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Global Kerosene Subsidies: An Obstacle to Energy Efficiency and Development

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Summary. — It is widely agreed that energy subsidies impede the efficient functioning of markets. The resulting distortions in prices work at odds with policies to improve energy efficiency and reduce the cost of energy services and associated externalities such as health and environmental damages. The analysis developed in this article finds that kerosene is used in 173 countries, at a cost to consumers of \$43.4B/y, \$60.3B/y including direct economic subsidies, and \$77.2B/y including certain externalities. Despite low world oil prices, direct economic subsidies for kerosene were \$18.4B in 2013, and \$34.7B including environmental externalities. These values correspond to 72% and 56% of total kerosene costs being passed through to consumers, respectively. When excluding advanced economies, the pass-through values fall to 40% and 35%. Approximately 52% of the global kerosene supply receives direct subsidy, or 63% when externality costs are considered. The cooking end use receives \$2.0B/y in direct kerosene subsidies, lighting \$7.1B/y, and heating and other residual uses \$9.3B/y, or \$76 per over all households each year. Defining subsidies at this level of granularity is useful for pinpointing policy issues and opportunities. Promoting a transition to energy efficient off-grid energy services is one of the most cost-effective ways of reducing dependency on subsidies. However, the very presence of subsidies undercuts this process by diluting market price signals and rendering energy efficiency investments less cost-effective, while competing with other social and development-focused budgetary needs. Kerosene subsidies are additionally counterproductive because the emerging technologies they impede (e.g., improved lighting and cook stoves) also improve productivity, safety, and quality of life. Forty-five countries—many in the developing world—have priced kerosene such that there are no direct subsidies, and twenty-two have done so even when accounting for environmental externalities, suggesting the practice is economically and politically feasible.

Key words — kerosene, subsidies, subsidy reform, lighting, cooking, heating

1. INTRODUCTION

While energy services are a key to quality of life, particularly in developing countries, the cost of energy also fuels poverty. Energy subsidies are typically employed to encourage the use of particular fuels or energy supply technologies, protect consumers from energy price volatility, or provide a safety net for low-income populations. In isolated cases an additional goal is steering users toward less polluting and environmentally damaging alternatives, although the reverse effect has historically been more common due to a diluted price-demand response. Yet, the cost of even subsidized energy used inefficiently can be unaffordable, and underwriting subsidy costs can be a major expense for governments in comparison with other social programs. For these reasons, subsidies can work at cross-purposes to development objectives.

Subsidies arise from differences between actual direct prices paid by consumers and true supply costs including transportation, distribution, retail operations and profits, as well as taxes and a host of indirect un-priced externalities. For oil exporting countries, the direct subsidy is the difference between the domestic consumer prices and the foregone value on the international market plus any uncollected tax revenues resulting from consumer price discounts.

Global subsidies across the entire energy sector (coal, natural gas, petroleum fuels, and electricity) reached \$5.3 trillion in 2015, 6.5% of GDP (Coady, Parry, Sears, & Shang, 2017). Excluding externalities and taxes, \$333 billion in direct subsidies were awarded in 2015. Petroleum fuels received \$1.5 trillion of this total, with \$135 billion in direct subsidies, including externalities (down from \$220 billion in 2011 when world oil prices were higher). This latter level is also referred to as the "post-tax" price. These Subsidies are also awarded on the supply side. These producer subsidies have been estimated at \$45 to \$75 billion for 24 OECD member countries (OECD, 2013) and \$88 billion annually for the G20 nations (Bast, Doukas, Pickard, Burg, & Whitley, 2015). No comprehensive estimates of global producer subsidies have been identified.

While the conceptual benefits of subsidies are evident, they are also subject to broad-based criticism for failing to efficiently achieve policy goals and for distorting markets. Most subsidies do not reach their intended target audiences (IMF, 2013), thereby amplifying the very inequalities they are intended to reduce. By underwriting inefficient consumption of energy, the economic "savings" in the cost of energy can in fact block technology changes in the direction of improved energy efficiency that would otherwise provide even greater

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long-term value in the form of energy savings and other benefits to consumers (IFC, 2012).

As an indication of their economic scale and significance, in the developing world energy subsidy outlays routinely exceed other government expenditures targeted to essential social functions such as healthcare and education. The increased energy use they induce also work at cross purposes to policy objectives such as improving public health, decongesting roadways, promoting energy efficient vehicles, increasing grid-independent rural electrification, reducing greenhouse-gas emissions, lessening energy import dependence, and ensuring competitive free-market conditions for emerging technologies. Governments are often compelled to relax subsidy reforms due to civil unrest during spikes in world oil prices—just when they are most needed (Baig, Mati, Coady, & Ntamatungiro, 2007).

Concern about energy subsidies has come from many quarters. The International Monetary Fund (IMF) has called on governments to reconsider and reform subsidy practices, as has the Kyoto protocol. The G-20 leaders have recommended subsidy reforms (G-20 Leaders, 2009). The World Bank finds subsidies to be an inefficient means of alleviating poverty in light of the fact that wealthier populations capture most of the benefits by virtue of using most of the energy (World Bank, 2012). The EU's Climate Commissioner has stated that: "Instead of offering unsustainable and environmentally damaging subsidies for fossil fuels, public finance should encourage the development of new industries and businesses that are emerging in the course of the low-carbon transition" (Maclellan, 2013).

The reduction of kerosene subsidies in particular has long been identified as a key need (Reddy, 1981), although past research and policy analysis on subsidies for this particular fuel is scant. More than a decade ago, the United Nations Development Program concluded that there is no effective way of subsidizing kerosene (UNDP, 2003). The omission of kerosene subsidy costs from macro-scale analyses (e.g., Bloomberg New Energy Finance and Lighting Global, 2016) understates the economic burden on nations and potential financial benefits of new technologies that can displace kerosene. Although kerosene use and associated subsidies are a small fraction of global totals, for some countries, kerosene subsidies can be the largest aggregate subsidy awarded to any fossil fuel (Budya & Arofat, 2011). This is due to the large numbers of un-electrified households using the fuel for lighting as well as in meeting goals to substitute biofuels with "modern" and "cleaner" kerosene for cooking. Importantly, the World Health Organization no longer regards kerosene as a "clean fuel" for any purpose, and recommends that governments and practitioners immediately stop promoting its use (WHO, 2016).

Prior efforts have tended to disaggregate subsidies only into broad and highly heterogeneous energy categories (e.g., electricity, petroleum, coal). The overarching original contribution of this article is to isolate kerosene subsidies from other fossil fuels, both globally and by region. This is important, as the geography and magnitude of kerosene subsidies often vary from that of other petroleum products. Country-specific illustrations are provided as well. The analysis is also unique in that it further disaggregates kerosene subsidies into specific end uses (lighting, cooking, and heating/other), and is accompanied with analysis of average and variance in per-household subsidies received. Illustrations are provided as to the anticompetitive effect of subsidies on emerging technologies that can eliminate the need for kerosene. The literature on economic, social, and environmental consequences of kerosene use is summarized for context. Such assessments are useful for policy analysis by helping illuminate the exact distribution of subsidies by types of end user, activity, and technology as well as the societal cost-benefit of technology change. This work substantially expands on a prior study by the author that focused exclusively on kerosene lighting in West Africa (Mills, 2014).

2. MATERIALS AND METHODS

(a) *Kerosene demand and end use allocations*

Energy subsidy price estimation is a function comparing unit prices to actual supply and externality costs, aggregated across population groups or geographies. Such analyses can rely on readily available statistics. Developing more granular estimates that allocate consumption and subsidies to specific fuels, sectors, and end-uses requires more extensive analysis, as these data are rarely available in national statistics.

Kerosene is used in more than 170 countries, and is often among the *primary* sources of energy among poorer populations. Global kerosene use trended around 1800 thousand barrels (kbbl) per day during 1987–2000, dropping by about 40% to ~1000 kbbl/day as of 2013, excluding kerosene for aviation (Figure 1). The decline occurred during a period in which there were growing government admonitions against the use of unvented kerosene heating in industrialized countries, efforts to shift from this "clean" cooking fuel to "cleaner" LPG (Gangopadhyay, Ramaswami, & Wadhwa, 2005; Malla & Timilsina, 2014) in some developing countries, and the inception and rapid market uptake of a new generation of compact, affordable solar lighting systems for off-grid populations (Bloomberg New Energy Finance and Lighting Global, 2016; Mills, 2005).

Compared to the earlier peak demand, kerosene consumption has fallen in every major region. The decline has been most rapid—both in terms of absolute magnitude and rate of decline—in the industrialized world, thereby increasing the relative share of kerosene use in developing countries. During 2000–13, kerosene consumption fell 4.4%/year globally, while, for example, the decline was only 1.3%/year in Africa. These trends stand as an "existence proof" of the potential for transitioning away from kerosene. The underlying drivers of kerosene demand, however, differ widely among countries. Even within the developing world, demand trends vary widely from country to country, perhaps most dramatically illustrated in the cases of India and Indonesia (Figure 2). In both countries demand grew steadily from the mid-1980s to the late 1990s, after which the trends shifted in a downward direction, most likely reflecting the rise of rural electrification and other programs to that helped displace kerosene for illumination and cooking. Indonesia's kerosene demand subsequently declined by 14.9%/year to nearly zero in parallel with a national fuel-substitution program and the suspension of subsidies. During this period, kerosene demand in India declined by 2.8%/year while subsidies continued to prevail. Over this same period kerosene demand in Benin rose by nearly 10.4%/year as subsidies cut consumer prices nearly in half. Similar dramatic shifts can be seen in industrialized countries, e.g., in the United States where kerosene use declined 16.7%/year and in Japan where it declined by 3.5%/year—in both cases likely reflecting efforts to discourage the use of unvented kerosene heaters (increasingly deemed a health hazard) combined with general trends toward improved energy efficiency.

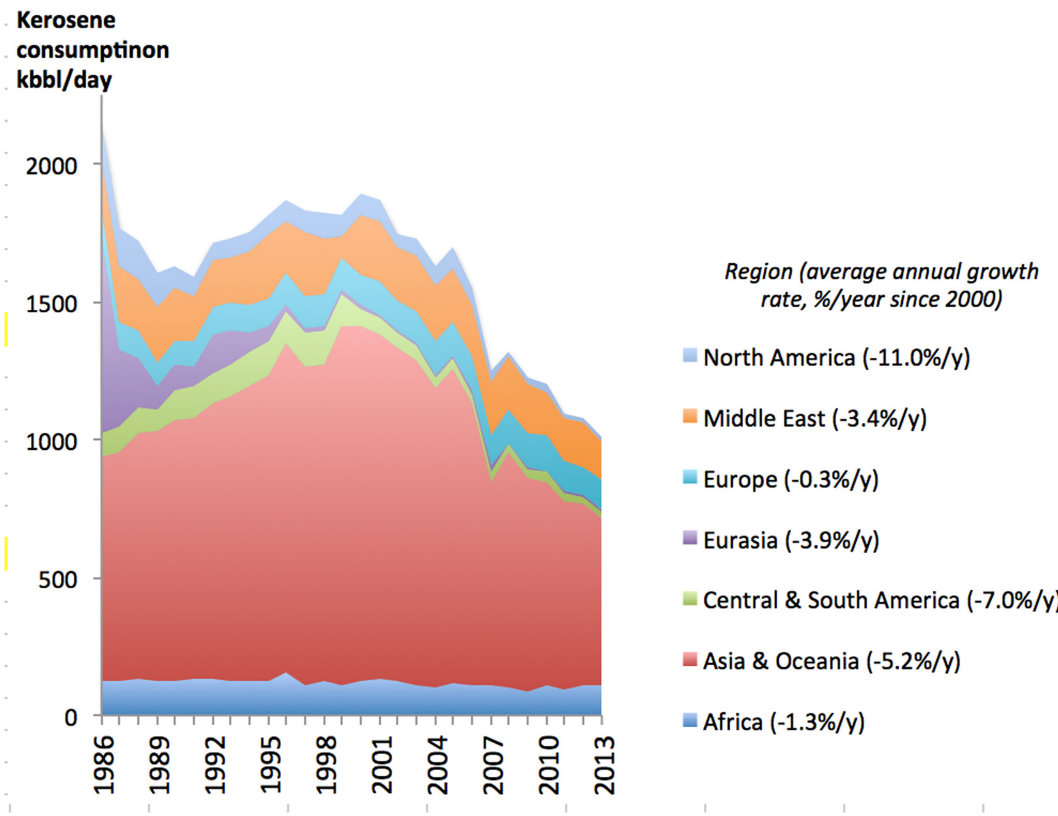

Figure 1. *World kerosene consumption by year and region. Source: USEIA (2016).*

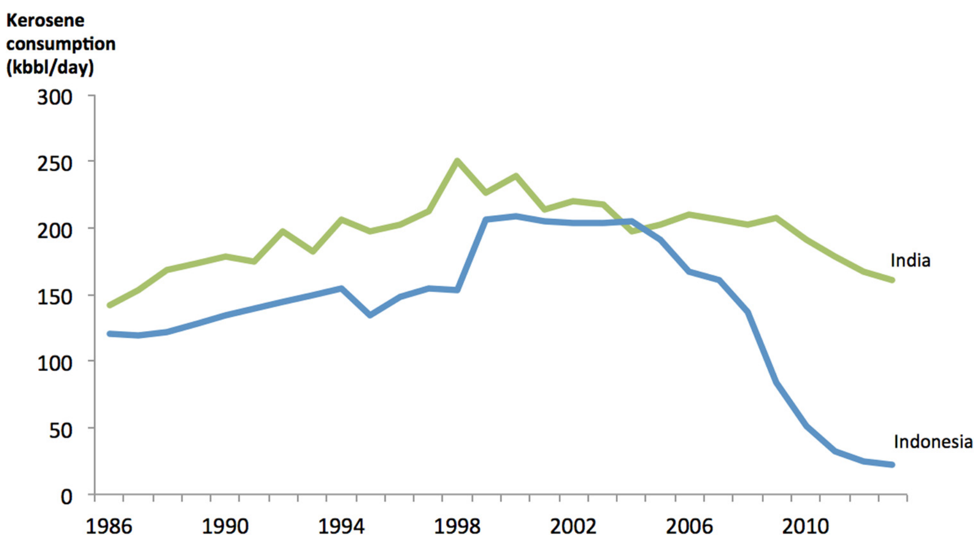

Figure 2. *Comparison of trends in kerosene consumption for two countries with large demand and differing subsidy policy trajectories. Source: USEIA (2016).*

Industrialized and developing countries alike rank among the largest kerosene consumers, with Japan in first position (31% of the global total in 2013 yet with only 1.7% of the world's population), followed by India (16%), Iran (8%) the U.K. (8%), South Korea (5%), Nigeria (5%), Iraq (4%), China (3%), Indonesia (2%), and Ireland (2%). As of 2013, Europe used as much kerosene as Africa (about 10% of world totals in each case).

Globally, households represented 65% of kerosene consumption in 2013, followed by commercial and public services (16%), industry (7%), and agriculture/forestry (2%) (Figures 3a–b). The balance is unspecified or represents non-energy uses. Sectoral use varies significantly across regions, however, with households dominant in most cases, representing 76% of total demand in non-OECD countries.

End-use splits also vary widely depending on national conditions, weather, and prevailing energy policies and pricing. Lacking official data, aggregate consumption statistics are apportioned in this analysis into specific end uses based on "bottom-up" estimates and reconciled with the totals. Table 1

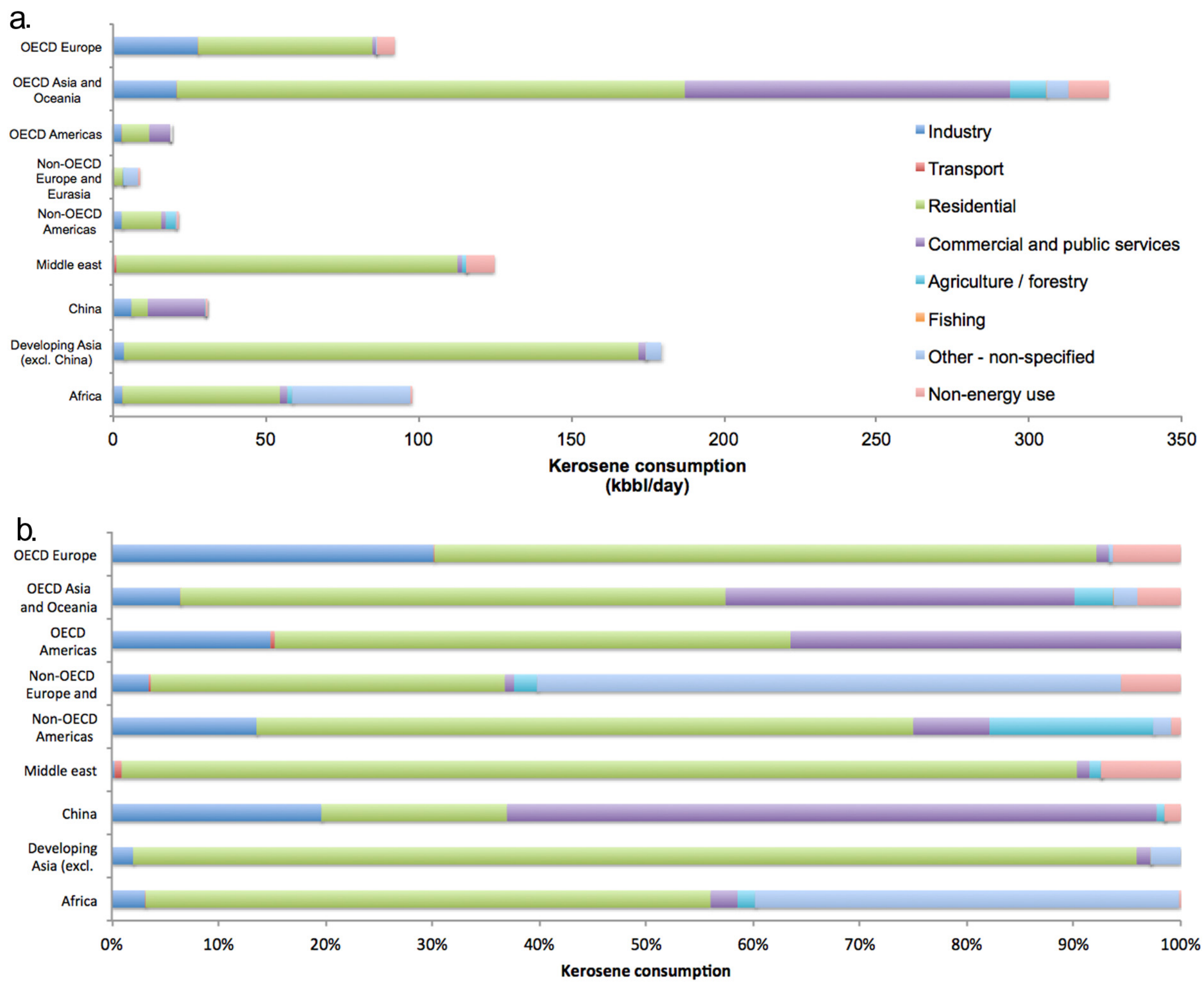

Figure 3. *a and b World kerosene use by region and sector in 2013. Source: IEA (2016).*

Table 1. *Datasets used in the analysis*

Metric	Number of countries in data series	Default assumptions*	Source
Population	233	No default estimates are made in cases of missing values	http://data.worldbank.org/data-catalog/Population-ranking-table
Electrification rates	258	No default estimates are made in cases of missing values	http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS
National kerosene consumption	173	No default estimates are made in cases of missing values	USEIA (2016)
Kerosene prices and externality costs	118	See Table 2	Coady et al. (2017) and supplemental IMF database; Kijima (2013)
VAT/GST	188	Average country-specific value: 15.5%	IMF (2015)
Numbers of households	200	Derived from total population using median household size	http://www.worldmapper.org/display.php?selected=191 and http://www.nakono.com/tekcarta/databank/full/16/
Fraction of households using kerosene as a heating fuel	6	Default is zero for countries lacking source data	WHO (2016), Soile and Mu (2015)
Kerosene lighting (household and business)	121	Population-weighted average UNEP value: 14.9 liters/capita-year	UNEP (2016)
Fraction of households using kerosene as a cooking fuel	89	Population-weighted average: 2.5% (zero for Advanced Economies)	Arif et al. (2011); WHO and UNDP (2009), WHO (2016); World Bank (2015a, 2015b)

Note: VAT is value-added tax and GST is general sales tax.
[*] Values applied when country-specific data are not available.

presents the datasets utilized for this purpose and key associated assumptions.

The UNEP's en.lighten program has developed the most comprehensive bottom-up estimate of kerosene use for lighting by country (net of that for other lighting fuels such as candles and batteries) (Scholand, 2016). In cases where these data significantly exceed official aggregate national statistics, the current analysis generally adjusts consumption downward to reconcile with total demand, net of cooking and heating/other residual uses, where applicable. Undocumented illicit cross-border transfers of fuels are one possible source of these discrepancies, which could result in underestimates of kerosene used for lighting. For countries not included in the UNEP analysis, per-household average lighting fuel consumption is combined with electrification rates to obtain national estimates.

On average, kerosene is the main cooking fuel in 2.5% of the population in low- and middle-income countries (WHO, 2009; WHO, 2016; World Bank, 2015a, 2015b). Cooking kerosene use is derived here by combining previously published national cooking fuel shares by country for kerosene with an estimate of daily use per household based on a fuel-use rate of 0.1 kg/h (Kim, Nghiem, & Phyu, 2002) and a representative assumption of three hours per day of cooking (Johnson & Chiang, 2015; Malla & Timilsina, 2014; Phyu, 2002). The resulting annual values are in line with other estimates (UNDP & ESMAP, 2003). Culturally specific cooking methods and cooking times are not broadly enough documented in the literature to vary these assumptions by country or other demographic variables.

Kerosene heating is seldom used in developing countries, while it is typically the only household use of kerosene in wealthier countries. The World Health Organization, finding heating-fuel surveys for only 13 low- and middle-income countries, calls the lack of more complete data "severe" (WHO, 2016). In the present analysis, the residual after accounting for lighting and cooking is allocated to "heating and other uses". Available data do not support estimation of kerosene used for cooking or heating in non-household contexts, and thus the residuals could pick up some of this influence. As kerosene diversion occurs between sectors within countries as well as across national boarders, the residual value may also include some of these quantities. Conversely, official estimates of total kerosene consumption in a given country will be low, by definition, due to illicit imports. In any case, the subsidies awarded remain attributed to that country in this analysis. As shown in Figure 4a, the resulting apportionment of kerosene consumption varies widely by region. Use for heating and other purposes dominates globally, but is centered primarily in Advanced Economies and the Middle East, North Africa, and Pakistan. End-use shares also vary widely (Figure 4b), with heating and other uses dominant in many regions, while lighting is dominant in Sub-Saharan Africa and Developing Asia.

(b) *Global kerosene pricing and subsidies*

Governments rarely report subsidized kerosene prices or the magnitude of national subsidies. In certain other cases, published statistics do not reconcile with what transpires in the marketplace. For example, official subsidized prices in Nigeria are often one-third to one-quarter of those observed, even at regulated petrol stations (Associated Press, 2013). This market failure is attributed to a wide variety of factors, ranging from hoarding of the product by resellers, to scarcity (and resulting price-gouging) caused by diversion of the fuel to other purposes (e.g., aviation) or smuggling out of the country for sale in markets with higher unsubsidized prices.

In lieu of accurate and credible official reports, the International Monetary Fund's "price-gap" approach is adopted here to estimate subsidies using their extensive fuel price database (Coady *et al.*, 2017; IMF, 2015). The price gap is the differential between actual consumer prices and market-based benchmark supply costs adjusted for regional variations in taxation. For petroleum products, the supply price has two components: port (or "hub") price and the cost of margins and shipping (for countries that are net importers). Port prices in the IMF database are taken from the International Energy Agency (IEA) and correspond to shipping nodes in the United States, NW Europe, and Singapore. Each country is mapped to one of these three ports based on region. Due to lack of data on subsidies to energy producers (OECD, 2013), only consumer subsidies are considered here.

In quantifying subsidies, three relevant price definitions are considered so as to obtain two corresponding subsidy steps using the price-gap method. The first is the difference between consumer prices paid by end users and the full, unsubsidized supply cost including VAT or other sales taxes applied to non-energy goods in the given country. This first unsubsidized price difference is referred to here as the "direct subsidy". The second step is the difference between the supply cost and full cost including externalities not otherwise included in the prices. For non-transportation fuels such as kerosene, these include climate change and the costs of local air pollution. The sum of both steps is referred to here as the "total subsidy".

IMF's estimates of environmental externalities for kerosene are adopted here (Coady *et al.*, 2017). Included are the costs of global climate changes caused by carbon dioxide emissions, and country-specific costs of local air pollution's effect on morbidity and mortality. The IMF companion methodology for transportation fuels includes roadway costs such as traffic accidents, congestion, and road damage. While these impacts are excluded in the current analysis of kerosene, there are in fact considerable externalities associated with increased air pollution caused by diesel and gasoline fuels that have been adulterated with kerosene, causing adverse health impacts (Mills, 2016; Sinah, 2012). The IMF methodology also excludes certain indirect impacts of energy use particularly applicable to kerosene. These include associated indoor health and safety risks described in more detail in Section 3a(iii). The IMF method also does not consider the important greenhouse forcing effect of black carbon, a particularly important emission from inefficiently burned kerosene that significantly amplifies the global warming potential stemming from the associated carbon dioxide emissions (Lam *et al.*, 2012; Klimont *et al.*, 2016).

As can be seen in Figure 5, consumer kerosene prices vary widely around the world. Table 2 summarizes the variance among prices globally and by region as of the year 2013. Consumers pay as little as $0.02/liter (Venezuela) and as much as $2.12/liter (Israel). Regional values range from a low of $0.45 in Developing Asia to $1.11 in Advanced Economies (and $1.84 in Emerging Europe, the presence of only one large country in the dataset skews that result). Some countries directly subsidize the fuel by as much as $1.08/liter (Angola) while others tax it up to $0.90/liter (Israel) beyond the externality costs estimated by IMF. The global population-weighted consumer price is $0.68/with an average direct subsidy of $0.37/liter (29% of the unsubsidized price), and an

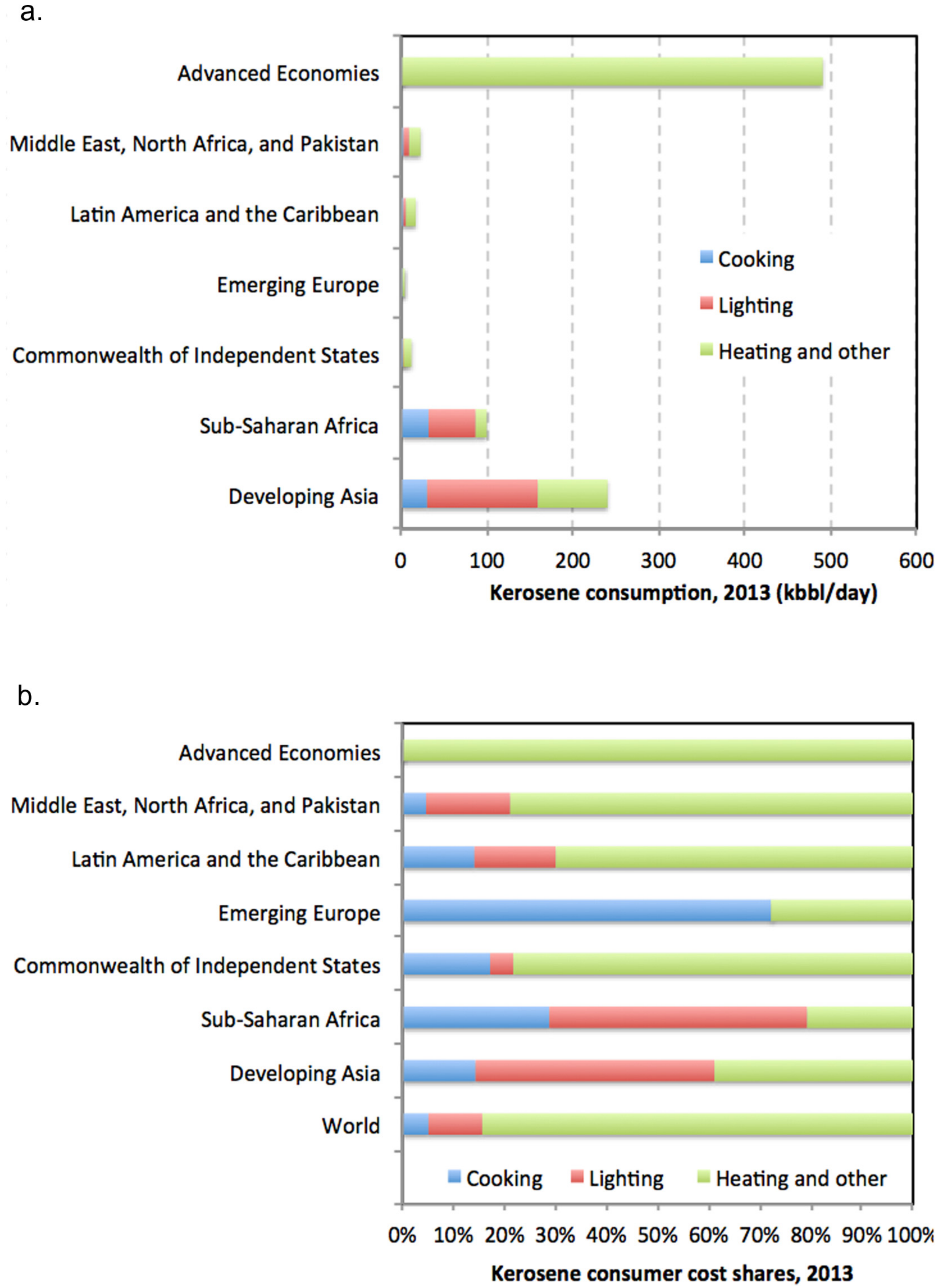

Figure 4. *Absolute world kerosene consumption by region (a) and by end use shares by region (b). Source: Author's analysis.*

average total subsidy of $0.58/liter (44% of the unsubsidized price, including externalities associated with carbon dioxide emissions and degraded local air quality).

Subsidies are most common in developing and emerging economies (particularly among oil producers) and some degree of taxation (elevating consumer prices above the market-based benchmark to capture certain externalities) is almost universal in advanced economies (Figure 6). Subsidies are often applied non-uniformly among various petroleum fuels, and those for kerosene tend to be greater than those awarded to transport fuels (Figure 7). The resulting temptation to adulterate transport fuels with kerosene rises when the ratio of motor fuel to kerosene prices is above 1.00. As shown in Figure 5, this is often the case, and the degree of such price disparities has

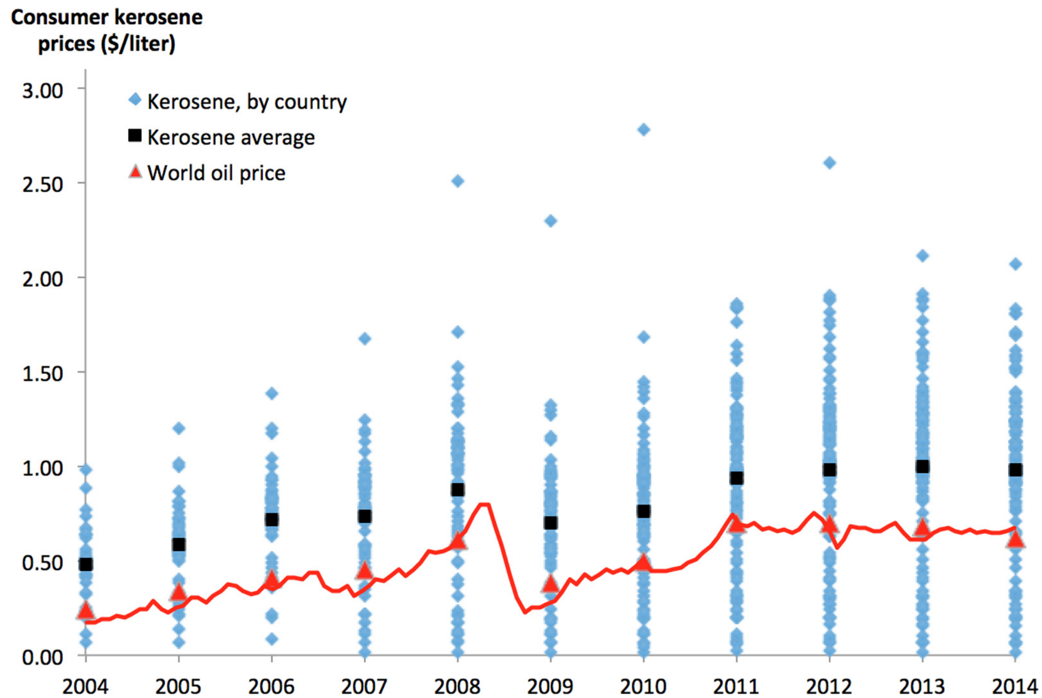

Figure 5. *Nominal retail consumer kerosene prices in the context of world oil prices: 2004–14. Source: Country-level kerosene prices and averages from the previously unpublished IMF energy price database. World oil price (curve is monthly) are Europe Brent Spot Price FOB.*

increased over time. Reverse adulteration, particularly with diesel, can occur when motor fuels are less expensive than kerosene or kerosene is scarce.

To estimate aggregate subsidy costs, the differences between consumer- and supply-cost price levels are applied to official statistics on national kerosene consumption as well as the sectoral and end-use breakdowns described in 2(a) 2() This analysis includes data for countries representing 96% of the global population.

(c) *Caveats and uncertainties*

Various challenges apply in estimating kerosene pricing and subsidy levels. Prices vary widely within national markets, particularly in the developing world, due to distribution chain dynamics and profit-taking for ultra-small-quantity sales. In the latter case, prices paid can be two- to three-times nearby pump prices (Tracy & Jacobson, 2012). In this case, the subsidy is captured by the intermediaries rather than the ultimate energy user, in what is yet another economic inefficiency associated with subsidies. By virtue of being based on national averages, the price-gap approach does not illuminate geographic or demographic variations in subsidies at the local level. Where quotas or shortages exist, black-market prices tend to rise well above official consumer prices. True market petroleum prices vary over time as well, and were 34% higher in mid-2008 than in 2014, for example. Even global supply prices may not be intervention-free, e.g., distorted by cartel behavior, military expenditures that seek to avoid price spikes due to security considerations, or public insurance-like programs that absorb externality costs such as pollution control or clean-up. Lastly, externality costs tend to be undercounted, as previously noted. Official kerosene consumption statistics are not always reliable, as they do not capture illegal diversion of fuels across borders, which can be very significant where inter-country price differences vary substantially. These statistics occasionally present wild year-to-year swings in kerosene use for many countries (nationally as well as among sectors) that seem implausible. For example, reported annual kerosene consumption in Nigeria varies by 40% and more (USEIA, 2016). Lastly, sufficient data were not available to allocate consumption and end-use amounts of kerosene between urban and rural areas. The corresponding patterns of subsidization are known to be quite different, e.g., with kerosene lighting being more common rural areas and kerosene cooking being more common in urban areas (Gangopadhyay *et al.*, 2005).

The price-gap approach thus has limitations, but centralized efforts to compel individual countries to disclose energy subsidies have not proven very effective and thus leave no better alternative (Koplow, 2009). On balance, the price-gap approach can be thought of as a lower bound of the actual prevailing subsidy.

3. RESULTS AND DISCUSSION

This analysis finds that average 2013 global consumption-weighted consumer kerosene prices were $0.68/liter, rising to $0.92/liter without direct economic subsidies and including sales taxes. The addition of externalities brings the price to $1.31 per liter. Corresponding global kerosene expenditures are $43.4 billion at prevailing consumer prices, rising to $60.3 billion including direct subsidies together with VAT/GST on those incremental amounts. Consideration of externalities brings the true cost to $77.2 billion/year (Figure 8 and Table 3). The figure illustrates that most direct subsidies occur in less developed countries, while the majority of externalities are generated in advanced economies. This latter result reflects the higher morbidity and mortality costs embedded in the IMF methodology. In aggregate, local air-pollution

Table 2. *Profile of global kerosene prices and unit subsidy levels as of 2013. Source (derived from IMF database, IMF 2015)*

	Consumer prices ($/liter)*	Supply costs ($/liter)	Externality costs ($/liter)	Total unsubsidized price ($/liter)*	Direct subsidy ($/liter)*	Total subsidy, with externalities ($/liter)*
Global totals						
Minimum	0.02	0.77	0.12	0.99	−0.90	−0.49
25th percentile	0.71	0.90	0.13	1.27	−0.12	0.06
Median	1.04	0.98	0.20	1.32	0.04	0.30
75th percentile	1.28	0.98	0.26	1.47	0.31	0.53
Maximum	2.12	1.21	0.55	2.12	1.08	1.30
Regional averages (population-weighted)						
World**	0.68	0.92	0.23	1.31	0.37	0.60
Developing Asia	0.45	0.96	0.24	1.33	0.63	0.87
Sub-Saharan Africa	0.85	0.87	0.14	1.18	0.16	0.29
Commonwealth of Independent States	1.00	0.87	0.33	1.51	0.08	0.40
Emerging Europe	1.84	0.97	0.21	1.84	−0.69	−0.48
Latin America and the Caribbean	0.85	0.84	0.28	1.31	0.17	0.46
Middle East, North Africa, and Pakistan	0.49	0.84	0.18	1.17	0.49	0.67
Advanced Economies	1.11	0.94	0.36	1.47	−0.04	0.32

* Includes sales taxes.
** Includes 105 countries for which consumer, supply, and externality cost estimates are available (the presence in the database of only one high-population for Emerging Europe skews the result).

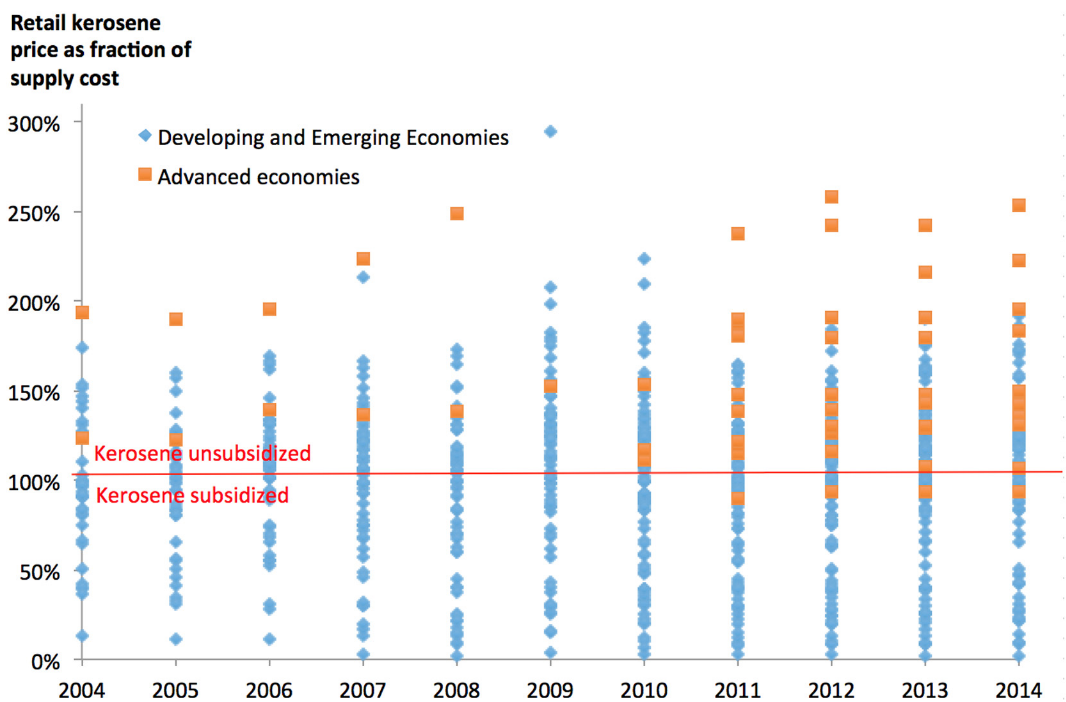

Figure 6. *Retail consumer kerosene prices as a fraction of supply cost: 2004–14. More data are available for advanced economies after 2010. Source: Ratios computed by the author from the IMF energy price database.*

externality costs are $12.9 billion/year, about twice that of carbon-dioxide-related costs ($6.6 billion/year), reflecting significant impacts associated with combustion-related emissions.

The implied direct subsidy (consumer *vs.* supply cost) is thus $18.4 billion/year in for the year 2013, roughly 42% greater than the cost calculated per consumer prices. Approximately 52% of the global kerosene supply receives some level of direct subsidy, rising to 64% when externality costs are considered. These shares are much higher in developing and emerging economies.

Subsidy levels tend to rise with world oil prices. For example, kerosene subsidies would be nearly twice the 2013 levels ($37 billion/year) at peak 2008 world oil prices, and $59 billion/year including externalities. World kerosene consumption fell by 24% during this period, which would make the differential even greater.

Subsidy levels vary considerably by region. Figure 9 contrasts the allocation of direct subsidies with the allocation of kerosene consumption. Disparities among the proportions for a given market segment are a reflection of the degree of subsidies received by those particular consumers. The greatest

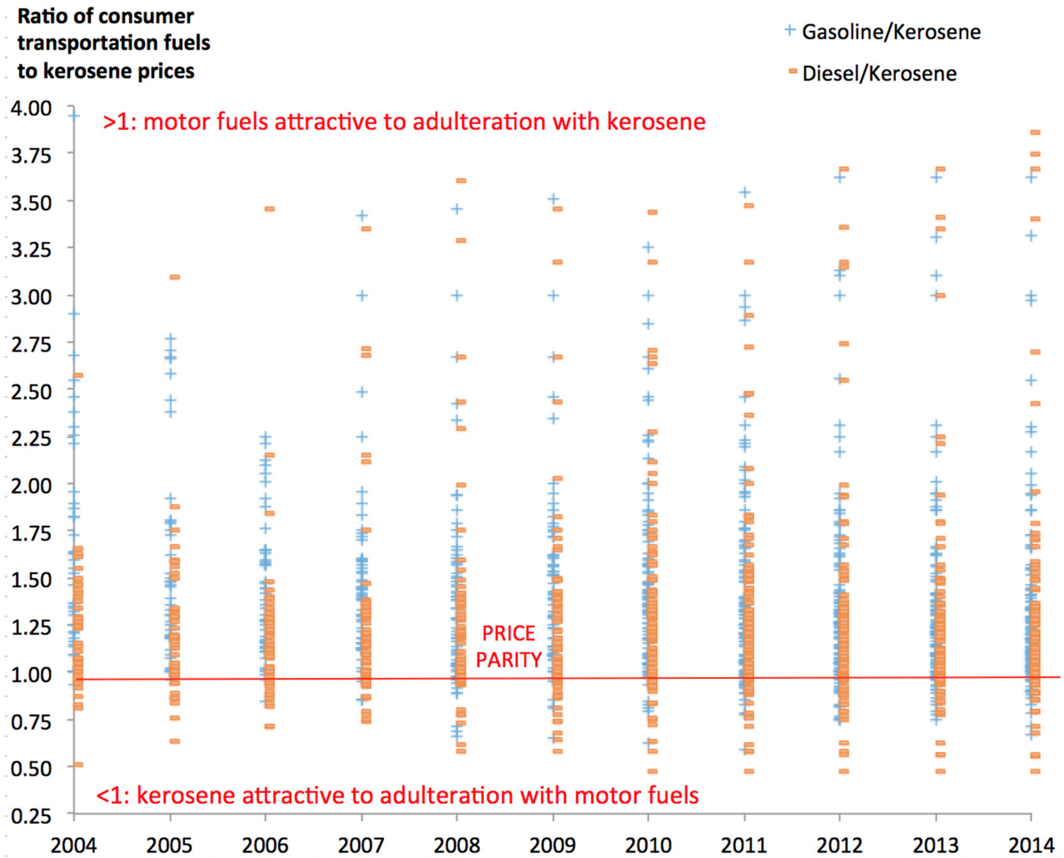

Figure 7. *Ratios of retail consumer motor fuel prices to kerosene prices: 2004–14. Source: Computed by the author from the IMF energy price database.*

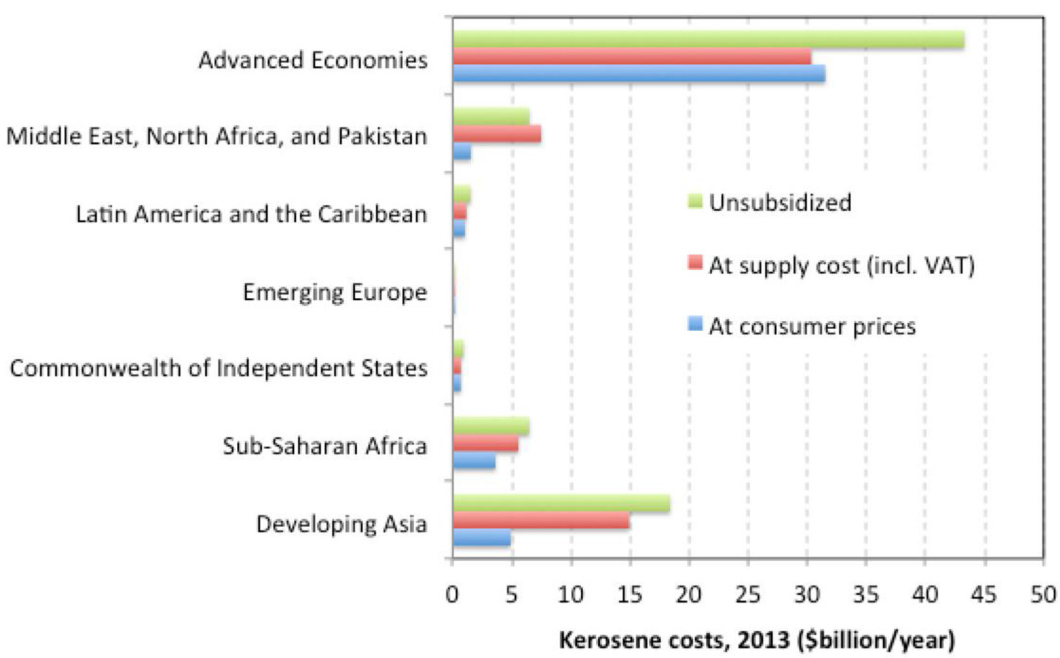

Figure 8. *World kerosene costs by region and level of subsidy. Source: Author's analysis.*

disparity among subsidy-receiving countries is seen in Developing Asia, followed by the Middle East, Northern Africa, and Pakistan. Pass-through amounts (fraction of total direct cost actually paid by consumers) vary from 89% in Latin America and the Caribbean to 21% in the Middle East, North Africa, and Pakistan. As a group, Advanced Economies pay

Table 3. *Kerosene end-use shares, aggregate costs, implicit subsidy levels. Source: Consumption (USIEA, 2016); subsidies are author's analysis*

	Kerosene consumption (kbbl/day)				Kerosene cost ($ billion/year)			Kerosene subsidy levels ($ billion/year)			
	Total	Cooking	Lighting	Heating and other	Consumer price (including taxes)	Supply cost (including VAT)	Full cost (including externalities)	Direct subsidy*	Total subsidy including externalities	Direct-cost pass-through**	Full-cost pass-through**
World	1,012	71	194	619	43.4	60.3	77.2	18.4	34.7	72%	56%
Developing Asia	241	30	129	81	4.9	14.9	18.4	10.1	13.5	33%	27%
Sub-Saharan Africa	99	32	55	13	3.6	5.6	6.5	2.0	2.9	65%	56%
Commonwealth of Independent states	12	2	1	9	0.7	0.7	0.9	0.0	0.2	98%	74%
Emerging Europe	2	1	–	0	0.2	0.1	0.2	0.0	0.0	163%	108%
Latin America and the Caribbean	20	3	3	11	1.0	1.2	1.5	0.2	0.6	89%	69%
Middle East, North Africa, and Pakistan	147	3	6	13	1.5	7.5	6.5	5.9	5.6	21%	24%
Advanced Economies	491	–	–	491	31.5	30.3	43.3	0.1	11.8	104%	73%
Subtotals and proportion of global totals allocated to developing and emerging market economies	521 52%	71 100%	194 100%	128 21%	11.9 27%	29.9 50%	33.9 44%	18.3 99%	22.9 66%	40%	35%

Note: Country categorization per IMF (Coady et al., 2017); kbbl is thousand barrels per day.
Note: "VAT" is value-added tax.
* Due to the presence of negative subsidy (net taxes) for some countries, the sum of regional totals can vary from the sum of individual countries.
** Direct cost pass-through is the fraction of unsubsidized costs (including taxes) paid by consumers; "Total-cost pass-through" includes externalities.

4% more than true costs owing to taxes, i.e., no direct subsidy exists for this group as a whole. Per-household direct subsidies range from approximately −~$150/year to ~$400/year around the world, with negative values resulting for countries that tax kerosene above the supply cost (Figure 10). The average subsidy among subsidy-receiving households is $76/year. Given diversions and local fuel-price mark-ups by fuel resellers, together with subsidized kerosene being purchased by the targeted populations, populations utilizing kerosene, actual subsidies are substantially higher per intended recipient.

Subsidies are also allocated differently among energy end uses, with lighting receiving the majority of direct subsidies in the developing world, while heating receives more industrialized countries (Figure 11a and b). Cooking receives $2.0 billion each year in direct kerosene subsidies (virtually all in developing world), lighting $7.1 billion, and heating and other miscellaneous uses $9.3 billion. When accounting for externalities, these values rise to $2.9 billion, $9.6 billion, and $22.3 billion/respectively.

The top-20 countries by consumption are responsible for 91% of the global kerosene use and the top 20 by direct subsidy are responsible for 98% of global direct subsidy expenditures. India is the country with the largest aggregate kerosene subsidy and ranks second (after Japan) in kerosene consumption (Table 4). Not surprisingly, large oil-exporting countries are often among the top providers of subsidies.

(a) *Inefficiencies and adverse effects of kerosene subsidies*

Kerosene subsidies create a myriad of market inefficiencies and other adverse effects. Some occur at the macroeconomic level, while others have more immediate impact on individuals.

(i) *Ineffective targeting*

As applied in the developing world, kerosene subsidies are less regressive (beneficial to wealthier consumers) than other types of energy subsidies (IMF, 2013), yet many studies show that the majority of benefits accrue to households other than those for whom the subsidy is primarily intended. A World Bank assessment of this "leakage" problem in five sub-Saharan Africa countries found that people in the highest income quintile received as much as 40% of all subsidy benefits, while the lowest quintile rarely received even the 20% that would be expected if there was no targeting of subsidies to those in need (World Bank, 2012). In Nigeria, the top quintile of the population by income was also found to receive greater benefit from kerosene subsidies than did the poorest quintile (Soile & Mu, 2015). A similar pattern has been observed in India, where detailed analysis found that wealthier households benefit more on a per-capita basis (primarily for cooking) than do poor households (primarily for lighting), and that urban households benefit approximately twice as much on a per-capita basis across all levels of income although they use less kerosene in aggregate (Gangopadhyay *et al.*, 2005). Some studies indicate that most income cohorts are willing to pay actual market costs for kerosene, i.e., without subsidy (Dube, 2003).

(ii) *Macroeconomic inefficiencies*

Subsidies constitute significant costs to governments, contribute to national deficits, undermine competitiveness, and distort energy markets. When oil-producing countries sell subsidized kerosene domestically they forego potential export revenue earnings. Disparate subsidy levels between countries can induce illegal movements of fuel across borders, thereby

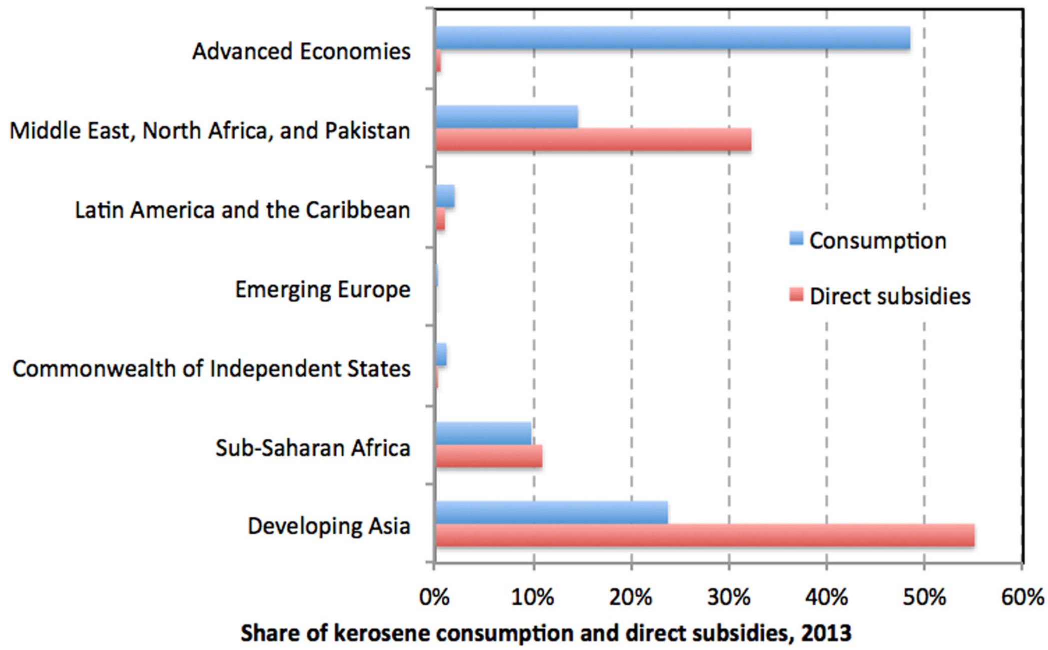

Figure 9. *Contrasting allocations of kerosene consumption and direct subsidies by region: 2013. Source: Author's analysis.*

denying tax revenues to both governments. The presumed near-term competitiveness benefits of subsidies are in the long run negated by the inefficiencies they engender (IMF, 2015). Subsidies can also inadvertently enhance the volatility of world energy prices by suppressing the energy price signals that keep demand in check.

In many countries, energy subsidies compete with—and sometimes exceed—public investment in healthcare, education, and other social programs (IMF, 2013). For example, kerosene subsidies in Nigeria amount to more than the entire government expenditures on security, critical infrastructure, human capital development, plus land and food security combined (Figure 12). Ghana was at one point spending 2.2% of GDP on fossil fuel subsidies, which exceeded their investment in public health (Laan, Beaton, & Presta, 2010). Before extensive subsidy reforms were undertaken in Indonesia, fuel subsidies there exceeded health spending by 400%, road and irrigation by 100%, and education spending by 25% (Yemtsov, 2010). In Yemen subsidies were at one time larger than public expenditures for health and education combined (Coady *et al.*, 2006). In India, far more households received kerosene subsidies in 2005 than food subsidies (Gangopadhyay *et al.*, 2005).

(iii) *Hampering improvements in energy efficiency and choices of cleaner fuels*

The prospects of unsubsidized new and more-efficient energy using technologies are undermined when they must compete against subsidized fossil fuels (Garg, Sharma, & Clarke, 2016). In one salient example, grid-independent electric lighting systems have become important alternatives to kerosene lighting (Bloomberg New Energy Finance and Lighting Global, 2016; Garg *et al.*, 2016; Mills, 2005). The energy efficiency and low cost of these systems typically result in the initial investment being recovered in less than one year assuming depending on prevailing kerosene prices.

A single year of subsidy costs for the fuel burned by a kerosene lantern can be on par with the entire alternative investment in a solar-LED lantern (Figure 13). Over its service life, the solar-LED lantern imposes far less cost on the consumer than continuing to use even heavily subsidized fuels for lighting, and improved lanterns deliver a vastly greater level of lighting services (Mills, 2005). These improved services contribute positivity to a host of productive uses in cottage industry, commerce, healthcare delivery, and education.

However, a 50% kerosene subsidy doubles the time period required to recover the cost of enhancing energy efficiency. This differentially disincentivizes more costly but higher quality systems with more features. For example, while a \$10 solar-LED lantern requires only three months longer to pay for itself under a 50% subsidy, a higher quality \$100 system providing additional services such as phone charging, requires 22 additional months. Approximately 40% of aggregate direct kerosene subsidies accrue to fuels used for lighting.

(iv) *Fueling illicit activity*

Kerosene subsidies fuel black markets when combined with quotas for end users or when shortages arise for other reasons. Reports from India indicate that when subsidies are limited to a specific consumer segment they can trigger widespread diversion to other sectors (most commonly transport fuels) where the subsidy is not available (Rao, 2012). Available estimates for such diversions in India range from 41% (Garg *et al.*, 2016)) to 50% (Gangopadhyay *et al.*, 2005) of subsidized kerosene never reaching the intended households. Transportation-fuel adulteration has been documented in Ghana (Laan *et al.*, 2010) and Senegal as well, in the latter case resulting in the diversion of half of all kerosene to diesel vehicles and a corresponding tax loss of \$25 million annually (Kane, 2005). Kerosene can be diluted into gasoline up to 5% and with diesel up to 20% without any effect noticed by energy users (Bacon, 2001).

Diversion also occurs to the aviation sector (Lawal, 2011), so much so in the case of Nigeria that imports of aviation fuel were at one time ceased as domestic household kerosene was widely diverted and sold at far higher prices (Ekundayo & Agabi, 2011; PPPRA, 2013). High mark-ups have been widely

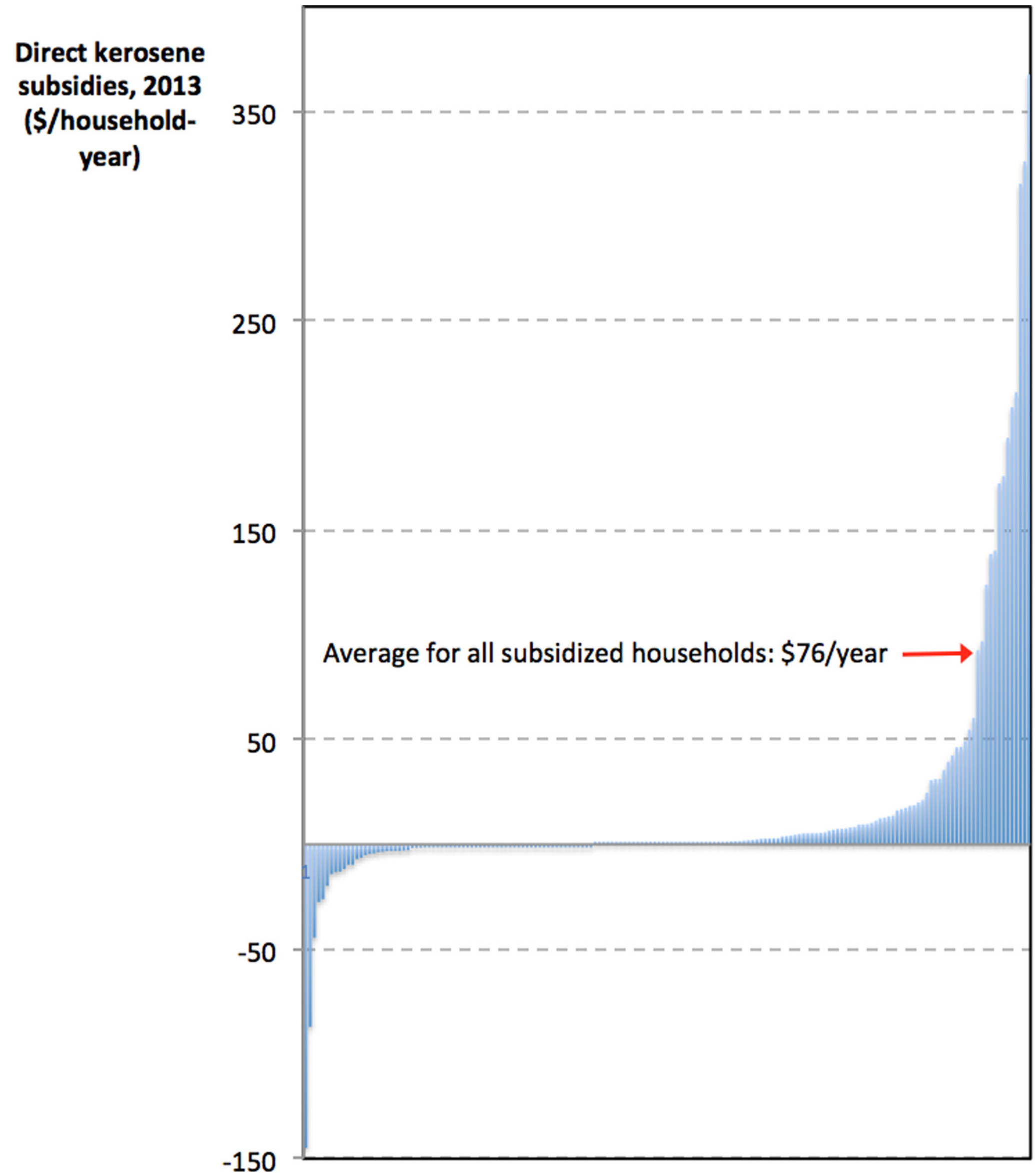

Figure 10. *Distribution of direct kerosene subsidies. Each bar represents a country. Negative values reflect market prices that exceed supply costs, prevailing taxes, and externalities. Source: Author's analysis.*

observed even for kerosene sold to households (Bello & Olowa, 2012), indicating that the subsidy payments are captured by unintended actors, rather than passed, as intended, to end-users.

Subsidies also encourage black markets that engage in smuggling of kerosene to neighboring states that do not provide subsidies. These activities are reported to involve private actors as well as corruption within the public sector. One-third of the kerosene being produced in Indonesia as of the year 2000 was unaccounted for and suspected to have been smuggled out of the country (Clements, Jung, & Gupta, 2003). For example, up to 20–30% of all petroleum consumed in Niger is smuggled primarily from Nigeria (ESMAP, 2009), where relative prices in 2013 were $0.32/liter and $1.00/liter, respectively. Similar rates of diversion have been reported from Tanzania to Malawi (LuminaNET, 2013), with relative prices $1.24/liter and $1.59/liter. Between 28% and 50% of India's kerosene is estimated to be smuggled to Bangladesh, where it is sold for four-times the subsidized price (Saikia, 2013).

(v) *Health, safety, and environmental impacts*

Energy subsidy policies tend to contradict environmental and health policy and thus suggest increased costs for public health interventions. In one important example cited above, transportation fuels adulterated with kerosene result in increased hazardous air pollution, leading to health issues.

Kerosene combustion, particularly for lighting, can cause a host of undesirable health outcomes (Mills, 2016). These include risks from burns and destruction of property by fire, indoor air pollution, poisoning from drinking of kerosene by children, visual health problems and complications of reduced visibility, and complications to the delivery of care

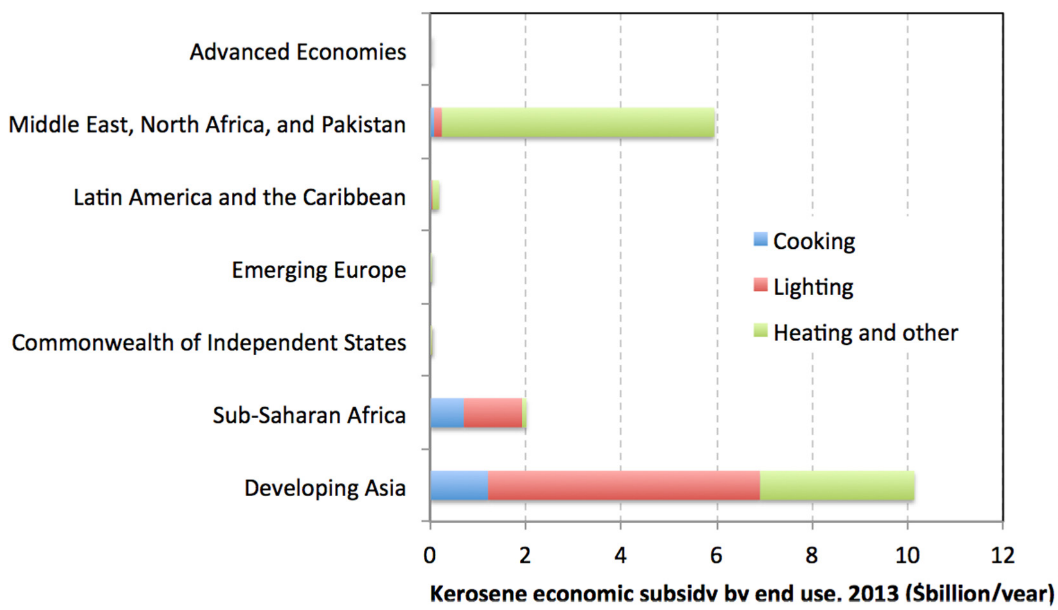

Figure 11. *World kerosene direct subsidy amounts by region and end use. Source: Author's analysis.*

Table 4. *Top-20 countries by kerosene consumption (USEIA, 2016) and subsidies (Author's analysis)*

Country	Kerosene consumption (kbbl/day)	Country	Direct subsidy* ($M/year)
Japan	311	India	7,491
India	161	Iran	3,334
Iran	79	Iraq	1,662
United Kingdom	76	Nigeria	1,545
Korea, South	55	China	1,380
Nigeria	52	Indonesia	1,049
Iraq	42	Saudi Arabia	349
China	35	Libya	297
Indonesia	22	Ethiopia	117
Ireland	16	Bangladesh	98
South Africa	9	South Africa	93
Canada	9	Egypt	91
Benin	8	Angola	86
Saudi Arabia	8	Venezuela	72
Bangladesh	7	United States	59
Kenya	6	Kenya	53
Libya	6	Yemen	50
Italy	6	Pakistan	50
Ethiopia	5	Sri Lanka	46
United States	5	Kuwait	36
Fraction of world total	91%		98%

* Excludes externality costs.

due to poor lighting in off-grid health clinics. Lam *et al.* (2016) estimated that kerosene subsidy reform in India could avert the loss of between 50,000 and 300,000 disability adjusted life years thanks to the associated demand response and corresponding reduction of PM 2.5 indoor pollutants. Particular adverse effects on women and children include maternal and infant mortality outcomes as well as reduced infant birth weights. Mental and emotional injury can often follow these events, in addition to the direct costs of medical aid, lost work productivity, and loss of homes and personal property. These categories of costs are not included in the IMF externalities adopted in the preceding analyses.

The greenhouse gases produced by kerosene contribute to climate change and its associated costs. The IMF has estimated that a 50% reduction of petroleum subsidies would result in CO_2 emissions being reduced by 14–17% (Coady *et al.*, 2010).

(vi) *Political risk*

Dependency on cheap fuel engenders political risk for policymakers, arising from the aforementioned socio-economic consequences. Despite the adverse impacts of subsidies, consumers become accustomed to subsidies and view them as entitlements with subsequent price increases attributed to

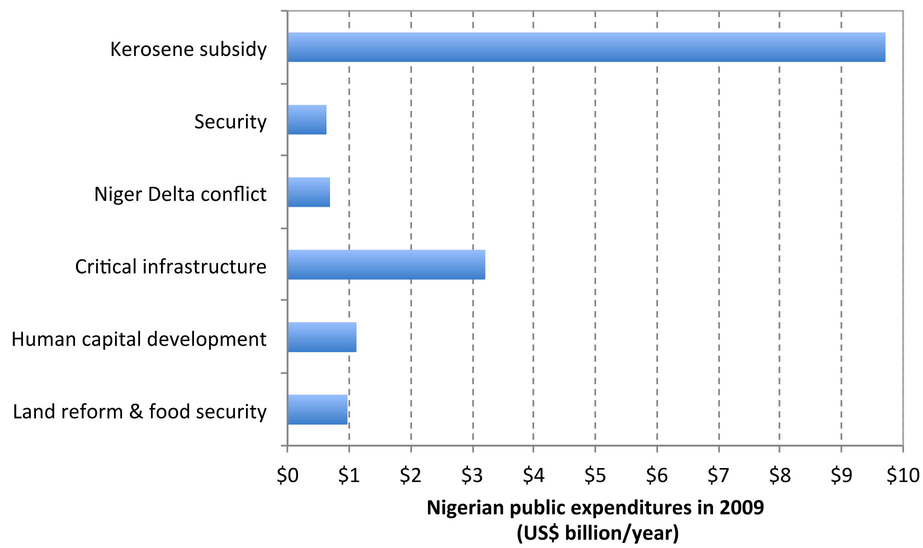

Figure 12. *Nigerian direct kerosene subsidies compared to other social program budgets: 2009. Source: Adapted from Adenikinju (n.d.).*

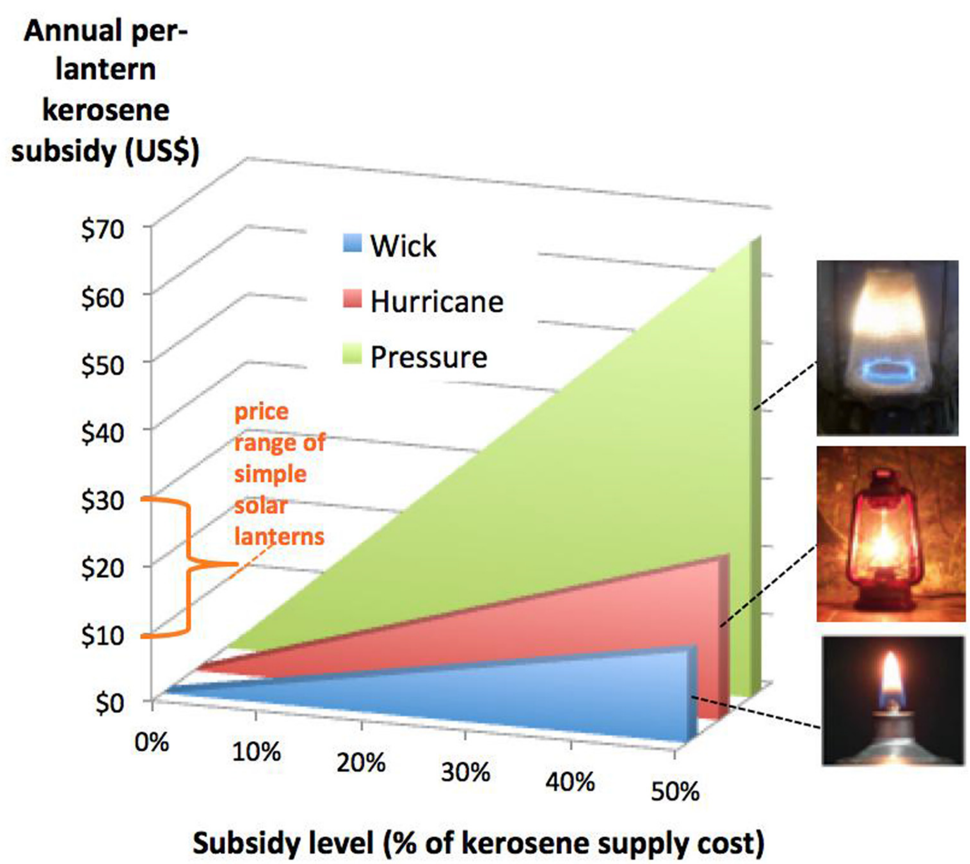

Figure 13. *Annual per-lantern kerosene subsidy by lantern type and direct subsidy level. Assumes 4-h per day operation and representative fuel-use rates (0.02 l/h for wick lamp, 0.035 l/h for hurricane lantern, and 0.10 l/h for pressure lantern). The unsubsidized kerosene supply cost is taken as $0.92/liter (excluding externalities), the population-weighted average value of the IMF dataset. Source: Author's analysis.*

arbitrary decisions by local governments rather than global energy market dynamics.

Civil unrest, in the form of protests and violence when subsidies are eased or removed has been documented in many countries. It is encouraging that in the case of India, nearly 6 million consumers voluntarily gave up their LPG subsidy in 2015, the first year of the "Give it Up" campaign sponsored by the national government (WHO, 2016).

4. POLICY STRATEGIES

While the use of cost-based prices contributes to well-functioning markets, it does not in and of itself ensure that the costs of energy services are minimized for consumers or that environmental externalities are internalized in decision-making. Subsidies are one of many market barriers to more efficient use of energy and reductions of energy-related externalities. Indeed, subsidies undercut the objectives of other policies, such as energy efficiency standards, by artificially reducing their cost-effectiveness.

(a) *Subsidy reforms*

Effective subsidy reforms improve the targeting of benefits to the intended populations, eliminate corruption that enriches non-intended audiences, and recouple pricing to changing world oil prices. According to the preceding analysis, forty-five countries—many in the developing world—have priced kerosene such that there are no direct subsidies, and twenty-two countries even when accounting for environmental externalities, suggesting the practice is economically and politically feasible.

Large inter-country and inter-fuel price differences undermine economic competitiveness, and present incentives for illegal fuel trading. The IMF (2011) has proposed harmonized regional practices to help address these problems.

Adequate information flow about the nature and purpose of the subsidies must be ensured. Yet, in practice, subsidy expenditures are rarely disclosed. The ineffectiveness of existing subsidies and goals of the reforms must also be communicated clearly to the public. Efforts to do so in Indonesia (IISD/GSI, 2012) and Ghana were viewed as a key element of making subsidy reform palatable (Coady *et al.*, 2010) while helping policymakers address national deficits. However, the Global Subsidies Initiative (2011) has found that only one in three countries were willing to make such disclosures. Together with information on subsidies, more objective and complete accounting of fossil fuel supply and demand is necessary, particularly in illicit markets (Kane, 2005).

Initiation of reforms can be timed with dips in world oil prices, but countries often reverse reforms when prices spike (Laan *et al.*, 2010). Following reforms, near-term increases in energy costs for consumers will occur if there are not countervailing increases in energy efficiency. To offset these impacts, policymakers have redirected the funds to other social programs (McFarland & Whitley, 2014). There are strong arguments for doing so. Direct cash transfers for other social goals such as education have been found to be more than twice as effective as subsidies in reaching the target audiences (Laan *et al.*, 2010). In one example, during kerosene subsidy reforms in Ghana funds were redirected to education, public health, and mass urban transport (del Granado, Coady, & Gillingham, 2010) as well as rural electrification (Coady *et al.*, 2006).

Given their relatively effective targeting to poor populations, kerosene subsidies are one of the most difficult to reform and maintain. In some cases, it has even been recommended that transport fuel subsidies be redirected to kerosene (del Granado & Adenauer, 2011). Ironically, this strategy increases the likelihood of kerosene then being used to adulterate gasoline and diesel fuels.

(b) *Redirecting resources spent on energy subsidies to more productive uses within the energy arena*

Energy efficiency and renewable energy policies tailored to reduce demand for purchased energy (and thus the cost burden of energy) have a number of advantages over the subsidy model. These include far more precision in targeting benefits to intended audiences, inducement for reduced (rather than increased) externalities, fewer avenues for corruption and black markets, and robust and increasing benefits in times of energy cost spikes (rather than increasing public costs resulting from political pressure to relax subsidies). Energy subsidies can thus be reduced without foregoing the important corollary public policy goal of poverty alleviation.

A large-scale example of reducing subsidy budgets while investing in more efficient and lower emissions end-use technology is Indonesia's targeted kerosene-to-LPG fuel switching program for cooking. To help alleviate the burden of a subsidy cost peaking at $5.24 billion in 2008 for kerosene as the nation's primary cooking fuel (9–18% of total state expenditures), the Indonesian government redirected kerosene subsidy budgets to more-efficient and cleaner-burning LPG and provided free "start-up" kits consisting of an LPG fuel tank, stove, and accessories (Budya & Arofat, 2011). LPG is also far less susceptible to diversion and is not usable to adulterate other fuels. The goal was to deploy 46 million of these kits across the country, funded by a one-time investment of $1.6 billion spread over 5 years. By the year 2012, the program was reported to be highly successful, with kerosene use reduced from 9.8 million liters/year to 1.7 million liters/year (IISD/GSI, 2012), surpassing the goal and reaching more than 50 million households accompanied by a 15%/year decline in national kerosene consumption. The effect can be seen in Figure 2. Benefits extended well beyond reducing state budget deficits, to include reductions in environmental impacts and alleviation of black markets and significant civil unrest caused by volatile kerosene pricing. Subsidy outlays were reduced by about one-third, yet thanks to the relative efficiency of LPG, cooking costs were also reduced by a similar amount. While this reform appears to have achieved a "cleaner" set of energy choices, together with other benefits, the environmental consequences (e.g., greenhouse-gas emissions) and economic consequences (adverse impacts on balance of trade from energy imports) are not fully addressed.

Subsidy funds can also be redirected to rural electrification. The most effective technology pathway for doing so is to stimulate introduction of efficient end-use technologies coupled with localized renewable energy sources such as solar photovoltaic power production. As a case in point, India's Ministry of New and Renewable Energy Solar Lantern Program drove down prices for 800,000 lanterns and country's Remote Village Solar Lighting Program did so for 600,000 larger solar home systems. Solar-LED lanterns have also been subsidized in Nepal, Pakistan and the Philippines. Entire solar home systems have been subsidized in many countries (N'Guessan, 2011).

However, subsidizing solar technologies can impose market biases and other adverse impacts on the emerging off-grid lighting markets where entrepreneurs are otherwise making good inroads (IFC, 2012; Kalkuhl, Edenhofer, & Lessermann, 2013; Mills & Jacobson, 2007). Many of the same problems caused by fuel subsidies can manifest when demand-side energy technologies are subsidized. Fortunately, solar lighting subsidies do not appear to be necessary. Off-grid lighting products have been available for some time with price points at or below the "willingness-to-pay" (Baker & Alstone, 2011; Mills, Gengnagal, & Wollburg, 2014; Mills & Jacobson, 2007). Approximately 20 million solar-LED lighting systems had been deployed by mid-2015 (serving 89 million people) using market-based business models (Bloomberg New Energy Finance and Lighting Global, 2016).

Governments have alternatives to providing direct financial incentives for improving technologies and removing barriers to innovation. These include:

- Establishing product quality assurance procedures and programs that build consumer confidence.

- Educating all market participants about the benefits of technology alternatives.
- Enhancing the effectiveness of supply chains for emerging technologies.
- Eliminating counter-productive import duties (which would translate to lower prices on products for consumers). A variety of compounding taxes and fees (import duty, excise duty, VAT, surcharges) are imposed on solar components, typically resulting in a 5–30% increase in the price of the final product. Such interventions could be revenue-neutral for governments, e.g., one million dollars of kerosene subsidy reduction could offset tariffs on approximately 250,000 solar lanterns. This assumes a landed cost of $25 and a tariff of 15%, or about $4 per lantern.
- Providing innovative financing such as revolving funds, pay-as-you go systems, or interest-rate buy-downs.

5. CONCLUSIONS AND POLICY CONSIDERATIONS

Energy subsidies undercut market forces that efficiently shape energy demand and stimulate development, while working at odds with energy policies designed to reduce the cost of energy services and address externalities such as health and environmental problems associated with energy use.

Based on the original analysis in this article, global kerosene expenditures were $43.4 billion in 2013 at actual consumer prices versus a true direct cost of $60.3 billion including direct subsidies with taxes. Consideration of externalities brings the full cost to $77.2 billion/year. The corresponding subsidy levels are $18.4 and $34.7 billion, respectively. Heating is the primary end use receiving kerosene subsidies in the Middle East, North Africa, and Pakistan, whereas lighting and cooking are primary recipients in sub-Saharan Africa and Developing Asia.

Today's low world oil prices result in subsidy levels smaller than in prior years. Direct kerosene subsidies would be twice as high—$37 billion—at peak world oil price levels of 2008.

The results are likely an underestimate of the true magnitude of kerosene subsidies. Producer subsidies are not included and important externalities unique to kerosene are not considered in the methodology adopted here. Given that the majority of subsidies do not reach the intended audiences, the efficacy of subsidies is far lower than their face value suggests.

Focusing on subsidies for specific fuels and end uses can illuminate energy policy issues and options not readily visible from more aggregate top-down analyses. Knowing which energy sources (e.g., kerosene as a component of "fossil fuels") and end-uses (e.g., kerosene lanterns) are affected can help target efficient interventions. In some areas, lighting will be the most promising area, while in others it may be cooking or heating. Normalizing the relative prices of other fuels that compel the diversion or adulteration of kerosene should also be of key concern to policymakers.

Simply shifting subsidies from kerosene to alternative devices such as solar lanterns has a certain intuitive appeal, but this strategy can be disruptive to otherwise well-functioning markets. More nuanced strategies and policies are needed to remove market barriers to innovation without the need to directly subsidize those alternatives, potentially creating new market distortions.

Kerosene subsidies are slowing the progress of market and policy mechanisms already delivering more efficient and less polluting energy systems that are also safer, more reliable, and more economical than kerosene in the long term. An often under-appreciated perspective among subsidy analysts is that the true consumer cost of energy services (cost per hour of light or to cook a meal or to heat a home) is distinct from a fuel's unit price. It follows that the ultimate costs of inefficient strategies—even when subsidized—can be higher than those of more efficient and unsubsidized alternatives. Contrary to conventional wisdom, kerosene subsidies can thus undercut the development process. It is encouraging that the practices of many governments have already demonstrated that kerosene can be priced in a way that reflects the true supply cost, tax revenue requirements, and associated externalities.

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