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The Long-run Macroeconomic Impacts of Fuel Subsidies

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Abstract

Many developing and emerging market countries have subsidies on fuel products. Using a small open economy model with a non-traded sector I show how these subsidies impact the steady state levels of macroeconomic aggregates such as consumption, labor supply, and aggregate welfare. These subsidies can lead to crowding out of non-oil consumption, inefficient inter-sectoral allocations of labor, and other distortions in macroeconomic variables. Across steady states aggregate welfare is reduced by these subsidies. This result holds for a country with no oil production and for a net exporter of oil. The distortions in relative prices introduced by the subsidy create most of the welfare losses. How the subsidy is financed is of secondary importance. Aggregate welfare is significantly higher if the subsidies are replaced by lump-sum transfers of equal value.

Keywords: oil, fuel-price subsidies, developing countries, fiscal policy
JEL Classifications: Q43, E62, H30, O23

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1 Introduction

Subsidies on petroleum products are an important policy issue for many developing and emerging market economies. One reason is the sheer cost these subsidies impose on the governments that provide them. Data from the International Energy Agency (IEA) and the International Monetary Fund (IMF) provide many examples for net oil importing countries where the subsidies are on the order of 1 to 2 percent of GDP, sometimes higher. For net oil exporting countries the subsidies are often larger. Despite their costs, these subsidies are difficult to remove once in place and attempts to remove them, even partially, have often failed. This has been true even with the significant increase in oil prices seen over the last decade.[1]

Given their cost and persistence, it seems probable that these subsidies have important macroeconomic implications. This paper asks three interrelated questions in regards to this. First, how do these subsides affect macroeconomic variables and aggregate welfare in the long-run? Second, what role does the method of financing the subsidy play in those results? Finally, does the distinction between being a net importer or exporter of oil matter?

To answer to these questions I construct a small open economy model with traded and non-traded sectors where households and firms use oil. The government subsidizes oil by selling it below its world price. The subsidy considered in this paper is a permanent (long-run) feature of the economy. As such it distorts the steady state and imposes a permanent financing constraint on the government.[2]

Two variants of the model are considered. The first is an economy that has no domestic production of oil. This variant is referred to as the net oil importing model. In this model the government finances the subsidy through one of three tax instruments: a non-distorting lump-sum tax, a tax on labor income, or a tax on non-oil consumption. In the second variant, the net oil exporting model, the government has an endowment of oil that is greater than domestic consumption of oil. In this case the government provides the subsidy by simply selling part of its oil endowment below the world price of oil.

[1] For more evidence please see Baig et al. (2007) and Coady et al. (2010).

[2] Some governments do not distort domestic fuel prices in the long-run but do smooth them out in the short-run by temporarily limiting the pass-through of a change in world prices. Chile is one such example. Considering these policies requires looking at short-run dynamics and working with second-order approximations to the model. Given the different nature of such short-run subsidies, this is left for future research.

For the net oil importer case the results show that the subsidy reduces aggregate welfare across steady states.[3] For a subsidy that costs 1 percent of GDP the welfare losses are relatively minor but these costs increase substantially for larger subsidies. Surprisingly, the method used to finance the subsidy has relatively little impact on this result. The distortion in relative prices introduced by the subsidy is responsible for the bulk of the welfare losses. This is confirmed by considering the losses that would occur if the government simply removed the subsidy and offset it with lump sum transfers of equal value. Aggregate welfare losses are about 20 times lower under this policy than the one with the subsidy.

In the net oil exporter case the government does not need to rely on an explicit tax to finance the subsidy. Surprisingly, the different financing method available to net exporters does not significantly alter the aggregate welfare results. This is due to the fact that the distortion in relative prices is the main reason that aggregate welfare is lower. That feature of the subsidy is exactly the same whether the country is a net oil exporter or importer.

Underlying the welfare results are the actual changes in macroeconomic variables that occur because of the subsidy. Regardless of how the subsidy is financed, it leads households and firms to over-consume oil products, drives up wages in the economy, and increases production in the traded sector. The subsidy also distorts the relative price of non-tradables to tradeable goods.

The change in other macroeconomic variables, such as non-oil consumption, production in the non-traded sector, and labor supply depends upon the tax instrument used to finance the subsidy. Essentially, households pay for the higher taxes required to finance the subsidy through some combination of lower non-oil consumption and higher hours worked. The exact breakdown depends upon which tax instrument is used because they distort household behavior in different ways. Using labor or consumption taxes to finance the subsidy usually leads to a crowding out of non-oil consumption. This in turn lowers production in the non-traded sector and leads to an inefficient allocation of labor across sectors as labor flows out of the non-traded sector into the traded sector. All of these are important effects of a fuel subsidy typically not discussed by policy makers when considering the pros and cons of the subsidy.

There is a large literature that focuses on oil and the macroeconomy. To my knowledge this is the first paper in that literature that looks at the

[3] Note these results do not provide any answers about how different groups within the economy are impacted, only how the economy as a whole is. It is quite possible that different groups may have higher or lower welfare depending upon how much of the subsidy they receive and how much of the tax burden they bear, amongst other things.

long-run macroeconomic impacts of fuel subsidies and the fiscal policy issues associated with them.[4] Several IMF working papers, such as Coady et al. (2006) and Kpodar (2006), have considered the distributional impacts of removing fuel subsidies on household expenditure by using social accounting matrix and input-output models. However, those models generally abstract from the fiscal policy aspect of the subsidy. As a consequence, removing a subsidy is unambiguously "bad" in those models because it means higher prices for all households. My model, which incorporates fiscal policy and general equilibrium effects, suggests things may be more complicated. While removing the subsidy forces households to pay higher fuel prices it also implies lower taxes and reduced deadweight losses in the economy.

A related literature focuses on monetary policy responses to changes in the price of food, another good often subsidized in developing countries. For example, Catao and Chang (2010) explore the role food prices play in determining what price index a central bank should stabilize in a small open economy. Anand and Prasad (2010) consider a similar question in a two sector New Keynesian model where there is a flexible price "food" sector and a "non-food" sector which has sticky prices. Agents who work in the food sector are unable to smooth consumption over time due to a credit constraint. Both of these show that under certain conditions a central bank may want to stabilize headline inflation as opposed to the usual result of stabilizing sticky-price inflation. Neither paper incorporates subsidies into their models.

The rest of the paper proceeds as follows. In the second section I motivate the paper by presenting some data on fuel subsidies. The third section introduces the model economy for the net oil importer case. The results for this case are presented in the fourth section. The fifth section presents results for the net oil exporter case. Section six shows results for sensitivity analysis. Section seven concludes.

2 Empirical Motivation

This section presents some evidence on the prevalence and size of fuel subsidies, and energy subsidies more generally, between the years of 2000 to

[4] Aissa and Rebei (2012) considered optimal monetary policy in a two sector, closed economy New Keynesian model where the government stabilizes the price of one of the goods in the short-run. However, the subsidy in Aissa and Rebei (2012) is a short-run phenomenon only and their analysis focuses on monetary policy, not fiscal policy.

2012.[5] The main source of data on these subsidies comes from the IEA, the IMF, and several other international agencies. For this reason, I first discuss how these agencies define and measure energy subsidies. I then document some features of the data available from them and conclude by giving more detail on the specifics of energy subsidies in three countries.

2.1 Defining Subsidies

The IEA focuses on subsidies that lower the price consumers pay for oil products, natural gas, coal, or electricity generated with one of those fuels.[6] These subsidies tend to be the easiest to quantify and in terms of their size appear to be the most important for the time frame being considered. The working definitions of other institutions, such as the IMF, appear to be quite similar in practice so they are not discussed explicitly.

To identify and quantity the size of these subsidies the IEA follows Larsen and Shah (1992) and uses the price-gap approach. In this approach subsidies are measured by calculating the gap between a domestic retail price and a reference price which attempts to measure the true economic cost of the product being subsidized.

Estimates of subsidies calculated using the price-gap approach can reflect both opportunity costs and explicit costs. For a country with no oil production the subsidy is an explicit cost, one typically paid for by the government. For a net oil exporter the subsidy is typically an opportunity cost because in many cases the government simply sells domestically produced oil below its world price. The estimate then simply reflects the foregone revenue from not selling the oil at its economic cost. For a net oil importer with some domestic production the estimate is both an explicit cost and an opportunity cost.

2.2 IEA Data on Fuel Subsidies

Currently the most comprehensive, publicly available data set on energy subsidies is from the IEA. These are annual estimates, in billions of dollars, on the size of consumer subsidies on oil products, natural gas, coal, and electricity generated using fossil fuels in a total of 37 countries. The data begin in 2007 and end in 2011. Here I touch upon some of the more relevant

[5]Data on fuel subsidies in the 1980s and 1990s was sparser. For that reason this section focuses on the time frame mentioned.

[6]For the exact definition please refer to IEA (2010) or IEA (2011).

features of the data for this paper. Those interested in more detail should refer to IEA (2010) or IEA (2011).

For the five years considered, the total value of all energy subsidies across all 37 countries was $342B, $555B, $311B, $412B and $523B, respectively. Changes in any given year were to a large extent driven by changes in the price of oil. Subsidies on oil products made up the largest share of the total, on average a little under 50 percent. Out of the 37 countries identified as having a subsidy, 34 had subsidies on oil products, of which 21 were net oil exporters and 13 were net oil importers.[7]

One way to rank which country has large subsidies is by considering the dollar value of the subsidies in place. If one ranks countries by this metric then the biggest subsidizers are generally either net oil importers which have large populations, such as China or India, or important net oil exporters such as Iran or Saudi Arabia. For illustrative purposes the top panel in table 1 ranks the top five net oil importing and exporting countries using the 2011 data as an example.

For the issues considered in this paper a better measure to consider is the size of the subsidies in relation to an economy's GDP. This provides some information on how much of a cost the subsidies impose on the government and the economy in question. The bottom panel of table 1 reconsiders the top five net oil importers and exporters according to this metric using the 2011 data. While absolute size of the subsidy does sometimes predict a large subsidy in relation to the domestic economy, this is not always the case. For example, China's fuel subsidies were huge in dollar terms but in relation to its economy they were fairly small, coming in at a quarter of a percent of GDP. On the other hand, Sri Lanka's subsidies were fairly small in dollar terms, less than a billion dollars, but relatively large in terms of the economy.

Measuring subsidies in relation to a country's GDP highlights an important dichotomy between many net oil exporters and importers. Figure 1 shows this graphically by plotting a histogram with countries categorized by their subsidy-GDP ratio. The data from 2011 is used as an example. For net oil importers every country was between 0 and 2 percent of GDP, except for Egypt. For net oil exporters there was a cluster of countries between 0 and 3 percent of GDP. But there was also an additional cluster of 6 countries which had subsidies between 5 to 9 percent of GDP, as well as an outlier

[7] Countries are defined as net oil exporters or net oil importers using data on annual oil supply and consumption from the Energy Information Administration (EIA) International Energy Statistics.

with subsidies well over 10 percent of GDP. The cluster of 6 countries were all OPEC countries, while the outlier was Iraq.

There are two reasons behind this tendency for subsidies to be larger in net oil exporting countries. First, many net oil exporters tend to subsidize a wider range of products than net oil importers. In many cases all domestically consumed products are subsidized. Holding all else equal, this enlarges the base being subsidized and increases the cost of the subsidy. A second factor is that net oil exporters often have significantly lower retail prices compared to net oil importing countries with subsidies. Taken together these two factors tend to increase the size of the subsidies found in net oil exporters.

For illustrative purposes table 1 and figure 1 used the data from 2011. For those interested in other years or other countries, the data for all 34 countries and 5 years can be found in a table C-4 in the appendix.

2.3 Considering Natural Gas and Electricity Subsidies

While attention often falls on fuel subsidies, both natural gas and electricity subsidies are also important in size. According to the IEA data, subsidies on electricity produced using fossil fuels and subsidies on natural gas averaged close to 27 percent and 23 percent of the total share, respectively, over the 5 years considered.[8] Natural gas subsidies were identified in 9 countries which were net importers of natural gas and 10 which were net exporters of natural gas. A total of 34 countries were identified as having electricity subsidies.

From an individual country's perspective, natural gas subsidies could often be modeled in a similar fashion to fuel subsidies. For example, consider the case of a net importer of natural gas with a subsidy. The government purchases natural gas at a price determined in a market (often linked to oil prices), sells it below cost, and must finance this through some form of taxation. If the country is a net exporter of natural gas then the government can finance the subsidy by selling domestically produced natural gas below its market price, in which case the subsidy is an opportunity cost.

In many cases electricity subsidies can also be treated in a similar manner. While electricity itself is often not traded between countries, it is in many cases generated using imported inputs such as oil products and natural gas. In this case an electricity subsidy is basically an indirect subsidy on the consumption of the imported fuel. For a net importer of the input, the end result is essentially the same for the government in question, and

[8] Consumer subsidies on coal were negligible in size and are henceforth ignored.

likewise for the government of a net exporting country.

In what follows, I continue to refer generically to fuel subsidies. However, in many cases this could be interchanged with natural gas subsidies or electricity subsidies and the general results should carry over for those cases. Two examples are provided in section 2.5 which highlight the similarities between the different types of subsidies.

2.4 Additional Sources of Data

Additional sources allow one to expand the IEA data by including more countries and considering years prior to 2007. For some countries, additional data on the costs of their subsidies is also available. Using the larger set of sources, I identified another 21 countries that had a fuel subsidy at some point in time between 2000 to 2012.[9] For subsidies on electricity produced using fossil fuels an additional 15 countries were identified. No other countries were found to have natural gas subsidies besides those listed in the IEA data.

Unfortunately, it is not possible to expand the quantitative data from the IEA for all of the additional countries or years. There are some countries with fairly detailed data on the costs of the subsidies, but in many cases the source documents mention the existence of a subsidy but provide no data on its cost. Consequently, there are too many gaps to construct a comprehensive estimate of the costs across countries and across time. However, a table in the appendix shows the subsidy costs, as a share of GDP, for the countries and years in which that data was available.

2.5 Country Experiences

Indonesia, Ukraine, and Lebanon provide useful examples of how different types of energy subsidies operate and what their costs are to the governments that choose to put them in place. Indonesia subsidizes a wide range of oil products; Ukraine subsidizes household consumption of natural gas; Lebanon subsidizes electricity, almost all of which is produced using imported oil products.

[9] A list of these countries and the sources used to identify them can be found in the appendix.

Fuel Subsidies in Indonesia[10]

Indonesia has had experience with subsidies on oil products as both a net exporter and net importer of oil.[11] Indonesia's national oil company, Pertamina, is heavily involved in the production, importation, and distribution of oil products in the country. Domestic retail prices are set by the government on an ad hoc basis and subsidies have been in place since the late 1960s. The subsidies take the form of explicit underpricing of the products compared to their actual cost. Pertamina is compensated for this and the costs of the subsidy are reflected in the Indonesian budget.

Most products are currently subsidized, except for some premium grades of gasoline. Using IMF data it is possible to get estimates on the costs of these subsidies, as a percent of GDP, from 2000 to 2012. These are listed in the second column of table 2. The subsidies have been more than 1 percent of GDP each year, and in many cases well above that.

Electricity Subsidies in Lebanon[12]

Lebanon provides a very good example of a country with subsidies on electricity produced using an imported fossil fuel. On average, about 94 percent of its electricity was generated using imported oil products between 2000 - 2010.

The state-run electric utility company, Electricite du Liban, has received direct transfers from the government every year since 1984. These transfers are often used to cover the gap between the cost of the imported fuel and the revenues the company generates from underpriced electricity. Electricity tariffs have been frozen since 1996 and are priced for $21 a barrel oil, according to an estimate in IMF (2012).

Data from the World Bank and the IMF allow one to calculate the cost of the subsidy, as a percent of GDP, from 1984 up to 2012. The third column of table 2 shows how the costs have varied from 2000 until 2012. The subsidy cost about 1 percent of GDP in the early part of the decade, but since 2005 has been roughly 3 percent of GDP or higher. The 2011 and 2012 estimates from the IMF come in at 4.5 percent of GDP. Projections up until 2016 currently put the cost over 4 percent of GDP each year.

Natural Gas Subsidies in Ukraine[13]

Ukraine is a net importer of natural gas with some domestic production. A state-owned company, Naftogaz, is heavily involved in the production,

[10] Sources: EIA (2011), EIA (2012), Clements et al. (2003), IISD (2012a), IISD (2012b) OECD (2010).

[11] Indonesia became a net importer of oil and oil products in 2004.

[12] Sources: EIA (2012), IMF (2012), World Bank (2008).

[13] Sources: EIA (2012), IEA (2012), Mitra and Atoyan (2012), Petri et al. (2002).

importation, and distribution of natural gas in the country. The gas is consumed by both industry and households and is also used to generate electricity. Household consumption of natural gas is heavily subsidized, with tariffs well below import cost. Industry usage is not subsidized and firms pay a price that reflects import costs.

Measuring the cost of natural gas subsidies in Ukraine is difficult as Naftogaz's activities are quasi-fiscal in nature and the cost of the subsidies has not always been fully reflected in the government's budget. However, the IEA dataset provides a dollar amount for these subsidies for the years from 2007 to 2011. For these five years the subsidies totaled \$4.8B, \$8.3B, \$5.3B, \$5.2B, and \$6.7B, respectively. As a share of GDP this translates to 3.4 percent, 4.6 percent, 4.5 percent, 3.8 percent, and 4 percent.

3 The Model for the Net Oil Importer

I consider a small open economy that produces a composite traded good and a non-traded good. Both goods are produced using labor and oil and one sector may be more or less oil-intensive than the other. The traded good is the numeraire and for convenience its price is fixed at unity. The traded good is either consumed by households or used to purchase oil from the rest of the world. The economy is small in that it has no effect on the world price of the traded good or the world price of oil.

The notation used in the exposition is as follows. The time derivative of the variable X is $\dot{X}$, $\bar{X}$ is the steady state value of X, and $\hat{X}$ is the log-differential of X, i.e. $\hat{X} = dX/X$.

3.1 Households

Household activity is controlled by an infinitely-lived representative agent who derives disutility from working and utility from the consumption of traded and non-traded goods, as well as fuel products.

Total labor supply is denoted as $L = L^T + L^n$ where L^T and L^n are labor supplied to the traded and non-traded sector, respectively. Consumption of the traded, non-traded, and oil goods are denoted as C^T, C^n, and O^h, respectively. The agent has access to a real domestic bond, denoted as b. The representative agent assumption implies this will be in net zero supply in equilibrium. Households do not have access to international capital markets.[14]

[14]Currency substitution is a feature of many of the countries that have fuel subsidies.

Preferences are given by

$$U = \int_0^\infty \left[\frac{C(C^T, C^n, O^h)^{1-\frac{1}{\tau}}}{1-\frac{1}{\tau}} - \kappa V(L) \right] e^{-\rho s} ds, \tag{1}$$

where

$$\begin{aligned} C(C^T, C^n, O^h) &= \left({C^T}^{\frac{\sigma_c - 1}{\sigma_c}} + a_1 {C^n}^{\frac{\sigma_c-1}{\sigma_c}} + a_2 {O^h}^{\frac{\sigma_c-1}{\sigma_c}} \right)^{\left(\frac{\sigma_c}{\sigma_c - 1}\right)}, \\ V(L) &= \frac{L^{1+\frac{1}{\mu}}}{1+\frac{1}{\mu}}. \end{aligned}$$

The parameter τ is the elasticity of intertemporal substitution; μ is the Frisch elasticity of labor supply; σ_c is the elasticity of substitution between the consumption goods, ρ is the time-preference rate; a_1, a_2, and κ are constants.

The agent maximizes equation(1) subject to the flow constraint

$$\dot{b} = (1-\tau^l) \left(W^n L^n + W^T L^T \right) + Tr + rb - (1+\tau^c) \left(C^T + P^n C^n \right) - P^s O^h - T. \tag{2}$$

Income from labor is given by $W^T L^T + W^n L^n$ where W^T and W^n are the wages in the traded and non-traded sectors. This income is taxed at a rate of τ^l. Interest income on savings is given by rb and will be zero in equilibrium. Lump-sum transfers from the government are given by Tr. Expenditure on non-oil consumption is given by $C^T + P^n C^n$ where P^n is the relative price of the non-traded good to the traded good. This consumption is taxed at a rate of τ^c. Lump-sum taxes are given by T. Expenditure on oil consumption is given by $P^s O^h$, where P^s is the subsidized price of fuel products. Denoting P^o as the world price of oil, the assumption is that $P^s \leq P^o$.

The first order conditions for the agent's problem can be written as[15]

$$\frac{U_n}{U_T} = P^n, \tag{3}$$

$$\frac{U_o}{U_T} = \frac{P^s}{1+\tau^c}, \tag{4}$$

$$\frac{\kappa V_l}{U_T} = \frac{1-\tau^l}{1+\tau^c} W^T, \tag{5}$$

To simplify the exposition I abstract from this possibility in the model. For some results with a model that incorporates this feature please see the previous version of this paper.

[15] Please see the appendix for the exact forms of the first order conditions

$$
\begin{aligned}
W^n &= W^T, \qquad (6)\\
\frac{\dot{\lambda}}{\lambda} &= \rho - r, \qquad (7)
\end{aligned}
$$

where λ is the multiplier on the flow constraint and U_n, U_T, and U_o are the derivatives of the utility function with respect to the non-traded, the traded, and the oil consumption good.

Equation (3) sets the marginal rate of substitution between traded and non-traded consumption goods equal to their relative price while equation (4) does the same for the oil consumption good. Equation (5) equates the marginal dis-utility of working an additional hour equal to the marginal benefit of doing so. Equation (6) states that wages are equivalent across the traded and non-traded sectors. This is because of the assumption that labor is mobile across sectors.

The subsidy directly distorts the first order conditions through the relative price term, P^s, in equation (4). There are additional distortions if consumption taxes or labor taxes are used to finance the subsidy, or if the subsidy impacts wages or the relative price of the non-traded good. All of these distortions will impact household consumption and labor supply decisions.

3.2 Production

Production in the two sectors is done by representative firms operating under perfect competition. The firms have a CES technology of the form

$$
Q^i(L^i, O^i) = \left[\left(A^i L^i\right)^{\frac{\sigma_i - 1}{\sigma_i}} + b^i \left(O^i\right)^{\frac{\sigma_i - 1}{\sigma_i}}\right]^{\frac{\sigma_i}{\sigma_i - 1}}, \qquad (8)
$$

where $i = T, n$ for the traded and non-traded sectors, A^i and b^i are constants, O^i is oil demanded by sector i, and σ_i is the elasticity of substitution between value-added (here labor) and oil.

The first order conditions for the firms are given by

$$
\begin{aligned}
Q_l^T &= W^T, \qquad (9)\\
Q_o^T &= P^s, \qquad (10)\\
Q_l^n &= \frac{W^n}{P^n}, \qquad (11)\\
Q_o^n &= \frac{P^s}{P^n}, \qquad (12)
\end{aligned}
$$

where Q_l^i and Q_o^i are the derivatives of the production functions with respect to labor and oil. The first order conditions equate the marginal products of each input with its respective marginal cost. The relative price term appears in the first order conditions for the non-traded sector due to the choice of the numeraire.

Cost functions

The functional form for the production function implies that unit costs for each firm, denominated in terms of the traded good, are

$$\Phi^i(W^i, P^s) = \left[\left(\frac{W^i}{A^i} \right)^{1-\sigma_i} + b^{i\sigma_i} \left(P^s \right)^{1-\sigma_i} \right]^{\frac{1}{1-\sigma_i}} \tag{13}$$

for $i = T, n$. Furthermore, the relative price of the non-traded good is given by

$$P^n = \frac{\Phi^n}{\Phi^T}. \tag{14}$$

One can derive two additional and very useful conditions using these cost functions and the equation for P^n.

Facing a constant world price for its output and under the assumptions made regarding production, the real unit cost in the traded sector, Φ^T, is equal to 1. Using this condition, one can immediately show that wages in the traded sector will increase if P^s is lowered in the long-run. More specifically, for small changes in P^s the change in the wage is given by

$$\hat{W}^T = -\frac{\alpha_o^T}{\alpha_l^T} \hat{P}^s, \tag{15}$$

where α_o^T and α_l^T are the cost shares of oil and labor in the traded sector.

Intuitively, lower energy costs would allow firms in the traded sector to sell their output below the world price of the traded good. This would increase demand for their good, and to meet this demand the firm would need to use more labor. The only way to attract this labor is for wages to increase. In the new long-run equilibrium the firm increases its production, and its demand for labor, until the point where its cost of producing an additional unit of output would once again equal the world price of the traded good. Equation (15) provides the exact change in wages required to ensure that this condition holds. The more oil-intensive the traded sector is the greater the increase in wages will be.

The household's first order condition in equation (6) implies that the change in W^T spills over into the non-traded sector. The increase in W^T, therefore, acts as a negative cost shock for the non-traded sector. Holding all else equal, this would drive up P^n. But, the non-traded sector also faces lower energy costs because it benefits from the subsidy. In the end which one of these forces wins out depends upon how oil-intensive the non-traded sector is. For a small change in P^s the change in P^n is given by

$$\hat{P}^n = \left(\alpha_o^n - \frac{\alpha_l^n \alpha_o^T}{\alpha_l^T} \right) \hat{P}^s, \tag{16}$$

where α_o^n and α_l^n are the cost shares of oil and labor in the non-traded sector. If the non-traded sector is oil-intensive enough then reductions in P^s reduce costs so much that P^n declines. Otherwise the increase in wages drives up costs and P^n increases.

3.3 The Government

The government earns revenue from lump-sum taxes, taxing labor income and taxing the consumption of non-oil consumption goods.[16] On the expenditure side, the government provides a subsidy on fuel products and lump-sum transfers to households. The government purchases oil at the world price of P^o and then sells it at the subsidized price P^s, with $P^s \leq P^o$. While simple in nature, this assumption regarding the subsidy captures the important fact that domestic prices are lower than world prices and that the subsidy must be financed by the government somehow.

In the steady state the government budget constraint reads

$$\bar{T} + \bar{\tau}^l \left(\bar{W}^T \bar{L}^T + \bar{W}^n \bar{L}^n \right) + \bar{\tau}^c \left(\bar{C}^T + \bar{P}^n \bar{C}^n \right) = \bar{T}r + \left(\bar{P}^o - \bar{P}^s \right) \left(\bar{O}^h + \bar{O}^T + \bar{O}^n \right). \tag{17}$$

3.4 Market Clearing and the Current Account

Market clearing in the non-traded sector implies

$$C^n = Q^n. \tag{18}$$

In the bond market the equilibrium condition is

$$b = 0, \tag{19}$$

both in and out of the steady state.

In the long-run trade balances so

$$\bar{Q}^T = \bar{C}^T + \bar{P}^o \left(\bar{O}^h + \bar{O}^T + \bar{O}^n \right). \tag{20}$$

[16] Consumption and income taxes were chosen on the basis of IMF country reports which showed that these two forms of taxation tend to be important sources of revenue for many developing countries. This is particularly true of taxes on goods and services.

3.5 Calibration

The model is calibrated to an initial steady state where there are no subsidies. Parameters and variables are calibrated to match features of a typical developing country that has had experience with fuel subsidies, such as Bangladesh, Sri Lanka, or Indonesia. Units are chosen so that real GDP is equal to 1, as are P^o and P^n. Lump-sum transfers, Tr, are set to 0. Total hours worked is set to 1/3. Table 3 lists the calibration of the model's other parameters and variables, along with short comments on the sources used in the calibration. Greater detail regarding the sources can be found in the appendix. The calibration of several elasticities and the amount of oil used by firms is discussed in more detail below.

- Elasticities of substitution (σ_c, σ_n, σ_T) - These parameters pin down the price-elasticity of demand for oil products. A survey done in Graham and Glaister (2002) shows that long-run elasticities for many countries tend to cluster around -.6 to -1 and that these are larger than short-run elasticities. The baseline calibration is in line with these findings. An alternative calibration of .25, more consistent with short-run price elasticities, is also considered.
- Frisch elasticity of labor supply (μ) - This parameter controls how responsive labor supply is to changes in wages, with larger values implying a greater responsiveness. Even for developed countries there is significant uncertainty surrounding this parameter. Reichling and Whalen (2012) provides a useful summary of the findings. Micro estimates tend to be smaller than macro estimates, often between 0 and 1, as an individual's hours worked tends to be unresponsive to changes in wages. Macro estimates are often between 2 and 4, reflecting the fact that in aggregate data this elasticity is capturing changes in both the intensive and extensive margins on how much people work. The baseline calibration sets μ equal to 1, but an alternative calibration of 3 is also considered.
- Firm demand for oil - Input-output tables for 11 developing countries are available from the OECD STAN database. These tables provide data on spending by firms on "Coke, refined petroleum products, and nuclear fuel." This provides the best estimate on total firm spending on oil products. In theory, one would like to have an estimate for spending only on "refined petroleum products" but unfortunately that data is not available. The average value was close to 5 percent of GDP for all firms. About 40 percent of that was due to firms in the traded sector

(defined as agriculture, mining, and manufacturing).

4 Results

Numerical solutions are calculated for how the model's variables change conditional on the method of financing the subsidy and the size of the subsidy, in relation to initial GDP. I consider subsidy costs that range from 1 to 4 percent of GDP. For each level of the subsidy, one of the tax instruments adjusts to clear the government budget constraint. Labor taxes, consumption taxes, or lump-sum taxes are each considered in turn. With three fiscal instruments this results in a total of 12 cases considered.

The analysis of the results focuses on how the model's variables change across steady states and on how aggregate welfare is impacted by the changes in those variables. Changes in the variables are calculated as percent changes across steady states, where the initial steady state (with no subsidy) is the point of reference.

If X_o and X_1 are the steady state values of variable X in the original and the new steady state, respectively, then the change in aggregate welfare across steady states is given by

$$\frac{1}{\rho}\left\{\left[\frac{C\left(C_o^T, C_o^n, O_o^h\right)^{1-\frac{1}{\tau}}}{1-\frac{1}{\tau}} - \kappa V(L_o)\right] - \left[\frac{C(C_1^T, C_1^n, O_1^h)^{1-\frac{1}{\tau}}}{1-\frac{1}{\tau}} - \kappa V(L_1)\right]\right\}.$$

However, looking at the change in aggregate welfare across steady states is not very informative since utility is ordinal. To make the comparisons more concrete, I solve for how much aggregate consumption in the initial steady state would need to be increased or decreased, in percentage points, to make welfare equal across the two steady states. Mathematically I solve for ω in the following equation,

$$\left\{\frac{\left[\omega C(C_o^T, C_o^n, O_o^h)\right]^{1-\frac{1}{\tau}}}{1-\frac{1}{\tau}} - \kappa V(L_o)\right\} - \left\{\frac{\left[C(C_1^T, C_1^n, O_1^h)\right]^{1-\frac{1}{\tau}}}{1-\frac{1}{\tau}} - \kappa V(L_1)\right\} = 0. \tag{21}$$

In general ω will be non-zero as welfare will be higher or lower across steady states. The welfare losses are calculated as

$$W_l = 100 * (1-\omega). \tag{22}$$

One way to interpret W_l is as follows. If W_l is positive then aggregate welfare is higher in the initial steady state. Intuitively, aggregate consumption would need to be lowered by W_l percent to match the lower utility in the new steady state. Alternatively, W_l tells one how much aggregate consumption would need to be increased to make the agent as well off in the new steady state as in the initial steady state.

When households and firms receive the subsidy, the solutions combine the effects brought about by changes in the relative price that households face for O^h and changes in the relative price that firms face for O^T and O^n. It is instructive to consider each of these channels separately. To do so I first solve for a case where the household pays the subsidized price but the firm pays the world price of oil. Second, the case where the firm receives the subsidy but households do not is considered. Finally, I present the results under the situation where both households and firms receive the subsidy.

4.1 Households Receive the Subsidy

In many countries, households are often specifically targeted as the beneficiaries of the subsidy. This is particularly true for certain oil products as well as electricity and natural gas, which are harder to divert from their intended recipients. For this reason, it is interesting to first consider the results under the assumption that only households receive the subsidy. Doing so only requires assuming firms pay the prevailing price for oil products, P^o, and the government only needs to raise revenue for under-pricing fuel products to households. All other aspects of the model remain the same.

The top panel in table 4 presents the results for aggregate welfare. Each row is for a different subsidy cost while columns two through four record the results for the different tax instruments. The numbers in each entry tell us how much aggregate consumption in the initial steady state would need to be decreased to get welfare equal across steady states. For example, if the subsidy costs 4 percent of GDP and is financed by a consumption tax W_l is equal to 1.4. This means that aggregate consumption in the initial steady state would need to be 1.4 percent smaller to match the (lower) aggregate welfare of the new steady state.

Regarding the subsidy's impact on aggregate welfare, the numbers in this table are all positive, so aggregate welfare is always lower with the subsidies. In consumption-equivalent terms the welfare costs are fairly small for subsidies on the order of one percent of GDP, coming in at little over a tenth of a percent of aggregate consumption. However, the losses steadily increase as the subsidy reaches higher levels and W_l is well over 1 percent by the time the subsidy reaches 4 percent of GDP.

Interestingly, the method of financing the subsidy is of secondary importance to the subsidy itself in terms of the welfare losses. There are differences between the different tax instruments but they are fairly small. In general, lump-sum taxes or labor taxes are slightly preferred to financing the subsidy through a consumption tax.

Underlying the welfare results are the actual changes in the variables across steady states. The top panel in table 5 shows these results. Each column is for a different tax instrument. For brevity's sake the results are shown only for the case where the subsidy costs 1 percent of GDP. Larger subsidies would increase the size of the changes that occur, so one should view the quantitative results in the table as a sort of lower bound. Note also that if one wanted to consider the implications of going from the steady state with the subsidy to the steady state without the subsidy, one needs only flip the signs on the results found in the table.

For the baseline calibration a subsidy of 1 percent of GDP leads to a reduction in the subsidized price of fuel by about 26 percent.[17] Regardless of how the subsidy is financed, lower fuel prices induce households to consume roughly 25 percent more fuel.

How the other variables change across steady states depends upon the method of taxation used. Essentially, households pay for the increased taxes by consuming less non-oil goods, working more, or both. The exact breakdown depends upon which tax instrument is used because different tax instruments distort household behavior in different ways.

Lump-sum taxes reduce disposable income but do not otherwise change the effective prices that households face and for this reason they make a useful baseline case. When the subsidy is financed by lump-sum taxes, households both consume less and work more. Consumption of non-oil goods declines by half a percentage point while hours worked increases by about half a percent.

By comparison, labor taxes reduce the incentive to work so hours worked increase less. However, as a consequence, households cut back consumption of non-oil goods by a greater amount. Consumption taxes not only reduce the incentive to work but also further distort the relative price of the consumption goods. Compared with lump-sum taxes, hours worked increase by much less, consumption of oil products rises more, and consumption of other

[17] The change in P^s is a mainly a function of the specified subsidy cost and how big the base being subsidized is. If a great deal of oil is consumed by the economy, then small changes in P^s are sufficient to reach a specified level of subsidy cost and vice-versa.

goods falls by a greater amount. The fact that the consumption tax introduces two distortions appears to be the reason it generates slightly higher welfare losses than the other two forms of taxation.

Although firms do not benefit from the subsidy, production variables are impacted indirectly. Reduced demand for the non-traded good causes production in that sector to decline, which lowers that sector's demand for labor and oil. In the long-run this labor flows into the traded sector. Despite labor re-allocating across sectors, wages remain unchanged as the traded-sector faces a constant real unit cost and a constant price P^o for oil inputs. What does happen is that the traded sector expands production by increasing its use of oil and labor proportionally.[18]

4.2 Firms Receive the Subsidy

Now suppose that firms pay the reduced price of P^s for oil while households continue to pay the world price P^o. The middle panel in table 4 shows the welfare results for this case. The format of the table is exactly the same as before. Each entry in the table is positive, showing that aggregate welfare is reduced by the subsidy. The losses are fairly small for subsidies on the order of one to two percent of GDP but start growing as the subsidy reaches higher levels. The choice of the tax instrument is again essentially irrelevant for the results.

The middle panel of table 5 shows how the variables change across steady states. With lower energy prices, production expands in the traded sector which brings about higher wages and greater labor usage in that sector. The intuition behind these results is exactly as explained in section 3.2.

For the non-traded sector, things are a little more complicated. As explained in section 3.2 the higher wages drive up costs in this sector but the subsidy lowers costs. For the baseline calibration, the non-traded sector is more oil-intensive than the traded sector. The end result is that lower energy costs drive down unit costs enough to override the increases caused by higher wages in the economy. As a result, there is a small decline in the relative price of the non-traded good to the traded good. In response to this reduction in P^n households are induced to consume more of the non-traded good leading output to expand in that sector as well.

While households do not directly receive the subsidy they do have to pay higher taxes. Which tax instrument is used to pay for the subsidy has some

[18]Demand for the two inputs increases proportionally because the firm faces a constant ratio of input prices. This can be seen by combining the first order conditions for labor and oil in the traded sector, equations (9) and (10).

implications for how consumption and hours worked respond. The decrease in P^n leads to increased consumption of the non-traded good regardless of the tax instrument used. However, when labor taxes or consumption taxes are used, consumption of the traded good gets crowded out. The consumption tax induces households to substitute away from the taxed goods into oil. Consumption and labor taxes also reduce the overall increase in hours worked by households compared to the lump-sum case.

Comparing the top and middle panels of table 4 shows that the welfare losses are lower when firms receive the subsidy than when households receive it. This is driven to some extent by the fact that the subsidies are being measured by their size in relation to GDP. The baseline calibration has firms using more oil than households, so a smaller drop in P^s is needed to reach a given subsidy cost. This can be confirmed by comparing how P^s changes in the two cases using table 5. An alternate method would be to calculate the welfare costs as a function of P^s instead of the subsidy cost. Figure 2 plots the welfare losses as a function of P^s for the three cases considered. The dashed line is for the case where households receive the subsidy, the solid line for the case where firms receive the subsidy, and the dashed-dotted line for the case where both receive the subsidy. This figure shows that for a given reduction in P^s, the losses are larger in cases with a bigger base being subsidized.

4.3 Households and Firms Receive the Subsidy

The bottom panel of table 4 records the welfare losses under the scenario where both households and firms receive the subsidy. In general the results are similar to the previous two cases. Comparing the three panels shows that the losses are smaller in this case than in the other two cases. This is explained by the fact that for a given subsidy cost the reduction in P^s is lowest in this case as the base being subsidized is the largest.

All of the movements in the variables are now combinations of the results for the two previous cases. Households face a lower relative price for the oil good and a slightly lower relative price for the non-traded good (compared to the traded good). Households increase their consumption of fuel products and reduce their consumption of traded goods. With P^n lower, consumption of the traded good falls relatively more than the non-traded good. Both labor and consumption taxes reduce hours worked and consumption of non-oil products relative to the lump-sum case. Likewise, consumption taxes drive up consumption of oil products at the expense of non-oil consumption compared to the lump-sum and labor tax case.

4.4 Transfers vs. Subsidies

Aggregate welfare is impacted by both the subsidy and the taxes necessary to finance the subsidy. One result shown in table 4 is that only minor differences are found for the change in aggregate welfare regardless of whether lump-sum taxes, labor taxes, or consumption taxes are used to finance the subsidy. One hypothesis for why this is the case is that the distortions in relative prices introduced by the subsidy are the main reasons that aggregate welfare is lower and not because of changes in T, τ^l, or τ^c.

To consider whether this might be the case I ask what the implications would be on aggregate welfare if instead of increasing subsidies by a certain percent of GDP the government increased lump-sum transfers by the same amount. This would require changing τ^l or τ^c by a similar amount to pay for the increased government spending on Tr but would keep P^s equal to the world price of oil.

The specific experiment considers transfers on the order of 1 to 4 percent of initial GDP. These are financed with either labor or consumption taxes. Table 6 compares the aggregate welfare losses between increased transfers and the subsidy. For brevity's sake only the results from the case where households and firms receive the subsidy are presented. The results are stark: the losses under the subsidy are about 20 to 25 times greater than under a system of transfers. While the increased taxation required on an aggregate level is similar in both cases the distorted relative price significantly increases welfare losses under the subsidy. Similar results are seen in the cases where only households or firms benefit from the subsidy.

This result might be of more than just theoretical importance. In general, it has been quite difficult for countries to remove fuel subsidies once they are in place. To increase the likelihood of a successful reform the IMF has often suggested their removal be offset with increased transfers. Generally it is argued that these transfers can be better targeted to the needy and are often less costly than the fuel subsidies they replace. The results in this paper offer an additional reason for considering this option: giving people money and allowing them to spend it where they want is significantly more efficient than inducing them to consume more fuel products by artificially lowering fuel prices.

5 The Case of a Net Exporter

A large number of net oil exporters also subsidize fuel products. An important reason for considering the case of net oil exporters separately is that they have an additional financing method available to them. The governments of these countries can simply sell domestically produced oil below its world price. This creates an opportunity cost for the government but negates the need to raise taxes to finance the subsidy.

To address whether this significantly alters the previous results about aggregate welfare this section modifies the baseline model by assuming the economy has an endowment of oil large enough to make it a net exporter of oil. The punchline of the work is that the results are surprisingly similar to the case of the net oil importer. The reason for this is that whether one is considering a net oil exporter or importer the subsidy distorts the relative price of fuel products and it is that distortion which drives most of the welfare results, not the method of financing the subsidy.

5.1 Households and Firms

No changes are made to the assumptions regarding household and firm behavior. Preferences and the budget constraint of the household are assumed to be equivalent for the net oil importer and exporter. Technology in the traded and non-traded sectors is also the same.

5.2 The Government

The major change to the model comes on the government side. In many net exporting countries the government is heavily involved in the production of oil. In line with this, I assume the government now has access to an endowment of oil, Q^o. I assume there is zero cost associated with the supply of oil.[19] The government earns revenue from selling oil domestically to households and firms at a subsidized price of P^s and exports the remaining supply at the world price, P^o. All revenue from the sales of oil, whether from exports or domestic sales, is funneled to the economy through a lump-sum transfer. For simplicity I assume the government does not levy taxes on either labor income or consumption nor does it spend the money on anything besides the transfer. Under those assumptions the steady state government budget constraint reads

$$\bar{P}^o\left(\bar{Q}^o - \bar{O}^h - \bar{O}^T - \bar{O}^n\right) + \bar{P}^s\left(\bar{O}^h + \bar{O}^T + \bar{O}^n\right) = \bar{T}r. \tag{23}$$

[19] This assumption potentially inflates the revenue the government receives from the sale of oil. However, I also considered a case where there was a fixed cost per unit of oil. The results were not significantly different.

There is a subtle point in the budget constraint worthwhile pointing out. If the net oil exporter has no subsidies in place, then government revenue is maximized at P^oQ^o. With a subsidy in place, government revenue is reduced below this amount. But this automatically means lower transfers to the economy. In a very real sense, the subsidy is actually being financed by a reduction in lump-sum transfers.

5.3 Market Clearing and the Current Account

Market clearing in the non-traded sector and the bond market are equivalent for the net oil importer and exporter.

The current account equation, however, is different. In the steady state the current account for the net oil exporter reads

$$\bar{Q}^T + \bar{P}^o\bar{Q}^o = \bar{C}^T + \bar{P}^o\left(\bar{O}^h + \bar{O}^T + \bar{O}^n\right). \tag{24}$$

Essentially, the net oil exporter has extra oil and uses that to trade for C^T whereas the net oil importer produces extra Q^T and trades that for oil.

5.4 Calibration

The model is calibrated to an initial steady state where there are no subsidies. Where possible the calibration found in table 3 is used for the model of the net oil exporter as this facilitates comparison between this case and the net oil importer case. The deep parameters, given by ρ, τ, σ_c, σ_T, σ_n, and μ are the same across models. Consumption expenditure shares and firm use of oil as a percent of GDP are also calibrated to the same starting values.

I calibrate Q^o as a proportion of total domestic consumption of oil. To guide the calibration I used EIA data on "Total Oil Supply" and "Total Oil Consumption" for Ecuador, a net exporter with large fuel subsidies. For that country, total oil supply was on average about 2.4 times the size of total oil consumption between 2007 and 2011 (the years for which data is available on subsidies in the country).

5.5 Results

Numerical solutions are calculated for how aggregate welfare varies across steady states, depending upon the size of the subsidy as a fraction of initial GDP. This is the same procedure that was done for the net oil importer.

Table 7 presents the welfare results.[20] For brevity's sake only the results for the case where households and firms receive the subsidy are presented. The second column shows the welfare costs for varying levels of the subsidy compared to the baseline case where there are no subsidies. While the method of finance is quite different from what occurs in the net importer model, the results are surprisingly similar. For subsidies of small size, the welfare costs tend to be small but they become increasingly large as the subsidies increase in cost.

This result may be unexpected. But it is in line with the intuition for the results in table 6 that the method of finance was of secondary importance for a net oil importer. The biggest driver of the welfare losses is the distortion in relative prices that occurs with the subsidies, not the tax instrument used to finance it. This distortion is a feature of the subsidy whether the country is a net oil exporter or importer. Consequently the aggregate welfare results are similar in both cases.

6 Sensitivity Analysis

As a robustness check sensitivity analysis is performed on several of the model's parameters and variables. For brevity's sake only the results for the net oil importing country where both households and firms receive the subsidy are presented.[21]

6.1 Low Price Elasticities

In the baseline calibration the elasticities of substitution for oil products are set at a level consistent with long-run price elasticities. However, there is some variation in the estimates of long-run elasticities and short-run elasticities tend to be much smaller. In this section the previous exercises for the net oil importer are repeated using a new calibration where σ_c, σ_T, and σ_n are set to 0.25. This is consistent with a smaller price elasticity of demand.

Table 8 show the results. Lowering the price elasticity does have quantitative implications for the aggregate welfare results and the changes in the

[20] One might be concerned that the assumption of a fixed world price of oil would be violated in this case as the country's exports change due to the subsidy. However, for any one individual country, the increase in exports would be fairly small. For example, Ecuador's entire domestic oil consumption in 2011 was only about .2 percent of total world demand. The increase in exports that would occur by removing the subsidies would only be a fraction of the total demand.

[21] Results for other cases are available upon request.

variables across steady states. Holding subsidy costs constant, the aggregate welfare costs are slightly reduced when compared to the baseline calibration. This is despite the fact that P^s drops by a greater amount when the elasticities are lower. The intuition for this is that with low price-elasticities both households and firms are much less responsive to the distorted relative price. Consequently consumption of oil products increases at a much lower pace than what occurs in the baseline model, and changes in other variables due to the distorted price are lower. This produces lower welfare losses across the board. This alternative calibration does not change the result that the method of financing the subsidy is of secondary importance to the results.

6.2 Higher use of Oil

Firm and household use of oil relative to the economy's GDP was calibrated using average values found in data on consumption expenditure shares and on firm spending on oil products found in input-output tables. Across countries there is a good deal of variation in those series, with some countries having higher shares than others. To consider the importance of this an alternative calibration is considered here where total firm spending on oil and the consumption expenditure share is doubled from the original calibration.

The results for this case are listed in table 9. Higher usage of oil in the economy increases the base that is being subsidized which means for a given subsidy cost the change in P^s is less than what occurs in the baseline calibration. Because of this, the welfare losses are smaller for a given subsidy size. Changes in the variables across steady states are qualitatively similar to the baseline calibration.

6.3 Asymmetric Taxation

The baseline model assumes that the traded and non-traded sectors are taxed at equal rates. However, this may not be the case for several reasons. First, in many developing countries there are excise taxes and import duties which get applied to imported goods. This might lead to consumption taxes falling more heavily on traded goods instead of non-traded goods. Second, the economies considered here often have large informal sectors, in the sense that portions of the economy avoid being taxed by the government. If one assumes that this is generally the non-traded services sector, then labor taxes might fall more heavily on employment in the traded sector. Both of these considerations can be handled in a relatively simple way in the model by assuming that different tax rates apply to the traded and non-traded consumption goods and to labor income earned in the traded and non-traded sectors.

To consider the importance of these issues I repeat the previous exercises but consider extreme cases where the non-traded sector completely avoids taxation. In other words, if the consumption tax is used to finance the subsidy, then only traded consumption goods get taxed. If labor taxes are used, then only income in the traded sector gets taxed.

Table 10 show the results for this case. In regards to aggregate welfare the results are fairly similar to the baseline calibration. There are some differences in the responses of the variables compared to the baseline situation. However, these have less to do with the subsidy and more to do with the fact that the asymmetric taxation opens gaps between the wages and relative prices in the traded and non-traded sectors. For example, if income from the traded sector is taxed but income from the non-traded sector is not, then on the margin households choose to work a little more in the non-traded sector and a little less in the traded sector. This generates a gap between the wages in the formal and informal sectors (here the non-traded sector).[22] This additional distortion affects aggregate welfare but not enough to overcome the large effects being driven by the subsidy itself.

6.4 High Frisch Elasticity of Labor Supply

The baseline calibration of μ was set to 1. As discussed earlier, there is a good deal of uncertainty regarding the calibration of this parameter and macro estimates are often larger than 1. An alternative calibration of the Frisch elasticity of labor supply to 3 is considered here. The results are contained in table 11. The alternative calibration does not significantly change the aggregate welfare results from the baseline calibration. In terms of the variables, the higher elasticity puts a slightly greater emphasis on increasing hours worked vis-a-vis reducing consumption, leading to marginally higher increases in labor supplied and marginally smaller decreases in the consumption variables.

7 Conclusion

This paper has considered the impact that fuel subsidies have on macroeconomic variables and aggregate welfare in both net oil importing and export-

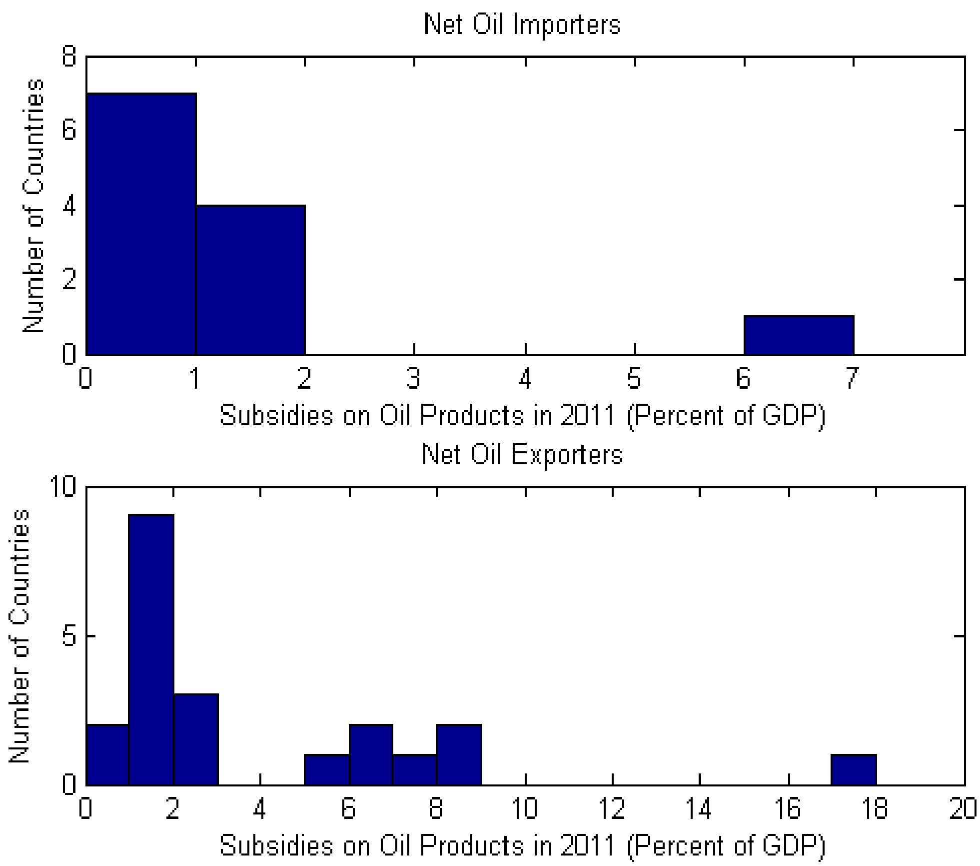
[22] Similar results can be found in papers that deal explicitly with the informal sector, such as Ihrig and Moe (2004) and references therein.

ing countries. There were several important results for the net oil importing case. First, the subsidy reduces aggregate welfare. The losses are fairly small for subsidy sizes on the order of 1 percent of GDP, but grow quickly as the subsidy become more costly. Second, the bulk of the welfare losses are due to the distortions in relative prices from the subsidy, and not the method of financing the subsidy. Third, replacing subsidies with lump-sum transfers of equal value is a significantly better policy option because it eliminates the distorted relative price and increases aggregate welfare by a large amount. Finally, the subsidy has a number of unintended consequences on other macroeconomic variables. These include the possibility of crowding out non-oil consumption, distorting inter-sectoral labor allocations, and distorting the relative price of non-tradables to tradeables.

The case of a net oil exporter was also considered. In this model the government provides the subsidy by selling a portion of its oil endowment below the world price of oil. Despite financing the subsidy in a different way, the implications of the subsidy on aggregate welfare for the net oil exporter turn out to be surprisingly similar to the case of the net oil importer. This is because the distorted relative price introduced by the subsidy is responsible for the bulk of the welfare losses.

This work considers the long-run implications of a particular type of subsidy that reduces the price of fuel in the steady state. There are several important directions on which this research could be expanded. First, all of the results here suppose that the country in question is small which implies that the subsidy does not influence the world price of oil. It would be interesting to consider the implications these subsidies (and their removal) might have on the world economy if the bloc of subsidizing countries changed their policies as a group. Distributional issues about the subsidies and the taxes that finance them have also been ignored in this paper but may be important. Such an approach would also be beneficial as it could ask about increasing transfers that target particular groups of households. Finally, this paper does not make any comments on the political economy aspects of fuel subsidies and why governments choose to have them. All of these areas are potentially fruitful avenues for future research on fuel subsidies.

Figure 1: The Size of Oil Subsidies Across Countries in 2011



Sources: IEA data, IMF World Economic Outlooks, author's calculations.

Figure 2: Welfare Costs as a Function of P^s

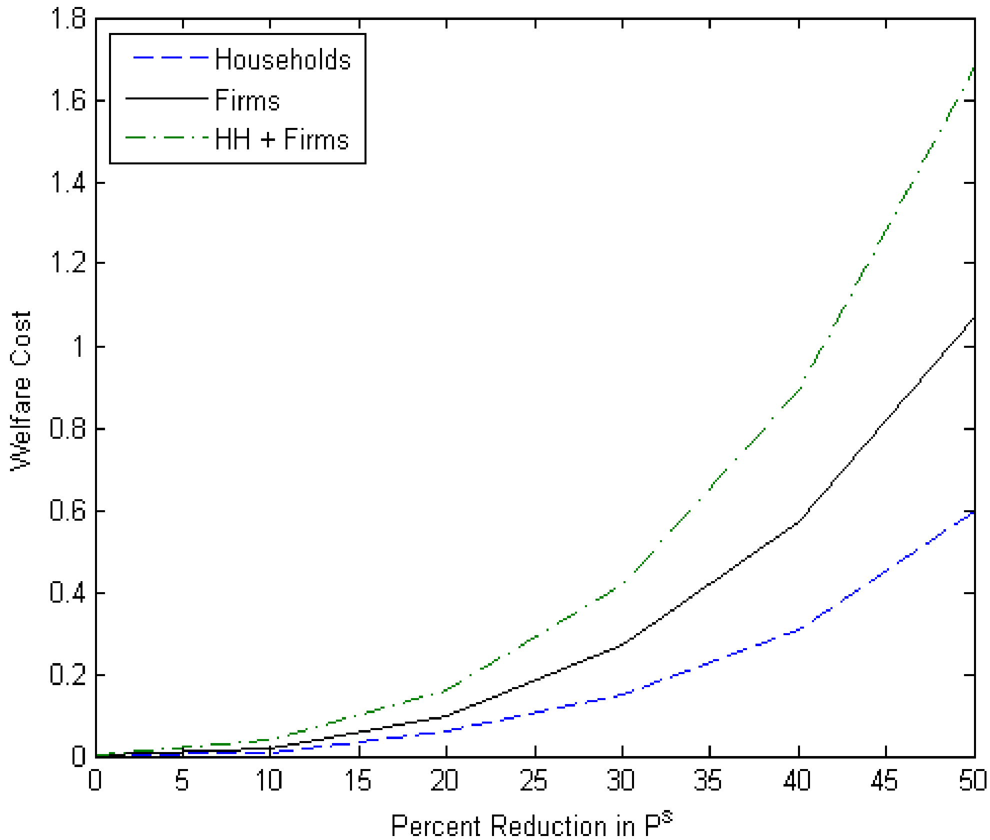


Table 1: Top Five Fuel Subsidizers in 2011 (IEA Data)

By Dollar Value

	Net Importers		Net Exporters	
Rank	Country	Total Subsidies ($B)	Country	Total Subsidies ($B)
1	India	30.9	Saudi Arabia	46.1
2	China	18.5	Iran	41.4
3	Indonesia	15.7	Venezuela	22.0
4	Egypt	15.3	Iraq	20.4
5	Thailand	3.3	Mexico	15.9

By Share of GDP

	Net Importers		Net Exporters	
Rank	Country	Share of GDP	Country	Share of GDP
1	Egypt	6.5	Iraq	17.8
2	Indonesia	1.9	Iran	8.6
3	India	1.7	Ecuador	8.2
4	Pakistan	1.3	Saudi Arabia	7.7
5	Sri Lanka	1.4	Libya	6.3

Sources: IEA, IMF WEOs, author's calculations.

Table 2: Subsidy Costs in Country Examples (Percent of GDP)

Year	Indonesia Oil	Lebanon Electricity	Ukraine Natural Gas
2000	5.4	1.1	N\A
2001	4.6	1.1	N\A
2002	1.9	1.0	N\A
2003	1.5	1.4	N\A
2004	3	2.1	N\A
2005	3.4	3.0	N\A
2006	1.9	3.4	N\A
2007	2.2	3.1	3.4
2008	2.8	5.1	4.5
2009	0.8	4.1	4.5
2010	1.3	3.0	3.8
2011	2.2	4.5	4.0
2012 (est.)	2.4	4.5	N\A

Sources: IEA, IISD (2012), IMF CRs, IMF WEOs, World Bank (2008), author's calculations.

Table 3: Calibration

Parameter or variable	Value	Source
Elasticity of intertemporal substitution (τ)	.50	Table 10.1 in Agenor and Montiel (1996)
Elasticities of substitution (σ_c, σ_T, σ_n)	.75, .25	Graham and Glaister (2002)
Frisch elasticity of labor supply (μ)	1, 3	See discussion in paper.
Time preference rate (ρ)	.06	Real interest rates in LDCs.
Consumption-expenditure share of oil	3%	Estimates from 19 developing countries.
Share of non-tradables in total consumption	50%	Buffie et al. (2008)
Total firm demand for oil	5% of GDP	Input-output tables for 11 developing countries.
Share of oil used by traded sector	40% of total	Input-output tables for 11 developing countries.

Table 4: Results for Net Oil Importer

Aggregate Welfare Costs of Subsidy

Case 1: Households Receive Subsidy

	Subsidy Financed by		
Subsidy Cost (% of GDP)	Lump-Sum Tax	Labor Tax	Consumption Tax
1 %	.11	.11	.12
2 %	.40	.40	.42
3 %	.82	.82	.86
4 %	1.34	1.34	1.40

Case 2: Firms Receive Subsidy

	Subsidy Financed by		
Subsidy Cost (% of GDP)	Lump-Sum Tax	Labor Tax	Consumption Tax
1 %	.07	.07	.07
2 %	.27	.27	.27
3 %	.57	.56	.56
4 %	.94	.94	.94

Case 3: Household and Firms Receive Subsidy

	Subsidy Financed by		
Subsidy Cost (% of GDP)	Lump-Sum Tax	Labor Tax	Consumption Tax
1 %	.05	.04	.05
2 %	.18	.17	.18
3 %	.38	.37	.39
4 %	.65	.64	.67

Table 5: Results for Net Oil Importer

Changes in Macroeconomic Variables

Case 1: Households Receive Subsidy			
	Subsidy Financed by		
Variable	Lump-Sum Tax	Labor Tax	Consumption Tax
P^s	-26.6	-26.6	-26.5
P^n	0	0	0
C^T	-0.4	-0.7	-0.8
C^n	-0.4	-0.7	-0.8
O^h	25.5	25.2	25.9
W^T	0	0	0
L	0.4	0.04	0.04
L^T	1.1	0.7	0.7
L^n	-0.4	-0.7	-0.8
Q^T	1.1	0.7	0.7
Q^n	-0.4	-0.7	-0.8
Case2: Firms Receive Subsidy			
	Subsidy Financed by		
Variable	Lump-Sum Tax	Labor Tax	Consumption Tax
P^s	-17.2	-17.3	-17.3
P^n	-0.5	-0.5	-0.5
C^T	0.1	-0.2	-0.2
C^n	0.5	0.1	0.1
O^h	0.1	-0.2	0.5
W^T	0.7	0.7	0.7
L	0.4	0.02	0.02
L^T	1	0.7	0.7
L^n	-0.4	-0.7	-0.8
Q^T	1.6	1.2	1.3
Q^n	0.5	0.1	0.1
Case 3: Households and Firms Receive Subsidy			
	Subsidy Financed by		
Variable	Lump-Sum Tax	Labor Tax	Consumption Tax
P^s	-11.4	-11.4	-11.4
P^n	-0.3	-0.3	-0.3
C^T	-0.1	-0.4	-0.4
C^n	0.1	-0.2	-0.2
O^h	9.4	9.1	9.9
W^T	0.5	0.5	0.5
L	0.3	0.01	0.02
L^T	1	0.7	0.7
L^n	-0.4	-0.7	-0.8
Q^T	1.4	1	1
Q^n	0.1	-0.2	-0.2

Table 6: Subsidies vs. Transfers in the Net Oil Importing Case

Households and Firms Receive Subsidy

	Labor Tax		Consumption Tax	
Cost (% of GDP)	Transfers	Subsidy	Transfers	Subsidy
1	.002	.04	.002	.05
2	.007	.17	.007	.18
3	.016	.37	.016	.39
4	.028	.67	.028	.67

Table 7: Aggregate Welfare Costs for the Net Oil Exporter

Households and Firms Receive Subsidy

Subsidy Cost (% of GDP)	Aggregate Welfare Cost
2 %	.20
4 %	.70
6 %	1.42
8 %	2.28

Table 8: Results for Low Price-Elasticity Case (Net Oil Importer)

Households and Firms Receive Subsidy

Aggregate Welfare Costs of Subsidy

	Subsidy Financed by		
Subsidy Cost (% of GDP)	Lump-Sum Tax	Labor Tax	Consumption Tax
1 %	.04	.04	.04
2 %	.15	.15	.15
3 %	.34	.33	.34
4 %	.59	.58	.58

Changes in Macroeconomic Variables

	Subsidy Financed by		
Variable	Lump-Sum Tax	Labor Tax	Consumption Tax
P^s	-12.1	-12.1	-12.1
P^n	-0.3	-0.3	-0.3
C^T	0.2	-0.1	-0.1
C^n	0.3	-0.1	-0.1
O^h	3.5	3.1	3.4
W^T	0.5	0.5	0.5
L	0.3	0.01	0.01
L^T	0.6	0.2	0.2
L^n	0.1	-0.3	-0.3
Q^T	0.7	0.4	0.4
Q^n	0.3	-0.1	-0.1

Table 9: Results for High Oil Use Case (Net Oil Importer)

Households and Firms Receive Subsidy

Aggregate Welfare Costs of Subsidy

	Subsidy Financed by		
Subsidy Cost (% of GDP)	Lump-Sum Tax	Labor Tax	Consumption Tax
1 %	.02	.02	.02
2 %	.09	.09	.09
3 %	.21	.20	.20
4 %	.36	.34	.34

Changes in Macroeconomic Variables

	Subsidy Financed by		
Variable	Lump-Sum Tax	Labor Tax	Consumption Tax
P^s	-6	-6	-6
P^n	-0.3	-0.3	-0.3
C^T	-0.1	-0.4	-0.5
C^n	0.2	-0.2	-0.2
O^h	4.6	4.3	5.1
W^T	0.4	0.4	0.4
L	0.3	0.01	0.01
L^T	0.9	0.6	0.6
L^n	-0.4	-0.7	-0.8
Q^T	1.3	0.9	1
Q^n	0.2	-0.2	-0.2

Table 10: Results under Asymmetric Taxation (Net Oil Importer)

Households and Firms Receive Subsidy

Aggregate Welfare Costs of Subsidy

	Subsidy Financed by	
Subsidy Cost (% of GDP)	Labor Tax	Consumption Tax
1 %	.04	.05
2 %	.16	.20
3 %	.36	.44
4 %	.61	.75

Changes in Macroeconomic Variables

	Subsidy Financed by	
Variable	Labor Tax	Consumption Tax
P^s	-11.5	-11.4
P^n	-2.1	-0.3
C^T	-1.1	-1.2
C^n	0.5	0.6
O^h	8.4	9.9
W^T	0.5	0.4
W^n	-1.4	0.4
L	0.01	0.02
L^T	0	0.03
L^n	0	0
Q^T	0.4	0.4
Q^n	0.5	0.6

Table 11: Results for High Frisch Elasticity Case (Net Oil Importer)

Households and Firms Receive Subsidy

Aggregate Welfare Costs of Subsidy

	Subsidy Financed by		
Subsidy Cost (% of GDP)	Lump-Sum Tax	Labor Tax	Consumption Tax
1 %	.05	.04	.05
2 %	.18	.17	.18
3 %	.38	.37	.39
4 %	.65	.64	.67

Changes in Macroeconomic Variables

	Subsidy Financed by		
Variable	Lump-Sum Tax	Labor Tax	Consumption Tax
P^s	-11.4	-11.4	-11.4
P^n	-0.3	-0.3	-0.3
C^T	0	-0.4	-0.4
C^n	0.2	-0.2	-0.2
O^h	9.5	9.1	9.9
W^T	0.4	0.5	0.5
L	0.4	0.02	0.02
L^T	1.1	0.7	0.7
L^n	-0.3	-0.7	-0.8
Q^T	1.5	1	1.1
Q^n	0.2	-0.2	-0.2

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A Model equations

$$\left(C^{T\frac{\sigma_c-1}{\sigma_c}}+a_1C^{n\frac{\sigma_c-1}{\sigma_c}}+a_2O^{h\frac{\sigma_c-1}{\sigma_c}}\right)^{\left(\frac{\sigma_c}{\sigma_c-1}\right)\left(1-\frac{1}{\tau}\right)-1}C^{T-\frac{1}{\sigma_c}}=(1+\tau^c)\lambda \tag{A-1}$$

$$\left(C^{T\frac{\sigma_c-1}{\sigma_c}}+a_1C^{n\frac{\sigma_c-1}{\sigma_c}}+a_2O^{h\frac{\sigma_c-1}{\sigma_c}}\right)^{\left(\frac{\sigma_c}{\sigma_c-1}\right)\left(1-\frac{1}{\tau}\right)-1}a_1C^{n-\frac{1}{\sigma_c}}=(1+\tau^c)P^n\lambda \tag{A-2}$$

$$\left(C^{T\frac{\sigma_c-1}{\sigma_c}}+a_1C^{n\frac{\sigma_c-1}{\sigma_c}}+a_2O^{h\frac{\sigma_c-1}{\sigma_c}}\right)^{\left(\frac{\sigma_c}{\sigma_c-1}\right)\left(1-\frac{1}{\tau}\right)-1}a_2O^{h-\frac{1}{\sigma_c}}=P^s\lambda \tag{A-3}$$

$$\kappa L^{\frac{1}{\mu}}=(1-\tau^l)W^T\lambda \tag{A-4}$$

$$\kappa L^{\frac{1}{\mu}}=(1-\tau^l)W^n\lambda \tag{A-5}$$

$$\frac{\dot{\lambda}}{\lambda}=\rho-r \tag{A-6}$$

$$(1-\tau^l)\left(W^nL^n+W^TL^T\right)+T=(1+\tau^c)\left(C^T-P^nC^n\right)+P^sO^h \tag{A-7}$$

$$Q^T=\left[\left(A^TL^T\right)^{\frac{\sigma_T-1}{\sigma_T}}+b^T\left(O^T\right)^{\frac{\sigma_T-1}{\sigma_T}}\right]^{\frac{\sigma_T}{\sigma_T-1}} \tag{A-8}$$

$$Q^{T\frac{1}{\sigma_T}}\left(A^TL^T\right)^{-\frac{1}{\sigma_T}}A^T=W^T \tag{A-9}$$

$$Q^{T\frac{1}{\sigma_T}}b^T\left(O^T\right)^{-\frac{1}{\sigma_T}}=P^s \tag{A-10}$$

$$\Phi^T=\left[\left(\frac{W^T}{A^T}\right)^{1-\sigma_T}+b^{T\sigma_T}\left(P^s\right)^{1-\sigma_T}\right]^{\frac{1}{1-\sigma_T}} \tag{A-11}$$

$$Q^n=\left[\left(A^nL^n\right)^{\frac{\sigma_n-1}{\sigma_n}}+b^n\left(O^n\right)^{\frac{\sigma_n-1}{\sigma_n}}\right]^{\frac{\sigma_n}{\sigma_n-1}} \tag{A-12}$$

$$Q^{n\frac{1}{\sigma_n}}\left(A^nL^n\right)^{-\frac{1}{\sigma_n}}A^n=\frac{W^n}{P^n} \tag{A-13}$$

$$Q^{n\frac{1}{\sigma_n}}b^n\left(O^n\right)^{-\frac{1}{\sigma_n}}=\frac{P^s}{P^n} \tag{A-14}$$

$$\Phi^n=\left[\left(\frac{W^n}{A^n}\right)^{1-\sigma_n}+b^{n\sigma_n}\left(P^s\right)^{1-\sigma_n}\right]^{\frac{1}{1-\sigma_n}} \tag{A-15}$$

$$C^n=Q^n \tag{A-16}$$

$$b=0 \tag{A-17}$$

Government budget constraint for net oil importer

$$\tau^l\left(W^TL^T+W^nL^n\right)+\tau^c\left(C^T+P^nC^n\right)+T=Tr+\left(P^o-P^s\right)\left(O^h+O^T+O^n\right) \tag{A-18}$$

Current account equation for net oil importer

$$Q^T = C^T + P^o \left(O^h + O^T + O^n\right) \quad \text{(A-19)}$$

Government budget constraint for net exporter

$$P^o \left(Q^o - O^h - O^T - O^n\right) + P^s \left(O^h + O^T + O^n\right) = Tr \quad \text{(A-20)}$$

Current account equation for net exporter

$$Q^T + P^o Q^o = C^T + P^o (O^h + O^T + O^n) \quad \text{(A-21)}$$

B Data used for calibration

B.1 Consumption expenditure shares

Estimates were found for 18 developing countries. The average value of the 18 countries was 3.15 percent for oil products. This was rounded to 3 in the model calibration. Table B-1 provides the estimates and the sources for those estimates.

B.2 Firm use of oil

The OECD STAN database contains input-output tables for 11 developing countries. These tables provide data on spending by firms on "Coke, refined petroleum products and nuclear fuel" which provides a rough estimate of total firm spending on oil products. For the countries considered, the average was 5.3 percent of GDP with about 36 percent of that spending due to firms in the traded sector (defined as agriculture, mining, and manufacturing). These were rounded to 5 percent and 40 percent in the model calibration. The input-output tables also include spending on "Electricity, gas, and water supply." Including this increases the total average to 9.9 percent of GDP with roughly 39 percent due to firms in the traded sector. These were rounded to 10 percent and 40 percent in the alternative calibration. Table B-2 lists the GDP ratios and the share that the traded sector makes out of the total. All calculations were done by the author.

C Additional countries and sources

C.1 Fuel subsidies

The IEA data lists 34 countries that had subsidies on fuel products at some point in time between 2007 and 2011. Using additional sources this list can

Table B-1: Consumption-Expenditure Shares

Country	Oil products	Electricity	Source
Bolivia	3.1	-	Coady et al. (2006)
Ghana	4.2	-	Coady et al. (2006)
Jordan	4.3	2.3	Coady et al. (2006)
Mali	2.9	0.4	Coady et al. (2006)
Sri Lanka	2.0	1.3	Coady et al. (2006)
Morocco	3.8	2.1	World Bank (2007)
Gabon	2.7	-	Bacon et al. (2010)
Madagascar	2.1	0.5	Bacon et al. (2010)
Bangladesh	1.4	1.1	Bacon et al. (2010)
Cambodia	1.2	0.8	Bacon et al. (2010)
India	3.4	2.4	Bacon et al. (2010)
Indonesia	3.8	3.4	Bacon et al. (2010)
Kenya	2.5	0.2	Bacon et al. (2010)
Pakistan	2.1	3.5	Bacon et al. (2010)
Thailand	6.7	3.1	Bacon et al. (2010)
Uganda	1.7	0.4	Bacon et al. (2010)
Vietnam	5.9	3.0	Bacon et al. (2010)
Burkina Faso	3.0	-	IMF CR 09/38

Table B-2: Energy-GDP ratios

Country	Oil	Traded sector share	Electricity	Traded sector share
Argentina	1.4%	35.7%	2.8%	32.1%
Brazil	4.7%	46.8%	5.4%	40.7%
Chile	4.3%	27.9%	5.3%	32.1%
China	7.2%	44.4%	9.0%	68.9%
India	7.1%	26.8%	4.5%	44.4%
Indonesia	6.4%	23.4%	2.5%	40.0%
Mexico	2.2%	27.3%	2.1%	33.3%
South Africa	9.7%	50.5%	2.6%	34.6%
Thailand	6.8%	32.4%	7.0%	44.3%
Turkey	3.1%	35.5%	5.6%	26.8%
Vietnam	5.6%	42.9%	3.5%	68.6%

be expanded to include additional countries and to consider years prior to 2007. In some cases quantitative data is also available regarding the size of a subsidy in a given year for a country. Table C-1 lists 21 additional countries identified as having a fuel subsidy sometime between 2000 and 2012.

C.2 Electricity subsidies

Additional sources also allow one to expand the list of countries with subsidies on electricity produced using fossil fuels. Table C-2 lists an additional 15 countries that had these subsidies at least one point in time between 2000 to 2012.

C.3 Data

Table C-4 provides the fuel subsidy data from the IEA for the 34 countries they identified for the years from 2007 to 2011. The dollar value has been converted into a subsidy-GDP ratio using GDP data from IMF World Economic Outlook reports.

Table C-5 provides additional data on costs of fuel subsidies and electricity subsidies, as a share of GDP. The numbers come from a variety of sources that have used different methods and data to calculate the costs of the subsidies. For this reason comparison across countries or with the IEA data should be done with extreme caution. Note that there are a number of gaps in the data. A blank entry does not mean the subsidy was non-existent. It merely means that no data was available for that year.

C.4 Sources

I relied heavily on Vagliasindi (2012), the GIZ International Fuel Prices surveys, and IMF country reports to identify the additional countries.

Maria Vagliasindi's book "Implementing Energy Subsidy Reforms: Evidence from Developing Countries" provided information on energy subsidies in 17 countries. Several countries were discussed in the book that are not found in the IEA data. These included Ghana, Jordan, Morocco, the Dominican Republic, and Yemen.

The GIZ releases an International Fuel Prices survey every two years. The latest edition is GIZ (2010). These surveys provide a data point for retail gasoline and diesel prices in a number of countries in November every two years. The time series for some countries goes back to 1991 but in most cases does not begin regularly until 1998. The following countries were

Table C-1: Additional Countries with Fuel Subsidies

Bahrain	Gabon	Oman
Bolivia	Ghana	Panama
Burkina Faso	Jordan	Senegal
Congo	Lebanon	Sudan
Dominican Republic	Mauritania	Syria
El Salvador	Morocco	Tunisia
Ethiopia	Nepal	Yemen

Table C-2: Additional Countries with Electricity Subsidies

Bolivia	Honduras	Mauritania
Cape Verde	Jordan	Mauritius
Djibouti	Lebanon	Nicaragua
Dominican Republic	Maldives	Panama
El Salvador	Mali	Senegal
Ghana		

identified using the GIZ International Fuel Prices Survey: Bahrain, Congo, Oman, and Syria.

IMF country reports and working papers identified the rest of the countries. Table C-3 lists the IMF reports used as sources. Country reports are shortened to CR and working papers to WP. The first column identifies the country, the second column the products discussed in one or more of the reports, and the third column provides a list of the documents. In the second column O is short-hand for oil products and E for electricity.

Please note that the list in the table is not exhaustive. For example, the IMF has country reports on the Dominican Republic which discuss electricity subsidies in that country. I omitted those country reports from the table since this country was already identified using Vagliasindi (2012). Reports which provided data on costs (which were not found elsewhere) are listed in the table.

The data on the costs of electricity subsidies in Honduras came from World Bank (2010).

Table C-3: IMF Sources

Country	Products	Reports
Bolivia	E, O	CR 12/149
Burkina Faso	O	CR 06/359, WP 11/202
Cape Verde	E	CR 10/349, 11/254
Djibouti	E	CR 09/216, 10/277, 12/197
El Salvador	E, O	CR 09/35, 10/307
Ethiopia	O	CR 06/159, 08/259, 08/264, 09/34
Gabon	O	CR 06/238, 08/24, 09/107, 13/55, WP 06/243
Honduras	E	WP 08/168
Jordan	E, O	CR 12/119, 12/120
Lebanon	E, O	CR 04/313, 06/201, 07/382, 09/131, 10/306, 12/39, 12/40
Maldives	E	CR 09/97, 10/28, 10/167, 11/293
Mali	E	CR 11/141, 12/3
Mauritania	E, O	CR 11/362
Mauritius	E	CR 05/281, 08/237
Nepal	O	CR 07/204, 07/366, 08/181, 10/185, 12/326
Nicaragua	E	CR 06/174, 10/376, 11/118, 11/322, 12/256, 12/257
Panama	E, O	CR 06/130, 09/207, 12/83
Senegal	E, O	CR 07/335, 08/221, 09/5, 10/363, 12/337
Tunisia	O	CR 06/207, 08/345, 09/329, 10/282, 12/255

Table C-4: Fuel Subsidies as a Percent of GDP (IEA data)

Country	2007	2008	2009	2010	2011
Algeria	3.0	3.8	2.8	5.2	5.7
Angola	0.9	1.2	0.3	1.1	1.0
Argentina	1.5	2.0	0.2	0.2	0.4
Azerbaijan	0.5	0.7	0.0	0.2	1.0
Bangladesh	0.5	0.7	0.0	0.3	0.8
Brunei	1.4	1.8	1.0	1.5	1.9
China	0.3	0.6	0.1	0.1	0.3
Colombia	0.3	0.4	0.1	0.2	0.2
Ecuador	6.8	8.0	3.1	6.4	8.2
Egypt	10.7	12.1	5.2	6.4	6.5
India	1.5	2.5	0.9	1.0	1.7
Indonesia	2.6	2.8	1.7	1.4	1.9
Iran	11.9	15.3	8.1	9.8	8.6
Iraq	14.5	14.6	7.7	17.2	17.8
Kazakhstan	1.3	1.2	0.4	1.4	1.7
Kuwait	2.4	2.8	1.8	2.3	2.7
Libya	3.7	3.6	2.7	4.3	6.3
Malaysia	1.4	2.0	0.8	1.6	1.9
Mexico	1.6	2.0	0.4	0.9	1.4
Nigeria	1.2	1.4	0.0	1.1	1.5
Pakistan	1.9	2.5	0.0	0.1	1.3
Peru	0.1	0.2	0.0	0.0	0.2
Philippines	0.1	0.1	0.0	0.6	0.6
Qatar	1.2	1.3	0.7	0.9	1.2
Saudi Arabia	6.2	7.6	5.9	6.7	7.7
South Africa	0.1	0.1	0.0	0.0	0.0
Sri Lanka	1.2	1.6	0.0	0.6	1.4
Taiwan	0.2	0.3	0.1	0.1	0.1
Thailand	0.6	0.8	0.5	0.7	1.0
Turkmenistan	2.8	3.3	3.7	3.9	3.0
UAE	0.6	0.6	0.4	0.9	1.1
Uzbekistan	0.0	0.0	1.3	0.7	2.3
Venezuela	5.7	5.2	3.2	5.3	6.9
Vietnam	0.4	1.2	0.0	0.0	0.8

Sources: IEA, IMF WEOs, author's calculations.

Table C-5: Additional Data on Subsidy Costs

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Fuel Subsidies													
Bolivia							0.5	0.9	2	1.3	1.7	2.9	
Burkina Faso							0.7		0.8				
Dominican Republic					0.7	0.4	0.5	0.4	0.5	0	0	0	
Gabon				0.4	0.7	1.6	2	1	1.3				1.8
Ghana				2	2.2	1.7	1.5	0	0.1	0.3	0.3		
Indonesia	5.4	4.6	1.9	1.5	3	3.4	1.9	2.2	2.8	0.8	1.3	2.2	2.4
Jordan			0.6	1.2	3.2	5.6	2.8	2.7	1.2	0.2	0.4	2.4	1.3
Morocco			0	0.6	1.1	1.4	1.3	3.9	3.7	1.5	1.2		
Tunisia					0.6	1.1	1.2	1	1.5	0.7	0.9	2.4	2.4
Senegal				0.0	0.2	0.3	1.3	1.0	1.2	0.5	0.2	0.2	0.1
Yemen	5.7	3.8	3	4.8	5.7	8.7	8.1	9.3	14.5	9.5	8.2		
Electricity Subsidies													
Dominican Republic					2	1.7	1.4	1.2	2.7	1.4	1.2		
Honduras			2.6	2.4	2.1	1	1.3						
Indonesia						0.3	0.9	0.8	1.7	0.9	0.9	1.2	1.1
Jordan											0.9	5.4	
Lebanon	1.1	1.1	1.0	1.4	2.1	3.0	3.4	3.1	5.1	4.1	3.0	4.5	4.5
Mali											0.3	0.4	0.4
Nicaragua						0.6							0.6
Senegal						1.8	2.7	1.5	1.6	1.1	1.7	2.1	
Yemen	0	0	0	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1		
Only Total Available													
El Salvador									2.5	1.4			
Mauritania									0.9	0.8	0	1.6	2.4

Sources: Refer to appendix.