

Welfare effects of energy subsidy reform in developing countries

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Abstract

We analyze the potential welfare effect of energy subsidy reforms. The income distributions of eleven developing countries from different geographical regions are simulated using the assumption that income is lognormally distributed. We use the concept of the compensating variation to measure how much compensation is required to compensate consumers for a price increase in formerly subsidized goods. The behavior of consumers is modeled by a standard Cobb–Douglas and a quasilinear utility function. In the Cobb–Douglas case, a fixed fraction of income is spent on the subsidized good, which does not change after a price increase. With quasilinear preferences, the optimal amount of the subsidized good does not vary with income, but does change as prices change. We show theoretically and empirically that the required compensating variation can be set below the saved expenditures on subsidies, so a budget neutral reform can have a positive effect on social welfare.

KEYWORDS

basic income, energy subsidies, subsidy reform, welfare, distributional impact, compensating variation, cash transfers

JEL CLASSIFICATION

D11; D30; D60; H20; H21; H22; H23; H31; I38; O13; Q41

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1 | INTRODUCTION

In many developing countries, subsidies are used for basic goods such as food, fuel (mainly gasoline, diesel, and LPG) and electricity. The main reason is to make these goods affordable to low income households. In the last two decades since the turn of the century, food and energy prices have increased and research has shown that the welfare impact of higher prices for necessities can be very large (Osei-Asare & Eghan, 2013; Wood, Nelson, & Nogueira, 2009), especially when poor households are affected more than rich households because they spend a larger fraction of income on necessities.

Although poverty relief is a legitimate goal for policy makers, the use of energy subsidies is an inefficient instrument to do so for four reasons. First, all income groups benefit from subsidies and rich households may benefit even more than poor households. Granado, Coady, and Gillingham (2012) show that approximately 65% of the benefits of fuel subsidies go to the top two quintiles of the income distribution. This is mainly due to the higher fuel and energy consumption levels of richer households. There is thus substantial leakage of the benefits of subsidies to the rich. Secondly, subsidies lead to overconsumption. As a result of subsidies, prices are below marginal costs and consumption takes place beyond the efficiency point where the marginal costs are equal to the marginal benefit for the consumer. Thirdly, in case of fuel and energy, inefficient overconsumption has a negative impact on the environment. Lin and Jiang (2011) show for China that removing all subsidies would result in a decrease of 3.6% in energy intensity and a reduction in CO₂ emissions of 7%. In Iran, before the reform in 2010 the price of fuel was kept well below the world price, which led to inefficient use. In contrast, demand was so high that oil was imported in large amounts. On the other hand, the artificial low price led to waste and even the smuggling of fuel across the border to sell at a higher price (Guillaume, Zytek, & Farzin, 2011). Finally, in many cases subsidy programs are poorly administrated. For instance, Basu (2018, pp. 16–17) reports that more than 40% of grain to be distributed at below market prices to ration shops by the Food Corporation of India (FCI) simply leak out of the system.

These inefficiencies of subsidies are recognized by institutions such as the IMF and the World Bank (Coady, Parry, Sears, & Shang, 2015; International Energy Agency (IEA), OPEC, OECD, and the World Bank, 2010). Figure 1 shows that many developing countries spend large fractions of GDP on fuel and energy subsidies. The main question that this paper tries to answer is how large the potential welfare improvement is from a subsidy reform, how this differs between countries and for different types of consumer behavior. Furthermore, it looks into the distributional effects of subsidies and reforms. To do so, we conduct a simulation of the welfare effect of removing subsidies and replacing them with a uniform per capita cash grant financed by the reduced expenditures on subsidies. We assume that income is lognormally distributed and derive the required compensating variation (henceforth CV) as the minimum cash grant that compensates consumers of the price increase under two types of behavior, modeled as a Cobb–Douglas and as a quasilinear utility function.

The analysis is produced for a set of countries that still have a system of subsidies in place capturing a significant fraction of GDP. The results indicate that a significant welfare improvement is possible with a budget neutral reform. The size of the potential improvement depends on consumer preferences.

This paper is structured as follows. First, the relevant literature on the topic of energy subsidies is discussed, covering many studies that use different methods to assess empirically what the impact is of subsidy reform or a general price increase. In Section 3, we illustrate the concept of CV that is the basis of the hypothesis that reforming subsidies could lead to a welfare improvement. In Section 4, the data and method used for the analysis are explained, how the income distribution is simulated and the model that is used to simulate the reform and measure welfare change. Two different utility functions are used to test how different consumer preferences affect the results. In Section 5 the main findings

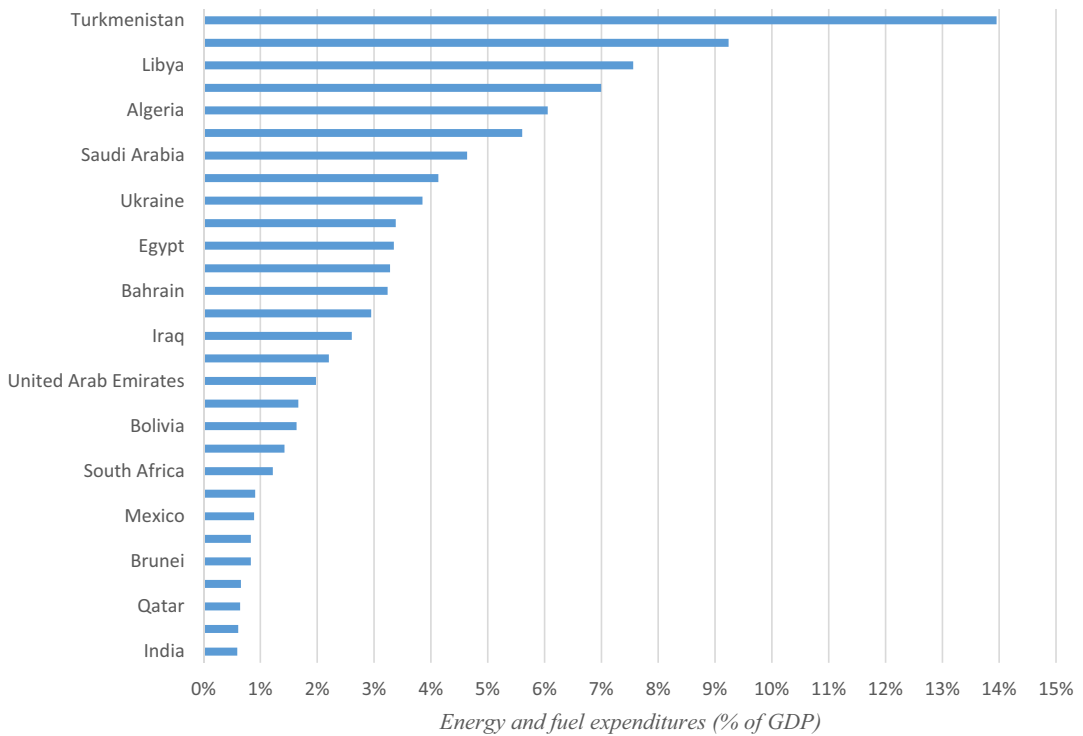


FIGURE 1 Energy and fuel subsidies per county (% of GDP)

Source. IEA (2016).

of the analysis are discussed. Both the resulting CV and distributional effects for poor, median, and rich households are discussed. The final section summarizes and concludes.

2 | LITERATURE

There is a wide range of literature on the role of energy (and food) subsidies in developing countries. Both country specific and cross-country studies have been made. Some studies assess the impact of subsidy reform economy-wide while others focus on the distributional effects or on the environmental impact. The literature also differs in methodology depending on the effects that are researched. When the overall effect on the economy is studied, a general equilibrium model is used. If, on the other hand, only the impact on household welfare is assessed, a more limited approach is taken. This section reviews the different methods and results from the literature on energy subsidies.

Granado et al. (2012) review evidence from country studies on the welfare effects of fuel price increases on households as a result of subsidy reform. Welfare is measured here as the decrease in households' real income. The effect of a price increase is split up between a direct and an indirect effect. The direct effect occurs as households consuming fuel face higher prices after a reform, which reduces their real income. It is calculated as the budget share a household allocates to fuel consumption, based on household survey data, multiplied by the percentage change in fuel price. So if the fraction of income allocated to fuel is 5% and the price increases by 50%, it results in a decrease of real income by 2.5%. This method assumes that households do not substitute goods, which would mitigate the impact. The authors therefore argue that the direct effect can be interpreted as the short run effect,

or the upper bound of the long run effect. The indirect effect comes from the price increase in other goods that use fuel products as inputs. To estimate this effect, data from input–output tables is used to calculate how much prices of other good categories increase as a result of the fuel price increase, assuming cost increases are fully passed onto consumers. These price increases are then multiplied by the household budget shares per category of goods. The total welfare effect is the sum of the direct and indirect effects. They also conclude that subsidy benefits are unequally distributed, as the top quintile receives on average six times more in subsidies than the lowest quintile. This shows that subsidies might be poorly targeted, and a balanced-budget reform could improve welfare. The same approach is used in an IMF report by Anand, Coady, Mohommad, Thakoor, and Walsh (2013) to calculate the welfare impact of a fuel price increase resulting from subsidy removal in India. They find that on average households' real income decreases by 4% of which only a quarter comes from the indirect effect.

Many studies focus on a single country. Araghi and Barkhordari (2012) research the case of energy subsidies in Iran and the effect on household welfare. They use a model with a rational Iranian household that maximizes a utility function that depends on the price of energy, the price of nonenergy goods, and income. The welfare impact of a price increase is then measured with the CV. The CV is defined as the sum of money required to compensate a household after the price change to bring it back to its original utility level. Subsidy reform is simulated by increasing the energy price from 100% up to 500% and calculating the CV for each situation. The prices of nonenergy goods remain constant in their model. They show that reallocating at maximum 50% of the government savings in reduced spending on subsidies in the form of cash grants is sufficient to maintain social welfare of households.

Other studies look at the effects of an energy or fuel price increase on, for example, employment or growth. This requires an extensive macroeconomic model specifying many relationships across markets. Lin and Jiang (2011) do this for China. To estimate energy subsidies in 2007 for China, the authors use the price gap approach. The subsidy is calculated as the difference between the end-use price and a reference price. The reference price could be, like in this study, the unsubsidized market price or the price on the world market. Then, to analyze the effects of an energy price increase on growth, welfare, and energy emissions, a computable general equilibrium (CGE) model is used. This is a model that simulates multiple markets using sets of equations that specify demand–supply behavior and elasticities (Ellis, 2010). In this case, estimates of price elasticities of energy goods are included in the model but cross-price elasticities are not. Thus, there is no substitution between energy products. They consider three scenarios, where scenario 1 considers complete subsidy removal without reallocation of savings and scenarios 2 and 3 include a reallocation of savings equal to 35% and 50% respectively. The simulation of scenario 1 shows that, although subsidy removal substantially reduces energy intensity and emissions, it has adverse effects on welfare, GDP, and employment. Scenarios 2 and 3, in which a fraction of the savings from abandoning the subsidies are reallocated to certain industries, result in positive changes in welfare, GDP, and employment. However, the effects on emission abatement are weakened. This is because the reallocation of resources into the economy stimulates production and employment.

Abouleinein, El-Laithy, and Kheir-El-Din (2009) use a CGE model to estimate the impact of gradually phasing out subsidies on petroleum and related energy products in Egypt. Using an input–output analysis they calculate how increases in the price of fuel translate into price increases of other product categories, for example, a 10% price increase in all petroleum products leads to an increase of the consumer price index (CPI) by 1.5 percentage points. The CGE model is used to assess the impact of gradually removing subsidies, simulating three different scenarios. In the first scenario only the removal of subsidies is simulated. In the other scenarios various forms of compensation from the government are included. Gradually removing subsidies reduces GDP growth by 1.5 percentage points. When 50% of the savings are used for a targeted transfer to the poorest two quintiles of the population,

which is the best performing scenario, growth still slows down. However, consumption growth rates of the poor increase, which reduces inequality. The authors conclude that subsidies on petroleum products are not an efficient way to relieve the poor from the high costs of consumption. There is also evidence that these subsidies mainly benefit the richer quintiles.

More country specific cases are included in a joint report by the IEA, OPEC, OECD, and the World Bank (IEA et al., 2010). In this report, practices of various countries that implemented subsidy reforms are mentioned. Poland managed to implement reforms particularly well. In a time of decreasing inflation and increasing household disposable income the government gradually increased the low VAT of 7% on energy products to the normal level of 22%. This reform was complemented by extra payments to the poorest households to compensate them for the higher prices.

The most comprehensive study of the impact of subsidy reform was done by Araar and Verne (2016) for five countries in the Middle-East and North Africa (MENA) region. They use household survey data for each of the five selected countries and standardize the key variables, including expenditure per capita on individual products and a set of household characteristics to assess the distribution of food and energy subsidies across income levels.¹ The relative importance of subsidies for each quintile varies, depending on the product and the country. This analysis is useful for policy makers to target benefits of subsidies better, or design the reform in such a way that it benefits the poor. They simulate a decrease of 30% in subsidies across all products and countries. The results show that the welfare impact can be very different for different products and countries. They also analyze how the government budget changes as a result of the reform and how much it would cost to bring back the poverty gap to the pre-reform level through universal transfers. In all cases, the government budget gain of reducing subsidy expenditures is higher than what it would cost to keep the poverty gap unchanged.

3 | COMPENSATING VARIATION

When subsidies for a good are abandoned, the price of that good will increase, which affects consumers' utility. At the same time, the government saves the money that was being spent on the subsidies. If the savings as a result of the reform are higher than it costs to compensate consumers to bring them back to their pre-reform level of utility, then the reform is potentially a welfare gain. To measure how much extra income consumers would need to make them as well off as before the reform, the concept of the CV is used, defined as the required change in income to compensate households for the higher prices to be as well off as before the reform.

We will show graphically, for the case of quasilinear preferences, how the elimination of a subsidy can be accompanied by handing out a cash grant as compensation for the price increase in such a way that a consumer is not worse off in utility terms. A quasilinear utility function is assumed here for three reasons. First, it is very suitable for needs-type of goods, because there is no income effect. Secondly, a quasilinear utility function is part of the class of utility functions (the so-called Gorman type) that allows aggregation of consumer surplus across agents. Thirdly, owing to the absence of the income effect, the change in consumer surplus is the appropriate measure of the required compensation following a price change, and equal to the CV (and also equal to the equivalent variation).²

In Figure 2, the concept of CV is demonstrated for a representative consumer, who initially consumes at point A, where the vertical axis measures consumption expenditures on all other goods than x . The price increase for good x after abolishment of the subsidy causes the budget constraint to shift inwards where, without compensation at point B, a lower utility level is reached. The required CV, equal to $y' - y$ then indicates by how much the budget constraint must shift upward after the price

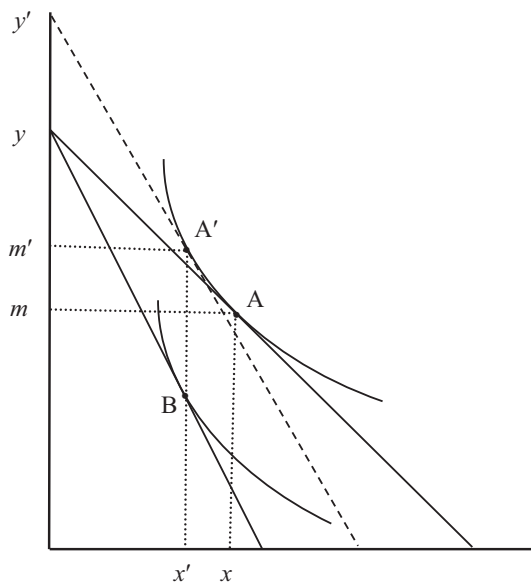


FIGURE 2 The compensating variation under quasilinear preferences

change to reach the initial utility curve. The consumption bundle then changes from point A to point A'.³ It is hypothesized that the CV will be smaller than the savings the government has when removing subsidies. In Section 4.2, we will show mathematically that the required CV is always below the budget savings as a result of the removal of subsidies. The potential for welfare improvement is then dependent on the difference between the initial per capita expenditures on subsidies and the required CV.

4 | DATA AND METHOD

In order to research the impact of subsidy reform on household welfare many studies make use of large datasets of household surveys, combined with input–output tables and eventually incorporated into a CGE model. We adopt a more straightforward and parsimonious approach by making the assumption that income in a country is lognormally distributed. The assumption of lognormality to model the income distribution is frequently made, for example, by Chotikapanich, Valenzuela, and Rao (1997), Pinkovskiy and Sala-i-Martin (2009), and Van Zanden, Baten, Foldvari, and Van Leeuwen (2014), despite the limitation that it does not adequately describe the distribution of income at the right tail of high incomes (Singh & Maddala, 1976). Although we are aware that the lognormality assumption has its limitations, it must be said that the high incomes are generally also underrepresented in surveys and that it will not change our results qualitatively. Moreover, the underestimation of the incidence of high incomes in the lognormal distribution means that the welfare effects of the subsidy reform are even higher than calculated in our analysis.

4.1 | Data

The data that are needed to simulate the income distribution are limited to three widely publicized indicators: GDP per capita, the Gini coefficient, and population size. We selected 11 countries; nine based on the importance of subsidies as a share of GDP, with a threshold of at least 3% of GDP on energy and

fuel subsidies (see Table 1)⁴; and two countries (India and South Africa) because in these two countries basic income is a lively debated topic in debates about poverty relief and policy reform.⁵ An additional reason to include India and South Africa is that contrary to most other countries in our set, they are net importers of energy. For energy and fuel subsidies, data on subsidies are readily available at the International Energy Agency (IEA). Turkmenistan has the highest subsidy expenditures with 14% of GDP, followed by Iran with 9.2%.

In Table 1, GDP per capita and population data are for 2016, except for Venezuela where the GDP per capita is for 2014. For the Gini coefficients we used the most recent years for which data is available. For Turkmenistan, Uzbekistan, Venezuela, and Azerbaijan we had to use the data of 1998, 2003, 2006, and 2008 respectively. For all other countries the Gini is for 2011 or later. Since the Gini coefficient does not fluctuate much over the years, the less recent values can still be used for the analysis.

To simulate the income distribution, the same methodology is used as in Groot and Van der Linde (2016). It starts from the assumption that income in a country is lognormally distributed, characterized by a long tail on the right side of the distribution, which is often seen in the real world. The parameters of the lognormal distribution, the mean μ and the standard deviation σ , can be estimated by GDP per capita \bar{y} and the Gini coefficient G . When income is lognormally distributed, the Gini coefficient only depends on the standard deviation according to $G = 2\Phi\left(\sigma/\sqrt{2}\right) - 1$, with Φ the cumulative density function of the standard normal distribution. The standard deviation σ can then be expressed as:

$$\sigma = \sqrt{2}\Phi^{-1}\left(\frac{G+1}{2}\right).$$

The mean of the lognormal distribution depends on the income per capita and the standard deviation and is given by:

$$\mu = \ln \bar{y} - \frac{\sigma^2}{2}.$$

Aggregate data on income per capita and the Gini coefficient can thus easily be translated into the parameters of the lognormal distribution for each country. To illustrate, Figure 3 shows the simulated income distribution of Egypt.

TABLE 1 Country data

Country	GDP per capita	Gini coefficient	Population	Energy/ fuel subsidy (%GDP)
Algeria	3,917	27.6	40.6	6.1
Azerbaijan	3,879	33.7	9.8	3.4
Egypt	3,478	31.8	95.7	3.3
India	1,717	35.1	1,324.2	0.6
Iran	5,219	38.8	80.3	9.2
Kazakhstan	7,715	26.9	17.8	3.3
South Africa	5,280	63.0	56.7	1.2
Turkmenistan	6,389	40.8	5.7	14
Ukraine	2,186	25.0	45.0	3.9
Uzbekistan	2,111	35.3	31.8	7
Venezuela	15,692	46.9	31.6	5.6

Source. World Bank/IEA.

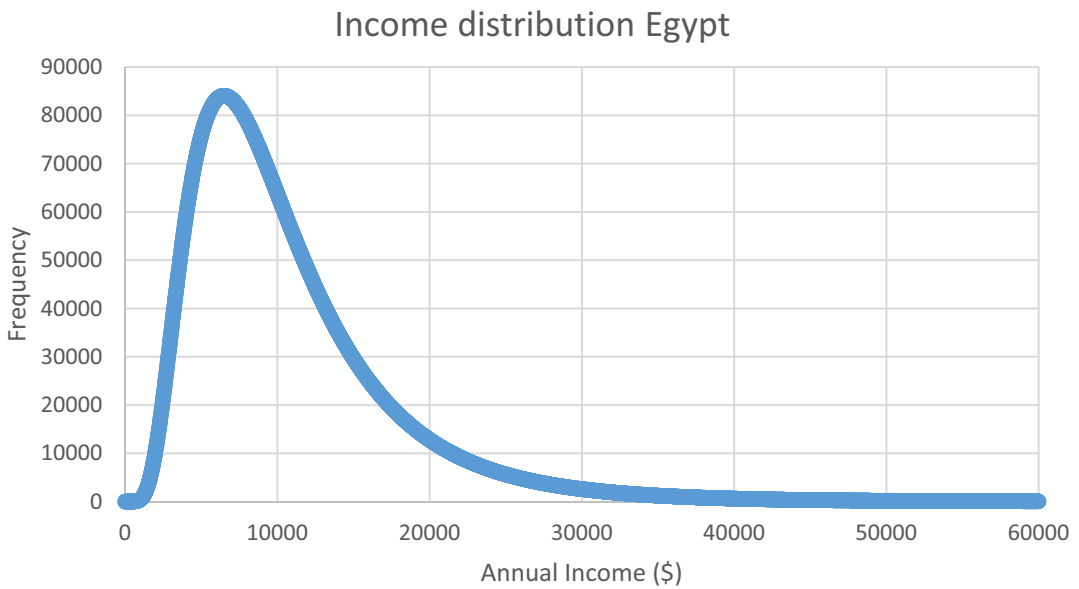


FIGURE 3 Income distribution Egypt [Colour figure can be viewed at wileyonlinelibrary.com]
Source. Based on World Bank data (2015).

4.2 | Model

We will use the measure of the CV, reflecting the monetary value to bring a household affected by higher prices back to its pre-reform level of utility, to assess the potential welfare impact of a subsidy reform. Therefore, it is necessary to define a utility function that reflects the consumer preferences. We will examine two extreme cases. In the Cobb–Douglas case, consumers spend a fixed fraction of income on the subsidized good, so all other things equal, a doubling of the price will lead to halving the quantity consumed. At the other extreme, in the quasilinear case, the consumption of the subsidized good does not differ across income levels. This function is especially useful when necessities are considered. The real world situation will probably be somewhere in between. The Cobb–Douglas case has the advantage that we do not need information about price elasticities and the parameters of the utility function can be estimated based on observed expenditure shares of subsidized goods. The disadvantage is that the subsidized commodity is not considered as a necessity at all since any price increase is accommodated by a decrease in demand such that the expenditure share stays constant. The quasilinear case has the advantage that it is fully in line with the absence of income effects characteristic for necessities, but it conflicts with real world observations that, for instance, energy demand is strongly correlated with income. The real world case can be represented as a combination of both utility preferences if total demand for a subsidized good can be approximated as a fixed amount independent of income (mimicking the quasilinear case) plus an amount dependent on income (conform the Cobb–Douglas case), where the size of both components are sensitive to prices.

4.2.1 | Cobb–Douglas utility function

The utility level depends on the consumption of an initially subsidized good x and on m , where m can be interpreted as the income left after consuming x and available for all nonsubsidized goods (with prices set to unity):

$$u = x^\alpha m^{1-\alpha} \quad (1)$$

and the budget constraint is:

$$px + m = y. \quad (2)$$

Maximizing utility subject to the budget constraint yields as first-order conditions:

$$\alpha = px/y, \quad 1 - \alpha = m/y. \quad (3)$$

The share of income that is spent on x is thus fixed at α and does not change with the price, for example, doubling the price reduces the consumption of x by half. Using (3), it can easily be derived that for x the income elasticity is unity and the price elasticity is minus unity. The pre-reform utility level of an individual, using the optimal consumption levels of x and m , can be expressed as:

$$u = (\alpha y/p)^\alpha [(1 - \alpha)y]^{1-\alpha}. \quad (4)$$

For each country, the fraction of GDP that is spent on subsidies is known, as well as the total consumption level of the subsidized goods. Therefore, the price subsidy on a single unit of x equals the total subsidy expenditure divided by the total amount of x that is consumed. This per unit subsidy is then the price increase that is simulated. Countries with higher subsidy expenditures therefore see larger price increases when subsidies are abandoned. After subsidies have been abandoned, the price level of the subsidized good will rise to $p' > p$. The post-reform utility level u' with income of y' can be expressed as:

$$u' = (\alpha y'/p')^\alpha [(1 - \alpha)y']^{1-\alpha}. \quad (5)$$

By definition, the CV is equal to the difference between y' and y under the condition that $u = u'$, so equating (4) and (5) and solving for $y' - y$ gives the following shorthand expression for the CV:

$$CV = (p'^\alpha - 1) y \quad (6)$$

with p set to unity. Accordingly, the higher the price increase and the higher the expenditure share α of the subsidized good, the higher the CV, and since households face the same price increase, the CV is the same fraction $(p'^\alpha - 1)$ of income for all households. Using (3), the savings in expenditures on subsidies is $(p' - 1)x = (p' - 1)\alpha y$, which is greater or equal to the CV required if $(p' - 1)\alpha - (p'^\alpha - 1) \geq 0$. For $p' \geq 1; \alpha \in [0; 1]$, this condition is always met.⁶

4.2.2 | Quasilinear utility function

When consumers have quasilinear preferences the optimal consumption of x is independent of income. We use the same utility function as analyzed in Silvestre (2012):

$$u = \sqrt{v(x) + m} \quad (7)$$

with the value function

$$v(x) = ax - \frac{b}{2}x^2. \quad (8)$$

The optimal amount x^* is defined by $v'(x^*) = p$, so the demand function for x is $p = a - bx$. The price elasticity can be expressed as:

$$E_p^x \stackrel{\text{def}}{=} \frac{\partial x}{\partial p} \cdot \frac{p}{x} = \frac{p}{p - a}. \quad (9)$$

It is possible to get an estimate for a when the elasticity E_p^x at price p is known. If necessities are considered, it would be logical to use a low elasticity. However, for fuel and energy products the elasticity may be relatively high. Lin and Jiang (2011) estimate price elasticities for different energy and fuel products, distinguishing between end users. Their lowest estimate is a price elasticity for energy of -0.158 for residents, but -0.6 for industrial users. Other products such as coal and natural gas have high elasticities, around -0.5 . We will use a low estimate of -0.1 and a high estimate of -1 for the elasticity of the subsidized good. Using (9), for the low elasticity of -0.1 , a equals 11 and for an elasticity of -1 , a equals 2, so the parameter a can be used to set the required price elasticity. The income elasticity under quasilinear preferences is always zero. Recall that under Cobb–Douglas preferences the price and income elasticities are minus unity and unity respectively. Now suppose that we do know from empirical research the exact price and income elasticities of a subsidized good. By choosing the parameter value a , we can always make a linear combination of Cobb–Douglas and quasilinear preferences such that the observed elasticities result, provided the income elasticity is below unity (ruling out luxury goods).⁷ In other words, the real world case can always be represented as a combination of both preference schedules, provided the income elasticity is below unity, which is very plausible given the nature of subsidized goods.

Parameter b of the value function can be obtained by using the equation for optimal consumption level of x . The pre-reform level of consumption of x is equal to on average 10% of income, equal to parameter α in the Cobb–Douglas specification. Since the consumption level of x in this model is the same for everyone, this corresponds to 10% of mean income. The value for b is thus chosen in such a way that before the price increase, total consumption of x is the same as in the previous model.

To derive the CV, we solve $u(x, y) = u'(x', y + CV)$ for CV. Using (7) to (9) and $p' = a - bx'$, the CV is:

$$CV = \frac{b}{2} (x^2 - x'^2) \quad (10)$$

thus the CV does not depend on income level. Therefore, the CV is the same amount for every household. For higher incomes this means the CV is only a very small fraction of income. The savings in subsidy expenditures are equal to $(p' - p)x$, which using $p = a - bx$ and $p' = a - bx'$ can be expressed as $b(x - x')x$. The required CV is always lower than or equal to the savings because $\frac{b}{2}(x^2 - x'^2) \leq b(x - x')x$ requires $(x - x')^2 \geq 0$, which is always satisfied. The next section will discuss the results of the simulation for the eleven selected countries.

5 | SIMULATION RESULTS

In the first part of this section, we present the simulation using the Cobb–Douglas utility function and in the second part the result under a quasilinear utility function. As argued before, under the former all households spend a fixed fraction of their income on the subsidized good, even after abolishing the subsidies. This implicitly assumes that there are ample opportunities to substitute to other goods after the price increase. Under the latter, all households consume the same quantity of the subsidized good, irrespective of their income. Removing the subsidy incentivizes all households to readjust their optimal quantity downward owing to the price increases (see also the change from x to x' in Figure 2), but the new optimal consumption level is still independent of income. In the simulation, we will distinguish between a low and high price elasticity case of the subsidized good.

5.1 | Results for the Cobb–Douglas utility function

In the case of a Cobb–Douglas utility function, the pre-reform level of consumption of the subsidized good x is a fraction α of income. The fraction of income that is spent on a subsidized good differs per country, per product, and also for different income levels. Araar and Verne (2016) report expenditure shares, estimated from household surveys, which vary not only across food, fuel, and energy products, but also across income levels and across countries. For example, in Morocco and Tunisia the expenditure share that is spent on electricity is around 3% while this is only around 1.5% for Libya and Iran. Furthermore, the expenditure shares also vary across income groups. For gasoline and diesel, the highest quintile sometimes spends a fraction of expenditures that is more than five times as high as for the lowest quintile. The overall expenditure share selected for the simulation must represent the share that is spent across the board. We choose an α equal to 0.1, so that the expenditure share on the subsidized good is 10%.

The results of the analysis are presented in Table 2. The first column shows the amount of subsidy each country has as a percentage of GDP. Given α , the first-order condition given in Equation 3 can be expressed in macroeconomic terms as $pX = \alpha Y$, where X stands for the aggregate national consumption of x and Y for GDP. The total amount of subsidies are $S = sY$, with s the rate of subsidies as a percentage (see the first column of Table 2). Using $p' - p = S/X$ and normalizing p to one, it can easily be derived that $p' = 1 + s/\alpha$. For example, for Algeria with $s = 0.061$, the price increase is 61%. In the second and third column, the percentage changes in consumption of the subsidized good and in utility are presented. For countries with relatively low subsidies, consumption is reduced by around a quarter. For countries with the highest subsidies, such as Turkmenistan and Iran, consumption falls by 58% and 48%, respectively. Without compensation, the decrease in utility as a result of the price increase is around 3% for low subsidy countries and more than 8% for Turkmenistan. On average a welfare loss of 4.5% arises when subsidies are abolished without compensation.

In the fourth column the CVs are given as a percentage of income, in line with Equation 6, $CV/y = (p'^\alpha - 1)$. For Algeria, $p' = 1.61$, so $CV/y = 4.9\%$. Comparing the values of the CVs with that of the subsidies in the first column indicates the room for a potential welfare gain, since compensating

TABLE 2 Effects on consumption, utility, CV and of a reform with a universal cash transfer, for the case of a Cobb–Douglas utility function

Country	Subsidy (% GDP)	Change in consumption (%)	Change in utility (%)	CV (% of income)	Utility change with cash transfer (%)
Algeria	6.1	−37.9	−4.7	4.9	1.16
Azerbaijan	3.4	−25.4	−2.9	3.0	0.42
Egypt	3.3	−24.7	−2.8	2.9	0.4
India	0.6	−5.6	−0.6	0.6	0.02
Iran	9.2	−47.9	−6.3	6.7	2.3
Kazakhstan	3.3	−24.8	−2.8	2.9	0.4
South Africa	1.2	−10.9	−1.1	1.1	0.06
Turkmenistan	14	−58.3	−8.4	9.2	4.44
Ukraine	3.9	−28.0	−3.2	3.4	0.53
Uzbekistan	7	−41.1	−5.2	5.5	1.46
Venezuela	5.6	−35.9	−4.4	4.6	1.01

households for the higher prices costs less than the savings of the reform. Approximately, the room for a potential welfare gain is measured by the difference between the subsidy and CV, both expressed as fractions of income. This presumes that the CV can be targeted at the household level, with differentiated compensation proportional to household income, for example, an across-the-board reduction of income tax rates. However, such a policy would only be feasible under a mature and comprehensive income tax administration, which is absent in many of the countries under consideration here.

Another way of estimating the welfare effect of the reform is to see how utility changes when the total amount that is spent on subsidies is now distributed equally over the population as a uniform cash transfer. The problem that we encounter is that richer individuals consume more of the subsidized good, so they also benefit more from the price subsidy. Table 3 shows the fraction of benefits each income decile receives. Even in a relatively equal country as Ukraine with a Gini of only 0.25, the top 20% of the income distribution still captures 35% of the subsidy expenditures, while for Venezuela the top quintile captures more than half of all subsidies. In general, the higher inequality, the larger the part of the budget for subsidies that is “consumed” by income groups that do not really need it.

Table 4 shows the utility gains specified by income decile under the universal cash program. Not surprisingly, for the top deciles, the cash grant is below the (income-dependent) CV and they

TABLE 3 Subsidy benefits per income decile, measured as the total consumption of the subsidized good of each decile multiplied by the price subsidy divided by the total amount of subsidy

Decile	Algeria	Azerb.	Egypt	Iran	Kazakh.	Turkmen.	Ukraine	Uzbek.	Venez.
1	3.7	2.9	3.1	2.2	3.8	2.1	4.0	2.6	1.5
2	5.3	4.3	4.6	3.7	5.4	3.4	5.8	4.2	2.7
3	6.3	5.5	5.6	4.8	6.4	4.5	6.4	5.1	3.7
4	7.2	6.5	6.8	5.8	7.4	5.6	7.9	6.5	4.8
5	8.3	7.6	8.0	7.1	8.3	6.9	8.4	7.5	6.1
6	9.5	8.9	9.0	8.4	9.5	8.2	9.6	8.7	7.6
7	10.7	10.6	10.6	10.2	10.7	10.1	10.9	10.5	9.5
8	12.4	12.5	12.5	12.6	12.4	12.6	12.1	12.6	12.3
9	14.9	15.8	15.6	16.5	14.8	16.6	14.5	16.0	17.2
10	21.8	25.3	24.2	28.7	21.3	30.0	20.4	26.3	34.6

TABLE 4 Distributional effects of a universal cash transfer (% change of utility)

D	Alg.	Azb.	Egypt	India	Iran	Kaz.	S.A.	Turkm.	Ukr.	Uzb.	Ven.
1	10.9	8.6	7.4	1.6	31.5	5.5	20.7	53.5	5.8	19.5	31.1
2	6.4	4.7	4.1	0.9	17.2	3.2	8.7	29.2	3.4	10.9	15.6
3	4.6	3.2	2.2	0.6	11.8	2.2	5.1	20.1	2.4	7.5	10.1
4	3.3	2.2	1.9	0.4	8.4	1.5	3.2	14.5	1.7	5.4	6.8
5	2.4	1.4	1.3	0.2	5.9	1.0	2.0	10.4	1.2	3.7	4.5
6	1.5	0.8	0.7	0.1	3.9	0.6	1.1	7.1	0.7	2.4	2.7
7	0.8	0.3	0.2	0.0	2.1	0.2	0.5	4.4	0.3	1.2	1.3
8	0.1	-0.3	-0.3	-0.1	0.5	-0.2	0.0	1.8	-0.2	0.1	0.0
9	-0.7	-0.8	-0.7	-0.2	-1.1	-0.6	-0.4	-0.7	-0.6	-1.0	-1.2
10	-2.0	-1.6	-1.5	-0.4	-3.3	-1.3	-0.9	-4.1	1.4	-2.6	-2.8

experience a loss in welfare. The welfare effect is strongly progressive as especially the lower deciles will see a large improvement: given their low income, the cash grant more than compensates for the price increase, even if they consumed the same bundle of goods as before the reform. Countries with high subsidy expenditures have very large welfare improvements for the poor, up to 53% in Turkmenistan. The overall results from this scenario are listed in the fifth column of Table 2. For policymakers in developing countries, these outcomes suggest the following strategy for subsidy reform: to the extent that subsidies are reduced, the savings in subsidy expenditures can be disbursed as uniform per capita grants and doing so guarantees that the bottom part of the income distribution will gain the most, even if they do not change their consumption behavior.⁸

5.2 | Results for the quasilinear utility function

Under quasilinear preferences, consumption of the subsidized good does not depend on income, but only on the price according to the demand equation $p = a - bx$. For the relationship between the price and demand of the subsidized good, an assumption about the price elasticity of demand has to be made. If the elasticity is zero, then consumption does not change after a price increase. The CV is then equal to the price change multiplied by the consumption level of the good. We will simulate two scenarios, the first with a low price elasticity of -0.1 and the second with a high elasticity of -1 . Using Equation 9, the chosen price elasticity determines the value of the parameter a . Given the demand equations $p = a - bx$ and $p' = a - bx'$, it can easily be derived that the relative change in the consumption level is $\Delta x/x = (1 - p') / (a - 1)$, listed in the first column of Table 5.

Probably the most interesting part is how the CV differs between the two scenarios because the difference between the CV and the expenditures on subsidies determines the size of the potential welfare improvement of a reform. The left panel shows that the CV even in the case of inelastic demand is always slightly below the subsidy expenditures as a percentage of GDP listed in Table 2. However, because the CV is the same amount of money for each household, the CV as a percentage of income is higher for low income groups. When the price elasticity is high, households adjust their consumption more after the price increase and the required CV is much lower. This means the potential welfare improvement of a reform is higher. For example, for Egypt the difference between the expenditures on subsidies and the CV equals $3.3 - 3.25 = 0.05\%$ of GDP in the low elasticity case. In the high elasticity case this becomes $3.3 - 2.76 = 0.24\%$ of GDP. For Iran, with much higher expenditures on subsidies, this difference changes from 0.4% to 4.2% of GDP. Thus, countries with higher expenditures on subsidies have the most to gain from a reform.

The utility change resulting from a reform where subsidies are abandoned and the savings are distributed equally over the population is not very high, especially in the low elasticity case. When elasticity is low, the cash transfer needed to compensate for the higher prices is close to the savings in subsidy expenditures. In the high elasticity case, the transfers can be substantially higher than the required CV, but the overall utility change is still modest. This is largely due to the absence of a strong redistribution effect, given that subsidy expenditures under quasilinear preferences are equally distributed. For those with higher than average income, the cash transfer is still only a small fraction of income. Across income deciles, the welfare effect ranges from 24% in the lowest decile to just 1.7% in the highest. This again shows that poor people have more to gain from a reform. This can be illustrated by expressing the CV as a percentage of income, as in Table 6, across deciles. The CV as percentage of income declines over the income deciles. Algeria and Egypt are relatively similar in terms of income per capita and inequality. However, Algeria spends much more on subsidies. Therefore, the price increases more after a reform and consequently the CV is higher in Algeria for each income decile. Turkmenistan and Venezuela are very different cases. Venezuela has comparable expenditures

TABLE 5 Effects on consumption, CV, and utility of a reform with a universal cash transfer for the case of a quasilinear utility function

Country	Low inelasticity (−0.1)			High elasticity (−1)		
	Change (%) consumption	CV (% of GDP)	Util. change with transfer	Change (%) consumption	CV (% of GDP)	Util. change with transfer
Algeria	−6.1	5.9	0.07	−61	4.2	1.0
Azerb.	−3.4	3.3	0.02	−34	2.8	0.3
Egypt	−3.3	3.3	0.02	−33	2.8	0.3
India	−0.6	0.6	0.0	−6	0.6	0.0
Iran	−9.2	8.8	0.16	−92	5.0	2.5
Kazakh.	−3.3	3.3	0.02	−33	2.8	0.3
S.A.	−1.3	1.2	0.21	−13	1.2	0.2
Turkm.	−14	13.1	0.37	−100	5.0	5.3
Ukraine	−3.9	3.8	0.03	−39	3.1	0.4
Uzb.	−7	6.8	0.09	−70	4.6	1.4
Venez.	−5.6	5.5	0.09	−56	4.0	1.0

TABLE 6 CV across income deciles as percent of income for a low elasticity, in the case of a quasilinear utility function

	Alg.	Azb.	Egypt	India	Iran	Kaz.	S.A.	Turkm.	Ukr.	Uzb.	Ven.
1	15.8	9.6	8.3	2.2	35.5	15.8	12.8	67.9	9.2	25.4	38.2
2	11.3	6.3	5.5	1.4	22.3	12.0	10.7	38.1	6.8	16.3	20.3
3	9.4	5.3	4.6	1.3	18.6	10.1	6.7	28.9	5.7	12.9	14.7
4	8.1	4.6	4.0	0.9	16.1	8.7	4.6	23.2	5.0	10.7	11.4
5	7.1	4.0	3.5	0.8	14.1	7.7	3.3	19.1	4.5	9.0	9.0
6	6.3	3.5	3.1	0.7	12.4	6.8	2.4	15.8	4.0	7.7	7.2
7	5.5	3.1	2.7	0.6	10.9	5.9	1.7	12.9	3.6	6.5	5.7
8	4.8	2.7	2.3	0.5	9.4	5.1	1.2	10.4	3.1	5.4	4.4
9	4.0	2.2	1.9	0.4	7.8	4.2	0.7	7.8	2.6	4.2	3.2
10	2.7	1.4	1.3	0.2	4.2	2.4	0.3	4.3	1.9	2.6	1.6

on subsidies as a share of GDP as Algeria, but inequality is much higher. Consequently, abolishing the subsidies and replacing it by a uniform CV translates into a much higher score of CV as a percentage of income for the lower income deciles in Venezuela compared with Algeria. The same applies for Turkmenistan, where inequality is not as high as in Venezuela, but the subsidy expenditure share (see Table 1) and hence the level of the CV is much higher. To summarize, under a low elasticity the scope for welfare improvement is limited owing to the fact that the required CV to neutralize the effect of the price increase without much change in consumption levels is close to the savings in subsidy expenditures. With a higher elasticity, the scope for welfare improvement is a bit higher, but still limited owing to the absence of a redistribution effect of replacing subsidies by cash grants.

5.3 | Impact on typical households

To assess the welfare effect of subsidy reform on typical households we focus on three income levels in Algeria and Egypt (see Table 7). Since income is assumed to be lognormally distributed, the median

TABLE 7 Welfare effects of subsidy reform and different forms of cash transfers (Algeria and Egypt)

	Cobb–Douglas		Quasilinear			
			Low elasticity		High elasticity	
	CV	CT	CV	CT	CV	CT
Algeria						
Poor	4.87	8.52	13.39	0.10	9.60	1.87
Median	4.87	1.94	6.69	0.07	4.80	0.99
Rich	4.87	−1.35	3.35	0.04	2.40	0.51
Egypt						
Poor	2.89	4.78	7.68	0.03	6.52	0.57
Median	2.89	0.99	3.84	0.02	3.26	0.30
Rich	2.89	−0.91	1.92	0.01	1.63	0.16

Note: CV expressed as percent of income; CT is effect of universal cash transfer as % change in utility.

income is equal to $y_m = e^{\mu}$. A poor and rich household are defined as half and double the median income. In Table 7, the CV is expressed as a percentage of income, which explains why it is a constant fraction under the Cobb–Douglas case. CT stands for the relative welfare effect of a budget neutral universal cash transfer and its effect is measured as the percentage change in utility. The table shows that under the Cobb–Douglas case, a uniform cash transfer to replace subsidies leads to a high welfare gain for the poor, against a modest welfare loss for households with twice the median income. Under the quasilinear approach, the CVs as a percentage of income are even higher for the poor, but the scope for welfare gains is still modest, except in the high elasticity scenario. The much lower welfare gains under quasilinear preferences are due to the fact that the subsidy expenditures are equally distributed across the income distribution, so replacing them by a universal grant does not result in social welfare gains owing to redistribution of income, as happens under the Cobb–Douglas case.

6 | SUMMARY AND CONCLUSION

The income distributions of eleven different countries were simulated using the assumption that income is lognormally distributed. We used the concept of CV to express the welfare impact of a reform in monetary terms. The behavior of consumers was modeled by a standard Cobb–Douglas function and a quasilinear utility function. These functions imply very different types of consumption behavior. In the Cobb–Douglas case, a fixed fraction of income is spent on the subsidized good, which does not change after a price increase. With quasilinear preferences the optimal amount of the subsidized good does not vary with income, but does change as prices change.

Under the Cobb–Douglas approach, for countries with relatively low expenditures on subsidies, where the price increase is thus relatively modest, the CV is around 3% of GDP. For countries with higher expenditures on subsidies the CV is larger, up to 9% in Turkmenistan. The required CV as a percentage of income is always lower than the saved expenditures on subsidies. Under quasilinear preferences, the consumption of the subsidized good is similar across income groups, so the benefits of the subsidy are distributed equally. However, for low income people, the consumption makes up a larger fraction of income. For poor people the CV as a percentage of income is therefore also higher than for rich people. This effect is even stronger in countries with more inequality. When the demand is inelastic, the CV is only slightly below the per capita expenditures on subsidies. The potential welfare improvement is then small. Since in this case the benefits of subsidies are already distributed equally, the redistributive effects of a universal cash transfer are smaller than under Cobb–Douglas preferences.

The bottom line of the model and the simulation analysis is that abandoning subsidies always yields more budget savings than the costs of compensating the population for the price increase. Therefore, countries with subsidy systems in place for fuel or food products could benefit from reforming these systems. Even under the assumption of inelastic demand where the required CV is close to the subsidy expenditures per capita, with consequently only room for a small welfare improvement, there are still arguments in favor of a reform. First, to the extent that consumption of fuel and energy lead to negative externality effects, a reduction of subsidies is warranted. Secondly, subsidies are an inefficient policy for poverty relief. Under the Cobb–Douglas approach, consumption of the subsidized good increases with income, so most of the subsidy expenditure flows to households who are less likely to need it. Even under the quasilinear approach where the benefits of the subsidy are distributed uniformly across income levels, a large part of the subsidy still flows to non-needy households. Thirdly, to the extent that higher income equality is considered a preferred outcome, a uniform cash grant funded by the savings from abolished subsidies will lead to a reduction of inequality. Iran, Turkmenistan, and Venezuela

are examples where inequality is high, while at the same time they are among the countries with the highest energy and fuel subsidy expenditures.

In many studies, as well as in this one, it is assumed that cash transfers are costless. Moreover, in the theoretical model and the simulation, we disregarded general equilibrium effects and issues of political feasibility that may compromise any reform. For economists, energy subsidy reform is a “nonbrainer,” owing to the large potential beneficial welfare effects. As remarked by Inchauste and Victor (2017, p. 1), the problem of energy subsidies is not a problem of expert knowledge, but a problem of political economy, while at the same time there is no “simple textbook for subsidy reform.” One of the main lessons they offer based on an extensive case study is that “... the central task for reformers is to make a credible offer to the public that the removal of visible benefits will deliver new yet currently invisible gains. Reformers must find a way not only to make that promise credible but also to communicate to the public what they are doing. Thus, many of the studies in this book find that communication is a central element of effective energy subsidy reform” (Inchauste & Victor, 2017, p. 7). Although this paper largely disregards the political dimension of policy reform, the simplicity of our approach and the parsimony in data required may serve the goal to convince a broader public that subsidy reform can be welfare improving. Another relevant lesson is that abolishing subsidies must go hand in hand with better social protection systems (Inchauste & Victor, 2017, pp. 9–11). They mention that there are no examples of major reforms “except when linked to other social reforms” (Inchauste & Victor, 2017, p. 28). Our study stresses the linkage of subsidy reform with universal cash grants, for example, the latter administrated by smart cards as done in the Dominican Republic and in the large scale *GiveDirectly* basic income field experiment in Kenya, with the additional benefit of being less vulnerable to corruption compared with other support schemes. If the reform is not linked with a social policy such as a cash grant, then the visible benefit of the subsidy is removed, against an invisible benefit in the form of a lower fiscal deficit or lower tax rates. Transforming subsidies in visible cash transfers allow a credible commitment to citizens for improved welfare outcomes, while it increases the political cost to oppose reforms by special interests.

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ENDNOTES

¹ The analysis does not include indirect effects, as there were not enough input–output tables available. Since previous research shows that the indirect effect can be significant, this is a shortcoming in the otherwise very sophisticated simulation of Araar and Verne. To include indirect effects one may choose to use a demand system (notably QUAIDS) specifying income- and (cross-) price elasticities for the substitution effects—see Attanasio, Di Maro, Lechene, and Philips (2013) for the case of replacing food subsidies by conditional cash transfers in Mexico. This approach, as well as using CGE models or static incidence analysis (Lustig, 2016), requires much more data than used in our analysis. For instance, a demand system allowing the estimation of price elasticities requires data on a long list of commodities, which needs to be grouped into aggregates, which involves a loss in the information of relative prices and substitution effects

² See Varian (2010, section 14.9).

³ Note that under quasilinear preferences, the consumption of x in points B and A' is equal since it does not depend on income, while under Cobb–Douglas preferences consumption of x is proportional to income, so B and A' will be points on the same ray from the origin.

⁴ Unfortunately, four countries, Bahrain, Kuwait, Saudi Arabia, and Libya, which pass the threshold, have missing values for the Gini coefficient and were excluded.

- ⁵ The 19th Basic Income Earth Network (B.I.E.N.) conference will be held in Hyderabad (India) in 2019, following the debates triggered by the basic income field experiments in Madhya Pradesh. Cape Town (South Africa) hosted the 11th B.I.E.N. conference in 2006. In both countries there is a growing constituency for basic income, for example, the largest trade union in South Africa, COSATU, is in favor of implementing a basic income and the idea is intensively debated in Gandhi's Congress party (for more details, see the B.I.E.N. website).
- ⁶ Taking the first derivative of this nonlinear expression to p' gives that a minimum of zero is attained for $p' = 1$.
- ⁷ For instance, suppose the observed price and income elasticities of the subsidized good are -0.6 and 0.5 respectively. Consumer behavior can then be approximated by a fifty–fifty mixture of Cobb–Douglas and quasilinear preferences with parameter a equal to 6.
- ⁸ In principle, a reform can be implemented in the form of a Pareto improvement if every household is given their income-dependent CV plus a small uniform cash grant, the latter equal to the difference between the savings in subsidy expenditures and the total cost of disbursing the CVs.

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