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 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 at high levels of inequality aversion there is a strong case for reducing the large subsidies on gasoline and kerosene, supporting the reforms that have been carried out recently.

JEL: D12, Q31
Key words: Demand elasticities, Energy, Fuels, Subsidies, Unit Values

I. Introduction

Managing the demand for energy is emerging as a critical policy issue as world fuel prices continue to rise sharply. While popular attention has focused on the plight of consumers in developed countries, the need for adjustment is likely to be far higher in some developing countries as energy markets in some developing countries are highly distorted, especially from consumer subsidies (IEA, 1999). For example, the Government of Indonesia spent over US$ 6 billion on consumer fuel subsidies in 2004. These subsidies have a major effect on the overall energy balance in Indonesia because households account for about 45 percent of total energy consumption. The subsidies also have large fiscal effects – rising world oil prices had caused spending on fuel subsidies for 2005 to rise as high as US$ 13 billion, which is about one-quarter of the government budget (Sen and Steer, 2005)

Dramatic reforms have been attempted 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 to Rp 2000 per litre[1] (Table 1). The prices for diesel and gasoline were raised by approximately 90 percent, following on from increases of 30 percent in March 2005. As a result of the price increases, domestic fuel prices in Indonesia are now closer to international prices – kerosene, gasoline and diesel are now 31 percent, 68 percent and 68 percent of international prices respectively (World Bank, 2005). Moreover, a timetable has been set for completely phasing out fuel subsidies, with those on gasoline and diesel to go by the end of 2006 and those on kerosene by the end of 2007. These energy subsidies are to be replaced with a set of targeted subsidies, whose benefits are meant to be restricted to low-income groups (Kompas, 2005 and Jakarta Post, 2005).

It is unclear whether these ambitious plans for reform will be realised because many previous attempts at reforming energy price policy in Indonesia have caused political difficulties. Attempted reforms in 2003 were reversed after widespread protests while the price

[1] As of April 2006, 1US$ ≈ Rp. 8,900.

rises in 1998 are believed to have precipitated the downfall of the Suharto regime (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 use kerosene as their main cooking fuel. This reliance on energy subsidies reflect the limited capacity for income transfers, which is a feature of many developing countries. 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 such that at the end of 1980, the price of kerosene was only 18 percent of world prices (Pitt, 1985)

The objective 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, we analyse the equity and efficiency of price reform in the household energy sector in Indonesia. To achieve this objective we estimate the marginal social costs of indirect taxes and subsidies on five fuels and energy sources; kerosene, gasoline, lubricant 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 public revenue rises (Ahmad and Stern, 1984). If a reform is optimally designed, the costs in terms of social welfare of the last dollar saved by cutting subsidies on each good should be equal. To obtain the two required parameters – the welfare derivative and the revenue derivative – information is needed on tax rates, consumption patterns, and aggregate demand responses. The analysis follows the recommendation of Newbery (2005) to use the basic principles of public finance to introduce order into discussions of how energy taxes and subsidies might rationally be set.

Energy subsidies in Indonesia have previously been discussed by Pitt (1985) who concluded that the price of kerosene should be increased on both equity and efficiency grounds. In part this conclusion rested on an estimate of the elasticity of kerosene consumption with respect to its own price of -1.04, suggesting that price distortions would create large substitution effects. One concern is that this elasticity is calculated from household survey data, with prices proxied by unit values (expenditures divided by quantities). Deaton (1990) shows that treating unit values as prices is likely to lead to elasticities being too large in absolute terms. This potential bias in consistent with time series estimates of the own-price elasticity of kerosene demand in Indonesia being between -0.3 and -0.5 (Summers, 1979).

To measure the required price responses more accurately, we use methods developed by Deaton (1990) to correct biases that result from using these data rather than actual market prices. It will, thus, be one of the few studies that uses this novel source of information to fill in the gaps which have previously prevented empirical analysis of tax and subsidy reform in many developing countries.

II. The Marginal Tax Reform Approach

Unlike the traditional optimal tax literature, which attempts to derive those tax rates that minimize welfare loss for the collection of a given revenue, marginal tax reform takes the existing tax system as given. The aim of the analysis is to identify the directions of reforms at the margin, taking the existing tax system as given, which may be more relevant for policy makers (Ahmad and Stern, 1984). 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 revenue to change at rate $\partial R / \partial \tau_i$. The ratio of these two derivatives gives the marginal social cost, λ_i of saving one unit of revenue by decreasing the subsidy rate on good *i*:

$$\lambda_i = -\frac{\partial V / \partial \tau_i}{\partial R / \partial \tau_i}. \qquad (1)$$

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 scope for beneficial reform.

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

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

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.[2] A range of values 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' which is based on ratios of total expenditures and gives the biggest weights to the richest households:

$$\tilde{w}_i = \sum_{m=1}^{M} x_m w_{im} \Bigg/ \sum_{m=1}^{M} x_m \,. \qquad (3)$$

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

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

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

[2] 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).

factor gives the share of tax in the final price. For example, lubricant oil faces a VAT rate of 10 percent in Indonesia, so the tax factor is $0.10/(1+0.10)=0.09,$ while kerosene prices 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 cost of saving fiscal expenditures from decreases in 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 revenue changes) from the change in the tax on good *i*.

III. Data and Estimation Methods

Data from the consumption module of the 1999 SUSENAS survey are used for 28,964 households located on Java.[3] 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 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 districts and regions. 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 lubricant oil contribute almost 4.4 percent of the average budget, ranging from LPG at 0.14 percent to electricity at 1.82 (Table 2). 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

[3] Java contains approximately 60 percent of the Indonesian population and, economic activity is also concentrated there, so the results should still be relevant to nationwide price reform.

household while information for items like LPG and gasoline is much 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. 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 needed for the marginal reform 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}):

$$w_{Gic} = \alpha_G^0 = \beta_G^0 \ln x_{ic} + \gamma_G^0 \cdot z_{ic} + \sum_{H=1}^{N} \theta_{GH} \ln p_{Hc} + (f_{Gc} + u_{Gic}^0) \tag{5}$$

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

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.

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 with dummy variables for each cluster in place of the unobserved price (a 'within' estimator). In addition to x_i and $\mathbf{z}_i$, this specification also controls for all cluster fixed effects, including those of unobserved prices, so 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. The first stage regressions also produce residuals 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^0_{Gic} and e^1_{Gic}, from equations (5) and (6) contain all the variability in w_{Gc} and v_{Gc} that are not explained by *x*, *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.

IV. Econometric Results

The first stage (within-cluster) estimation of the budget share equations explains from 47 percent (kerosene) to 27 percent (lubricant oil) of the variation in budget shares (see Table 3).[4] The budget share equations also indicate three luxury goods – gasoline, LPG and lubricant oil, each with expenditure elasticities between 2.69 and 2.80. Kerosene has an expenditure elasticity of 0.43 and for electricity it is 1.10. The only unit value to show any response to household expenditures is lubricant oil, where the *quality elasticity*, is 0.07.

Table 4 contains the estimated own- and cross-price elasticities. The symmetry restrictions from demand theory have been imposed on these estimates. In addition to the five energy sources, there is an extra row and column for "other consumption", 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

[4] In addition to total expenditures, the other variables used at the first stage include (log) household size, a set of demographic variables (the number of household members in each of thirteen age and sex categories as a

mentioned above, but also on a set of province and urban dummy variables. These dummy variables are used at the second stage (between-clusters) to control for any longer-term interregional price differences.[5] Such controls are needed because Deaton (1997) argues that the response to price changes in the short-run is most relevant for evaluating tax and subsidy reform.

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 63.8 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 elasticity estimates was normal, 0.638 is the fraction of a normal random variable within two standard deviations of the mean (Deaton, 1997).

The estimated own-price elasticity of demand for kerosene is -0.96 (with a standard error of 0.11). This is close to the estimate obtained by Pitt (1985) who also used household survey data, but without the corrections for the possible biases caused by unit values that Deaton (1990) introduced. The similarity of elasticity estimates, and the contrasts from the 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

ratio of household size), and nine educational dummies. These variables are based on those used by Deaton (1990).

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

electricity is precisely estimated. This suggests that subsidies will have caused a considerable amount of substitution into these products.

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 equation (4). The first column shows the tax factors, 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. The largest effects are for kerosene and then electricity, for whom raising prices would save the largest amount from the government's subsidy budget (ignoring any cross-price effects). However, the cross-effects are largest for gasoline and LPG and once these are taken account of, the most attractive candidate for price rises are kerosene followed by gasoline.

In Table 6, the results of bringing in the equity effects are reported for a range of values 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 of the relative tax costs. The marginal cost of raising kerosene prices is lowest, and for raising lubricant oil prices (which are already taxed) is highest amongst the fuels. However, all of the λ_i for the energy sources are much lower than for "other consumption" indicating the general desirability of removing energy subsidies.

Moving across to the right-hand side of Table 6, equity effects become increasingly stronger, and kerosene loses its place as the most attractive candidate for a price rise. Instead, with an inequality aversion parameter of $\varepsilon=2$ the lowest cost of additional revenue would come from raising LPG prices, followed by gasoline prices. The best candidate for a subsidy at these higher inequality aversion levels is electricity.

VI. Conclusions

In this paper we have used household budget survey data from Java to estimate the marginal social cost of indirect taxes and subsidies on five 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. From a policy perspective, the results suggest that there is a strong case for reducing the large subsidies on gasoline and kerosene in Indonesia, supporting the reforms that have been carried out recently.

In terms of methodology, the main feature of the study is that we correct for the biases that are likely to affect price elasticities estimated from unit values. To the extent that most other countries have household budget surveys like the one used here, this method could be used more widely to provide some empirical underpinnings to recommendations about price reforms.

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Table 1. Developments of Regulated Fuel Products Prices (Rupiah per litre)

	Jan 2003-Feb 2005	Mar-Sep 2005		October 2005		
	Fixed Price	Price	% change from Feb 05	Price	% change from Mar 05	% change from Feb 05
Gasoline	1,810	2,400	33%	4,500	88%	149%
Kerosene (household)	700	700	0%	2,000	186%	186%
Automotive Diesel	1,650	2,100	27%	4,300	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
Lubricant 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
Lubricant 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	Lubricant 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)
Lubricant 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 ( ); * statistically significant at 5% level. Results for "Other Cons" 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	0.24	2.93
LPG	-0.43	-0.63	0.27	1.57	2.84
Kerosene	-2.23	-1.61	3.58	0.47	5.05
Gasoline	-0.47	0.00	0.00	2.03	3.03
Lubricant Oil	0.09	-0.59	-0.05	0.95	1.90
Other consumption	0.09	-0.97	-0.09	-0.07	0.84

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	0.34	0.95	0.33	0.91	0.31	0.85	0.29
LPG	1.00	0.35	0.78	0.27	0.58	0.20	0.29	0.10
Kerosene	1.00	0.20	1.11	0.22	1.17	0.23	1.19	0.24
Gasoline	1.00	0.33	0.82	0.27	0.67	0.22	0.47	0.15
Lubricant Oil	1.00	0.53	0.79	0.42	0.64	0.34	0.44	0.23
Other consumption	1.00	1.19	1.00	1.20	1.01	1.20	1.01	1.21