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ABSTRACT

Today, a confluence of factors, such as growing concerns about associated consumption externalities and socioeconomic pressures, is building the momentum towards reducing fossil fuel consumption for road transport and rationalizing prices to reflect direct, indirect and externality costs. While limited country specific work has been done, considering optimal transport fuel prices, (e.g. Parry 2012), we have found no attempts to do so with the breadth and scope of our analysis. Thus in this paper, we make three main contributions. First, we survey policies aimed at reducing transport fuel consumption. Out of these policies, we chose fiscal instruments for our extensive quantitative analysis carried out in a supply and demand framework for 123 countries. Second, we quantify the rationalized cost of transport fuels to reflect the direct costs (production), indirect costs (road maintenance), and negative externalities (climate change, local pollutants, traffic accidents and congestion). Finally, we measure the change in demand, environmental emissions, government revenues and welfare induced by successively phasing in our three cost categories. By rationalizing prices, we estimate that total demand for gasoline could be reduced by 8.5 percent and that of diesel by 5.7 percent. This would lead to not only reduction in associated negative externalities, but also generate an estimated $400 billion in revenues to governments.

Keywords: transport policy, energy demand, subsidy, externalities, gasoline, diesel

1. Introduction

Externalities from transport fuels result from a combination of miles traveled and fuels consumed. Among the long list of negative direct externalities, Parry and Small (2005) argue that quantitative estimates rank climate change, pollution, congestion and traffic accidents on top of the list.

Under a business-as-usual scenario, global greenhouse gas emissions will rise by about 70% between now and 2050 (OECD, 2009). As shown in Figure 1, the transport sector is responsible for 23 percent of CO_2 emissions generated by fossil fuels. By fuel, gasoline represents 55 percent of road transport emissions, and diesel another 43 percent. Local pollutants are increasingly being internalized in the industrial countries, where regulations have reversed the increasing trend.[3] However, local pollutants are on an upward trajectory in emerging economies (EDGAR, 2013). For instance, Asian emissions of sulfur dioxide (SO_2) from burning transportation fuels increased 50 percent and nitrogen oxides (NO_X) emissions increased over 20 percent from 2000 to 2006. Traffic congestion is a major challenge facing mega cities around the world (Gurjar et al., 2008). Figure 2 presents air quality and travel time per mile for 14 megacities around the world. According to the International Road Federation (2010), over half a million people are killed every year by traffic accidents. Climate change, pollution, congestion and traffic accident externalities have adverse negative effects on productivity and health, potentially limiting the economic growth of nations.

[3]For example, highway vehicle emissions of carbon monoxide fell over 75 percent in the U.S. from 1970 to 2008.

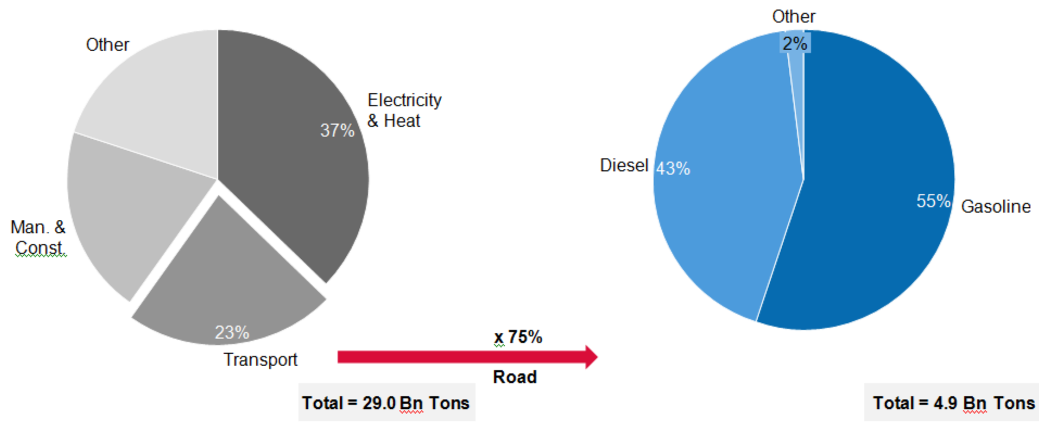


Figure 1: CO_2 emissions by sector on the left and emissions by fuel in road transport on the right (2009). Source: IEA (2011b)

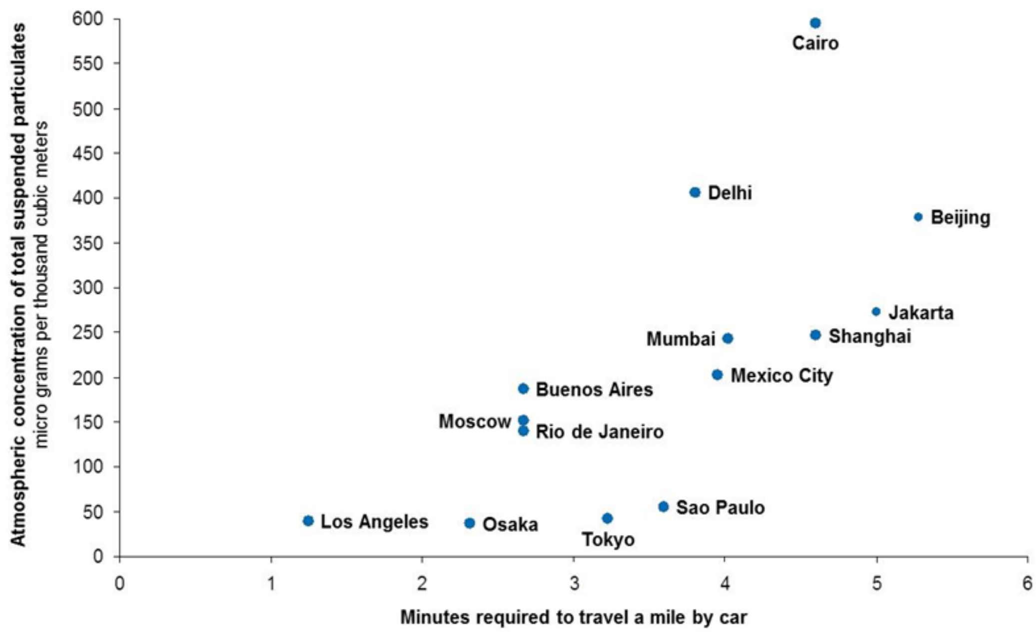


Figure 2: Air quality and congestion in selected cities. Source: Parry (2012)

The existence of such externalities calls for corrective actions by governments. While different policies could be available, fiscal instruments are often considered to be the most effective (Parry, 2012). Fiscal instruments attempt to address externality problems by exploiting the various behavioral responses throughout the economy in a least cost manner. Furthermore, fiscal instruments generate revenues for governments, essential for developing countries, in addition to potential 'double dividend effects'[4] (Parry, 2012).

On another front, socioeconomic issues associated with the subsidy of transport fuel prices, especially in hydrocarbon-rich countries, are putting pressure on governments to reform pricing policies. Issues associated with subsidies include the weakening of incentives for higher fuel economy (Morgan, 2007), the flow of subsidies to higher income groups instead of equal distribution among nationals or targeted groups (IMF, 2010), and a suboptimal allocation of gasoline to the domestic and export markets, leading to losses in foreign exchange revenues (IEA, 2011b; Birol et al., 2010; de Moor, 2001).

Going forward, the concerns around consumption externalities coupled with socioeconomic pressures will further build up the pressure on governments to rationalize their transport fuel prices to reflect direct, indirect and externality costs. In this context, Parry and Small (2005) find that the gasoline tax in the U.S. is below the socially optimal level, contrary to Britain where they find taxes are too high. Parry et al. (2007) draw further on the case of the U.S. through analyzing the effects of the U.S. Corporate Fuel Efficiency (CAFE) standards on the level of externalities associated with transport fuels. Recently, Parry (2012) carried out an application of rationalizing gasoline taxes to internalize consumption externalities for Mauritius. While these represent limited country specific cases, no one has looked at the global impact of rationalizing transport fuel prices on fuel consumption levels and environmental emissions, which we will do in this paper.

This paper is structured as follows. The first section provides a brief survey of policies affecting transport fuel consumption. Pricing is the most prominent of these policies, for instance we have found no country that does

[4]Supporters of double dividend argue that when a government rationalizes prices it realizes a first dividend from internalizing the externality and a second one from reducing other fiscal distortions (i.e. income and capital taxes) offset by the revenues from the corrective tax (Summers, 1991; Nordhaus, 1993). Opponents of this view argue that the economy wide effects are more distortive (Bovenberg and de Mooij, 1994). Parry (1995) draws on the literature in this topic to conclude that the idea of a double dividend is specific to the fiscal regime in place and context of the economy structure, requiring the need for general equilibrium settings.

not either tax or subsidize transport fuels. For this most ubiquitous of policies, we next consider rationalizing pricing schemes so that prices include both direct and indirect externality affects. In Section 2, we consider such price rationalization schemes for 123 countries responsible for over 98 percent of the global demand for gasoline and diesel. In Section 3, we present the data and methodology for measuring the change in quantity demanded and environmental emissions induced by rationalizing prices. We explain the approach for impact analysis and data in Section 4. We present results and sensitivity analysis in Section 5 with concluding remarks in Section 6.

2. A Survey of Transport Fuels Policies

The world's weighted average of price less taxes in 2008 for gasoline is around \$1.94 per gallon and \$2.79 per gallon for diesel. However, there is great heterogeneity in transport fuels prices across countries. Differences in these internationally traded commodities are largely the result of varying transfer levels (i.e., subsidy, tax), as demonstrated in Figure 3. See the Appendix for the computation of taxes and subsidies. Diamonds below the dotted green line are subsidizing diesel fuel and to the left of the dotted red line are subsidizing gasoline. Our computations and Figure 3 suggest that 21 countries were subsidizing gasoline and diesel fuel and another 7 countries were subsidizing only diesel fuel in 2008. However, more often countries were taxing fuels and sometimes quite heavily.

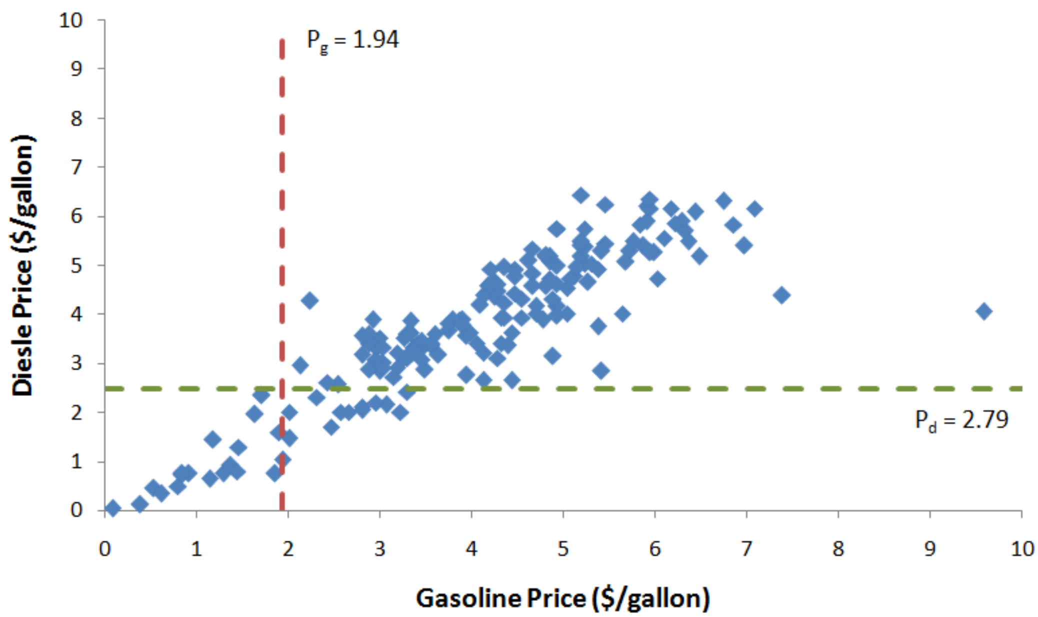


Figure 3: Gasoline and diesel retail prices across 171 countries as of November 2008 ($/gallon). Source: GTZ (2009) and author computations

Transport fuel taxes have arisen for various reasons. High transport fuel taxes in Western Europe originated from the need to fund post World War II reconstruction plans. Gasoline, considered a luxury good with inelastic demand, was highly taxed. Somewhat lower diesel taxes, as noted in Figure 4 (countries listed in the gray area have higher gasoline than diesel taxes), were aimed at keeping down freight transport rates and enabling their industry to be more competitive. This differential, coupled with changing vehicle technologies, has encouraged a major switch of the passenger fleet towards diesel engines in some countries. For instance, over two thirds of new light duty passenger vehicle sales in France and just over half of new light duty passenger vehicles in Western Europe in 2010 had diesel engines. With rapid diesel penetration, the share of total light duty passenger diesel registrations had reached about 35% in Western Europe by 2009 (ACEA, 2012). In the U.S., the picture is reversed. Diesel is slightly more heavily taxed with regulations related to local pollutant emissions. This higher price and early negative experiences with diesel engines hindered the penetration of diesel in the consumer transport sector. Overall, transport fuel taxes in the U.S. have been much lower than in Europe, and they have been more closely earmarked for highway funding. For instance, 90% of the Federal gasoline tax goes to the Federal Highway Trust, 8.5% goes towards Mass Transit, and 1.5% goes to the Leaky Underground Storage Trust (U.S. Federal Highway Administration, 2010).

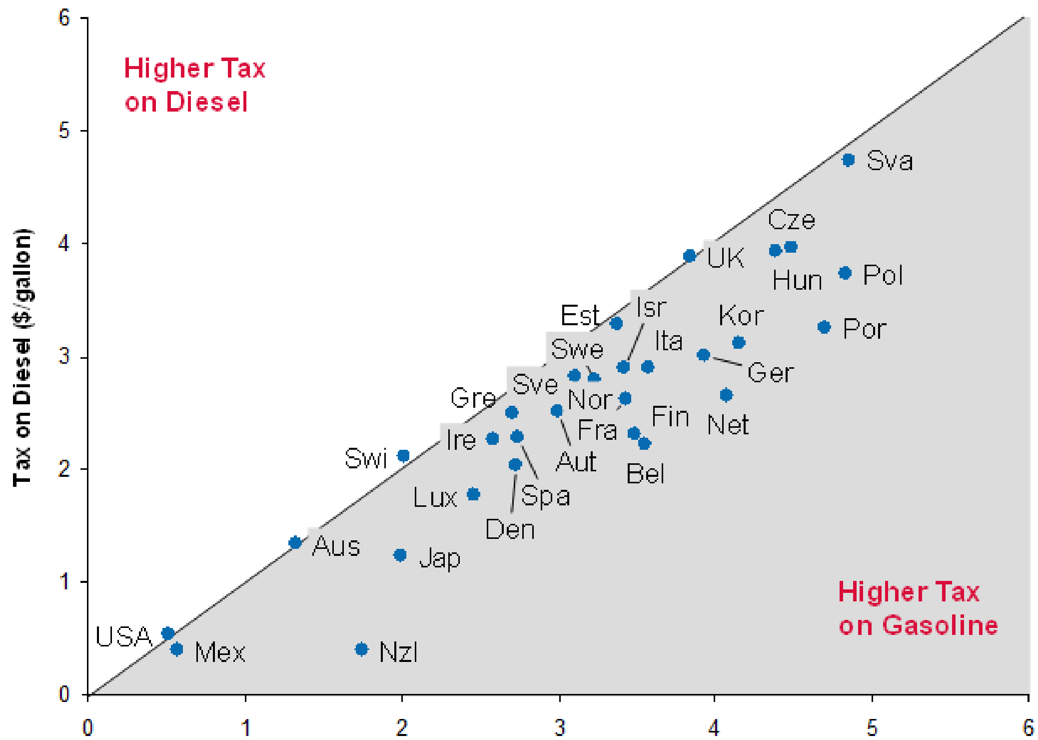


Figure 4: Gasoline vs. diesel taxes in select countries in 2009. Source: IEA (2010a)

Early energy subsidies for transport fuels were more often located in oil producing countries where they were considered to be a means of resource wealth sharing (IEA, 2011b). Examples include Venezuela and Saudi Arabia, which have some of the lowest retail gasoline prices in the world. In non-energy exporting emerging markets, subsidies were sometimes used to shield their inhabitants from rapidly increasing prices such as from 2004–2008.[5] Sometimes fuel subsidies may have had ulterior motives. For example, some

[5]See Kojima (2009) for discussion of such subsidies and stabilization funds for 49 developing countries.

recent subsidies for transportation bio-fuels described in OECD (2012) are criticized as being used to protect domestic agricultural support programs with little true environmental benefits (Doornbosch and Steenblik, 2007). The U.S. is a case in point, where ethanol production had been highly subsidized,[6] ethanol tariffs had been in place, while the U.S. Energy Independence and Security Act of 2007 (U.S. Government Printing Office, 2007) mandates increasing use of renewables as transport fuels.[7] Subsidies in some countries in Europe have been even higher with estimates in some cases of over $6 per gallon for ethanol and over $2.50 per gallon for biodiesel based on the fossil fuel displaced (Doornbosch and Steenblik, 2007).

Concerns about transportation fuel consumption externalities (e.g., local pollution, climate change, energy security) in many importing countries have led governments to target and re-enforce policies specifically aimed at total transport fuel use and mix. U.S. CAFE standards, enacted in 1975 after the first oil embargo, were aimed at increasing vehicle fuel efficiency and reducing fuel consumption. Those standards were increased in U.S. Government Printing Office (2007).[8]

Brazil's ethanol vehicle program, enacted in the late 1970's, required ethanol to be blended into gasoline with the goal of changing the fuel mix away from petroleum-based fuels towards a domestic renewable fuel (Rico, 2007). More recently with the manufacture of flex fuel vehicles, over 90% of new Brazilian vehicles sold can burn multiple fuels (Freitas and Kaneko, 2011). Other similar policies include "gas guzzler" taxes on less efficient vehicles, "Cash for Clunkers" to get the worst pollution offenders off the road, and feebates that tax inefficient vehicles while offering rebates to efficient ones (Greene et al., 2005; Goerlich and Wirl, 2012).

In addition, governments have urban policies not directly focused on fuel use that can have large effects on private transport fuel use. Good choices and proper resources applied to urban transit can have profound effects on urban land use, reducing congestion, increasing mobility as well as conserving

[6] Around a 50 cents per gallon tax break is offered.

[7] After more than 30 years, the U.S. tax break and the tariff on ethanol was allowed to lapse on December 31, 2011, although the mandates remain in force (The New York Times, 2012).

[8] See An et al. (2011) for a discussion of other examples of efficiency standards and other policies that have been implemented to improve vehicle fuel efficiency.

fuel (Schipper, 2010).[9] Road pricing and taxing private vehicles entering the central business district during peak traffic hours as well as limiting the number of publically available parking spaces can also send better pricing signals impinging on private fuel use (Small and Gomez-Ibanez, 1998; Goh, 2002).

Local land use policies that have no direct link to transportation services can also have a major effect on transportation energy use. For example, zoning regulations designed to maintain a quiet suburban lifestyle may significantly limit population and jobs per square mile of metropolitan area. Such suburban sprawl greatly reduces the feasibility of providing public transport services.[10]

Overall, the landscape of transport fuel policies has been shaped by countries' self-interests as well as their historical context. Nowadays, a variety of policies directly and indirectly influence transport fuel consumption. In the next section, we will focus our attention specifically on tax and subsidy policies for transport fuels.

3. Country Specific Rationalization Schemes

Economic theory tells us that the socially optimal price is the marginal social production cost, which includes the direct cost of production, any indirect costs as well as externality affects. Next we will evaluate each of these costs for gasoline and diesel by country and fuel.

For the direct cost, IEA (2011a) reports retail prices and taxes for 41 countries for gasoline and 43 countries for diesel. For these countries, we compute the direct production cost, without transfers, to be the retail price less the tax. For the remaining countries, where tax data is unavailable or countries are subsidizing the products, we evaluate the direct cost of fuels as equal to the wholesale price plus an ad valorem transportation and distribution margin. As discussed in the appendix, we assume that the wholesale price for each country is that of the nearest hub. We compute the margin by minimizing the total squared error between the calculated direct prices and implied wholesale prices for countries where retail and tax data are not available. As a result, we get an 82.0 percent margin for gasoline and a 47.8 percent margin

[9] For an excellent survey on factors affecting public transit use, see Litman (2012).

[10] See Litman and Steele (2012) for a discussion of how land use factors influence vehicle travel, etc.

for diesel. The higher margin for gasoline is consistent with high use of diesel for freight and commercial use characterized by fewer distribution centers, larger volumes per sale and more bulk sales.

The main indirect cost associated with transport fuels is road maintenance cost. GTZ (2009) indicates that a cost of $0.10 per liter is a rule of thumb number that should be sufficient to maintain highway roads with an added cost of $0.03–$0.05 per liter for urban road and transit needs. Statistics Norway reports that 32 percent of road maintenance cost is labor wages while the rest is material cost. Based on that, we extrapolate the inflation adjusted average road maintenance cost reported by GTZ (2009) by adjusting the labor component of the cost to reflect country specific labor costs using data reported by World Minimum Wage Resource (2009) (See Appendix).

Moving to externalities, we start with climate change. The U.S. government's Interagency Working Group on Social Cost of Carbon puts CO_2 cost at $21 per ton and CO_2 has traded around this value in the EU emissions trading scheme. Although CO_2 currently has been trading at below $10 per ton, this low price is likely related to the European financial crisis and a surfeit of permits and is not likely to reflect a long term cost.[11] We start with the U.S. number, $21 per ton, and then extrapolate this figure to the remaining countries by adjusting for differences in purchasing power of each country.[12] As per IEA (2010a), we assume that gasoline combustion results in 8 kg of CO_2 per gallon and diesel combustion results in 10 kg of CO_2 per gallon (see Appendix).

Turning to local pollutant externalities, the National Research Council (NRC, 2009) puts the lifecycle cost of local pollutant damages from gasoline and diesel at 29.02 and 43.81 cents per gallon, [13] respectively. Small and Verhoef (2007) report a value for gasoline that is close to that of NRC (2009). Assuming that 30 percent of the cost is incurred in the combustion

[11]Median estimates for CO_2 equivalent costs from the Energy Modeling Forum 21 or stabilizing greenhouse gases at 550 ppm are $27 per ton in 2020. However for stabilizing at the lower 450 ppm the median carbon cost is more than twice this number in 2020.

[12]The United Nations Framework Convention on Climate Change states the principle of "common but differentiated," indicating that rich countries should bear a larger burden of mitigation responsibilities.

[13]NRC table 3-3 reports a cost of 38.65 cents per gallon of gasoline equivalent for low sulfur diesel, we translate that into gallons of diesel using the heat conversion factor between gasoline and diesel.

phase and adjusting for inflation, we get a marginal cost of 9.0 cents per gallon for gasoline and 16.5 cents per gallon for diesel.[14] The main damage from local pollutants results from particulate matter and the combination of NO_x and volatile organic compounds (VOCs), that form tropospheric ozone (O_3), causing premature mortality (Ostro et al., 2006; NRC, 2009; Muller and Mendelsohn, 2012). As such, we extrapolate the above figures by adjusting for the value of a statistical life and the rate of fleet local pollutants emissions of each country relative to the U.S. (See Appendix).

Parry et al. (2007) argue that the cost of congestion is the marginal delay due to an additional vehicle times the value of time (VOT). This externality is road specific and more generally city specific. Estimating the country level cost is data intensive, especially for the marginal delay component. FHWA (1997) uses speed-flow curves to calculate the marginal costs for a selection of urban and rural roads in the U.S. and then weights these values by the mileage shares in order to calculate a national cost. Fisher et al. (2007) build their national estimate for the marginal cost of congestion in the U.S. based on a computational model for Washington D.C. They extrapolate the marginal cost from the capital to the national level by mileage per pavement ratio and population shares. Parry (2012) builds his estimate for Mauritius based on travel speed data in the capital, assumptions on marginal delays and the share of travel that takes place in the capital, other urban areas and rural areas. For the VOT, Parry argues that it is half of the market wage in general and evaluates the value for Mauritius by adjusting that of the U.S. by the ratio of GDP per capita. In our case, driven by data availability, we use the inflation adjusted cost of congestion estimated by Parry et al. (2004) for the U.S., 36 cents per gallon for gasoline, as the basis and carry out three adjustments. First, we adjust for urbanization relative to the U.S. using data from UN (2011). Second, whenever available, we adjust for vehicles per km of road based on data in The World Bank (2011). Finally, we adjust for the VOT using the Parry (2012) approach. The cost is converted to cents per gallon of diesel using a heat conversion factor.

Moving to traffic accidents, International Road Federation (2010) data on fatalities from accidents is aggregated into one category and thus does not allow us to consider those not internalized by drivers (i.e., drivers internalize the risk of death to themselves when deciding how much to drive). In order

[14] As shown in figures S-3 in NRC (2009).

to estimate the marginal cost of traffic accidents for countries in our sample, we apply Parry's (2011) approach to fatalities reported by the International Road Federation (IRF) and calibrate the results to match the marginal cost of accidents for the U.S. reported by Parry and Small (2005). Details are presented in the Appendix.

Applying the above, we get country specific levels of gasoline and diesel direct costs, road maintenance costs and externality costs. The Appendix provides calculation details and results in Table A.5. Given the number of assumptions and extrapolations, our findings should be taken with caution. To this end, we later carry out, sensitivity analysis on our findings to test the impact of our assumptions.

Now that we have all the costs, we can rationalize prices by computing the socially optimal tax that would cause each country to price gasoline and diesel at their social marginal cost.

4. Approach for Impact Analysis and Data

We will measure the impact of rationalizing gasoline and diesel prices on quantity demanded, CO_2 emissions, and potential revenues to be raised taking 2008 as the base year. We carry out this analysis by moving the market prices towards the optimal social prices in a series of steps, as follows:

1. Remove fuel subsidies by raising all subsidized gasoline prices to production cost;
2. Increase prices so that retail price equals at least the direct cost and indirect road maintenance cost;
3. Increase prices to include external costs so that all retail prices equal at least the direct, indirect and externality costs;
4. Change all prices to the rationalized schemes. Thus, raising low taxes as in case 3, but also lowering taxes where they are too high.

For each scenario, we will measure the change in demand induced by a change in price levels from the current retail prices (P_i) to the policy scenario price (P_{i2}), holding all other variables (i.e., income (Y) and population (Pop)) constant. Building on Dahl (2012):

$$Q_i = \beta P_i^{\beta_2} Y_i^{\beta_3} Pop_i^{(1-\beta_3)} \tag{1}$$

Where the post policy scenario demand can be presented as:

$$Q_{i2} = \beta P_{i2}^{\beta_2} Y_{i2}^{\beta_3} Pop_{i2}^{(1-\beta_3)} \tag{2}$$

The ratio of post policy scenario demand to 2008 levels can be written as:

$$\frac{Q_{i2}}{Q_i} = \frac{\beta P_{i2}^{\beta_2} Y_{i2}^{\beta_3} Pop_{i2}^{(1-\beta_3)}}{\beta P_i^{\beta_2} Y^{\beta_3} Pop^{(1-\beta_3)}} \tag{3}$$

Holding income and population levels constant, predicted Q_2 can be represented as:

$$Q_{i2} = Q_i \left(\frac{P_{i2}}{P_i} \right)^{\beta_2} \tag{4}$$

We use the elasticities reported in Dahl (2012) for all countries with price data available in GTZ on a 2008 base year.[15] See Appendix Table A.5 for the list of countries. In her paper, Dahl shows that price elasticities varied somewhat by fuel price and income level, as outlined in Table 1 and Table 2. As such, we adjust the gasoline and diesel price elasticities as prices change for each rationalized scheme accordingly.[16]

Since there is not much systematic statistical evidence that quantitatively captures substitutions across the two fuels (Dahl, 2012) and the rationalizing schemes do not change the relative prices very much, we assume that the cross price elasticity between the two fuels is zero.

Table 1: Fuel price elasticities stratified by GDP per capita (Y) in dollars per capita and price (P_g) in cents per gallon for Gasoline.

Gasoline	$P_g < 107$	$107 \leq P_g < 267$	$267 \leq P_g$
$Y < \$10,680$	-0.15	-0.22	-0.26
$\$10,680 < Y \leq \$21,360$	-0.11	-0.24	-0.32
$\$21,360 \leq Y$	-0.22	-0.22	-0.33

[15]Due to data availability, Uzbekistan is excluded for diesel and Zambia is excluded for gasoline leaving 123 countries for each fuel.

[16]For example, take a country that has a GDP per capita lower than \$10,680, a retail price lower than 107 cents per gallon, and a socially optimal price greater than 267 cents per gallon, and initial price elasticity of s the new demand for gasoline is computed as: $Q_2 = Q_1 \left(\frac{107}{P1}\right)^s \left(\frac{267}{107}\right)^{s\frac{0.22}{0.15}} \left(\frac{P2}{267}\right)^{s\frac{0.26}{0.22}}$

Table 2: Fuel price elasticities stratified by GDP per capita (Y) in dollars per capita and price (P_g) in cents per gallon for Diesel.

Diesel	$P_d < 267$	$267 \leq P_d$
$Y < \$16,020$	-0.22	-0.38
$\$16,020 \leq Y$	-0.13	-0.27

Note:1 Tables 1 & 2: Price and GDP per capita numbers are converted from 2006 to 2008 dollars using U.S. CPI of 1.068. Source for Table 1 & 2: Dahl (2012).

Initial gasoline and diesel consumption data is from IEA (2010b) with gasoline and diesel retail prices for November 2008 from GTZ (2009).

5. Empirical Results and Sensitivity Analysis

Figure 5 shows the percentage change in fuel consumption for rationalization schemes 1-3. Removing direct subsidies on the 21 countries that subsidize gasoline and the 29 that subsidize diesel reduces world gasoline and diesel fuel for road transport between 2-3%. Adding in the seven countries that price gasoline between the direct cost and road maintenance, and the 15 that do so for diesel adds another 1% or more reduction. Adding in externalities for the 18 countries that price gasoline at greater than the direct plus indirect cost but less than costs including externalities more than doubles the saving in gasoline use, while adding 30 comparable countries for diesel increases the savings in diesel fuel use about another 60 percent. This translates into a reduction of CO_2 emissions from road transport of around six percent.

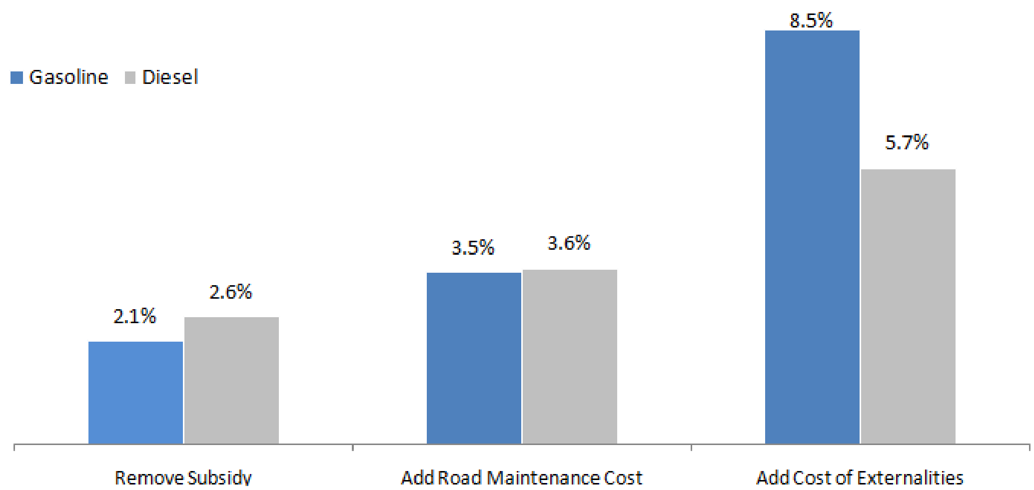


Figure 5: Total change in global quantity demanded by rationalization scheme.

Rationalizing prices also leads to the generation of over $400 billion in governments revenues. We estimate that removing subsidies will generate $86 billion,[17] reflecting road maintenance cost will add an additional $51 billion, internalizing externalities generates another $269 billion. The breakdown by fuel of generated revenues is presented in Figure 6. The increase in government revenues can be above five percent of a country's GDP, especially in those that export oil. Figure 7 presents the incremental revenues as a percentage of GDP versus the income per capita of all countries in the sample.

[17]This only includes the revenue changes in the domestic market but not any changes for the export market.

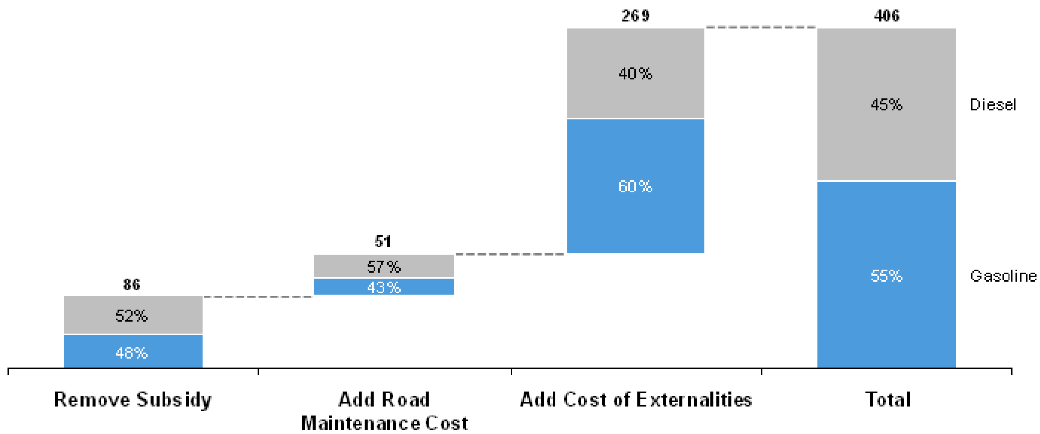


Figure 6: Expected revenues from rationalization schemes, in billion dollars.

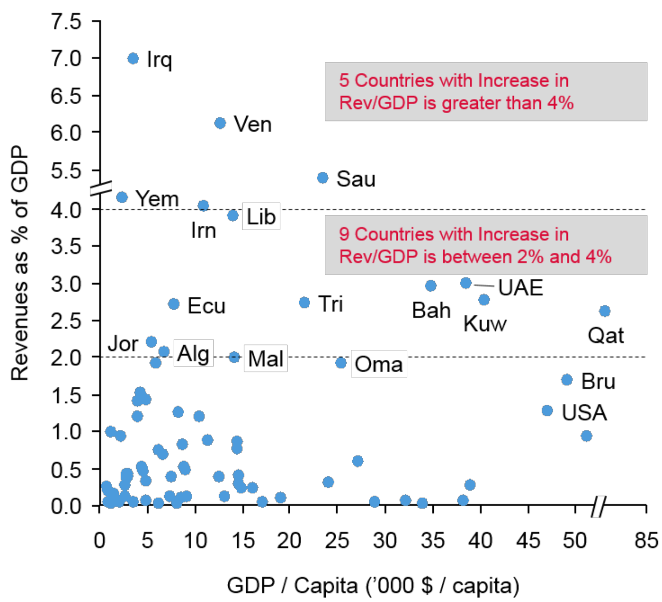


Figure 7: Revenues as percentage of GDP vs. GDP per capita.

Rationalizing prices will directly impact consumers' welfare. Equivalent variation is the typical metric used to assess the pre-implementation impact of a policy on the change in consumers' welfare. Given that we do not observe the Hicksian demand functions for gasoline and diesel, Mas-Colell et al.

(1995) suggest approximating equivalent variation by area variation (AV)[18] when the welfare effect of the good whose price is changed is minimal. In the case of gasoline and diesel, we can assume that these constitute a small share of consumers' expenditure on goods and services. Looking at Figure 8, we see that the welfare impact is highest across resource-rich developing countries, mainly OPEC countries. The result reflects the level of difference between the current prices and rationalized levels. For most of OPEC countries, the change in welfare is between 50 and 300 USD per capita.

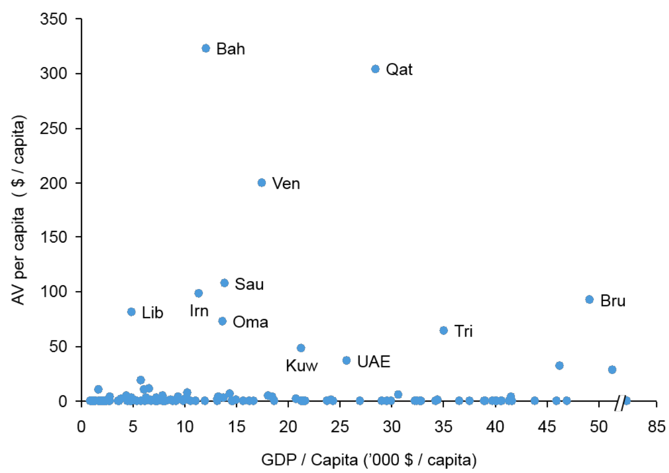


Figure 8: AV per capita versus the average GDP per capita.

Given that our analysis relies heavily on assumptions, we carry out sensitivity analysis to test the robustness of our findings. We vary the following parameters one parameter at a time—gasoline and diesel elasticities, distributional margins, CO_2 cost and elasticity of the value of statistical life (VSL) with respect to income. Table 3 documents the parameters tested with their baseline, lower and upper values in addition to a rationale for these values. Table 4 presents the change in demand for gasoline and diesel and implied change in government revenues under the different scenarios of sensitivity analysis.

[18]For details, refer to Mas-Colell et al. (1995) equation (3.I.8)

Table 3: Parameters considered in sensitivity analysis.

	Rationale		
Parameter	Baseline	Lower/Upper	Description
Gasoline and diesel elasticities	ϵ_0, ϵ_d	$+\sigma/-\sigma^*$	• Based on the second moment of the gasoline and diesel price elasticities in sample (0.14 for gasoline and 0.12 for diesel)
Distribution margin	m_g, m_d	$-\sigma/+\sigma$	• Based on the second moments of our sample (0.26 for gasoline and 0.22 for diesel)
Road maintenance cost (cents/gallon)	56.6	52.6/60.6	• Higher and lower bounds presented by GTZ for road maintenance cost
CO_2 cost (\$/ton)	21.0	7.0/44.1	• The lower cost reflects the ETS value for April 14th 2012 as reported by Bloomberg • The upper cost is what is needed for the 550 ppm stabilization (OECD, 2009)
μ_{vsl} (elasticity of VSL to income)	1.0	1.5/0.5	• Viscusi and Joseph (2007) for the lower • Viscusi (2010) argue for a μ_{vsl} greater than unity for developing countries

* The higher bound of elasticities is limited to zero.

Table 4: Sensitivity analysis on change in gasoline and diesel consumption from baseline level (Percentage change from the baseline reduction in gasoline and diesel consumption).

	Gasoline						**Diesel**					
	Change in Demand (Mn gal)			Change in Revenues (Bn $)			Change in Demand (Mn gal)			Change in Revenues (Bn $)		
	Low Case	Base Case	High Case	Low Case	Base Case	High Case	Low Case	Base Case	High Case	Low Case	Base Case	High Case
Own Price Elasticity*	-12,152		-41,434	247		207	-4,021		-19,355	193		172
Distribution Margin	-26,883		-30,487	206		245	-10,193		-14,125	129		239
Road Maintenance Cost	-27,008	-27,979	-28,935	211	224	238	-11,774	-12,044	-12,314	175	182	189
CO_2 Cost	-25,403		-32,180	207		253	-11,356		-13,185	170		201
VSL Elasticity	-27,196		-33,421	215		267	-10,716		-15,301	165		234

*Low is less elastic or closer to zero and High is more elastic or more negative.

As shown in Table 4, the change in demand for both gasoline and diesel is significantly affected by our parameter assumptions. Across our scenarios, we find gasoline consumption falls from about 12.2 billion gallons up to 41.4 billion, while government revenues from gasoline tax changes vary from 206*to*267 billion and revenues from diesel fuel vary from 129*billionto*239 billion.

Let's consider first sensitivity tests for price elasticity. A low price elasticity is less elastic or closer to zero and a high price elasticity is more elastic or more negative. For the gasoline low price elasticity, we add 0.14 to the price elasticity in table A6 truncating any positive elasticities to zero and for the high elasticity case we subtract 0.14. We do the same for diesel except the standard deviation to add and subtract is slightly smaller at 0.12. With the less elastic demand, the reduction in gasoline and diesel consumption is less than half of the change in the base case, while the increase in elasticity increases the reduction almost 50 percent or better for both. The high price elasticity case shows the greatest reduction in gasoline and diesel consumption and hence emissions of all the scenarios in the table. We do some further experimentation to put these changes in perspective. We find as a rule thumb that for each increase in price elasticity of -0.1, reduces the consumption of gasoline by 6.8 Bn gallons and that of diesel by 5.4 Bn gallons.

With differing fuel consumption, government revenues also are changed for the different elasticities. The gasoline revenue increase is about 10 percent higher than that in the base case for the low elasticity case but about 8% lower for the high elasticity case. Diesel revenue changes show a similar pattern but the changes relative to the base case changes are about half as large. We see some asymmetry for both consumption and revenues as the result of the truncation positive price elasticities at zero because of higher price elasticities at higher prices.

Our elasticity changes from plus to minus one standard deviations made the largest difference in fuel consumption and indirectly influenced revenue collected through these quantity changes but not through tax changes. For all the other sensitivity tests in the table, we change the tax, which gets added into price to reflect cost changes. Now the low value is a lower price case and fuel consumption drops less than in the base case and the high value corresponds to a higher price and fuel consumption drops less than in the base case. None of the fuel consumption decreases match the drop for the high price elasticity case, but for the remaining parameters a high VSL produces the largest drop compared to base case for both fuels with a 19%

drop for gasoline and a 27% large drop for diesel. Nor do any of the changing cost scenarios see as small a drop in consumption as the low price elasticity case.

Revenue deviations are more similar to those for the price elasticity deviations and in some cases even deviate more. Revenues are 91-96% of base case for all the low cost scenarios except the low diesel distribution margin, which receives only 71% of base case revenues. This low distribution margin case collects the least revenues for both gasoline and diesel fuel. There is more variation across the higher revenue cases. More collections are no more than 10% higher than the base case including the low elasticity cases for gasoline and diesel. The exceptions are high costs scenarios for gasoline CO2 and VSL and the high cost cases for diesel distribution margins and distribution margins. Since the last four sets of sensitivity tests all relate to costs, we did one last set of experiments to put them into perspective. As a rule of thumb, we find an increase of 10 cents in the price of gasoline reduces the total demand by approximately 2.7 Bn gallons, while the same increase in the price of diesel reduces the total demand by approximately 0.7 Bn gallons. Again we see asymmetric responses for low and high cost cases. The asymmetries are larger where the costs increases are measured as a percent or an elasticity.

These sensitivity results suggest that the rationalization of transport fuel prices requires a closer look at the underlying assumptions. Fuel consumption appears to be most sensitive to price elasticities, whereas, value of statistical life and diesel distribution margins provided more variation across revenues collected.

6. Conclusion

Building on the template provided by Parry (2012), we design price rationalization schemes for 123 countries representing over 98 percent of global transport fuel demand. This is done by including the direct, road maintenance, climate change, local pollutants, congestion, and traffic accidents costs into fuel prices. By feeding in the designed schemes into country specific partial equilibrium models, we find that the global demand for gasoline can be reduced by nine percent and for diesel by six percent. This curbs CO_2 emissions from these fuels in the transport sector by around six percent. In addition, this should generate over 400 billion dollars in revenues.

The analysis in this paper was carried out in a static partial equilibrium setting. However, removing subsidies and rationalizing prices would lower for transport fuels, and could lower the world prices. As a result, the consumption in some countries (mainly developed) would decreaseless and the final impact on reduction in emissions level may be limited. In addition, the effect of revenues recycling from removing subsidies and other general equilibrium feedback effects would have an impact on the change in consumption and emissions level. Furthermore, the phase in of rationalized prices and dynamic effects are important aspects to consider. To study these effects, we hope to join other researchers in next taking this analysis to a general equilibrium environment.

Appendix A. Details on Calculations Underlying Chapter

In this appendix, we represent and explain different types of costs including direct cost, road maintenance cost, marginal cost of climate change, marginal cost of local pollutants, and marginal cost of traffic accidents. In addition, at the end of this appendix we represent a Figure depicting frequency analysis of externality costs (Figure A.9), and a Table with country factsheet and counterfactuals for 2008 (Table A.6).

Direct Cost

Where data exist, we compute the direct production cost without transfers for the i^{th} fuel (g for gasoline and d for diesel), in the j^{th} country ($P^t_{i,j}$) to be the market price ($P_{i,j}$) minus tax ($T_{i,j}$), or

$$P^t_{i,j} = P_{i,j} - T_{i,j} \tag{A.1}$$

Using retail prices and taxes reported by IEA (2011a), we calculate the gasoline direct cost for 40 countries and that of diesel for 42 countries. Where tax data is unavailable or countries are subsidizing the products, we evaluate the direct cost of fuel $i(P^t_{i,j})$ as equal to the wholesale price ($P^w_{i,j}$) for fuel i plus an ad valorem transportation and distribution margin (m_i):

$$P^t_{i,j} = P^w_{i,j}\,(1 + m_i) \tag{A.2}$$

The November 2008 wholesale price is measured at three international ports where products are traded and the price is transparent—New York Harbor (NYH), Amsterdam/Rotterdam/Antwerp (ARA), and Singapore. The nominal wholesale prices for gasoline are 128, 119, 115 cents per gallon and for diesel are 239, 241, 235 cents per gallon in NYH, ARA, and Singapore, respectively (IEA, 2010a).[19] For each country, we assume the wholesale price to be that of the nearest hub. Building on that, we compute margins (m_i)

[19] The U.S. prices are a weighted average of spot price for conventional regular gasoline and a weighted average number 2 low sulfur diesel fuel from New York Harbor, the U.S. Gulf Coast, and Los Angeles with weights of (0.45, 0.45 and 0.10.) from averages of daily data for November, 2008. To convert the U.S. gasoline to premium \$0.19 per gallon is added to the gasoline price, which is the difference between premium and regular gasoline for the United States. Diesel prices for Rotterdam and Singapore are computed from the average daily gas oil prices for November, 2008 with two cents added, which is the difference in price between number 2 diesel fuel and heating oil in the United States. (*Weekly Petroleum Status Report* summarized at http:

from countries where tax data is available. We choose the m_i that minimizes the total squared error (TSE_i) between our direct costs measured as price less tax and our computed direct cost $P^w_{i,j}(1+m_i)$ or:

$$\min_{m_i}(TSE_i) = \min_{m_i} \in \sum_j \left[P_{i,j} - T_{i,j} - P^w_{i,j}(1+m_{i,j})\right]^2 \tag{A.3}$$

Using the taxes reported by IEA (2012) for 41 countries we get an 82.0 percent margin for gasoline and a 47.8 percent margin for diesel using data on 43 countries.

Road Maintenance Cost

We start with a value of 56.6 cents per gallon reported by (GTZ, 2009), and then we extrapolate this figure to our 123 countries by adjusting the labor component of the cost. Statistics Norway (2004) reports that 32 percent of road maintenance cost is labor wages while the rest is material cost. Using this breakdown, we adjust the labor part of the cost based on the minimum wage ratio of each country (W_j) to the U.S. (W_{us}) using data reported by World Minimum Wage Resource (2009). The non-labor part of the cost, mainly material, is assumed to be equal across countries. Therefore the road maintenance cost for each country (j) is:

$$MC^{Rd}_j = MC^{Rd} \times \left[0.32 \times \frac{W_j}{W_{\text{U.S.}}} + 0.68\right] \tag{A.4}$$

Marginal Cost of Climate Change

As mentioned above, we start with the U.S. number, \$21 per ton and then adjust for differences in purchasing power of each country. This is calculated as the ratio of PPP foreign exchange to the nominal exchange rate, both expressed in local currency per dollar. Given that countries have different fleet characteristics (e.g., age distribution, size of vehicles and respective emissions per gallon), we adjusted the cost of CO_2 by multiplying it by a fuel specific emissions factor (FEF_i) that represents the tons of CO_2 emitted by every gallon of gasoline or diesel. As such, the marginal cost of climate

//www.eia.doe.gov/emeu/international/prices.html\#Motor) Premium gasoline prices for Rotterdam and Singapore are for premium gasoline from Energy Prices and Taxes, International Energy Agency Online database, for November of 2008.

change can be represented as:

$$MC_{i,j}^{CC} = 21 \frac{\$}{\text{tonne}} \times \frac{FX_{PPP_j}}{FX_{Nom_j}} \times FEF_i \tag{A.5}$$

Marginal Cost of Local Pollutants

We start with the NRC (2009) values of $MC_{g,US}^{lp} = 9.0$ cents for gasoline and $MC_{d,US}^{lp}$ =16.5 cents per gallon for diesel.[20] We extrapolate these figures to the sample countries by adjusting for the value damage and fleet emissions efficiency in each country. The greatest damage caused by local pollutants is premature mortality NRC (2009). As such, we extrapolate the above figures by adjusting for the value of a statistical life (VSL_j). OECD (2012) suggests the use of unit transfer with income adjustment methodology when considering the use of VSL in environment, health and transport policies. In our context, the marginal cost is adjusted based on the ratio of VSL of each country to the U.S. The latter is reported by NRC (2009) to be \$7.2 million, in 2007.

$$\frac{\text{VSL}_j}{\text{VSL}_{\text{U.S.}}} = \left(\frac{\text{Real GDP/Capita}_j}{\text{Real GDP/Capita}_{\text{U.S.}}} \right)^{\eta_{\text{VSL}}} \tag{A.6}$$

where η_{VSL} is the elasticity of the VSL with respect to income. Viscusi and Joseph (2007) use revealed preference on occupation risk in labor markets and find the value of η_{VSL} between 0.5 and 0.6. More recently, Viscusi (2010) argues from a meta-analysis that the earlier range was too low and that it should be around 1.0 for the general public. Robinson and Hammitt (2010) argue that income elasticities larger than 1 should be used for estimating the VSL of low-income countries based on high-income ones. Their argument is built on analysis of cross-country relationship between VSL and economic growth, in addition to estimates of VSL by income quantile.[21]

In our case, we assume a value of 1.0 applied on all countries. Next, we adjust the marginal cost to reflect the fleet emissions efficiency of every country. We do this by multiplying the marginal cost by the ratio of the sum of NOX and VOC of each country relative to the U.S. Here, IEA (2011b) reports this data on 29 countries out of the 123 countries considered. In order to estimate the ratio across the remaining countries, we carry out

[20] As shown in figures S-3 in NRC (2009).

[21] See OECD (2012) for a discussion on VSL.

a cross-section regression analysis where the sum of NOX and VOC is regressed on a constant, gasoline consumption (Q_g), diesel consumption (Q_d) and GDP per capita (Y_{percap}):

$$\text{NOX} + \text{VOC} = \alpha_0 + \alpha_1 Y_{\text{percap}} + \alpha_2 Q_g + \alpha_3 Q_3 \tag{A.7}$$

The results of the regression are presented in Table A.5. Using these findings in equation A.3, we estimate the NOX + VOC level for each country.

Table A.5: Cross-sectional analysis of NOX + VOC data. Source: IEA (2011b)

	Constant (α_0)	GDP/Capita (α_1)	Q_g (α_2)	Q_d (α_3)
Coefficient (t-stat)	187.1791 (2.0601)	−4.7339 (−2.1071)	0.0148 (11.1440)	0.0186 (4.7628)
Observations	29			
R^2	98.97%			

In total, the country specific marginal cost of local pollutants by fuel type can be written as:

$$MC^{lp}_{i,j} = MC^{lp}_{i,\text{US}} \times \frac{\text{VSL}_j}{\text{VSL}_{\text{US}}} \times \frac{(\text{NOX} + \text{VOC})_j}{(\text{NOX} + \text{VOC})_{\text{US}}} \tag{A.8}$$

Marginal Cost of Congestion

Driven by data availability, we use the inflation adjusted cost of congestion estimated by Parry et al. (2004) for the U.S., 36 cents per gallon for gasoline, as the base and carry out three adjustments. First, we adjust for the urbanization ratio to the U.S. using data from UN (2011). Second, whenever available, we adjust for vehicles per km of road based on The World Bank (2011). Finally, we adjust for the value of time (VOT) using the Parry (2012) approach. The cost is converted to cents per gallon of diesel using a heat conversion factor.

Marginal Cost of Traffic Accidents

The International Road Federation data on fatalities from accidents (International Road Federation, 2010) is aggregated into one category and thus does not allow us to consider those not internalized by drivers (i.e. drivers considering the risk of death when they decide on driving). In order to estimate them, we apply Parry's (2012) approach to fatalities reported by IRF and calibrate the results to match the inflation adjusted marginal cost of accidents reported by Parry and Small (2005), thus applying an adjustment factor of 15 percent to IRF's fatalities. In cents per gallon, the marginal cost of accidents is calculated as:

$$MC_j^{AC} = \frac{\text{Traffic Fatalities } (j) \times \text{VSL}_j \times 15\%}{Q_j} \times \frac{\text{TOE}_j}{\text{gallon}_j} \times 100 \qquad \text{(A.9)}$$

Where TOE is 0.357 kTOE per Mn gallons of gasoline and 0.315 kTOE per Mn gallons of diesel. An analysis of the distribution of the marginal costs of externalities is presented in Figure A.9.

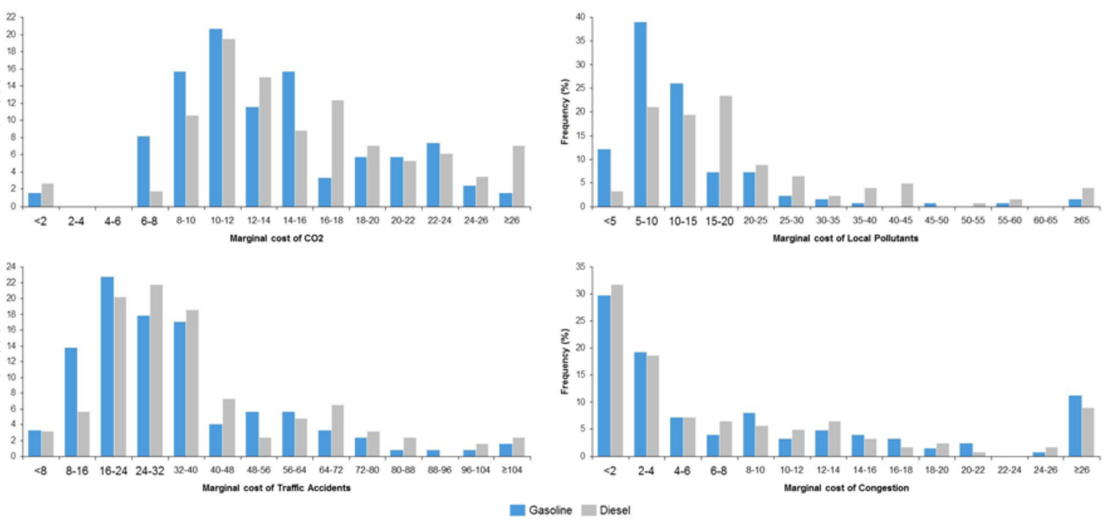
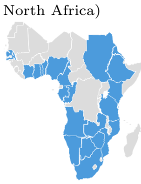


Figure A.9: Frequency analysis of externality costs.

Table A.6: Country factsheet and counterfactuals for 2008.

Region	Country	Code	GDP/Capita ($000/capita)	Consumption (Mn gallons)		Price (c/gallon)		Price Elasticity		Income Elasticity		Decrease in Consumption Level (Mn gallons): Remove Subsidy		Add Maintenance Cost		Add Cost of Externalities	
				Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
Africa (Excluding North Africa)	Angola	Ang	6.27	209	182	201	148	−0.22	−0.22	1.26	1.34	4	25	14	35	20	42
	Benin	Ben	1.43	156	77	390	390	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	Botswana	Bot	14.93	137	85	333	386	−0.26	−0.13	1.26	1.34	0	0	0	0	2	2
	Cameroon	CMR	2.14	130	104	431	394	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	Congo, R.	COG	3.92	37	78	307	216	−0.26	−0.13	1.26	1.34	0	3	0	6	0	9
	Cote d'Ivoire	Cot	1.64	50	92	503	454	−0.14	−0.46	−1.07	1.19	0	0	0	0	0	0
	Eritrea	Eri	0.67	2	10	958	405	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	Ethiopia	Eth	0.88	57	349	348	337	−0.39	−0.22	0.74	1.79	0	0	0	0	0	2
	Gabon	Gab	14.58	17	50	431	341	−0.22	−0.22	1.26	1.34	0	0	0	0	0	4
	Ghana	Gha	1.52	202	178	341	341	−0.26	−0.13	1.26	1.34	0	0	0	0	0	2
	Kenya	Ken	1.70	134	203	454	431	−0.26	−0.13	1.75	1.34	0	0	0	0	0	0
	Mozambique	Moz	0.89	37	95	647	519	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	Namibia	Nam	6.70	145	56	295	333	−0.33	−0.38	0.90	1.46	0	0	0	0	6	5
	Nigeria	Nig	2.16	2,675	386	223	428	−0.22	−0.22	1.65	1.34	0	0	108	0	163	0
	Senegal	Sen	1.76	45	179	511	477	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	South Africa	Zaf	10.45	2,953	1,899	246	170	−0.26	−0.13	0.54	1.20	0	126	0	188	109	276
	Sudan	Sud	2.31	243	484	602	473	−0.26	−0.22	1.26	1.34	0	0	0	0	0	0
	Tanzania	Tan	1.36	95	259	420	492	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	Togo	Tog	0.82	68	32	337	333	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	Zambia	Zam	1.46	44	–	643	609	−0.26	−0.13	1.26	1.34	0	–	0	–	0	–
	Zimbabwe	Zim	0.35	50	63	492	397	−0.22	−0.22	1.26	1.34	0	0	0	0	0	0
Asia & Oceania	Australia	Aus	38.25	5,259	2,245	280	356	−0.29	−0.65	0.55	0.69	0	0	0	0	24	57
	Bahrain	Bah	34.88	220	129	79	49	−0.50	−0.19	1.04	1.34	129	34	149	39	166	45
	Bangladesh	Ban	1.41	133	281	443	265	−0.09	−0.22	2.06	1.66	0	0	0	9	0	28
	Brunei	Bru	49.16	84	45	144	79	−0.24	−0.27	0.90	1.34	7	12	11	14	20	18
	Cambodia	KHM	2.03	62	66	356	337	−0.26	−0.13	1.26	1.34	0	0	0	0	0	1
	China	Chi	6.19	21,931	15,523	375	382	−0.26	−0.22	0.97	0.59	0	0	0	0	0	104

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Region	Country	Code	GDP/Capita ($000/capita)	Consumption (Mn gallons)		Price (c/gallon)		Price Elasticity		Income Elasticity		Decrease in Consumption Level (Mn gallons)					
												Remove Subsidy		Add Maintenance Cost		Add Cost of Externalities	
				Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
	Chinese Taipei	Tai	32.22	2,695	1,178	242	261	−0.69	−0.28	2.02	0.43	0	0	0	0	0	86
	Georgia	Geo	4.91	132	62	413	439	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	Hong Kong	HKG	43.82	125	338	738	439	−0.12	−0.36	0.42	0.50	0	0	0	0	0	0
	India	Ind	2.87	4,299	8,322	413	265	−0.36	−0.13	1.37	1.12	0	0	0	161	0	717
	Indonesia	IDN	3.99	5,783	2,296	189	159	−0.20	−0.38	1.89	1.58	118	347	350	524	510	676
	Japan	Jap	34.00	16,063	7,148	537	492	−0.15	−0.26	1.39	0.99	0	0	0	0	0	56
	Korea, South	Kor	32.30	2,805	4,337	572	530	−0.90	−0.38	1.14	0.88	0	0	0	0	0	0
	Malaysia	Mal	14.15	3,136	1,664	201	201	−0.13	−0.22	0.95	1.61	18	71	102	157	179	255
	Mongolia	Mon	3.55	140	7	522	537	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	Myanmar	Mya	1.15	152	185	163	197	−0.22	−0.13	1.26	1.34	8	5	14	11	22	20
	Nepal	Nep	1.16	25	73	428	310	−0.26	−0.57	1.26	1.34	0	0	0	0	0	1
	New Zealand	NZL	27.14	859	579	413	322	−0.10	−0.38	0.87	1.79	0	0	0	18	0	57
	Pakistan	Pak	2.62	580	2,192	318	291	−0.41	−0.22	0.73	1.37	0	0	0	0	0	37
	Philippines	Phi	3.51	966	1,272	344	307	−0.35	−0.13	0.57	1.34	0	0	0	0	0	4
	Singapore	Sin	51.24	309	481	405	341	−0.33	−0.12	0.66	0.36	0	0	0	0	51	40
	Sri Lanka	Sri	4.59	192	376	541	284	−0.40	−0.17	1.02	1.04	0	0	0	2	0	20
	Thailand	Tha	8.24	1,819	3,286	329	242	−0.16	−0.23	0.91	1.33	0	8	0	186	29	594
	Vietnam	Vie	2.80	1,231	1,365	303	291	−0.26	−0.22	1.26	1.34	0	0	0	0	12	61
Europe & Central Asia	Albania	Alb	6.91	29	186	515	496	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	Austria	AUT	39.89	622	1,615	519	541	−0.81	−0.16	−0.79	1.79	0	0	0	0	0	0
	Azerbaijan	Aze	8.73	353	200	280	212	−0.22	−0.22	1.26	1.34	0	6	0	17	16	37
	Belarus	BLR	12.59	185	277	503	401	−0.39	−0.22	−0.37	1.34	0	0	0	0	0	22
	Belgium	Bel	36.34	540	2,260	568	507	−0.51	−0.38	−0.79	1.79	0	0	0	0	0	0
	Bosnia and Her.	Bos	7.79	119	182	428	447	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	Bulgaria	Bul	12.34	224	479	484	519	−0.39	−0.13	0.74	1.34	0	0	0	0	0	0
	Croatia	Cro	18.60	254	354	481	519	−0.48	−0.13	0.82	1.79	0	0	0	0	0	0
	Cyprus	Cyp	29.03	140	86	484	473	−0.33	−0.38	0.72	1.34	0	0	0	0	0	1
	Czech Republic	Cze	25.09	737	1,102	519	549	−0.32	−0.38	0.89	1.34	0	0	0	0	0	0
	Denmark	Den	37.51	642	778	583	583	−0.60	−0.20	−0.11	1.79	0	0	0	0	0	0

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												Decrease in Consumption Level (Mn gallons)					
Region	Country	Code	GDP/Capita ($000/capita)	Consumption (Mn gallons)		Price (c/gallon)		Price Elasticity		Income Elasticity		Remove Subsidy		Add Maintenance Cost		Add Cost of Externalities	
				Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
	Estonia	Est	20.33	120	123	447	492	−0.32	−0.38	1.02	1.34	0	0	0	0	0	0
	Finland	Fin	36.21	566	713	594	526	−0.50	−0.05	0.56	1.35	0	0	0	0	0	0
	France	Fra	34.18	3,014	9,631	575	549	−0.53	−0.24	−0.77	1.79	0	0	0	0	0	0
	Germany	Ger	35.66	7,478	8,126	590	590	−0.42	−0.38	0.68	1.79	0	0	0	0	0	0
	Greece	Gre	30.23	1,512	690	466	534	−0.33	−0.44	1.89	1.18	0	0	0	0	0	0
	Hungary	Hun	19.55	560	818	481	522	−0.32	−0.38	1.07	1.34	0	0	0	0	0	0
	Iceland	Ice	40.69	57	38	435	496	−0.33	−0.38	0.66	1.34	0	0	0	0	0	0
	Ireland	Ire	41.83	639	808	590	621	−0.30	−0.38	0.81	1.41	0	0	0	0	0	0
	Italy	Ita	30.56	4,073	7,457	594	617	−0.57	−0.24	−0.52	1.79	0	0	0	0	0	0
	Kazakhstan	Kaz	11.45	1,398	128	314	273	−0.26	−0.22	1.26	1.34	0	0	0	2	97	15
	Latvia	Lat	17.19	139	213	424	466	−0.48	−0.13	1.21	1.79	0	0	0	0	0	0
	Lithuania	Lit	19.11	153	295	428	462	−0.48	−0.13	0.80	1.79	0	0	0	0	0	2
	Luxembourg	Lux	82.16	154	529	530	503	−0.50	−0.38	0.14	1.34	0	0	0	0	0	0
	Macedonia	Mkd	9.20	44	70	435	424	−0.39	−0.13	−0.37	1.34	0	0	0	0	0	1
	Malta	MLT	24.15	26	33	628	590	−0.48	−0.13	−0.40	1.34	0	0	0	0	0	1
	Moldova	Mol	3.00	35	62	454	394	−0.26	−0.13	1.26	1.34	0	0	0	0	0	1
	Netherlands	Net	41.32	1,557	2,086	636	549	−0.34	−0.01	0.60	1.31	0	0	0	0	0	0
	Norway	Nor	52.87	485	668	617	617	−0.42	−0.07	−0.64	2.08	0	0	0	0	0	0
	Poland	Pol	17.58	1,497	2,635	541	530	−0.48	−0.13	−0.31	1.34	0	0	0	0	0	0
	Portugal	Por	23.08	558	1,391	609	556	−0.38	−0.29	0.99	1.79	0	0	0	0	0	0
	Romania	Rom	12.64	543	936	420	462	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	Russia	Rus	16.03	11,842	3,619	337	326	−0.10	−0.22	0.23	1.79	0	0	0	13	44	202
	Slovakia	SVA	22.04	234	399	594	636	−0.48	−0.38	0.66	1.34	0	0	0	0	0	0
	Slovenia	SVE	29.57	240	407	447	477	−0.50	−0.38	0.32	1.79	0	0	0	0	0	0
	Spain	Spa	30.86	2,304	7,862	466	484	−0.36	−0.38	−0.64	1.79	0	0	0	0	0	0
	Sweden	Swe	37.88	1,261	1,212	522	575	−0.48	−0.25	−0.61	1.39	0	0	0	0	0	0
	Switzerland	Swi	41.40	1,265	692	492	575	−0.37	−0.43	1.48	1.18	0	0	0	0	0	0
	Turkey	Tur	13.12	869	2,708	708	617	−0.29	−0.13	0.57	2.27	0	0	0	0	0	0
	Ukraine	Ukr	7.35	1,985	809	333	363	−0.26	−0.13	1.26	1.34	0	0	0	0	3	12
	United Kingdom	Ukm	36.08	6,250	6,592	545	625	−0.50	−0.38	−0.23	1.79	0	0	0	0	0	0
	Uzbekistan	Uzb	2.61	501	74	–	121	−0.39	−0.22	−0.37	1.34	0	11	0	14	0	20
Latin & North America	Argentina	Arg	14.41	1,503	2,298	295	220	−0.08	−0.22	−1.09	1.34	0	108	5	268	18	383
	Bolivia	Bol	4.35	176	228	257	201	−0.22	−0.22	1.26	1.34	0	15	7	27	13	38
	Brazil	Bra	10.53	5,189	9,028	477	390	−0.39	−0.32	1.37	0.90	0	0	0	0	0	0

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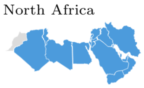
Region	Country	Code	GDP/Capita ($000/capita)	Consumption (Mn gallons)		Price (c/gallon)		Price Elasticity		Income Elasticity		Decrease in Consumption Level (Mn gallons): Remove Subsidy		Add Maintenance Cost		Add Cost of Externalities	
				Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
	Canada	Can	39.03	11,312	3,587	288	341	−0.48	−0.74	0.72	1.26	0	0	0	0	260	385
	Chile	CHL	14.61	877	1,046	360	360	−0.38	−0.13	0.40	0.70	0	0	0	0	21	16
	Colombia	Col	9.00	1,162	1,184	394	276	−0.06	−0.22	−0.73	1.79	0	0	0	37	0	97
	Costa Rica	Cos	10.79	248	234	469	416	−0.44	−0.13	1.26	1.34	0	0	0	0	0	0
	Cuba	Cub	5.32	121	81	632	572	−0.26	−0.13	1.26	1.34	0	0	0	0	0	0
	Dominican Republic	Dom	8.06	336	155	394	356	−0.29	−0.13	1.13	1.34	0	0	0	0	0	1
	Ecuador	Ecu	7.77	779	539	193	102	−0.18	−0.17	1.25	1.21	41	80	66	101	82	116
	El Salvador	ElS	7.61	156	116	295	307	−0.26	−0.13	1.95	1.34	0	0	2	1	6	3
	Guatemala	Gua	4.88	330	285	326	310	−0.50	−0.22	1.43	1.34	0	0	0	2	7	9
	Honduras	HND	4.48	154	175	303	303	−0.30	−0.13	1.26	1.34	0	0	1	1	5	4
	Mexico	Mex	14.55	12,677	4,346	280	204	−0.31	−0.30	1.25	0.86	0	0	201	143	655	357
	Nicaragua	Nic	2.95	68	81	329	310	−0.26	−0.22	1.26	1.34	0	0	0	0	1	3
	Paraguay	Par	4.79	73	282	443	363	−0.22	−0.13	0.84	1.34	0	0	0	0	0	0
	Peru	Per	8.61	321	991	537	375	−0.37	−0.43	1.46	1.05	0	0	0	0	0	26
	Trinidad and Tobago	Tri	21.57	167	100	136	92	−0.22	−0.27	0.80	1.34	22	25	31	33	38	40
	United States	USA	47.16	133,476	38,872	212	295	−0.30	−0.07	0.63	1.00	0	0	622	282	16,868	1,047
	Uruguay	Uru	12.70	101	183	447	443	−0.26	−0.13	1.06	1.34	0	0	0	0	0	0
	Venezuela	Ven	12.73	4,647	768	8	4	−0.14	−0.17	0.70	1.65	2,203	389	2,378	412	2,487	428
Middle East & North Africa	Algeria	Alg	6.76	824	1,032	129	76	−0.45	−0.22	−0.59	1.87	175	263	235	311	281	352
	Egypt	Egy	5.90	1,669	2,109	185	76	−0.21	−0.22	1.36	0.86	57	538	119	625	157	680
	Iran	IRN	10.91	6,840	5,236	38	11	−0.20	−0.15	1.11	1.68	2,701	1,963	3,029	2,071	3,220	2,155
	Iraq-P05	IRQ	3.48	1,518	1,850	145	129	−0.09	−0.17	0.63	1.34	49	185	79	259	97	315
	Israel	Isr	28.71	836	369	519	643	−0.23	−0.19	1.20	0.46	0	0	0	0	0	0
	Jordan	Jor	5.49	324	196	231	231	−0.26	−0.22	0.42	1.05	0	3	10	13	30	29
	Kuwait	Kuw	40.47	904	356	91	76	−0.09	−0.02	0.82	0.61	66	7	84	9	134	12
	Lebanon	Leb	13.10	535	4	288	288	−0.26	−0.22	0.74	1.34	0	0	0	0	4	0
	Libya	Lib	14.07	462	666	53	45	−0.14	−0.22	−0.38	1.34	97	222	115	253	121	266
	Oman	Oma	25.38	603	50	117	144	−0.52	−0.27	0.96	1.34	158	7	208	10	269	15
	Qatar	Qat	80.79	370	579	83	72	−0.08	−0.15	0.66	1.34	26	100	33	124	44	164

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Region	Country	Code	GDP/Capita ($000/capita)	Consumption (Mn gallons)		Price (c/gallon)		Price Elasticity		Income Elasticity		Decrease in Consumption Level (Mn gallons): Remove Subsidy		Add Maintenance Cost		Add Cost of Externalities	
				Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
	Saudi Arabia	Sau	23.49	6,120	4,590	61	34	−0.09	−0.12	1.02	0.79	1,027	967	1,248	1,085	1,437	1,198
	Syria	Syr	4.82	490	792	322	201	−0.22	−0.22	1.26	1.96	0	34	0	74	0	113
	Tunisia	Tun	8.89	157	338	363	318	−0.22	−0.28	0.75	1.21	0	0	0	3	1	33
	UAE	UAE	38.56	1,420	1,408	170	235	−0.14	−0.17	0.63	1.34	41	10	92	94	144	182
	Yemen	Yem	2.41	541	132	114	64	−0.22	−0.22	1.26	2.36	68	34	89	39	102	43

Source: IMF (2010), IEA (2010b), GTZ (2009), Dahl (2012).

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