it} &= \alpha_{1p} + \beta_{1p}(price\ gap)_{it} + \beta_{2p}(price\ gap)_{it-1} + \beta_{3p}(price\ gap)_{it-2} \\ &\varphi_{1p}(price\ gap)^2{}_{it} + \varphi_{2p}(price\ gap)^2{}_{it-1} + \theta_{1p} I_{i,1998} + \tau_t + c_i + \eta_{it} \end{aligned} \quad . \qquad (1c)$$

GDP *per capita* $growth_{it}$ and $(price\ gap)_{it}$ are for *each country* i *in each of the World Bank Regions* at year t. Time and country fixed effects are denoted by τ_t and c_i, respectively. η_{it} is the error term. Statistically positive and significant β_{2p} and β_{3p} indicate that a country will experience an increase in its *current* GDP per capita growth by β_{2p}% and β_{3p}% if it had pursued fuel price reforms by increasing its fuel retail price by 1 cent per liter relative to a specific fuel reference price (i.e. Δprice gap = 1 cent/liter), during each of the past two years, respectively. There will be in addition a change of β_{1p}% in the current GDP per capita growth if there is also an increase of 1 cent in the current price gap. A negative β_{1p} should not however lead us to reject our underlying *hypothesis*, given that β_{2p} and/or β_{3p} are positive. Such a result would only indicate that fuel price reforms do not have immediate positive effects on output, but rather work positively through the economic system over time. On the other hand, a significant positive/negative φ_{1p} and φ_{2p} would indicate increasing/diminishing returns, in terms of growth, to increasing energy prices in the previous and current period. This is predicted by our theoretical model and illustrated in Figure 4.

Accordingly, one should expect the *lagged effects* (of the last past one- or two-year fuel price gaps), and the *contemporaneous effects* (of current fuel price gaps) on contemporaneous GDP growth, to differ. Increases in fuel retail prices today will likely increase fuel costs for enterprises leading to abrupt adjustments in their production, investment and employment, and thereafter to a reduction in growth in the same year as when the fuel subsidy reforms are implemented (unless these fuel increases are compensated contemporaneously via increased money transfers to the public). This will be echoed with a negative value of β_{1p}. Nonetheless, with time, a country that puts into practice enduring fuel price reforms will likely encounter positive effects on its economy in the following periods, with positive values of β_{2p} and/or β_{3p}. The GDP per capita in such reforming countries could start rising in the following periods via a number of different “pathways” (lower budget deficits, larger social and infrastructure investment, elimination of negative externalities), while enterprises adjust their businesses to the new fuel pricing.

5. Estimation Results

5.1 Cross-Sectional and Pooled Cross-Sectional Analysis on the effect of energy subsidies on GDP per capita growth across all countries excluding High-Income OECD countries

We here present the fixed-effects estimates of equation (1a). Selected relevant estimates are displayed in Table 1. We consider the entire period 1998 – 2012; and the sub-periods 1998-2002; 2003 – 2007; and 2008-2012.

The estimates for both the entire period, and the sub-period 2003 – 2007 (when the oil price was rising), are statistically insignificant. For the sub-period of 1998 – 2002, only the estimates for gasoline are significant, while for the period 2008 - 2012, our estimates are all significant at reasonable statistical levels. These last estimates indicate that for a given level of average fossil fuel subsidy, a 20 US$ cents average increase in the diesel and gasoline price per liter has caused an average increase in GDP per capita growth rates by about 0.30 percent and 0.48 percent, respectively. For the period between 1998 and 2002, a 20 US$ cents increase in gasoline price per liter caused a rise in GDP per capita growth by 1.33 percent.

These results are interesting, a decrease in subsidies could have then helped the countries to achieve increased rates of economic growth over the periods of 1998 – 2002 and 2008 – 2012. This appears less likely to have been the case between 2003 and 2007 when the oil prices were high and rising steadily. Note that during the years between 1998 and 2002, fossil fuel prices were never as high as during the period between 2003 and 2012. In the period from 2008 to 2012, which includes the years of global financial crisis from 2008 on, many countries faced fiscal budget constraints that were far more serious than in previous years, even though the oil prices were still high. It is then likely that during the 2008 financial crisis, it became less affordable for the governments to finance energy subsidies. This might explain why possible rises in fossil fuel prices in the period between 2008 and 2012, must have had very modest effect on economic growth.

Note also that additional increases in the price gap (i.e. higher subsidies) must have caused a modest decrease in GDP per capita growth. Nevertheless such result gives an indication that the relationship between economic growth and subsidies is concave, that is, and inverted U curve.

Table 1: Cross-Sectional Analysis: GDP per capita growth (%) and Koplow's fuel price gap (US$ cents per liter)[a]. All countries except OECD. OLS robust estimates[b]

Cross-Sectional Analysis: **Effect on GDP per capita growth; 1998-2012**		
RHS Variables	**Gasoline Price**	**Diesel Price**
Koplow's fuel price gap	0.00948 (0.0108)	0.00297 (0.0091)
(Koplow's fuel price gap)^2	-0.00020* (0.00011)	-0.00019 (0.00013)
Observations	157	157
F; Prob > F	2.53; 0.059	2.04; 0.1106
Pooled Cross-Sectional Analysis: **Effect on GDP per capita growth 1998 – 2002; 2003 – 2007; 2008 – 2012**		
RHS Variables	**Gasoline Price**	**Diesel Price**
Koplow's fuel price gap)	0.00700 (0.00858)	0.00746 (0.00729)
(Koplow's fuel price gap)^2	-0.000162** (0.000085)	-0.000267** (0.000123)
Observations	369	369
F; Prob > F	2.94; 0.0331	3.16; 0.0248
Cross-Sectional Analysis: **Effect on GDP per capita growth; 1998 – 2002**		
RHS Variables	**Gasoline Price**	**Diesel Price**
Koplow's fuel price gap	0.06657* (0.04013)	0.00804 (0.03430)
(Koplow's fuel price gap)^2	-0.00154** (0.000716)	-0.00021 (0.00081)
Observations	122	123
F; Prob > F	2.03; 0.113	0.52; 0.6665
Cross-Sectional Analysis: **Effect on GDP per capita growth; 2003 – 2007**		
RHS Variables	**Gasoline Price**	**Diesel Price**
Koplow's fuel price gap	0.01000 (0.01632)	0.01511 (0.01552)
(Koplow's fuel price gap)^2	-0.000162 (0.000171)	-0.000327 (0.00030)
Observations	123	123
F; Prob > F	4.67; 0.004[c]	4.70; 0.0039[c]
Cross-Sectional Analysis: **Effect on GDP per capita growth; 2008 - 2012**		
RHS Variables	**Gasoline Price**	**Diesel Price**
Koplow's fuel price gap	0.02396*** (0.00858)	0.01513** (0.00704)
(Koplow's fuel price gap)^2	-0.00022*** (0.000078)	-0.000372*** (0.00012)
Observations	123	123
F; Prob > F	4.22; 0.007	4.87; 0.0031

[a] A positive price gap implies a tax on this fuel; a negative price gap implies a subsidy.

[b] Error terms in parentheses. * Significant at 1% level; ** significant at 5% level; *significant at 10% level.**

[c] The value of F is relatively large because the initial income is high statistically significant.

Our *pooled cross-sectional* (fixed effect) analysis, i.e. the estimation of equation (1b), provides us with few statistically significant estimates. The message here is that, it was important to distinguish the effect of subsidies per period of time.

In MENA, most countries subsidize gasoline; while in ECA, most countries tax it, as shown in Figures 1 and 2. Consider simple correlations for 1998 - 2012 between the average of the gasoline Koplow's price gap, and the average *GDP per capita growth* for these two regions. We notice, from Figures 5 and 6, that low fuel price gaps (high energy subsidies) in the MENA countries have, on the whole, been harmful to their economic growth over this period. The opposite holds for the ECA region (excluding OECD countries). MENA and ECA regions thus represent two opposing and contrasting sets of fuel tax policies. A clear lesson here is that one needs to analyze these patterns by region, which cannot be done using the cross-sectional approach.

Figure 5. Correlation between GDP per capita growth and Gasoline Price Gap: Subsidies (-) Taxes (+) ($ cents/liter)

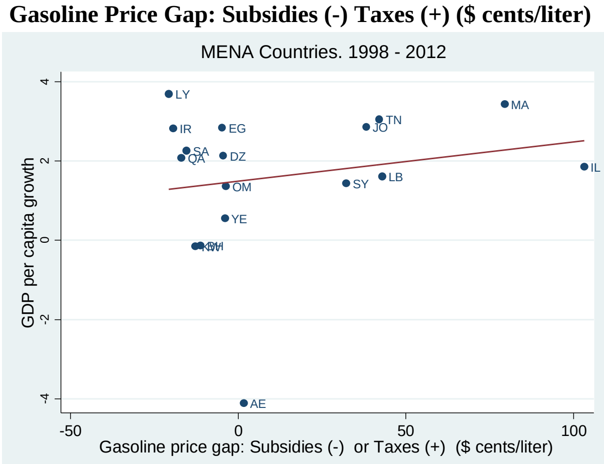
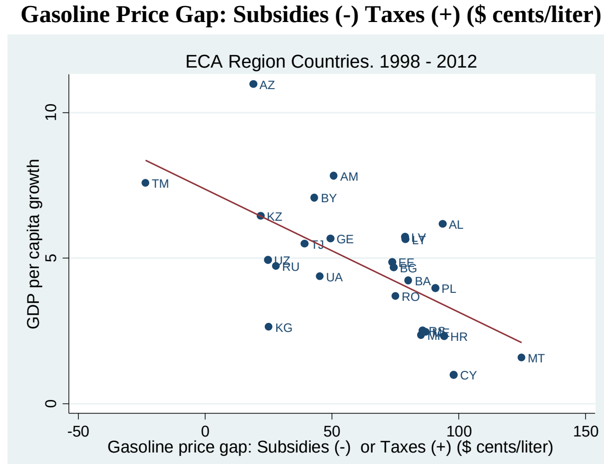


Figure 6. Correlation between GDP per capita growth and Gasoline Price Gap: Subsidies (-) Taxes (+) ($ cents/liter)



5.2 Panel Country Analysis of effects of energy subsidies on GDP per capita growth by World Bank Region

We have constructed a panel dataset of countries by each World Bank Region, to estimate equation (1c) and test the underlying hypothesis. This estimation procedure automatically checks for collinearity among levels of independent variables and differences. Variables that create multicollinearity problems are dropped from the estimation. Tables 2 and 3 show the empirical results of the effect of countries' diesel and gasoline price policies on growth, respectively. We consider the countries in the MENA, LAC, ECA, EAP and AFR World Bank regions, but also the

OECD group.[9] For the EAP region, five countries (Australia, Japan, Hong Kong, New Zealand and Singapore) are not part of the estimation since these are high-income countries. For the same reason, Israel is not included in MENA region; nor do we include OECD countries in the ECA region.

Higher fossil fuel retail prices today imply higher costs for enterprises which could lead to negative short-run impacts on their production, investment and employment, thus reducing growth per capita in the year when a fuel subsidy reform is implemented. This will be reflected in a negative value of β_{1p} or even β_{2p} in equation (1c). A fuel price reform made today will however be beneficial in the subsequent periods or long run. The transition from the original pre-subsidy stage (the initial equilibrium) to the final subsidy-free stage (the new equilibrium) is likely to involve frictions. There will be a contraction in capital-intensive industries along with layoffs, and an initial low rate of economic growth. However, the GDP per capita in reforming countries will start rising in the following periods via a number of different "pathways", as industries adapt to more labor intensive and the new energy prices, and as increased revenues are spent productively by governments. The gains from eliminating energy subsidies are then reaped in full, and employment level will most likely rise relative to the pre-subsidy stage. Such effects will be reflected in positive values of β_{2p} and/or β_{3p} in equation (1c). Our results are presented in Tables 2 and 3.

Because the ECA region and OECD have so different energy price policies from countries in the other regions, we will first discuss the results for the MENA, LAC, EAP and AFR regions. We thereafter proceed to explain the results for ECA and OECD.

We find that reducing fossil fuel (diesel or gasoline) subsidies has immediate positive effects in LAC and AFR regions but not in EAP or MENA, as β_{1p} is either negative or statistically insignificant. This reduction in subsidies will continue to have positive effects in the subsequent years, including also in EAP and MENA. Indeed, the estimated parameters β_{2p} and/or β_{3p} (parameters of the RHS variables $(\text{price gap})_{t-1}$ and $(\text{price gap})_{t-2}$, respectively) in equation (1c) are found to be statistically significant and positive. These results indicate that the benefits of decreasing fuel (diesel or gasoline) subsidies today will be felt in each of the next two years. Thus, a subsidy reduction in t-1 or t-2 will cause an increase in GDP per capita growth in period t in all World Bank regions.

[9] The list of countries in each region are presented in the Appendix B.

Table 2: GDP per capita growth (%) and Koplow's diesel price gap (US$ cents per liter)[a]. 1998-2012[b]. System GMM

RHS Variable	MENA (minus Israel)	LAC	EAP (minus 5 HIC)	AFR	ECA (minus OECD)	OECD
Diesel Price Gap1$_t$	0.0142 (0.0190)	**0.0875*** (0.0344)**	-0.1770*** (0.0659)	**0.0559*** (0.0017)**	-0.0603*** (0.0063)	-0.1311*** (0.0055)
Diesel Price Gap1$_{t-1}$	**0.1311*** (0.0452)**	**0.0725** (0.0320)**	**0.2039*** (0.0754)**	**0.0121*** (0.0034)**	-0.0465*** (0.0123)	-0.0664*** (0.0088)
Diesel Price Gap1$_{t-2}$	-0.00845 (0.0323)	**0.0255*** (0.0079)**	**0.0456*** (0.0124)**	0.00073 (0.0033)	-0.0216*** (0.0021)	-0.0089 (0.0029
(Diesel Price Gap1)^2_t	0.00087** (0.00044)	-0.00040 (0.00032)	0.0013*** (0.00046)	-0.00030*** (0.00002)	0.00055*** (0.000357)	0.00104*** (0.000033)
(Diesel Price Gap1)$^2_{t-1}$	0.00275*** (0.00066)	-0.00131*** (0.00038)	-0.0025*** (0.00065)	0.00013*** (0.00002)	-0.00015** (0.000073)	-0.00097*** (0.000050)
AR(1) test[c]	z = -1.085 Pr>z=0.278	z = -1.913 Pr>z=0.056	z = -1.7856 Pr>z=0.074	z = -3.622 Pr>z=0.000	z = -3.228 Pr>z=0.001	z = -3.454 Pr>z=0.006
AR(2) test[c]	z = 1.1146 Pr>z=0.265	z = 0.485 Pr>z=0.628	z = 1.504 Pr>z=0.133	z = -0.556 Pr>z=0.578	z = -3.032 Pr>z=0.002	z = -0.158 Pr>z=0.875
Sargan test[d]	Prob>chi2 = 0.99	Prob>chi2 = 0.95	Prob>chi2 = 1.00	Prob>chi2 = 1.00	Prob>chi2 = 1.00	Prob>chi2 = 1.00
Observations	219	333	221	507	286	442

[a] A positive price gap implies a tax on this fuel; a negative price gap implies a subsidy.

[b] Standard errors in parentheses. *** Significant at the 1% level; ** significant at the 5% level; *significant at the 10% level

[c] These are the Arellano-Bond test for AR(1) and AR(2) in first differences. There, the corresponding null hypotheses (H_0) are respectively:

- There is no first-order serial correlation in residuals
- There is no second-order serial correlation in residuals

[d] With the Sargan statistics, one can test the null hypothesis of correct model specification and valid overidentifying restrictions

Table 3: GDP per capita growth (%) and Koplow's gasoline price gap (US$ cents per liter)[a]. 1998-2012[b]. System GMM

Variable	**MENA (minus Israel)**	**LAC**	**EAP (minus 5 HICs)**	**AFR**	**ECA (minus OECD)**	**OECD**
Gasoline Price Gap2$_t$	-0.0136 (0.0398)	**0.0948*** (0.0300)**	0.0055 (0.0264)	**0.0454*** (0.0077)**	-0.00467 (0.0210)	-0.07283*** (0.00989)
Gasoline Price Gap2$_{t-1}$	-0.0606*** (0.0207)	**0.0460* (0.0286)**	0.0721 (0.0935)	**0.0210*** (0.0036)**	-0.0724*** (0.0112)	-0.04176*** (0.00493)
Gasoline Price Gap2$_{t-2}$	**0.0853*** (0.0276)**	-0.0062 (0.0078)	**0.0533*** (0.0096)**	-0.00059 (0.00124)	-0.0343*** (0.00081)	-0.03690*** (0.00219)
(Gasoline Price Gap2)^2_t	-0.00021 (0.00043)	-0.00047* (0.00028)	-0.00016* (0.000097)	-0.00024*** (0.00003))	0.00013*** (0.00005)	0.00042*** (0.000055)
(Gasoline Price Gap1)$^2_{t-1}$	0.0012* (0.00071)	-0.00084*** (0.00018)	-0.00076 (0.00050)	-0.00011*** (0.00001)	0.00024*** (0.000037)	0.000199*** (0.000024)
AR(1) test[c]	z = -1.097 Pr>z=0.273	z = -2.023 Pr>z=0.043	z = -2.175 Pr>z=0.030	z = -3.737 Pr>z=0.000	z = -2.565 Pr>z=0.010	z = -2.679 Pr>z=0.007
AR(2) test[c]	z = -0.4145 Pr>z=0.678	z = -0.1815 Pr>z=0.856	z = -1.019 Pr>z=0.308	z = -0.5889 Pr>z=0.556	z = -3.063 Pr>z=0.002	z = -1.146 Pr>z=0.252
Sargan test[d]	Prob>chi2 = 0.99	Prob>chi2 = 0.99	Prob>chi2 = 0.97	Prob>chi2 = 0.99	Prob>chi2 = 0.99	Prob>chi2 = 0.96
Observations	219	333	221	506	286	442

[a] A positive price gap implies a tax on this fuel; a negative price gap implies a subsidy.

[b] Standard errors in parentheses.*** Significant at the 1% level; ** significant at the 5% level; *significant at the 10% level

[c] These are the Arellano-Bond test for AR(1) and AR(2) in first differences. There, the corresponding null hypotheses (H_0) are respectively:

- There is no first-order serial correlation in residuals
- There is no second-order serial correlation in residuals

[d] With the Sargan statistics, one can test the null hypothesis of correct model specification and valid overidentifying restrictions

The estimated φ_{1p} and φ_{2p} (or the sum of the two) are in most cases significantly negative but small, except in MENA. Thus, countries in most regions experience that small additional hikes in fossil fuel prices might decrease somewhat any rising rate of economic growth. By contrast, in MENA, the region with the highest energy subsidies, additional decreases in fossil fuel subsidies contribute to even higher rates of economic growth. We can conclude that countries in the MENA, LAC, EAP and AFR are all on the increasing segment of the inverted U curve (e.g. between L and H), and can thus continue benefiting from higher economic growth when fossil fuel subsidies are further reduced or eliminated.

With respect to the ECA and OECD countries which mostly have fossil fuel taxes and not subsidies. As we discussed above, these regions seem to experience decreasing returns to scale as a result of their energy price policies. In these countries, GDP per capita growth rates are generally reduced when domestic retail fossil fuel prices increase further. It is well possible that higher taxes are affecting negatively private savings which in turn prevent sufficient capital investment. An alternative explanation could be that these higher taxes are not enhancing sufficient competitiveness and innovation among the enterprises in the ECA and OECD countries, as Hicks (1939) and Porter (1991) had expected.

Referring again to Figure 4, most of the countries in all World Bank regions seem to be on the left-rising (upward-sloping) part of curve G. Interestingly, for the ECA region (and OECD countries) results are directly opposite in response to decreases in these countries' fossil fuel subsidies.

6. Will reductions in diesel subsidies increase, or reduce, employment in the MENA and ECA Regions?

The effects of a reduction in diesel subsidies on employment, labor participation of youth aged 15 to 24, and labor participation of the populations aged from 15 to 65 (all measured with respect to total populations above 15 years of age), are important. We estimate an empirical relation similar to (1c), except that the employment variables are on the left-hand side. The effect is particularly strong for the case of diesel subsidies. The results are shown in Table 4 for MENA and ECA countries, for comparison purposes. *Much more significant positive effects of subsidy reductions* *on employment and participation in the labor force are found for MENA than for ECA countries, even when the effects occur with some delay.*[10]

Table 4. MENA and ECA Regions: Employment, Labor Force Participation and Koplow's diesel price gap (US$ cents per liter)[a]. 1998-2012.[b] System GMM.

Effect on Total Employment/Population, age 15+ (%)			***Effect on Labor Force Participation ages 15 to 24/Population, age 15+ (%)***			***Effect on Labor Force Participation ages 15 to 65/Population, age 15+ (%)***		
MENA								
Diesel Price Gap$_t$	**Diesel Price Gap$_{t-1}$**	**Diesel Price Gap$_{t-2}$**	**Diesel Price Gap$_t$**	**Diesel Price Gap$_{t-1}$**	**Diesel Price Gap$_{t-2}$**	**Diesel Price Gap$_t$**	**Diesel Price Gap$_{t-1}$**	**Diesel Price Gap$_{t-2}$**
0.01589 (0.03294)	**0.09256*** (0.03981)**	-0.03372 (0.02048)	-0.01961** (0.00914)	**0.03450*** (0.00562)**	**0.00874*** (0.00197)**	-0.0326*** (0.00692)	**0.0515*** (0.00774)**	0.00089 (0.00581)
AR(1) test[c]: z=0.0169; Pr>z=0.9865			**AR(1) test[c]**: z=1.3305; Pr>z=0.1834			**AR(1) test[c]**: z=0.328; Pr>z=0.743		
AR(2) test[c]: z=1.5647; Pr>z=0.1177			**AR(2) test[c]**: z=1.1187; Pr>z=0.2633			**AR(2) test[c]**: z=1.1519; Pr>z=0.2494		
Sargan test[d]: Pr > chi2 = 1.00			**Sargan test[d]** Pr > chi2 = 1.00			**Sargan test[d]**: Pr > chi2 = 1.00		
ECA								
Diesel Price Gap$_t$	**Diesel Price Gap$_{t-1}$**	**Diesel Price Gap$_{t-2}$**	**Diesel Price Gap$_t$**	**Diesel Price Gap$_{t-1}$**	**Diesel Price Gap$_{t-2}$**	**Diesel Price Gap$_t$**	**Diesel Price Gap$_{t-1}$**	**Diesel Price Gap$_{t-2}$**
-0.0568*** (0.00139)	-0.0053*** (0.00091)	**0.0109*** (0.00072)**	-0.0381*** (0.00681)	-0.0314*** (0.00463)	-0.0049*** (0.00222)	-0.0312*** (0.00162)	-0.0232*** (0.00210)	**0.0061*** (0.00096)**
AR(1) test[c]: z=-0.9002; Pr>z=0.3680			**AR(1) test[c]**: z=0.2246; Pr>z=0.8223			**AR(1) test[c]**: z=2.0839; Pr>z=0.0372		
AR(2) test[c]: z=-0.7057; Pr>z=0.4804			**AR(2) test[c]:** z=1.8578; Pr>z=0.0632			**AR(2) test[c]:** z=0.0589; Pr>z=0.9530		
Sargan test[d]: Pr > chi2 = 1.00			**Sargan test[d]**: Pr > chi2 = 1.00			**Sargan test[d]**: Pr > chi2 = 1.00		

[a] A positive price gap implies a tax on this fuel; a negative price gap implies a subsidy.

[b] Standard errors in parentheses.***Significant at 1% level;**significant at 5% level;*significant at 10% level

[c] These are the Arellano-Bond test for AR(1) and AR(2) in first differences. There, the corresponding null hypotheses (H_0) are respectively:

- There is no first-order serial correlation in residuals
- There is no second-order serial correlation in residuals

[d] With the Sargan statistics, one can test the null hypothesis of correct model specification and valid overidentifying restrictions

It should be noted that raising diesel taxes might reduce labor participation in the very short run (as subsidies are removed), including for youths aged 15 to 24 in the MENA countries. But as the entire economy adjusts and reallocates resources to less capital- and energy-intensive sectors in response to the new and higher energy prices, and with the help of better infrastructure and better supply of public services (which is what we find and present below), labor market participation and employment will increase in subsequent years. For example, a *20 cents increase in the diesel retail price* for two consecutive periods is found to *increase employment as a*

[10] Not significant, statistically and numerically, effects were found when considering gasoline subsidies.

percentage of working population above 15 years old by 2.2%; and youth labor force participation as a percentage also of working population above 15 years old by 0.86%.

A report from the World Bank (2014) emphasizes that energy subsidies have encouraged energy-intensive production in the MENA countries, which also tends to be capital-intensive, and discourages employment. Thus, if the MENA countries substantially reduce their levels of energy subsidies, their levels of employment will increase, in particular among the young.

7. Will savings from reducing fuel subsidy expenditures be reallocated to productive public investments and thereby spur economic growth?

As Figure 3 above indicates, a disproportionate amount of resources is used to finance subsidies in the MENA Region relative to those used for public investment. It is of relevance to learn whether any savings from reduced fuel subsidies, made by the MENA countries, have been (and would likely be) redirected toward more productive public investment.

Due to limited data availability, we only consider health expenditures and public education expenditures as a percentage of GDP; the number of students enrolled in tertiary education as a proportion of the population of the same age group (that officially corresponds to the level of education); infrastructure expenditures relative to GDP; and the percentages of the rural population that have access to water, and sanitation, respectively. We estimate the following relationship:

$$(X)_{it} = a + b_1(price\ gap)_{it} + b_2(price\ gap)_{it-1} + b_3(price\ gap)_{it-2} + \tau_t + c_i + \xi_{it} \qquad (2)$$

X_{it} is a matrix containing variables related to *Education, Health,* or *Infrastructure* for each country at time t. The other explanatory variables have been defined above. ξ_{it} is the error term.

Much of the government savings due to reduced gasoline and diesel subsidies have been used to increase spending on health in the MENA countries. An increase in the price of diesel or gasoline by 20 cents per liter for two consecutive years can lead to an increase in health expenditures by 0.24 percent of GDP. See Table 5.

It is however evident from Table 5 that subsidy savings have not been large enough to sustain higher health expenditures for long periods into the future. This is also confirmed by Figure 3. The governments might need other funding sources as well as longer-lasting reductions in fuel subsidies to sustain permanent increases in health expenditure. This is reasonable since adjustments in the personnel and infrastructure would need continuously more funding to have a positive and lasting impact on the health sector. For comparison purposes, we also present the empirical results for the ECA countries which indicate that these countries consistently use their fuel tax revenues to maintain higher health expenditures over longer periods of time.

Table 5. MENA and ECA Regions: Health Expenditures and Koplow's fuel price gap (US$ cents per liter)[a]. 1998 – 2012.[b] System GMM.

***Effect on Health Expenditures/GDP* (%)**		
MENA - Diesel		
Diesel Price Gap$_t$	**Diesel Price Gap$_{t-1}$**	**Diesel Price Gap$_{t-2}$**
0.00946* (0.00167)**	**0.00254* (0.00147)**	-0.00189 (0.00196)
AR(1) test[c]: z=-0.7538; Pr>z=0.4510; **AR(2) test**[c]: z=0.7794; Pr>z=0.4357 **Sargan test**[d]: Pr > chi2 = 1.00		
ECA - Diesel		
Diesel Price Gap$_t$	**Diesel Price Gap$_{t-1}$**	**Diesel Price Gap$_{t-2}$**
0.00898* (0.00152)**	**0.00737* (0.00460)**	**0.00460*** (0.00097)**
AR(1) test[c]: z=0.6709; Pr>z=0.5023; **AR(2) test**[c]: z=-0.0962; Pr>z=0.9234 **Sargan test**[d]: Pr > chi2 = 1.00		
MENA - Gasoline		
Gasoline Price Gap$_t$	**Gasoline Price Gap$_{t-1}$**	**Gasoline Price Gap$_{t-2}$**
0.00092 (0.00232)	**0.00968*** (0.00099)**	**0.00245** (0.00114)**
AR(1) test[c]: z=-0.6355; Pr>z=0.5251; **AR(2) test**[c]: z=-1.8511; Pr>z=0.0642 **Sargan test**[d]: Pr > chi2 = 1.00		
ECA - Gasoline		
Gasoline Price Gap$_t$	**Gasoline Price Gap$_{t-1}$**	**Gasoline Price Gap$_{t-2}$**
0.00627* (0.00043)**	**0.00615*** (0.00034)**	**0.00242** (0.00015)**
AR(1) test[c]: z=0.2794; Pr>z=0.7799; **AR(2) test**[c]: z=-0.5392; Pr>z=0.5897 **Sargan test**[d]: Pr > chi2 = 1.00		

[a] A positive price gap implies a tax on this fuel; a negative price gap implies a subsidy.

[b] Standard errors in parentheses. ***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level

[c] These are the Arellano-Bond test for AR(1) and AR(2) in first differences. There, the corresponding null hypotheses (H_0) are respectively:

- There is no first-order serial correlation in residuals
- There is no second-order serial correlation in residuals

[d] With the Sargan statistics, one can test the null hypothesis of correct model specification and valid overidentifying restrictions

Investments in infrastructure have been delayed from the time the governments obtain savings from reduced diesel subsidies. This can be seen in Table 6.[11] We find that in the MENA countries, it takes at least one year to observe a positive and statistically significant reallocation of subsidy savings toward infrastructure investments. This is much in contrast to the ECA countries, which seem to not only immediately redirect a larger proportion of their fuel taxes to infrastructure investments, but also allocate more permanent such taxes into future investments.

Table 6. MENA and ECA Regions: Infrastructure Investment and Koplow's diesel price gap (US$ cents per liter)[a]. 1998 – 2012[b]

Effect on Public Infrastructure/GDP			*Effect on % Rural Population with improved water access*			*Effect on % Rural Population with improved sanitation access*		
MENA								
Diesel Price Gap2$_t$	**Diesel Price Gap2$_{t-1}$**	**Diesel Price Gap2$_{t-2}$**	**Diesel Price Gap2$_t$**	**Diesel Price Gap2$_{t-1}$**	**Diesel Price Gap2$_{t-2}$**	**Diesel Price Gap2$_t$**	**Diesel Price Gap2$_{t-1}$**	**Diesel Price Gap2$_{t-2}$**
-0.0201** (0.00865)	**0.01602* (0.00919)**	-0.0595*** (0.00704)	**0.02748*** (0.00787)**	-0.01771 (0.01825)	-0.02402 (0.01609)	-0.0461*** (0.00565)	**0.01840*** (0.00356)**	-0.0867*** (0.0067)
AR(1) test[c]: z=-1.0994; Pr>z=0.2716			**AR(1) test**[c]: z=1.5031; Pr>z=0.1328			**AR(1) test**[c]: z=0.9885; Pr>z=0.3229		
AR(2) test[c]: z=-0.7954; Pr>z=0.4264			**AR(2) test**[c]: z=1.3522; Pr>z=0.1763			**AR(2) test**[c]: z=2.6115; Pr>z=0.009		
Sargan test[d]: Pr > chi2 = 1.00			**Sargan test**[d]: Pr > chi2 = 1.00			**Sargan test**[d]: H_0: Pr > chi2 = 1.00		
ECA								
Diesel Price Gap2$_t$	**Diesel Price Gap2$_{t-1}$**	**Diesel Price Gap2$_{t-2}$**	**Diesel Price Gap2$_t$**	**Diesel Price Gap2$_{t-1}$**	**Diesel Price Gap2$_{t-2}$**	**Diesel Price Gap2$_t$**	**Diesel Price Gap2$_{t-1}$**	**Diesel Price Gap2$_{t-2}$**
0.01307 (0.00624)**	-0.00295 (0.00569)	**0.01044*** (0.00375)**	**0.06947*** (0.01480)**	**0.03503*** (0.00478)**	**0.03777*** (0.00517)**	**0.06197*** (0.00316)**	**0.03019*** (0.00208)**	**0.01579*** (0.00286)**
AR(1) test[c]: z=-1.7701; Pr>z=0.0767			**AR(1) test**[c]: z=2.4226; Pr>z=0.0154			**AR(1) test**[c]: z=0.281; Pr>z=0.437		
AR(2) test[c]: z=-1.0064; Pr>z=0.3142			**AR(2) test**[c]: z=-2.4377; Pr>z=0.0148			**AR(2) test**[c]: z=0.519; Pr>z=0.6494		
Sargan test[d]: Pr > chi2 = 1.00			**Sargan test**[d]: Pr > chi2 = 1.00			**Sargan test**[d]: Pr > chi2 = 1.00		

[a] A positive price gap implies a tax on this fuel; a negative price gap implies a subsidy.

[b] Standard errors in parentheses. *** Significant at 1% level; ** significant at 5% level; *significant at 10% level

[c] These are the Arellano-Bond test for AR(1) and AR(2) in first differences. There, the corresponding null hypotheses (H_0) are respectively: i) There is no first-order serial correlation in residuals.
ii) There is no second-order serial correlation in residuals

[d] With the Sargan statistics, one can test the null hypothesis of correct model specification and valid overidentifying restrictions

Raising diesel taxes or eliminating diesel subsidies have improved access to water and sanitation among rural populations in the MENA countries.[12] Today's savings of about 20 cents

[11] The data on infrastructure comes from the IMF which was used in their World Economic Outlook (IMF (2014a)). The source for data on employment comes from the International Labor Organization while the data for Health Expenditures, Water and Sanitation Access comes from the World Development Indicators.

[12] We have also considered urban populations and the results are available upon request.

per liter on diesel subsidies can facilitate i) an immediate up-front investment which gives water access to an additional 0.55 percent of the rural population; and a year later ii) another 0.37 percent of the rural population gains access to sanitation facilities and iii) an increase in infrastructure spending by 0.32 percent of GDP.

Nevertheless, today's diesel subsidy savings are not enough to finance infrastructure spending beyond two years. See Table 6. The estimated coefficients, b_2 and/or b_3 in equation (2), are not significant and may even be negative. The MENA countries need to make any reductions in fuel subsidies substantial and permanent to obtain more steady revenues.

The countries in the ECA Region seem to have practices which contrast sharply with those of the MENA Region. They benefit more from their more persistent positive fuel taxes. These allow them to experience more long-term positive effects and boosting their aggregate demand through the short-run fiscal multiplier, crowding in private investment and benefitting from the highly complementary nature of infrastructure services.

Table 7 shows how *savings in diesel subsidies can be redirected toward education expenditures,* in the MENA and ECA countries.

For instance, in MENA countries, today's education spending will increase by around 0.27 percent of GDP if a government saves today 20 cents per liter in diesel subsidies. However, savings from reducing or eliminating fuel subsidies in a specific year t only serve to finance education expenditures the same concurrent year and not beyond that year. For the ECA countries by contrast, the same amount of forgone subsidies are used for at least three consecutive future years to finance public education.

With regard to enrollment in tertiary education, we see that this increases in response to higher fuel prices in countries of both regions. The enrollment increases by about 2.8 percent in response to a 20 cents increase in retail diesel price. Higher enrollment to acquire more education might aid individuals to i) increase their likelihood to participate in the labor force and be able to finance the new higher costs of fuel consumption; and/or ii) respond to a demand for specific skilled labor as their countries' production structure changes in response to reduced subsidies. Note also here the contrasting situation between the MENA and ECA countries.

Table 7. MENA and ECA Regions: Education Expenditures and Koplow's diesel price gap (US$ cents per liter)[a]. 1998 – 2012.[b] System GMM.

***Effect on Education Expenditures/GDP* (%)**			***Effect on Enrollment in Tertiary Education/Population of same age* (%)**		
MENA					
Diesel Price Gap2$_t$	**Diesel Price Gap2$_{t-1}$**	**Diesel Price Gap2$_{t-2}$**	**Diesel Price Gap2$_t$**	**Diesel Price Gap2$_{t-1}$**	**Diesel Price Gap2$_{t-2}$**
0.00957* (0.00244)**	-0.00279 (0.00242)	-0.00629*** (0.00282)	**0.05864*** (0.01219)**	**0.08343*** (0.01615)**	-0.11354 (0.01359)
AR(1) test[c]: z=0.90325; Pr>z=0.3664 **AR(2) test[c]**: z=0.4564; Pr>z=0.6481 **Sargan test[d]:** Pr > chi2 = 1.00			**AR(1) test[c]**: z=0.652; Pr>z=0.4241 **AR(2) test[c]**: z=0.581; Pr>z=0.6624 **Sargan test[d]:** Pr > chi2 = 1.00		
ECA					
Diesel Price Gap2$_t$	**Diesel Price Gap2$_{t-1}$**	**Diesel Price Gap2$_{t-2}$**	**Diesel Price Gap2$_t$**	**Diesel Price Gap2$_{t-1}$**	**Diesel Price Gap2$_{t-2}$**
0.00681* (0.00272)**	**0.01089*** (0.00318)**	**0.01365*** (0.00212)**	**0.10415*** (0.00975)**	**0.09673*** (0.00973)**	**0.09409*** (0.00958)**
AR(1) test[c]: z=-0.535; Pr>z=0.651 **AR(2) test[c]**: z=-1.3511; Pr>z=0.342 **Sargan test[d]**: Pr > chi2 = 1.00			**AR(1) test[c]**: z=-0.3823; Pr>z=0.2531 **AR(2) test[c]**: z=-1.011; Pr>z=0.2542 **Sargan test[d]**: Pr > chi2 = 1.00		

[a] A positive price gap implies a tax on this fuel; a negative price gap implies a subsidy.

[b] Standard errors in parentheses. ***Significant at 1% level; **significant at 5% level; *significant at 10% level

[c] These are the Arellano-Bond test for AR(1) and AR(2) in first differences. There, the corresponding null hypotheses (H_0) are respectively:

- There is no first-order serial correlation in residuals
- There is no second-order serial correlation in residuals

[d] With the Sargan statistics, one can test the null hypothesis of correct model specification and valid overidentifying restrictions

In the empirical work above, we demonstrated that i) a reduction in subsidies is likely to spur economic growth; and ii) especially in the MENA countries, a fraction of government savings from reducing energy subsidies is redirected toward public expenditures such as health, education and infrastructure. We find that there might be some costs of implementing fuel price reforms in countries like those in MENA. There could be reduced employment and GDP per capita immediately after the subsidies are reduced or eliminated. However, if the fuel price reform becomes permanent, the reformer country will experience in following periods (one year or two years later) a rise in its GDP and labor participation via a number of pathways stimulated by the positive effects that fuel price reform implies. An important policy application from this analysis is that resources that become freed up from subsidy reform can be used to finance public investments. Such reforms should however become permanent to sustain continuous investment in infrastructure. But more importantly, such investments can serve as the channels by which elimination of subsidies can potentially contribute to higher economic growth.

8. Conclusions

To fully understand why and how a country can gain from eliminating energy subsidies, it would require a comprehensive analysis involving various fields; not only economics, but also politics and life sciences, to mention just a few, and a good understanding of human behavior and the government's role in the lives of its citizens.

Our objective and approach have been more modest, and has aimed to focus on certain economic benefits of phasing out energy subsidies. This paper has specifically studied the relationships between fossil fuel subsidies and economic growth, and the channels by which removing fossil fuel subsidies or imposing fossil fuel taxes can spur growth.

At least three advantages of reducing or eliminating fossil fuel subsidies are here highlighted: i) it increases entrepreneurial activity and employment; ii) it leads to higher efficiency in the use of inputs of production; and iii) it provides governments with more revenues that can be spent on additional long-term public investments to enhance their countries' productivities. These indirect effects of an optimal energy pricing polity are shown to be the channels by which reduction in subsidies will have a positive on economic growth.

We empirically test our two main hypotheses. First, that a country that initially subsidizes its fossil fuels, and implements a reform to eliminate or reduce these subsidies, will experience higher GDP growth. Secondly, that there are diminishing returns in terms of growth if fuel prices rise too much, in particular when fossil energy taxes are increased in countries where such taxes are already too high. For such countries, further energy tax increases may lead to lower economic growth.

Our empirical results confirm these hypotheses, both from analyzing jointly all countries of all the World Bank regions (*cross-sectional and pooled cross-sectional analysis*); but also the countries individually for each World Bank region (*panel analysis*).

We find in fact that taxing fuels, or reducing fuel subsidies, will lead to higher rates of GDP per capita growth for countries with high initial fuel subsidies, such as most of the countries in the MENA region. These countries are thus the most likely candidates to reap economic gains by subsidizing these fossil fuels less and/or taxing them more; and to gain the most by growing at higher rates. On the other hand, countries which at the outset have relatively high taxes on their fuels, such as most of the ECA and OECD countries, have less to gain from further fuel price increases; growth rates might here in fact be reduced.

We analyze empirically the channels by which reduced energy subsidies, or positive and increased energy taxes, may increase economic growth. It is found that reducing fossil fuel subsidies at a given current period in the MENA countries increases both their current and future expenditures on health, education, public infrastructure investments, and also employment.

Note however that in the case of the MENA countries, savings from temporary reductions in energy subsidies might not sustain higher health, education and infrastructure expenditures for long periods into the future; more long-lasting reductions in fuel subsidies are necessary. In contrast, governments in the ECA countries can rely on their steady high fossil fuel taxes to sustain their high public goods expenditures over time.

Our final important empirical result is a significant positive effect of subsidy reductions on employment and labor force participation in the MENA countries. Such effects are particularly strong when diesel subsidies are phased out. We found that raising diesel taxes might reduce labor participation in the very short run (as subsidies are removed), including among youths aged 15 to 24 in these countries. But as the economies adjust and reallocate resources in response to the new and higher energy prices, and infrastructure and public services improved (which is what we find), labor market participation and employment increase substantially in subsequent years.

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APPENDIX A

Data sources. The data set is on annual basis and has been gathered by the Environment and Energy Team at the Development Research Group of the World Bank (DECEE), and also contains relevant and important political and economic variables for this study. The original sources for DECEE's data are:

GDP per capita growth	World Bank national accounts data, and OECD Accounts data files
GDP	World Bank national accounts data, and OECD Accounts data files
Gasoline and diesel prices	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), IMF, U.S. Energy Information Administration (EIA), International Energy Agency (IEA)
Employment	Penn World Tables 7.0 and World Bank Development Indicators
Population	Penn World Tables 7.0 and World Bank Development Indicators
Labor force participation	World Bank Development Indicators
Health expenditures	World Bank Development Indicators
Public Infrastructure	IMF
Rural population with improved water access	World Bank Development Indicators
Rural population with improved sanitation access	World Bank Development Indicators
Education expenditures	World Bank Development Indicators and IMF
Enrollment in tertiary education	World Bank Development Indicators

APPENDIX B.

Table B1. List of countries by World Bank Region

GDP per capita in 2010 USD (GDPpc); diesel price gap (dpg); gasoline price gap (gpg)

AFRICA (AFR)

Country	GDPpc	dpg	gpg
Angola	1884.57	-34.62	-16.94
Benin	535.39	16.10	0.26
Botswana	5460.94	10.19	13.16
Burkina Faso	402.96	35.24	53.18
Burundi	150.17	48.51	56.32
Cameroon	908.17	23.22	28.21
Cape Verde	2114.00	36.11	91.76
Central African R.	375.67	62.66	73.99
Chad	560.66	37.39	47.78
Congo (Brazzaville)	1716.79	2.55	28.48
Congo, D. R.	231.32	28.75	41.20
Eritrea	223.99	14.77	102.09
Ethiopia	176.50	-5.36	13.98
Gabon	6454.38	5.48	26.64
Gambia	437.39	28.50	36.61
Ghana	528.48	.97	6.52
Guinea	300.43	24.71	32.20
Ivory Coast	968.28	31.58	58.37
Kenya	535.48	25.17	40.74
Lesotho	739.95	17.25	19.85
Madagascar	277.66	27.85	52.76
Malawi	227.46	56.87	67.51
Mali	443.33	29.09	52.14
Mauritania	716.55	11.08	34.64
Mozambique	313.08	23.98	42.69
Namibia	3588.09	14.09	16.18
Niger	267.38	26.84	38.19
Nigeria	774.37	-3.47	-20.55
Rwanda	281.35	52.52	56.92
Senegal	751.88	36.33	56.49
Sierra Leone	325.40	22.56	25.41
South Africa	5203.75	17.34	23.96
Sudan	686.61	-27.24	-8.32
Swaziland	2318.77	22.49	23.87
Tanzania	377.63	33.31	39.90
Togo	396.64	21.59	26.81
Uganda	327.73	37.72	56.36
Zambia	645.58	56.76	71.22
Zimbabwe	512.35	27.79	45.20

EAST ASIAN PACIFIC (EAP)

Country	GDPpc	pgd	pgg
Brunei	25706.64	-44.46	-27.23
Cambodia	471.64	11.02	27.14
China, P.R.	1925.91	1.57	9.10
Fiji	3501.68	19.92	38.08
Indonesia	1315.82	-32.64	-15.69
Korea, S.	18582.99	42.72	77.79
Lao PDR	494.39	1.66	18.49
Malaysia	5545.86	-30.82	-17.58
Mongolia	1050.87	16.95	19.14
Philippines	1220.03	-3.47	11.13
Thailand	2674.06	-7.28	18.00
Vietnam	711.92	-10.52	3.01

EASTERN AND CENTRAL EUROPE (ECA) without OECD countries

Country	GDPpc	pgd	pgg
Albania	2870.58	38.58	66.00
Armenia	1565.52	7.94	23.08
Azerbaijan	1884.38	-29.05	-8.61
Belarus	3256.13	-0.76	15.69
Bosnia and Herzegovina	2812.52	47.04	52.52
Bulgaria	3680.18	41.07	46.85
Croatia	9678.3	53.38	66.57
Cyprus	22138.17	47.41	70.35
Georgia	1478.36	17.55	21.70
Kazakhstan	3671.41	-20.30	-5.72
Kosovo	2293.01	46.07	56.76
Latvia	6629.77	44.28	51.11
Liechtenstein	106731.2	70.97	66.35
Lithuania	7556.04	42.30	51.34
Macedonia	2959.18	35.51	57.70
Malta	15126.24	48.78	97.11
Montenegro	3873.11	45.43	59.54
Romania	4658.58	38.93	47.42
Russian F.	5250.44	-7.39	0.31
Serbia	3294.75	44.59	58.06
Tajikistan	333.69	2.32	11.49
Turkmenistan	1939.50	-55.34	-51.12
Ukraine	1716.53	10.12	17.53
Uzbekistan	584.33	-18.17	-2.86

Table B1 (continues …). List of countries by World Bank Region

GDP per capita in 2010 USD (GDPpc); diesel price gap (dpg); gasoline price gap (gpg)

LATIN AMERICA AND CARIBBEAN (LAC)				MIDDLE EAST AND NORTH AFRICA (MENA)			
Country	**GDPpc**	**dpg**	**gpg**	**Country**	**GDPpc**	**pgd**	**pgg**
Argentina	5428.47	5.32	22.94	Algeria	2884.06	-48.04	-32.00
Barbados	14118.62	24.08	44.03	Bahrain	17739.15	-47.67	-38.79
Bolivia	1059.20	-17.71	-0.62	Egypt	1305.95	-50.39	-32.35
Brazil	4893.55	7.35	4.46	Iran	2741.77	-59.95	-46.92
Chile	7627.37	10.86	37.67	Jordan	2359.11	-22.01	10.50
Colombia	3507.04	-5.44	0.22	Kuwait	1214.7	-45.85	-40.39
Costa Rica	4749.45	14.48	33.12	Lebanon	5890.33	-8.89	15.26
Cuba	3811.82	22.24	58.1	Libya	322.93	-53.10	-48.24
Dominican Republic				Morocco	1995.46	13.11	51.78
	3899.29	10.98	33.83	Oman	13034.22	-33.02	-31.25
Ecuador	3003.24	-39.61	-18.73	Qatar	55909.04	-49.31	-44.69
El Salvador	2788.76	6.27	16.05	Saudi Arabia			
Grenada	6084.12	16.87	28.26		14001.1	-56.71	-42.98
Guatemala	2183.71	2.03	14.46	Syria	1499.32	-39.09	4.62
Guyana	1119.88	0.58	11.91	Tunisia	3262.94	-9.82	14.41
Haiti	467.54	-1.43	27.88	United Arab Emirates			
Honduras	1392.46	7.47	22.57		37732.1	-18.13	-25.91
Jamaica	4189.65	9.33	16.05	Yemen	802.60	-45.99	-31.53
Mexico	7850.98	-8.30	5.04				
Nicaragua	1156.63	7.10	17.27				
Panama	5029.14	-4.95	0.63				
Paraguay	1560.93	7.53	29.65				
Peru	2856.47	18.51	41.76				
Suriname	3584.83	17.63	27.81				
Trinidad & Tobago							
	11931.39	-39.88	- 9.97				
Uruguay	5692.98	29.96	60.44				
Venezuela	5625.45	-62.32	-57.28				

APPENDIX C. The theoretical model

As a theoretical background to support our econometric work, we develop an endogenous growth model (building on and extending Romer (1986, 1990); Prescott and Boyd (1987); Lucas (1988); Bencivenga and Smith (1991); Bencivenga et al. (1995); Aghion et al. (2005)).

The economy studied in our model consists of a sequence of three-period-lived, overlapping generations (OLG). Each generation includes a continuum of agents. Time is indexed by t=0,1,2,…There is no population growth. By considering an OLG model, we avoid assuming a representative agent, and allow for economic interactions in which the decisions made by "younger" generations will affect the "older" generations. This approach also provides a tractable alternative to infinite-horizon representative agent models, and allow us to think of capital formation as taking place from one generation to the next.

Each young agent is endowed with a single unit of labor supplied inelastically in their first period. There are no labor endowments at ages 2 and 3. At t=0 there is an initial old generation, endowed with an initial per-firm capital of k_0 units, and an initial "middle-aged" generation, which is endowed with an initial per-firm capital stock of k_1 units. In the subsequent periods, only entrepreneurs own capital. Capital depreciates completely after use.[13] The economy has a single consumption good, a single capital good, k_t, and has abundant fossil fuel resources that are used to generate energy.

Our economy is characterized by the following sequence of events involving the government and private agents:

i) Each young agent is born with the need to consume a fixed *percentage*, ε_t, of their labor income in energy consumption.[14] The young agent's *amount* of consumption of energy is however influenced, not only by ε_t, but also by his/her real wage (w_t), the level of energy tax (τ_t) or subsidy ($-\tau_t$) rates determined by their government, the international energy prices (P_t), and the domestic energy prices which is equal to $(1+\tau_t)P_t$. They also face an income tax rate, T. The domestic and international energy prices are taken as given by

[13] Thus, capital totally depreciates at the end of the life of the old generation.
[14] This implies that the income elasticity are equal to one.

everyone. The young's amount of energy consumption is denoted by e_t (ε_t, w_t, τ_t, T, P_t). Note that in contrast to income taxes, the main objective of taxing energy consumption is to reduce such consumption and consequently the externalities and distortions it creates.

ii) Young agents only care to consume energy. Immediately after paying (income and energy) taxes, individuals save what is left. If they become entrepreneurs, they can "rent" their savings to obtain a return in terms of the capital good, *R*, if savings are not withdrawn prematurely. These savings are essential to entrepreneurs because they will use this capital together with labor provided by the young generation of workers, and benefit from government's long-term investments in R&D and infrastructure when producing the single consumption good.

iii) The government allocates a certain proportion ($1 – n_t$) of energy taxes (and income taxes) received from the young at time t to short-term investments, and another proportion (n_t) to long-term investments.[15] The short-term investment (e.g. savings, mutual funds) allow the government to pay to (middle-age) agents who do not become entrepreneurs (at t+1) a return $r_{1t}(n_t)$ in terms of the consumption good. At that point, the investment that is not consumed is liquidated. The government's long-run investments which are made until time t+2, will yield a return $r_{2t}(n_t)$ in terms of R&D. If the long-run investment is liquidated before t+2, its "scrap value" will be zero. Thus, the returns depend on the government portfolio of investment, n_t.

iv) The government, subject to the law of large numbers, assesses how many become entrepreneurs and how many will not.

Including the group of middle-aged individuals is important for understanding how high energy subsidies could incentivize a large fraction of the population into not becoming entrepreneurs, and thus not contributing to productive economic activity.

The main problem of the government is here to maximize the expected utility of the representative young agents at time t, while anticipating that some but not all middle-aged agents

[15] The government will have fewer resources if it instead applies subsidies ($-\tau_t$)

will become entrepreneurs, and determine the optimal allocation of its resources into long-run infrastructure investments.

The most important economic relations in this model are presented below. Recalling that agents do not obtain any utility from the consumption good when they are young (at age-1), we define the following CRRA utility function for all young agents:

$$u(c_1, c_2, c_3; \varphi) = -\frac{(c_2 + \varphi c_3)^{-\gamma}}{\gamma}; \tag{1}$$

where c_i is the amount of the *consumption good at age i*; γ>-1, and φ is an individual-specific random variable (shock) that is realized at the beginning of the agents' age-2, and *determines the agents' time consumption preferences* subject to the following probability distribution:

$$\varphi = \begin{cases} 0 \ \textit{with probability} \ 1-\pi \\ 1 \ \textit{with probability} \ \pi \end{cases} . \tag{2}$$

The realization of the shock φ triggers a proportion (1 - π) of the individuals to prefer not to be entrepreneurs and only consume during age-2 (i.e. φ = 0); while a fraction π of them will only obtain utility by postponing consumption until age-3 (i.e. φ = 1) and become instead entrepreneurs.

The government's energy policy as explained below, together with the occurrence of the exogenous shock φ at the beginning of the second period of the agents' life, determine the proportion of agents that will become entrepreneurs at age-3. These agents will forgo consumption of the only good in the economy at age-2.[16] The rest of the agents *only* consume until the end of their middle age, and play no role in the economy thereafter since they neither produce nor work.

Energy subsidies induce suboptimal allocation of production inputs, and affect consequently cause affect entrepreneurs' efficiency. The factor A_t will here measure the degree of inefficiency and enters in the entrepreneurs' production function. A_t depends on the level of energy tax (subsidy) rates τ ($-\tau$). An entrepreneur who employs L_t units of labor at t, paying each a real wage w_t, produces the consumption good according to the following production function:

$$y_t = A_t \bar{k}_t^{\delta} k_t^{\theta} L_t^{1-\theta}; \text{ where} \tag{3}$$

[16] This assumption is not crucial for the results and conclusions of the model.

$$A_t = A(\tau); \quad where \ \frac{\partial A}{\partial \tau} > 0;$$

and $\bar{k}$ is the "average resources" (capital input, infrastructure and R&D) available to each entrepreneur. Thus, the smaller the energy taxes (or higher subsidies) the smaller the productivity and allocative efficiency A_t. $\theta \in (0,1)$, $\delta = 1 - \theta$. (δ is distinguished from $1 - \theta$ to represent an "external effect".)

Assuming the production function (3), and taking as given the real wage rate, the demand for labor that maximizes the representative entrepreneur's profits will be:

$$L_t = k_t \left[\frac{(1-\theta) A(\tau_t) \bar{k}_t^{\delta}}{w_t} \right]^{1/\theta}. \tag{4}$$

In (4), low levels of A_t reduce employment. Thus, energy subsidies discourage employment creation. This result predicts the current situation in countries of the (MENA) region which experience high levels of unemployment.

Since there is no population growth and the probability of becoming an entrepreneur is π, labor market equilibrium is achieved when $L_t = 1/\pi$.[17] Averaging (4) across firms and equating the result to $1/\pi$, we find that the equilibrium real wage at t is:

$$w_t = A(\tau_t) \bar{k}_t (1-\theta) \pi^{\theta}. \tag{5}$$

The level of profits per entrepreneur, Φ, after using (3), (4) and (5), will be:[18]

$$\Phi_t = \theta A(\tau_t) \bar{k}_t^{\delta} k_t^{\theta} L_t^{1-\theta} = \theta \psi A(\tau_t) k_t; \quad \text{where } \psi = \pi^{\theta-1}. \tag{6}$$

We can subsequently show that there are significant spillovers (e.g. on employment, wages and profits) from high energy subsidies to the economy.

The problem of the government is to choose the optimal amount of short- and long-run investment, $(1 - n_t)$ and n_t, respectively, in order to maximize the expected utility of the representative young agent. Such investment allocation will necessarily influence the levels of r_{1t} and r_{2t}. Taking into account the law of large numbers, the government will maximize:

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[17] The ratio of the number of workers to the number of entrepreneurs is always ($1/\pi$) to one.

[18] Since the marginal value of the working capital is $\theta A(\tau_t) \bar{k}_t k^{\theta-1} L^{1-\theta}$,

$$EU = -\left(\frac{1-\pi}{\gamma}\right)\left[\underbrace{(1-T)(1-\varepsilon(1+\tau_t))w_t}_{savings} + \underbrace{r_{1t}(n_t)\underbrace{(Tw_t + \tau_t\left(1-T\right)w_t\varepsilon)}_{taxes}}_{returns\ in\ terms\ of\ consumption\ goods}\right]^{-\gamma} -$$

$$\left(\frac{\pi}{\gamma}\right)\left[\underbrace{\theta\psi A(\tau_t)\{\underbrace{(1-T)(1-\varepsilon(1+\tau_t))w_t R}_{returns\ to\ savings\ in\ terms\ of\ capital\ goods=k_{t+2}}\}}_{profits} + \underbrace{r_{2t}(n_t)(Tw_t + \tau_t(1-T)w_t\varepsilon)}_{returns\ to\ taxes\ in\ terms\ of\ Infrastructure}\right]^{-\gamma}. \tag{7}$$

The expression (7) follows from the fact that at t, all young agents (of age-1) pay taxes on their incomes and energy consumption. Also, a fraction *1-π* of agents (of age-2) are expected to only consume at age-2 an amount $(1-T)(1-\varepsilon_t(\tau_t)(1+\tau_t))w_t + r_{1t}(Tw_t + \tau(1-T)w_t\varepsilon_t)$ of the consumption goods (i.e. $\varphi = 0$). A fraction π are however expected to become entrepreneurs, and forgo consumption until they are of age-3, i.e. $\varphi = 1$. These entrepreneurs will consume i) their profits equal to $\theta\psi A(\tau_t)k_{t+2}$ (see equation (6)), derived from their returns on their savings in terms of capital; plus ii) their returns on their income and energy taxes equal to $r_{2t}(Tw_t + \tau(1-T)w_t\, \varepsilon_t)$ in terms of infrastructure and R&D.

Equilibrium conditions

In equilibrium we have:

$$\overline{k}_{t+2} = (1-T)(1-\varepsilon_t(1+\tau_t))w_t R_t + r_{2t}(n_t)(Tw_t + \tau_t(1-T)w_t\varepsilon_t). \tag{8}$$

Equation (8) indicates that at equilibrium the total capital (capital investment, infrastructure and R&D) at t+2, $\overline{k}_{t+2}$, depends on how much of each unit of tax the government allocates into investments in infrastructure and public goods (n_t); the returns r_{1t} and r_{2t} which also depend on n_t, (as indicated above); the probability that individuals could become entrepreneurs, π; the income tax rate T_t; the energy tax rate τ_t; the fraction of the real labor income allocated to energy consumption, ε; the output elasticity of capital, θ; real wages (w_t); and the return to entrepreneurs' private savings, R_t. Particularly, note that at t+2, $\overline{k}_{t+2}$ depends on variables determined at t, which means that capital formation takes place over two generations.

Inserting from (5) into (8) and dividing by $\overline{k}_t$ yields:

$$\frac{\bar{k}_{t+2}}{\bar{k}_t} = (1-\theta)\pi^{\theta} A(\tau_t)\left[\underbrace{(1-T)(1-\varepsilon_t(1+\tau_t))R}_{Savings} + r_{2t}(n_t)\underbrace{(T+\tau_t(1-T)\varepsilon_t}_{Taxes}\right] = 1 + g_{t+2}. \qquad (9)$$

Equation (9) gives the *equilibrium output growth rate,* because there is no population growth and the *equilibrium output per firm* at time t equals $\bar{k}_t^{(\delta-(1-\theta))/\theta} k_t \psi$, after considering the production function (equation (3)), and the optimal level of employment (equation (4)) and real wage (equation (5)).

In equation (9), g_{t+2} is the rate of output growth rate between t and t+2. If ($1+g_{t+2}$) is *greater than one*, the economy is experiencing *positive growth* (i.e. g_{t+2} *is positive*). If ($1+g_{t+2}$) is *less than one,* this economy is facing negative growth (i.e. g_{t+2} *is negative*). Equation (9) points to the following Results:

Result 1. Keeping everything unchanged, the larger the energy subsidy (i.e. more negative τ) or the lower the energy tax, the lower $A(\tau_t)$, and the smaller the economic growth (lower $\bar{k}_{t+2} / \bar{k}_t$ = ($1+g_{t+2}$)).

Thus, the government should reduce energy subsidies to avoid the negative effects on allocative efficiencies.

Result 2. Ceteris paribus, the impact on economic growth from carrying out energy pricing reforms will depend on the existing levels of energy taxes or subsidies. One outcome involves higher economic growth (high $\bar{k}_{t+2} / \bar{k}_t$ (= ($1+g_{t+2}$)>1)) in response to reduction in energy subsidies given that the economy has *presently* high energy subsidies. In such as case, tax revenues, (T + (τ_t(1–T)ε_t), surge[19]. A second outcome follows when energy taxes are *already* high, in which case, setting these taxes even higher can cause a significant decline in *savings* ($1-T$)($1-\varepsilon_t(1+\tau_t)$). A relative insufficient private savings could result in lower economic growth ($\bar{k}_{t+2} / \bar{k}_t$ is still greater than 1 but relatively lower because g_{t+2} is lower).[20] This second result indicates that there are

[19] τ becomes less negative.

[20] A reduction in subsidies, when a country is currently implementing subsidies, will also reduce savings. However, since τ is negative when there are subsidies and positive when there are taxes, the negative impact on savings will be

diminishing returns, in terms of economic growth, to higher energy taxes when these are already high at the outset.

The main conclusions are *first*, the strongest positive effects on economic growth in response to energy price reform can be expected in countries with high initial energy subsidies. Too high levels of energy taxes will however lead to suboptimal levels of private savings which entrepreneurs need to make their investments in capital goods, and consequently lower economic growth. *Second*, removing energy subsidies will enhance allocative efficiency in the use of the inputs of production, to subsequently generate positive spillovers to the economy such as higher employment, productivity and profits. *Third*, it is crucial that the government invests its reserves from fuel subsidy reductions or tax increases, in high-return long-run investments such as infrastructure and R&D in order to increase the economy's productive capacity and give private agents the adequate incentives to engage in entrepreneurial activities.

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significantly smaller when reducing subsidies (in an economy that is currently subsidizing) than when increasing taxes (in an economy that is currently taxing) because of the factor $(1+\tau)$ entering in the savings expression.