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Household Energy Demand and the Equity and Efficiency Aspects of Subsidy Reform in Indonesia

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Abstract

The proper design of price interventions in energy markets requires consideration of equity and efficiency effects. In this paper, budget survey data from 29,000 Indonesian households are used to estimate a demand system for five energy sources, which is identified by the spatial variation in unit values (expenditures divided by quantities). We correct for the various quality and measurement error biases that result when unit values are used as proxies for market prices. The price elasticities are combined with tax and subsidy rates to calculate the marginal social cost of price changes for each item. The results suggest that even with high levels of inequality aversion there is a case for reducing the large subsidies on kerosene in Indonesia, supporting the reforms that have been announced recently.

Keywords

demand elasticities
energy
subsidies
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D12, Q31

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I. Introduction

Energy demand is rising rapidly in developing countries. The energy pricing policies of those countries are therefore increasingly important to the efficient use of the world's energy supply. Energy markets in some developing countries are highly distorted, especially from consumer subsidies (IEA, 1999). For example, the Government of Indonesia spent over US$13 billion dollars on consumer fuel subsidies in 2005. These subsidies have a major effect on the overall energy balance in Indonesia because households account for about 45 percent of total energy consumption. There also are large fiscal effects, with about one-quarter of the government budget (and about five percent of Indonesian GDP) going on fuel subsidies (Sen and Steer, 2005).

Dramatic reforms have been attempted by the Indonesian government in response to this escalating cost of fuel subsidies. In October 2005 the subsidised price of kerosene was raised 186 percent, from Rp 700 per litre (US 7 cents) to Rp 2000 per litre (US 19 cents). The prices for diesel and gasoline were raised by approximately 90 percent, following on from increases of 30 percent in March 2005 (Table 1). These earlier price increases did not apply to kerosene. Moreover, a timetable has been set for completely phasing out fuel subsidies, with those on gasoline and diesel timetabled to go by the end of 2006 and those on kerosene by the end of 2007. These energy subsidies are meant to be replaced with a set of targeted subsidies, whose benefits are to be designed so that they are restricted to low-income groups (Kompas, 2005; Jakarta Post, 2005).

It is unclear whether these ambitious plans for reform will be realised. The first reason is that despite the substantial price rises enacted in 2005, there is still a long way to go if Indonesian fuel prices are to be set at world levels. The kerosene price in October 2005 was only 31 percent of the world price, while gasoline and diesel prices were about two-thirds of the world level (Table 1). The second reason for doubting that these ambitious plans can be achieved is that many previous attempts at reforming energy price policy in Indonesia have failed because of the resulting political difficulties. Attempted reforms in 2003 were reversed after widespread protests while the price rises in 1998 are believed to have precipitated the downfall of the Suharto regime (BBC, 2005; Economist, 2005). Moreover, these subsidies have been long-term features of the Indonesian economy, dating back to the mid-1970s (Dick, 1980). The subsidization of especially kerosene has been seen as one feasible way of meeting equity objectives, because the poor are presumed to use kerosene as their main cooking fuel.[2] However there are debates about whether the poor are the main beneficiaries of kerosene subsidies (Sumarto and Saryahadi, 2001). Indeed, even though there was early evidence that a disproportionate share of the subsidy was being captured by richer urban households, the subsidy policy continued to be strengthened and kerosene prices were held below one-fifth of the world level as far back as 1980 (Pitt, 1985).

The aim of this paper is to provide empirical evidence to help assess whether the proposed reforms of energy price policy in Indonesia are likely to be welfare-enhancing. Specifically, the equity and efficiency effects of price changes in the household energy sector are analysed. To achieve this aim, the marginal social costs of indirect taxes and subsidies are calculated for five fuels and household energy sources: kerosene, gasoline, oil, LPG, and electricity. These marginal social costs depend on the rate at which household welfare falls as prices increase, and on the rate at which net public revenue rises (Ahmad and Stern, 1984). If a reform is optimally designed, the costs in terms of social welfare of the last Rupiah of government expenditure saved by cutting subsidies (or raising taxes) on each good should be equal. To obtain the two required parameters – the welfare derivative and the revenue derivative – information is needed on tax and subsidy rates, consumption patterns, and aggregate demand responses. Thus, the analysis follows the recommendation of Newbery (2005) to use the basic

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[2] This reliance on energy subsidies reflects the limited capacity for income transfers, which is a feature of many developing countries.

principles of public finance to introduce order into discussions of how energy taxes and subsidies might rationally be set.

This empirical analysis is needed because the previous literature on energy demand in Indonesia does not provide clear guidance for evaluating the subsidy reforms. On the one hand, Pitt (1985) concluded that the price of kerosene should be increased on both equity and efficiency grounds. In part, this conclusion rested on an estimate from household survey data that the elasticity of kerosene demand with respect to its own price was -1.03, suggesting that price distortions would create large substitution effects. However, other estimates of the price elasticity of demand for kerosene are not nearly so large: Koshal *et al.* (1999) use time series data to estimate a long-run own-price elasticity of demand of only -0.17. If the demand for kerosene really is this price inelastic the efficiency losses from the subsidy might be evaluated as being less important than the presumed benefits in the form of transfers to the poor.[3] Consequently, once distributional concerns were taken into account by Yizhaki and Lewis (1996) they reached the opposite conclusion to Pitt (1985); specifically, Yitzhaki and Lewis concluded that there would be aggregate improvements in welfare from increasing the subsidy on kerosene.

In addition to providing analysis that can help to assess the recent subsidy reforms in Indonesia, a further aim of the paper is to demonstrate how a common source of data in developing countries can be used to estimate the matrices of demand elasticities that are needed for evaluating energy pricing policies. While there are several time series studies of energy demand in developing countries, and specifically Indonesia (Dahl and Kurtubi, 2001; Koshal *et al*. (1999)), these have two major limitations: first, the time series is often very short. For example, McRae (1994) uses just 15 annual observations to estimate gasoline demand models for Indonesia and several other Asian countries. Second, the growing reliance on targeting means that aggregate elasticities from time series studies may no longer be the most relevant ones for assessing pricing interventions. Instead, disaggregated elasticities for target groups such as rural households or the poorest quintile of households may be needed.

Household surveys are one source of data that can be used to calculate disaggregated energy demand elasticities, with prices proxied by unit values (expenditures divided by quantities) and the identification of demand responses coming from spatial rather than temporal variation in prices. Indeed this was the source of data used by Pitt (1985). However, there are at least three problems with the use of such data. In contrast to market prices, unit values reflect household-specific quality and reporting error effects, and are subject to sample selection effects because they are unavailable for non-purchasing households. Deaton (1990) shows that ignoring these problems (as Pitt did) is likely to lead to elasticities being too large in absolute terms, causing substitution possibilities to be overstated and tending to raise the calculated efficiency costs of subsidies. Therefore, in this paper we use the estimation methods developed by Deaton (1990) to correct the biases that result from using unit values rather than actual market prices. Our example may help economists elsewhere who are considering the use of household survey data for estimating demand responses, particularly in the context of developing countries where spatial price variation is greatest and time series are typically shortest.

The rest of the paper is organised as follows. The next section discusses the theoretical framework underlying the calculation of the social costs of marginal tax and subsidy reform. In Section III, we describe the data and econometric estimation methods used in this paper. Particular attention is paid to the method developed by Deaton (1990) for estimating price elasticities from household survey data. Section IV presents the estimation

[3] Noting again that there is contention about how much of the subsidy is captured by the poor. This issue is

results for the disaggregated household energy demand system. Section V looks at the implications of the elasticity estimates for the reform of household energy and fuel prices in Indonesia. This section also discusses evidence about whether the poor benefit the most from kerosene subsidies. Section VI presents our conclusions.

II. The Marginal Tax Reform Approach

In an influential paper, Ahmad and Stern (1984) proposed a methodology for evaluating marginal tax and subsidy reforms. The crucial parameter of the Ahmad and Stern model is what they call the marginal social cost (MSC) of a unit of public revenue. This is made up of two components: a welfare derivative and a revenue derivative. Specifically, a decrease in the subsidy rate, τ_i on good *i,* (or equivalently, a tax increase) will cause welfare to change at rate $\partial V / \partial \tau_i$ and net government revenue to change at rate $\partial R / \partial \tau_i$. The ratio of these two derivatives gives the marginal social cost, λ_i of raising one unit of net revenue (saving one unit of expenditures) by decreasing the subsidy rate on good *i*:

$$\lambda_i = -\frac{\partial V / \partial \tau_i}{\partial R / \partial \tau_i}. \tag{1}$$

Goods with low λ_i ratios are those that are candidates for either a tax increase or a subsidy reduction. When all the ratios are the same there is no further scope for beneficial reform.

This approach can be implemented by noting that the welfare derivative (the numerator of (1)) is just the ratio of two average budget shares: $w_i^{\varepsilon} \big/ \widetilde{w}_i$ (Deaton, 1997). The first average budget share, w_i^{ε} is weighted to reflect equity considerations:

$$w_i^{\varepsilon} = \left[\sum_{m=1}^{M} (x_m / n_m)^{-\varepsilon} x_m w_{im} \right] \Big/ \sum_{m=1}^{M} x_m \tag{2}$$

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discussed in the penultimate section of the paper.

where w_{im} is the budget share for good i in household m, x_m and n_m are the total expenditure and size of household m, and ε is the coefficient of inequality aversion.[4] A range of values of ε between zero (no inequality aversion) and two (a high degree of inequality aversion) are commonly used to see whether tax reform recommendations are robust to particular ethical judgements (Ahmad and Stern, 1984). In terms of the calculation of equation (2), the larger is ε the closer the average budget share will be to budget shares of the poorest households in the sample. The second average budget share is the so-called 'plutocratic budget share' (Prais, 1957) which is based on ratios of total expenditure (rather than averages of ratios) and gives the biggest weights to the richest households:[5]

$$\tilde{w}_i = \sum_{m=1}^{M} x_m w_{im} \Big/ \sum_{m=1}^{M} x_m . \tag{3}$$

The denominator of the λ-ratio represents the efficiency aspect of tax- and subsidy-induced price changes. A given price change will produce a larger net revenue effect, the greater is the total consumption of the good and the less the substitution away from taxed goods:

$$\lambda_i = \frac{w_i^{\varepsilon} / \tilde{w}_i}{1 + \dfrac{\tau_i}{1+\tau_i}\left(\dfrac{\theta_{ii}}{\tilde{w}_i} - 1\right) + \sum_{k \neq i} \dfrac{\tau_k}{1+\tau_k} \dfrac{\theta_{ki}}{\tilde{w}_i}} . \tag{4}$$

The total consumption of the good is shown by $\tilde{w}_i$, while the substitution effects are shown by θ_{ki}, the derivative of the budget share for good k with respect to the (log) price of good i. The tax factor gives the share of tax in the final price. For example, in Indonesia household purchased of oil face a VAT rate of 10 percent, so the tax factor is $0.10/(1+0.10) = 0.09$, while subsidies

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[4] Consider judgements about the effect of taking Rp1000 from someone to give some of it to a person with half the income and destroying the rest (e.g., due to efficiency losses). When ε=0 the judge would approve of this transfer only if the poorer person received all Rp1000. But when ε takes the values of 1 (or 2) the amount the poorer person receives has to be only Rp500 (or Rp250 if ε=2) in order for the resulting distribution to be judged as giving the same level of social welfare as before the transfer (Creedy, 1996).

[5] The plutocratic budget share is widely used in Consumer Price Index calculations. According to calculations by Deaton (1998a) the "average consumer" according to plutocratic budget shares in the United States was located at about the 75th percentile of the distribution of household expenditures.

meant that kerosene prices since October 2005 are only 31 percent of the prices in other countries, so the tax factor is $-0.69/(1-0.69)=2.23$.

The first term of the denominator in equation (4) measures the own-price distortionary effect of the tax or subsidy. If it is large and positive, as would be the case for a heavily subsidised and price elastic good, the term will contribute to a small λ_i and would indicate the low social cost of raising net revenue by decreasing the subsidy on this good. The last term is the sum of the tax factors multiplied by the cross price elasticities, and captures the effects on other goods (and the resulting net revenue changes) from the change in the tax on good *i*.

This framework for evaluating marginal reforms can be contrasted with the requirements for calculating optimal tax and subsidy rates. More information is needed to calculate optimal tax and subsidy rates because explicit utility functions are needed for agents since demand responses have to be evaluated at the optimum, which is a point that may be far away from the current position of the economy. Furthermore, estimates have to be made of how behavioural responses themselves change in response to taxes and subsidies (Madden, 1996).

III. Data and Estimation Methods

Data from the consumption module of the 1999 SUSENAS survey are used for 28,964 households located on Java.[6] Respondents in this survey are asked to recall their expenditures over the past month for approximately 300 different products. For food, fuels and electricity they are also asked about the quantity purchased so that unit values can be derived. These

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[6] This household budget survey is only carried out every three years and the 1999 results were the most recent when the analysis was begun. Java contains approximately 60 percent of the Indonesian population and, economic activity is even more heavily concentrated there, so the results should still be relevant to nationwide price reform.

unit values are needed because the survey does not collect market prices. The survey's sampling procedure involves selecting clusters of up to sixteen households within census enumeration areas. This spatial clustering encourages the assumption that households within each cluster face the same prices and this feature is exploited by the estimation method used below.

The five energy products considered – electricity, LPG, kerosene, gasoline and oil – contribute almost 4.4 percent of the average household budget, ranging from LPG at 0.14 percent to electricity at 1.82 percent (Table 2).[7] The first three columns of Table 2 describe some of the characteristics of the unit values. Items like electricity and kerosene have unit values available for almost every household while information for items like LPG and gasoline is less readily available. Means of unit values are also shown in the table. These are computed from those households who make market purchases of the commodity under consideration. On average, consumers in 1999 paid approximately Rp. 460 per litre for kerosene, while gasoline and oil cost more than Rp. 1,000 per litre. The mean prices of these energy products vary somewhat by location, with rural households paying a slightly higher price than urban households for all of the commodities except oil, perhaps because of high transport costs in rural areas (Appendix Tables 1a and 1b). The coefficient of variation indicates the degree of heterogeneity within each group, which is least for commodities like kerosene and gasoline where there is little quality variation.

The procedure used to get the price responses that are needed for the marginal social cost calculations starts with a two-equation system of budget shares (w_{Gic}) and unit values (v_{Gic}) that are both functions of the *unobserved* prices, (p_{Hc}):

$$w_{Gic} = \alpha^0_G = \beta^0_G \ln x_{ic} + \gamma^0_G \cdot z_{ic} + \sum_{H=1}^{N} \theta_{GH} \ln p_{Hc} + (f_{Gc} + u^0_{Gic}) \qquad (5)$$

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[7] While gasoline and oil can also be considered as transport fuels they are widely used in the household sector to power domestic generators, and in fact are more widely consumed than LPG, especially in the rural sector.

$$\ln v_{Gic} = \alpha_G^1 = \beta_G^1 \ln x_{ic} + \gamma_G^1 \cdot z_{ic} + \sum_{H=1}^{N} \psi_{GH} \ln p_{Hc} + u_{Gic}^1 \tag{6}$$

the G indicates goods, i indicates households and the c indexes clusters. Amongst the explanatory variables, x_i is total expenditure of household i, p_H are the unobserved prices, $\mathbf{z}_i$ is a vector of other household characteristics, f_{Gc} is a cluster fixed-effect in the budget share for good G and u_{Gic}^0 and u_{Gic}^1 are idiosyncratic errors. The estimation proceeds in three stages, which are discussed fully in Deaton (1997).

In the first stage, the procedure removes the household-specific effects of income and other demographic characteristics from the budget shares and unit values. To do so, equations (5) and (6) are estimated using OLS, where in addition to x_i and $\mathbf{z}_i$, the specification also controls for all cluster fixed effects, including those of unobserved prices, so that the $\beta_G^0, \gamma_G^0, \beta_G^1$, and γ_G^1 parameters can be estimated consistently, even in the absence of market price data. These four parameters are used to create *adjusted* budget shares and unit values that have the quality effects due to income and other factors removed. For example, if richer households buy higher grade gasoline (which will have a higher unit value) the first stage regression can account for this and the adjusted unit value is more like a price because prices should not vary across households in the same community.

The first stage regressions also produce the residuals that are needed in the second stage for estimating the covariances that are used to correct for the effect of any measurement error in unit values and budget shares. The error terms, e_{Gic}^0 and e_{Gic}^1, from equations (5) and (6) contain all the variability in w_{Gc} and v_{Gc} that are not explained by x, $\mathbf{z}$, or the cluster fixed effects. Assuming a single price per cluster, the unexplained variation around the cluster mean can indicate measurement error.

In the second stage of the Deaton procedure, a between-clusters errors-in-variables regression is applied to the (adjusted) average budget shares and unit values, which have been purged of household characteristics at the first stage. If it were not for the effect of prices on cluster-wide quality variation, the parameters estimated at the second stage would be sufficient for calculating the price responses. Instead, a separability theory of quality (Deaton 1988) has to be used to identify the price effects at the third and final stage. Full details of the estimation method can be found in Deaton (1997).

One feature of the procedure is that the budget share equation (5) is unlike Tobit-style models in that it pays no special attention to non-purchasing households, who have budget shares of zero. Since the revenue effect of a tax increase does not depend on whether demand changes take place at the extensive or intensive margins, when studying tax and revenue reform one needs to include all households, whether they purchase or not (Deaton, 1990). Therefore, equation (5) is simply viewed as a linear approximation to the regression function of the budget share conditional on the right-hand-side variables, averaging over both zeros and non-zeros in much the same way that an aggregate demand function does (Deaton, 1997).[8]

IV. Econometric Results

Table 3 contains results from the first stage (within-cluster) estimation of the budget share and unit value equations. The coefficients reported are for the effects of log total expenditures on budget shares, β^0 and on log unit values, β^1 plus summary statistics for each equation. The tables also include the elasticity of quantity demanded with respect to total expenditures, which depends on coefficients from both the budget share and unit value equations.[9] The other (unreported) variables used at the first stage include (log) household size, a set of demographic variables (the number of household members in each of thirteen

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[8] Other studies applying Deaton's method to household survey data also follow the same specification and include households with budget shares of zero. See, for example, Nicita (2004).

[9] See equation 5.36 of Deaton (1997) for a derivation.

age and sex categories as a ratio of household size), and nine educational dummies. These variables are based on those used by Deaton (1990) in his study of food demand from the same survey in an earlier year. As can be seen from Table 3, the first stage estimation of the budget share equations explains from 27 percent of the variation for oil to 47 percent for kerosene. More of the variation in unit values is explained, ranging from 31 percent for gasoline to 66 percent for oil.

LPG, gasoline and oil attract positive β^0 coefficients – indicating luxury goods whose expenditure elasticities are greater than one, and whose budget shares will rise more than proportionally as household expenditure rises. The total expenditure elasticity for kerosene is 0.44, which is consistent with the estimates made by Pitt (1985) and Yitzhaki and Lewis (1996), indicating that kerosene is a necessity.[10] Appendix Tables 2a and 2b show that rural households tend to have higher expenditure elasticities than urban households. For instance, rural households have expenditure elasticities of 3.08 and 4.08 for gasoline and LPG compared with 2.38 and 2.36 for urban households. These results imply that rural households are likely to have larger proportionate increases in demand for these products as their income rises.

The *quality elasticities,* β^1 are estimated from the effect of changes in the logarithm of total expenditure on the log of the unit value. These show how unit values differ between rich and poor households in the same communities, where this variation is presumed to reflect the purchase of higher quality commodities by the rich. Yet according to the estimates shown in column 5 of Table 3, with the exception of kerosene and oil, all of the quality elasticities are negative although none are very large. Thus, rather than richer households paying more per unit they pay less, presumably because of bulk purchases or more favourable

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[10] In developed countries, kerosene has been found to be an inferior good (Kennedy, 1974). A plausible explanation for this is that in developed countries, other energy sources are used for cooking and lighting.

electricity tariffs for these households than are available to the poor. However, the magnitude of these effects is small, and it is only for the unit value of oil, where the *quality elasticity* is 0.07, that there would appear to be any significant within-cluster variation in unit values. The small size of these quality effects is consistent with other studies using the Deaton method and is also intuitively sensible because the quality variation within a household energy source is likely to be less than that within a food group (e.g. steak versus hamburger). Therefore it is the ability of this method to also mitigate the effect of measurement error in unit values that becomes its crucial feature (Deaton, 1997).

Table 4 contains the estimated own- and cross-price elasticities for Java. The symmetry restrictions from demand theory have been imposed on these estimates in order to improve precision of the estimates. In addition to the five energy sources, there is an extra row and column for "all other goods", the estimates for which are obtained from the homogeneity and adding-up restrictions. The elasticities are conditional not only on household size and the dummy variables for household characteristics mentioned above, but also on a set of province and urban dummy variables.[11]

In addition to the price elasticities, the table also include bootstrapped estimates of "standard errors". To calculate these standard errors, 1000 random draws are taken from the second stage data (i.e., the cluster average budget shares and unit values, after the effect of household total expenditures and other characteristics have been controlled for). For each of these random draws, all of the elasticities are recalculated, in effect creating 1000 versions of Table 4. The length of the interval around the mean of each bootstrapped elasticity that contains 68.3 percent of the bootstrap replications is calculated and one-half of this interval is used as the estimate of the standard error. The rationale is that if the distribution of the

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[11] It is not possible to add them at the first (within-cluster) stage because the cluster fixed effects would obliterate them.

elasticity estimates was normal, 0.683 is the fraction of a normal random variable within two standard deviations of the mean (Deaton, 1997).

The own-price effects are well determined as are several cross-price effects. All of the estimated own-price elasticities are negative, as they should be. The estimated own-price elasticity of demand for kerosene in Java is found to be -0.96 (with a standard error of 0.11). Disaggregating this result, the demand for kerosene appears considerably more price elastic in rural areas than in urban areas, possibly reflecting the lower incomes of the rural population. Specifically, a 10 percent increase in the price of kerosene will bring about a 13.3 percent decline in the quantity of kerosene bought by the rural households, but only 6.4 percent decline in the urban sector (Appendix Tables 3a and 3b). These are close to the estimates obtained by Pitt (1985) who also used household survey data, but did not correct for the possible biases caused by unit values. The similarity of elasticity estimates, and the contrasts with the much more inelastic time series estimates, suggests that Pitt's conclusion that it would be both equitable and efficient to reduce the subsidy on kerosene may in fact have been correct.

The own-price elasticities are also large (in absolute terms) for electricity and LPG, although only the one for electricity is precisely estimated. This suggests that subsidies will have caused a considerable amount of substitution into these products. Amongst the cross-price elasticities, the demand for electricity, LPG, gasoline and oil with respect to the price of kerosene is negative, and in some cases, large in absolute value. This apparent complementarity may reflect the limited but specialized use of these energy sources by Indonesian households, who use electricity mainly for lighting, while they use LPG mainly for cooking.

Even with the spatial price variation provided by 1900 clusters, and with the imposition of theoretical symmetry restrictions, a majority of the cross-price effects are imprecisely estimated. Possibly more success would come from using a sample from all regions of Indonesia, because of the greater impact of transport costs in causing relative price differences, but expanding the sample would also bring the risk of greater uncontrolled heterogeneity.

V. Marginal Social Cost Calculations

Table 5 shows the efficiency effects of cutting subsidies (or raising taxes) on each of the goods, distinguishing between the terms in the denominator of the marginal social cost formula (equation (4)). The first column shows the tax factors (calculated from comparison of the world and domestic prices), while the second column shows the own price elasticities of quality and quantity together. The product of the first and second columns, which is shown as the third column, gives the own-good contributions to the tax distortion that would be caused by a marginal increase in price. As can be seen from the table, the own effects for these energy products are reasonably small, with the exception of kerosene and electricity, for whom raising prices would save the largest amount from the subsidy budget (ignoring any cross-price effects). With regard these cross-price effects, they are largest for gasoline and LPG. According to the combined results in the last column of Table 5, and noting that nothing yet has been said about distributional issues, kerosene and then LPG are the most attractive candidates for price rises.

In Table 6, the results of bringing in the equity effects are reported for a range of the distributional parameter, ε. The first two columns are for $\varepsilon = 0$, where there are no distributional concerns; the cost-benefit ratios are simply the reciprocals of the last column in Table 5 and give the same ranking in terms of relative marginal social costs as was given by the revenue derivatives. The marginal cost of raising kerosene prices is lowest, and for raising oil prices (which are already taxed) is highest amongst the energy sources. However, all of the λ_i for the energy sources are much lower than for "other consumption" indicating the general desirability of removing all energy subsidies.

As we move across to the right-hand side of Table 6, and the ε parameter increases, the equity columns give larger values to the goods most heavily consumed by the poor and relatively smaller values to those consumed by households that are better off. For $\varepsilon = 0.5$, kerosene receives the highest social weight, with $w^{\varepsilon}/\widetilde{w}$ greater than unity. Consequently, as ε increases further, kerosene loses its place as the most attractive candidate for a price rise, becoming the second most attractive when $\varepsilon = 1$ and the third most attractive when $\varepsilon = 2$. Indeed, with an inequality aversion parameter of $\varepsilon = 2$ the lowest social cost of reduced government expenditure (or equivalently additional revenue) would come from raising LPG prices, followed by raising gasoline prices. The best candidate for a subsidy at these higher inequality aversion levels is electricity.

When the results are disaggregated into the rural and urban sector the recommendations are largely the same. In the rural sector kerosene is the best candidate for price increases when inequality aversion levels are low, with LPG becoming the best candidate at higher inequality aversion levels (Appendix Table 5b). Electricity and gasoline appear to be best candidates for any price subsidy in rural areas, as these commodities attracts the highest λ_i ratios. In the urban sector LPG is consistently ranked as the commodity with the lowest social cost of price increases and the attractiveness of raising kerosene prices diminishes with the degree of inequality aversion that is assumed.

The results suggest that at low levels of inequality aversion kerosene is the best candidate for reduced subsidies but that there may be some reluctance by policy makers who are more inequality averse to cut kerosene subsidies. Given this possible ambiguity over the recommended policy reform, additional evidence on household kerosene use may be useful. Table 7 reports for each sector (rural and urban) and each quintile of the household expenditure distribution, the average quantity of kerosene consumed, the kerosene budget share and the proportion of households who use kerosene stoves.

While kerosene does have a larger share of the budgets of poor households, the difference is only marked in comparison to the richest quintile of households. Indeed, in the rural sector, the budget share is almost constant (at 1.4 percent) across the first four quintiles. The results in the table also show that it is not true that kerosene is predominantly the fuel of the poor. In rural areas there is a monotonic increase in the proportion of households using kerosene stoves and in the consumption level of kerosene when moving from poorer to richer quintiles. In urban areas the three middle quintiles all have higher rates of kerosene stove usage than the poorest quintile and the consumption level of kerosene is roughly constant across quintiles. Thus, a majority of the kerosene subsidies will not be captured by the poor, especially in rural areas, and the replacement of energy subsidies with targeted income subsidies is likely to be both more efficient and more equitable.

VI. Conclusions

In this paper we have used household budget survey data from Indonesia to estimate the marginal social cost of indirect taxes and subsidies on five household energy sources. Regardless of assumptions about inequality aversion, all of these energy sources are attractive candidates for price increases, when compared with the social cost of revenue raised from taxes on other goods and services. The calculations also show that reducing expenditure on subsidies by allowing further increases in the consumer price of kerosene would be desirable, taking into account both efficiency and equity. Thus the suggested directions of reform are in line with the actual price reforms carried out in 2005, and they indicate the desirability of furthering these reforms.

The motivation for these reforms in Indonesia has been the heavy cost of maintaining consumer energy subsidies as world energy prices soar. There are likely to be other developing countries facing a similar set of issues. From a methodological point of view, the availability of household survey data in other developing countries suggests that similar analyses could be carried out in settings where price elasticity estimates are needed to evaluate the effects of price distortions in consumer energy markets.

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Table 1. Recent Changes in Regulated Fuel Products Prices, Rupiah per litre and percentage change (percent of world price)

	Jan 2003-Feb 2005	Mar-Sep 2005		October 2005 onwards		
	Price	Price	% change from Feb 05	Price	% change from Mar 05	% change from Feb 05
Gasoline	1,810 (36%)	2,400 (56%)	33%	4,500 (68%)	88%	149%
Kerosene (household)	700 (11%)	700 (11%)	0%	2,000 (31%)	186%	186%
Automotive Diesel	1,650 (33%)	2,100 (45%)	27%	4,300 (68%)	105%	161%

Source: World Bank (2005)

Table 2. Commodities, Sample Sizes and Budget Shares for Java, 1999

Commodities	Number of households with unit values (a)	Mean unit value (b)	Coefficient of variation of unit value (c)	Number of clusters with unit values (d)	Number of households in clusters in (d) (e)	Percentage shares of total expenditure (f)
Electricity	26,536	191.475	0.684	1,817	26,952	1.816
LPG	2,321	1,346.07	0.189	650	2,334	0.142
Kerosene	23,677	456.074	0.160	1,846	23,967	1.470
Gasoline	5,735	1,014.38	0.094	1,430	5,784	0.735
Oil	3,698	1,056.44	0.617	1,430	5,238	0.199

Note: (a) is the number of households with a well-defined unit value, which equals the number of purchasing households minus those who report in irregular units.
(b) in Rupiah.

Table 3. First Stage Estimates: Effect of Total Expenditures on Quantity and Quality for Java

	Budget Share Equation			Unit Value Equation			
Commodities	β^o	$t(\beta^o)$	R^2	β^1	$t(\beta^1)$	R^2	ε
Electricity	-0.0003	-1.320	0.313	-0.0302	-4.460	0.593	1.104
LPG	0.0025	25.660	0.310	-0.0150	-0.950	0.500	2.740
Kerosene	-0.0083	-36.790	0.467	0.0004	0.110	0.344	0.435
Gasoline	0.0123	37.600	0.326	-0.0121	-1.600	0.312	2.691
Oil	0.0037	28.020	0.273	0.0745	3.580	0.661	2.800

Note: β^o is the derivative of the budget share with respect to log total expenditures, β^1 is the derivative of the (log) unit value with respect to log total expenditures (a.k.a. the ‘quality elasticity’), R^2 is for the budget share and unit value regressions, and ε is the expenditure elasticity of quantity.

Table 4. Symmetry Constrained Estimates of Own and Cross Price Elasticities for Java, 1999

	Electricity	LPG	Kerosene	Gasoline	Oil	Other Cons
Electricity	**-1.043**	-0.006	-0.081	-0.068	-0.025	0.239
	(0.02)	(0.02)	(0.03)	(0.05)	(0.02)	(0.06)
LPG	-0.108	**-0.321**	-0.226	-6.017	-0.260	4.207
	(0.21)	(0.89)	(0.97)	(4.42)	(0.30)	(3.51)
Kerosene	-0.073	-0.015	**-0.960**	-0.406	-0.059	1.160
	(0.03)	(0.08)	(0.11)	(0.26)	(0.04)	(0.22)
Gasoline	-0.198	-1.164	-1.030	**-0.080**	0.214	-0.421
	(0.13)	(0.85)	(0.65)	(1.28)	(0.15)	(0.87)
Oil	-0.262	-0.186	-0.570	0.791	**-0.382**	-2.265
	(0.15)	(0.21)	(0.32)	(0.54)	(0.14)	(0.67)
Other Cons	-0.001	-0.002	-0.004	-0.002	0.000	**-0.263**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.37)

Note: Standard error in ( ); Results for "All Other Goods" derived from homogeneity and adding up restriction.

Table 5. Efficiency Aspects of Price Reform in Java with Symmetry Restriction

Commodities	$\frac{\tau_i}{1+\tau_i}$	$\frac{\theta_i}{\tilde{w}_i} - 1$	Own effect	Cross effects	Total
Electricity	-1.60	-1.05	1.69	0.38	3.06
LPG	-0.43	-0.63	0.27	3.26	4.53
Kerosene	-3.18	-1.61	5.11	0.81	6.92
Gasoline	-0.95	0.00	0.00	2.70	3.70
Oil	0.09	-0.59	-0.05	1.08	2.02
Other consumption	0.09	-0.97	-0.09	-0.10	0.81

Table 6. Equity Effects and Cost-Benefit Ratios for Price Reform in Java with Symmetry Restrictions

	$\varepsilon = 0$		$\varepsilon = 0.5$		$\varepsilon = 1$		$\varepsilon = 2$	
Commodities	$w^{\varepsilon}/\tilde{w}$	λ	$w^{\varepsilon}/\tilde{w}$	λ	$w^{\varepsilon}/\tilde{w}$	λ	$w^{\varepsilon}/\tilde{w}$	λ
Electricity	1.00	0.33	0.95	0.31	0.91	0.30	0.85	0.28
LPG	1.00	0.22	0.78	0.17	0.58	0.13	0.29	0.06
Kerosene	1.00	0.14	1.11	0.16	1.17	0.17	1.19	0.17
Gasoline	1.00	0.27	0.82	0.22	0.67	0.18	0.47	0.13
Oil	1.00	0.49	0.79	0.39	0.64	0.32	0.44	0.22
Other consumption	1.00	1.23	1.00	1.23	1.01	1.24	1.01	1.24

Table 7. Kerosene Consumption, Budget Shares and Kerosene Stove Use

	Budget share (%)		Quantity (litre/month)		Kerosene Stove Use	
Quintile	Rural	Urban	Rural	Urban	Rural	Urban
1 (= poorest)	1.40	2.44	2.82	6.16	0.19	0.58
2	1.38	2.18	3.13	5.79	0.29	0.62
3	1.34	2.03	3.41	6.01	0.37	0.78
4	1.36	1.73	4.16	5.97	0.45	0.75
5 (=richest)	0.99	0.92	4.29	4.53	0.53	0.53

Appendix Table 1a. Commodities, Sample Sizes and Budget Shares for Urban Java, 1999

Commodities	Number of households with unit values (a)	Mean unit value (b)	Coefficient of variation of unit value (c)	Number of clusters with unit values (d)	Number of households in clusters in (d) (e)	Percentage shares of total expenditure (f)
Electricity	12,305	182.738	0.667	829	12,018	2.05
LPG	2,088	1,344.86	0.185	527	1,706	0.28
Kerosene	10,371	444.335	0.155	823	10,338	1.62
Gasoline	3,531	1,005.72	0.082	729	3,103	1.01
Oil	2,206	1,070.15	0.620	582	2,739	0.25

Note: See Table 2.

Appendix Table 1b. Commodities, Sample Sizes and Budget Shares for Rural Java, 1999

Commodities	Number of households with unit values (a)	Mean unit value (b)	Coefficient of variation of unit value (c)	Number of clusters with unit values (d)	Number of households in clusters in (d) (e)	Percentage shares of total expenditure (f)
Electricity	14,231	199.029	0.693	988	14,574	1.63
LPG	233	1,356.88	0.225	123	627	0.03
Kerosene	13,306	465.224	0.161	1,023	13,616	1.35
Gasoline	2,204	1,028.26	0.109	701	2,676	0.52
Oil	1,492	1,036.18	0.613	567	2,493	0.16

Note: See Table 2.

Appendix Table 2a. First Stage Estimates: Effect of Total Expenditures on Quantity and Quality for Urban Java

	Budget Share Equation			Unit Value Equation			
Commodities	β^o	$t(\beta^o)$	R^2	β^1	$t(\beta^1)$	R^2	ε
Electricity	0.001	2.120	0.275	-0.005	-0.620	0.612	1.042
LPG	0.004	20.980	0.301	-0.012	-0.740	0.478	2.358
Kerosene	-0.013	-42.970	0.494	0.004	0.770	0.323	0.218
Gasoline	0.014	26.460	0.340	-0.012	-1.450	0.304	2.382
Oil	0.004	18.480	0.320	0.074	2.880	0.655	2.427

Note: See Table 3.

Appendix Table 2b. First Stage Estimates: Effect of Total Expenditures on Quantity and Quality for Rural Java

	Budget Share Equation			Unit Value Equation			
Commodities	β^o	$t(\beta^o)$	R^2	β^1	$t(\beta^1)$	R^2	ε
Electricity	-0.002	-6.140	0.342	-0.058	-5.570	0.577	0.952
LPG	0.001	12.660	0.226	-0.357	-0.350	0.666	4.076
Kerosene	-0.004	-11.510	0.471	-0.003	-0.490	0.346	0.718
Gasoline	0.011	26.150	0.286	-0.003	-0.200	0.341	3.080
Oil	0.004	20.890	0.209	0.053	1.470	0.677	3.271

Note: See Table 3.

Appendix Table 3a. Symmetry Constrained Estimates of Own and Cross Price Elasticities for Urban Java, 1999

	Electricity	LPG	Kerosene	Gasoline	Oil	Other Cons
Electricity	**-0.990**	-0.014	-0.011	-0.073	0.008	0.043
	(0.03)	(0.02)	(0.03)	(0.06)	(0.03)	(0.08)
LPG	-0.128	**-0.365**	0.126	-3.213	-0.106	1.340
	(0.14)	(0.62)	(0.67)	(1.69)	(0.19)	(1.87)
Kerosene	0.003	0.027	**-0.635**	0.005	-0.034	0.416
	(0.04)	(0.11)	(0.18)	(0.16)	(0.04)	(0.29)
Gasoline	-0.175	-0.894	-0.027	**-0.868**	0.234	-0.640
	(0.11)	(0.47)	(0.26)	(0.23)	(0.14)	(0.62)
Oil	0.039	-0.119	-0.260	0.942	**-0.372**	-2.731
	(0.21)	(0.21)	(0.28)	(0.55)	(0.16)	(0.71)
Other Cons	-0.001	-0.002	0.001	-0.002	0.001	**-0.274**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.35)

Note: See Table 4

Appendix Table 3b. Symmetry Constrained Estimates of Own and Cross Price Elasticities for Rural Java, 1999

	Electricity	LPG	Kerosene	Gasoline	Oil	Other Cons
Electricity	**-1.108**	-0.029	-0.132	0.000	-0.065	0.439
	(0.03)	(0.04)	(0.06)	(0.00)	(0.02)	(0.08)
LPG	-1.493	**-1.616**	-5.008	0.000	0.118	3.960
	(2.13)	(2.85)	(8.91)	(0.18)	(1.92)	(10.51)
Kerosene	-0.157	-0.119	**-1.331**	0.000	-0.168	1.059
	(0.07)	(0.21)	(0.25)	(0.00)	(0.09)	(0.36)
Gasoline	-0.036	0.000	-0.032	**-1.000**	0.000	-2.010
	(0.02)	(0.01)	(0.00)	(1.09)	(0.00)	(1.02)
Oil	-0.707*	0.024	-1.460	0.000	**-0.489**	-0.692
	(0.21)	(0.39)	(0.77)	(0.00)	(0.20)	(0.92)
Other Cons	-0.002	-0.001	-0.003	0.000	-0.001	**-0.264**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.26)

Note: See Table 4

Appendix Table 4a. Efficiency Aspects of Price Reform in Urban Java with Symmetry Restriction

Commodities	$\frac{\tau_i}{1+\tau_i}$	$\frac{\theta_i}{\tilde{w}_i} - 1$	Own effect	Cross effects	Total
Electricity	-1.60	-0.99	1.58	0.08	2.66
LPG	-0.43	-0.35	0.15	2.53	3.68
Kerosene	-3.18	-0.53	1.68	0.07	2.75
Gasoline	-0.95	-0.89	0.84	0.48	2.32
Oil	0.09	-0.53	-0.05	-0.10	0.85
Other consumption	0.09	-1.00	-0.09	-0.02	0.89

Appendix Table 4b. Efficiency Aspects of Price Reform in Rural Java with Symmetry Restriction

Commodities	$\frac{\tau_i}{1+\tau_i}$	$\frac{\theta_i}{\tilde{w}_i} - 1$	Own effect	Cross effects	Total
Electricity	-1.60	-1.09	1.74	0.33	3.07
LPG	-0.43	-1.07	0.46	2.07	3.53
Kerosene	-3.18	-1.36	4.33	0.25	5.59
Gasoline	-0.95	-1.00	0.95	0.00	1.95
Oil	0.09	-0.75	-0.07	2.62	3.55
Other consumption	0.09	-0.99	-0.09	-0.05	0.86

Appendix Table 5a. Equity Effects and Cost-Benefit Ratios for Price Reform in Urban Java with Symmetry Restrictions

	$\varepsilon = 0$		$\varepsilon = 0.5$		$\varepsilon = 1$		$\varepsilon = 2$	
Commodities	$w^{\varepsilon}/\tilde{w}$	λ	$w^{\varepsilon}/\tilde{w}$	λ	$w^{\varepsilon}/\tilde{w}$	λ	$w^{\varepsilon}/\tilde{w}$	λ
Electricity	1.00	0.38	0.95	0.36	0.91	0.34	0.85	0.32
LPG	1.00	0.27	0.78	0.21	0.58	0.16	0.29	0.08
Kerosene	1.00	0.36	1.11	0.40	1.17	0.42	1.19	0.43
Gasoline	1.00	0.43	0.82	0.35	0.67	0.29	0.47	0.20
Oil	1.00	1.17	0.79	0.92	0.64	0.75	0.44	0.51
Other consumption	1.00	1.13	1.00	1.13	1.01	1.13	1.01	1.14

Appendix Table 5b. Equity Effects and Cost-Benefit Ratios for Price Reform in Rural Java with Symmetry Restrictions

	$\varepsilon = 0$		$\varepsilon = 0.5$		$\varepsilon = 1$		$\varepsilon = 2$	
Commodities	$w^{\varepsilon}/\tilde{w}$	λ	$w^{\varepsilon}/\tilde{w}$	λ	$w^{\varepsilon}/\tilde{w}$	λ	$w^{\varepsilon}/\tilde{w}$	λ
Electricity	1.00	0.33	0.95	0.31	0.91	0.30	0.85	0.28
LPG	1.00	0.28	0.78	0.22	0.58	0.16	0.29	0.08
Kerosene	1.00	0.18	1.11	0.20	1.17	0.21	1.19	0.21
Gasoline	1.00	0.51	0.82	0.42	0.67	0.34	0.47	0.24
Lubricant Oil	1.00	0.28	0.79	0.22	0.64	0.18	0.44	0.12
Other consumption	1.00	1.16	1.00	1.17	1.01	1.17	1.01	1.18