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# EQUITY, EXTERNALITIES AND ENERGY SUBSIDIES

## The Case of Kerosene in Indonesia*

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This paper examines two arguments used to justify the subsidy provided kerosene, the primary commercial fuel of Indonesian households. One argument holds that the subsidy reduces deforestation externalities resulting from wood gathering. Econometric analysis of a large cross-section of households finds that firewood/kerosene substitution is very limited in Java, where the deforestation problem is most severe, so that kerosene subsidy is not an effective means of alleviating the problem. The second argument holds that social equity requires the subsidization of 'basic needs' such as kerosene. It is found that the kerosene subsidy disproportionately benefits urban and wealthier households.

## 1. Introduction

In the modern sectors of the developing countries, as in the industrialized countries, most of the energy consumed is in the form of what is commonly referred to as commercial energy — coal, petroleum, natural gas and hydroelectricity and nuclear power. Households account for 45 percent of total energy consumption in developing countries but only 10 to 20 percent of commercial energy consumption [World Bank (1980)]. Over 2 billion people depend almost exclusively on wood, dung, and other non-commercial household fuels. These traditional fuels provide developing countries with the equivalent of almost 5 million barrels of oil per day and represent about 28 percent of the caloric value of their total energy consumption [Dunkerley et al. (1981)].

Wood and charcoal provide over 80 percent of traditional energy in caloric value. In many densely populated areas, the destruction of forests to meet fuel wood requirements is the 'energy crisis'. In Nepal and Java, the illegal removal of wood from forests on mountain slopes has caused severe erosion, flooding and the siltation of reservoirs [Dunkerley et al. (1981)]. Indonesia, one of the poorest among the oil-exporting nations, has justified very large subsidies on kerosene with the claim that the environmental

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externality associated with wood fuel requires the subsidization of a substitute fuel. Recently, Dick (1980) has claimed that this argument is unsupportable. On the basis of fieldwork evidence from certain areas of Java, he claims that the consumption of wood fuels is insensitive to the price of petroleum fuels. In addition, he notes that higher wood fuel prices provide an incentive for commercial firewood production through spontaneous reforestation.

Even if kerosene subsidy were found to be an ineffective device for dealing with the deforestation problem, the major argument for subsidy has always been stated in terms of social equity. Kerosene is considered one of a set of basic commodities whose prices the government has pledged to control so as to protect the interests of consumers. Kerosene is the major fuel of politically volatile urban consumers and is second to wood fuels as an energy source for rural consumers. In subsidizing kerosene, the Indonesian government has stated that its intention is to make available a 'basic need' at a price affordable to the poor.

This paper examines the empirical basis for both the deforestation and equity arguments for kerosene subsidy in Indonesia. Making use of a large household consumption survey, demand equations for firewood, charcoal and kerosene are estimated. The functional forms chosen are sufficiently flexible so as to permit very different household demand responses across income, regional and urban/rural groups. The analysis strongly calls into question the empirical validity of both the equity and externality arguments for kerosene subsidy in Indonesia. Section 2 of this paper reviews the pattern of energy demand and recent trends in energy subsidies in Indonesia. In section 3, the estimation of the demand equations is described. Section 4 discusses the demand elasticities and their implications. Our findings are summarized in section 5.

## 2. Energy and energy subsidies in Indonesia

As a major oil exporting country, energy plays a dominant role in Indonesia's economic development. Petroleum and gas account for 75 percent of total exports and 60 percent of the government's budgetary revenues. Although energy consumption in Indonesia is low, even by developing country standards, it has grown very rapidly in the last decade. Commercial energy consumption grew at a rate of 14.7 percent per annum during 1972–1977, almost twice as fast as the GNP growth rate, and among the fastest such rates of growth in the world. Undoubtedly a major factor behind this rapid growth of commercial energy demand has been the subsidization policies of the government.

Indicative of the trend in fuel subsidies is the ratio of the wholesale price of kerosene, the pre-eminent petroleum fuel of the household sector, and the price of Sumatran light crude. This ratio fell 75 percent between 1971 and 1975, and by 1980, the kerosene/crude oil price ratio stood at just 15 percent of its 1971 level. At the end of that year, the price of kerosene was only 18 percent of its international price. The economic subsidy provided petroleum in 1980–1981 was nearly $3.7 billion, roughly 5.4 percent of GDP. Summers (1979b) has estimated that the pure deadweight loss associated with these subsidies may range from 0.25 to 0.50 percent of GDP, depending on the assumed price elasticity of demand for oil products. His calculation does not take into account any externalities resulting from subsidies. For comparison, Arrow and Kalt (1978) have estimated that the deadweight loss associated with U.S. price controls was only 0.1 percent of GNP in 1978.

Kerosene accounts for the largest share of petroleum fuel consumption in Indonesia and also receives the largest rate of subsidy. Seventy-five percent of all kerosene is consumed by households, and its consumption by them increased at nearly 10 percent per annum during the 1970s. Nevertheless, kerosene is the primary fuel only in urban areas. Wood fuels provide 75 percent of the kilocalories consumed as fuel by rural Indonesian households (81 percent of all Indonesian households are officially classified as rural), and accounted for 57 percent of their energy expenditure.[1] Table 1 provides basic information on the levels of fuel expenditure, consumption and prices faced by a sample of households drawn from the 1978 'Socio-Economic Survey of Indonesia' (SUSENAS). Since the only information on firewood consumption collected in the survey was the market value of household firewood consumption, estimates of its relative physical consumption are based on the assumed proportionality of charcoal and firewood prices. Charcoal is merely refined firewood and is widely produced in a competitive market with simple technology. While this proportionality assumption does not seem unrealistic within rural areas or within urban areas, it is likely that the ratio of wood to charcoal prices is higher in urban areas. This would reflect the lower costs of transporting charcoal from rural to urban areas than wood. Consequently, the relative measures of urban firewood consumption presented in table 1 should be considered upper-bound estimates.

Table 1 indicates that kerosene expenditure exceeds that of the sum of the two wood fuels in the urban areas of both Java and the Outer Islands.[2] The last row of table 1 also demonstrates that urban households are significantly better off than rural households. In particular, urban Javanese households, the largest consumers of kerosene, enjoyed a level of average per capita total expenditure two and one-half times that of rural Javanese households, the

[1]In the survey data, the consumption of goods produced by households is valued at local market prices and included in expenditure. Thus, *expenditure* is defined here to be the sum of cash and non-cash expenditure. This is important because most of the firewood consumed in Indonesia is collected by household members.

[2]The Outer Islands consist of all areas except the islands of Java and Madura. Sumatra, Kalimantan (Borneo), and Sulawesi (Celebes) are the most important of the Outer Islands.

Table 1

Expenditure, consumption and prices of kerosene, charcoal and firewood for Indonesian households (mean values per household).[a]

| | Rural Java | Urban Java | Rural outside Java | Urban outside Java | Indonesia |
|---|---|---|---|---|---|
| *Kerosene* | | | | | |
| Expenditure (Rp/month) | 426.74 | 1089.71 | 461.22 | 790.84 | 538.98 |
| Quantity (liters/month) | 14.06 | 40.67 | 12.38 | 24.78 | 17.36 |
| Price (Rp/liter) | 30.34 | 26.79 | 37.27 | 31.91 | 31.05 |
| *Charcoal* | | | | | |
| Expenditure (Rp/month) | 5.21 | 87.47 | 22.88 | 52.97 | 21.24 |
| Quantity (kg/month) | 0.11 | 1.20 | 0.36 | 0.87 | 0.36 |
| Price (Rp/kg) | 47.14 | 72.93 | 64.05 | 60.93 | 58.23 |
| *Firewood* | | | | | |
| Expenditure (Rp/month) | 856.73 | 101.72 | 411.16 | 436.21 | 605.07 |
| Share of total firewood expenditure attributable to this group (percent) | 72.3% | 1.9% | 20.7% | 5.1% | 100.0% |
| Share of total firewood consumption attributable to this group (percent)[b] | 78.0% | 1.3% | 16.4% | 4.3% | 100.0% |
| Index numbers of monthly household firewood consumption (all Indonesia average = 100)[b] | 152.7 | 11.7 | 53.9 | 60.2 | 100.0 |
| Share of kerosene, charcoal and firewood in total household expenditure | 7.1% | 2.5% | 2.6% | 2.5% | 4.3% |
| Location of Indonesian households by region | 51.1% | 11.4% | 30.4% | 7.1% | 100.0% |
| Total expenditure per capita (Rp/month) | 3,992 | 10,122 | 6,036 | 7,729 | 5,568 |

[a]SUSENAS 1978, sub-round 2.
[b]Estimates based on the proportionality of firewood and charcoal prices. See text for interpretation.

smallest consumers of kerosene. Rural households outside of Java spend only slightly more on kerosene than on wood fuels, but rural Javanese households spend twice as much on firewood as on kerosene. The prices of these fuels also vary substantially by location. Average kerosene prices are lowest in urban Java where kerosene consumption is greatest. They are greatest in rural areas outside Java where monthly household consumption is least.

Firewood consumption is of greatest importance in rural Java. This region was estimated to account for as much as 78 percent of all Indonesian household firewood consumption, with the average rural Javanese household consuming 13 times the firewood of urban Javanese households. Firewood prices, as proxied by the charcoal price, are also significantly lower in rural

Java than in the other regions. Even though the stock of trees is clearly smaller in Java than in most areas outside of Java, labor costs are perhaps the most important determinant of the price of firewood. Thus, it is not surprising that rural Java has a low firewood price given its relatively low wages. Note as well that average total monthly household expenditure is significantly lower in rural Java than in any of the other areas.

In summary, these data show that the highly subsidized fuel, kerosene, is consumed disproportionately by wealthier urban groups, especially urban Java, thus suggesting that its subsidization also benefits these groups disproportionately. Further evidence that this is the case is presented below. However, nothing can be said as yet about any effect kerosene subsidy may have on reducing wood fuel demand and hence on alleviating the deforestation externality. What is required are the relevant price elasticities of demand.

## 3. Econometric model

The econometric analysis is restricted to combustible fuels. Modeling the demand for electricity is complicated because individual households are not able to purchase all the electricity they want at its market price. Only six percent of Indonesian households have access to electricity. Many households which may desire to consume electricity given its price per Watt are not able to do so because access to distribution facilities is rationed. For those households which cannot obtain an electrical connection, the price of a Watt of power is irrelevant in their energy consumption decisions. Even households with electrical connections may be restricted from achieving desired consumption levels due to Wattage limitations on their connections. Thus, it is not unreasonable to exclude the price of electricity when studying the demand for combustible fuels.

Expenditure equations relating households expenditure of each combustible fuel to its price, the level of total household expenditure and a set of household characteristics are estimated below. The household characteristic variables are the logarithms of household size and the number of household members of age 11 or above, and 0–1 dummy variables for rural/urban and Java/outside Java location. These location variables allow for inter-household differences in fuel consumption in addition to that attributable to differences in prices, total expenditure and other household characteristics.

The expenditure equations are of the form

$$V_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log m + \sum_k \theta_{ik} h_k, \qquad i,j = \text{K, F, C}, \tag{1}$$

where $p_j$ is the price of fuel $j$, $m$ is total household expenditure, $h_k$ is the $k$th household characteristic, $\alpha_i$, $\gamma_{ij}$, $\beta_i$ and $\theta_{ik}$ are parameters to be estimated and K, F and C refer to kerosene, firewood and charcoal, respectively. Recognizing that household demand response to exogenous variables may vary across expenditure groups, all of the slope parameters ($\gamma_{ij}, \beta_{ij}$ and $\theta_{ik}$) of the underlying expenditure equations are allowed to vary linearly with the logarithm of per capita expenditure, as follows:

$$\gamma_{ij} = \gamma_{ij}^0 + \gamma_{ij}^m \log(m/s), \tag{2}$$

$$\beta_i = \beta_i^0 + \beta_i^m \log(m/s), \tag{3}$$

$$\theta_{ik} = \theta_{ik}^0 + \theta_{ik}^m \log(m/s), \tag{4}$$

where $s$ is household size.[3] As a result, energy demand response to prices and other exogenous variables may vary substantially across income groups.

The expenditure equations (1) for kerosene, charcoal and firewood are estimated with cross-section data on the consumption of individual households. Most households do not consume all three fuels, and thus zero consumption levels are often observed. In such a case, it is well known that application of ordinary least squares estimation techniques would result in biased estimates of the expenditure equation parameters. The bias would be very small in the case of kerosene since it is consumed by 98.8 percent of the households in the sample, but would be quite large for charcoal and firewood which are consumed by 19.4 and 47.3 percent of sample households, respectively. Instead the equations are estimated with Tobit [Tobin (1958)] maximum likelihood techniques, which specifically take into account the probability of non-consumption.

The data used in the estimation are from the tapes of the Survai Sosial Ekonomi (SUSENAS) 1978, sub-round 2, by the Biro Pusat Statistik. The sample size used in the estimation totaled 5880 households. Households reported their expenditure on kerosene, charcoal and firewood as well as the physical quantities of kerosene and charcoal consumed during the previous month. For kerosene, prices were calculated at the village level by grouping sample households into their respective villages and calculating the average

[3]The prices of other commodities are not included as regressors in the demand equations for combustible fuels. This is justifiable if preferences are weakly separable in these fuels. The equations are best thought of as reduced forms since electricity access can be considered a function of urban/rural and regional status and total expenditure. The availability of household electrical connections in Indonesia is clearly most prevalent in urban areas and particularly in the well established urban neighborhoods where higher income households tend to reside. The coefficients on the urban/regional and regional dummies and on total expenditure therefore pick up the effects on combustible fuel demands of the non-market allocations of electrical connections. We could not estimate these demand equations as a complete system of demand equations in any case because of the well known problems of reconciling the Tobit model (see below) with the system of demand equations approach.

price of the kerosene consumed.[4] For charcoal, prices were calculated at the regency (kabupaten) level through a similar grouping procedure. There were 300 regencies in Indonesia in 1978. It has already been noted that firewood prices are not available from the survey and that it is reasonable to assume that firewood prices are proportional to charcoal prices within rural or urban areas but not across them. Nevertheless, the eqs. (1) can still be estimated with only the data at hand. The rural/urban dummy variable captures any proportional difference between the rural and the urban charcoal/firewood price ratios. Of course, it also captures other fixed effects associated with rural/urban location. Since not all the parameters of eqs. (1) can be identified, the estimated response to the charcoal price represents the sum of the responses to firewood and charcoal prices and thus this price will henceforth be denoted as the 'wood fuel' price.

Although the wholesale price of kerosene was fixed by the government at Rp 18 per liter during 1978, the retail price was uncontrolled and varied substantially across the country. In our household survey data, the sample mean kerosene price is Rp 31.05 per liter with a standard deviation of 9.78. These data reflect about the same variation found in market surveys carried out by the Central Bureau of Statistics.[5] Our sample mean charcoal price is Rp 58.23 per kilogram with a standard deviation of 26.92.

## 4. Results

Parameter estimates for the three fuel expenditure equations are difficult to interpret because the underlying parameters vary with per capita expenditure as in (2), (3) and (4). Instead, we will closely examine elasticities evaluated at the means of exogenous variables for important sub-samples of the data set. The precisions of the estimates are best presented in terms of joint test statistics on the pairs of parameters $(\gamma_{ij}^{0}, \gamma_{ij}^{m})$, $(\beta_i^0, \beta_i^m)$ and $(\theta_{ik}^0, \theta_{ik}^m)$ rather than standard errors for each of the estimated parameters. Approximate standard errors are provided for most of the elasticity estimates. The full set of parameter estimates for the three fuel expenditure equations are presented in the appendix.

Table 2 provides test statistics for the null hypothesis that each of the

[4]There is very little intra-village price variation because enumerators were instructed to estimate prices both on the basis of household responses and on information obtained directly from the village market. These prices were then entered in the questionnaire by the enumerator along with quantity consumed. Expenditure was then computed as the product of price and quantity [Biro Pusat Statistik (1977)].

[5]A survey of village markets in thirteen provinces [Biro Pusat Statistik (1979)] found 1978 provincial averages of monthly village market kerosene prices ranging from Rp 23.00 to Rp 58.35 per liter, with a mean of Rp 40.44 and standard deviation of 8.61. A survey of market prices in twenty-six cities [Biro Pusat Statistik (1980)] found 1978 average monthly kerosene prices ranging from Rp 23.13 to Rp 50.00 per liter with a mean of Rp 31.89 and a standard deviation of 6.00.

Table 2

Test statistics for the fuel expenditure equations.

| Coefficients tested | Expenditure equation | | |
|---|---|---|---|
| | Kerosene | Charcoal | Firewood |
| Price of kerosene[a] | 9.29 | 18.32 | 46.22 |
| Price of wood fuel[a] | 14.17 | 16.07 | 9.11 |
| Household expenditure[a] | 25.69 | 93.85 | 61.23 |
| Household size[a] | 11.60 | 13.88 | 2.94 |
| Household members[a] aged 11 years and above | 5.18 | 1.88 | 15.71 |
| Rural[a] | 267.22 | 142.38 | 299.67 |
| Java[a] | 215.72 | 30.47 | 218.13 |
| All interaction parameters[b] | 94.45 | 203.59 | 389.81 |

[a]The test statistics are Wald tests. The critical values of the Chi-squared distribution with two degrees of freedom are 5.99 and 9.21 at the 0.05 and 0.01 levels, respectively.

[b]The test statistics are log-likelihood ratios. The critical Chi-squared values with 7 degrees of freedom are 14.07 and 18.48 at the 0.05 and 0.01 levels, respectively.

underlying varying parameters $(\gamma_{ij}, \beta_i, \theta_{ik})$ of the expenditure equations is zero. The Wald test statistics indicate that all the price parameters $\gamma_{ij}$ are significantly different from zero at the 0.05 level.[6] Households are sensitive to both own and cross-prices in choosing levels of fuel expenditure for all three fuels. The location variables are significant in all cases as well, but one of the two demographic variables is not significantly different from zero in each of the equations.

A likelihood ratio test strongly supports the contention that household demand response to exogenous variables varies with household expenditure per capita. The set of interaction parameters $(\gamma_{ij}^m, \beta_{ij}^m, \theta_{ik}^m)$ are jointly different from zero at the 0.05 level in every expenditure equation.

Separate sets of price elasticities were calculated for seven different population groups and are presented in table 3. Elasticities (and approximate standard errors) were computed at the means of the exogenous variables for households in four geographic locations: rural Java, urban Java, rural outside Java and urban outside Java.[7] In addition, elasticities were calculated for three representative households which are identical except for total expenditure levels. Each of these three households has five members, three of whom

[6]Wald tests are preferred on computational grounds to the more commonly presented likelihood ratio test. Wald tests do not require reestimation for each set of restrictions.

[7]Approximate standard errors are calculated on the assumption that the probability of consuming a fuel is constant and equal to the population group means of their estimated values. In the Tobit model, this probability is the normal cumulative function evaluated at the predicted value of the Tobit latent variable.

Table 3
Price elasticities of demand for important population groups (approximate standard errors in parentheses).

| | Kerosene | | Charcoal | | Firewood | |
|---|---|---|---|---|---|---|
| | Price of kerosene | Price of wood fuels | Price of wood fuels | Price of kerosene | Price of wood fuels | Price of kerosene |
| 1. Rural Java | −1.095 (0.049) | 0.081 (0.024) | −0.710 (0.156) | −1.439 (0.349) | −1.103 (0.036) | −0.005 (0.074) |
| 2. Urban Java | −0.934 (0.034) | 0.040 (0.017) | −0.707 (0.080) | −0.246 (0.168) | −1.143 (0.094) | 1.223 (0.183) |
| 3. Rural outside Java | −1.015 (0.043) | 0.080 (0.021) | −0.656 (0.105) | −0.986 (0.234) | −1.103 (0.036) | 0.262 (0.071) |
| 4. Urban outside Java | −0.972 (0.033) | 0.054 (0.016) | −0.710 (0.073) | −0.552 (0.158) | −1.124 (0.052) | 0.576 (0.102) |
| 5. Rp 20,000 household expenditure | −1.095 (0.049) | 0.080 (0.024) | −0.719 (0.152) | −1.394 (0.338) | −1.113 (0.040) | −0.006 (0.082) |
| 6. Rp 35,000 household expenditure | −0.984 (0.036) | 0.064 (0.018) | −0.674 (0.086) | −0.727 (0.188) | −1.106 (0.041) | 0.404 (0.080) |
| 7. Rp 50,000 household expenditure | −0.932 (0.042) | 0.056 (0.021) | −0.644 (0.092) | −0.426 (0.193) | −1.103 (0.057) | 0.714 (0.110) |
| 8. Java | −1.039 (0.040) | 0.067 (0.019) | −0.708 (0.074) | −0.566 (0.160) | −1.104 (0.035) | 0.031 (0.073) |
| 9. Outside Java | −1.002 (0.034) | 0.072 (0.017) | −0.683 (0.087) | −0.764 (0.191) | −1.105 (0.037) | 0.296 (0.073) |
| 10. Rural | −1.069 (0.046) | 0.081 (0.023) | −0.684 (0.128) | −1.219 (0.286) | −1.103 (0.034) | 0.077 (0.071) |
| 11. Urban | −0.944 (0.031) | 0.044 (0.016) | −0.708 (0.076) | −0.327 (0.160) | −1.131 (0.066) | 0.811 (0.129) |
| 12. Indonesia | −1.027 (0.038) | 0.068 (0.019) | −0.700 (0.079) | −0.634 (0.170) | −1.104 (0.035) | 0.118 (0.071) |

are aged 11 years or above and have mean values for all other independent variables except total expenditure. These households, having total monthly expenditure levels of Rp 20,000, Rp 35,000 and Rp 50,000, represent the 47th, 77th and 90th percentiles of the per capita monthly expenditure distribution. The elasticities for households by geographic location have also been weighted and summed to create elasticities for larger aggregates (e.g., Java). The reader is reminded that elasticities with respect to the price of wood fuels represent the sum of the two separate (unmeasured) elasticities with respect to firewood and to charcoal.

The elasticity of kerosene consumption with respect to its own price is close to $-1$ for all the population groups identified in table 3. This is in contrast to a rather high long-run estimate of −1.78 obtained by Strout (1978) from 1969 SUSENAS data and estimates of −0.3 to −0.5 from time-series data reported by Strout (1978) and Summers (1979a). Estimated elasticities of kerosene consumption with respect to the price of wood fuel are fairly small. They range from 0.081 in rural Java to 0.041 in urban Java. Nevertheless, all of these cross-price elasticities are statistically different from zero at the 0.05 level. These estimates are less than Strout's 'best guess' of 0.2–0.4.

The elasticities of charcoal demand with respect to the price of wood fuels are somewhat smaller than those of firewood and the own-price elasticities of kerosene. If charcoal and firewood are substitutes, which seems likely, their own-price elasticities are larger in absolute value than the wood fuel price elasticities reported. The elasticity of charcoal consumption with respect to the price of kerosene is negative and, in some cases, large in absolute value. This cross-price elasticity appears to be larger in rural areas and outside of Java. The charcoal/kerosene complementarity may reflect the limited but specialized use of charcoal by households. Kerosene is the primary fuel for lighting purposes and can substitute for firewood in cooking. In cooking, it can impart an oily taste to food and is particularly unsuited for the grilling of meat (sate). As a result, the substitution of kerosene for firewood in cooking may also involve the increased use of charcoal for those cooking purposes in which kerosene is inappropriate on taste grounds. Charcoal is rarely used as the major cooking fuel, and as table 1 demonstrates, is of relatively minor importance. Besides its use in cooking, charcoal is used mainly for ironing.

Elasticities for firewood with respect to the price of wood fuels are greater than unity in absolute value for all population groups and thus its demand is probably own-price elastic. In most cases, the estimated elasticities are significantly different from −1. Perhaps of greatest importance from the policy point of view, the elasticity of demand for firewood with respect to the price of kerosene is not statistically different from zero (indeed it is negative) for rural Java. This small elasticity reflects, in part, the small share of kerosene relative to wood in total rural Java energy consumption. This finding would argue that the Javanese deforestation externality rationale for kerosene subsidy is not supported by these data. Note that in the other three geographic regions, this cross-price elasticity is positive and statistically different from zero at conventional levels of significance. It is particularly high in urban Java where it exceeds unity. Nevertheless, because urban households account for only two percent of firewood consumption in Java, the all-Java firewood demand elasticity with respect to kerosene prices is only 0.03, a value which is not significantly different from zero. The situation outside of Java is quite different. In both rural and urban areas outside of Java, this cross-price elasticity is positive and significant, and for all of outside Java it is 0.30. However, increased levels of wood consumption outside of Java have not been a serious matter of concern since the problems of deforestation and erosion resulting from household wood gathering are much less severe than in Java. Note that for Indonesia as a whole, the cross-price elasticity is only 0.118, and again this estimate is not statistically different from zero. Also note that since charcoal is a wood product, and its demand elasticity with respect to the price of kerosene is negative, an elasticity of demand for wood which included the wood required in charcoal production would be somewhat less than 0.118, although probably not much less than 0.100.[8]

Even if there was a substantial, positive cross-price elasticity, the deforestation externality argument could not justify the subsidy. As Gillis (1980) has calculated, if kerosene were a substitute for firewood, the subsidy protects at most 20,000 hectares of land vulnerable to erosion. He estimates that the subsidy program cost about U.S. $77,000 per hectare protected in fiscal year 1979–1980, whereas replanting costs only $500 per hectare.

The pattern of use and substitutability between firewood, charcoal and kerosene reflects important differences in their end uses. Kerosene is the only one of the three which can provide light, which explains why it is consumed by 99 percent of sampled households. Cross-price elasticities are low in rural areas because kerosene is used primarily for light and cooking is done almost entirely with food fuels [Dick (1980)]. The pattern is very different in urban areas. Firewood is seldom used in urban Java, and is an important fuel only in Outer Island towns close to forested hills. The main urban cooking fuel is kerosene, and more of it is used for this purpose than for lighting [Dick (1980)].

Rows 5, 6 and 7 of table 3 provide estimates of demand elasticities for three representative households which are identical except for total household expenditure levels. In every case, own-price elasticities do not appear to be very sensitive to household expenditure. The elasticities of charcoal and firewood with respect to the price of kerosene, on the other hand, demonstrate great sensitivity to the expenditure levels of households. In the case of firewood, poorer households are less sensitive to kerosene price changes, while for charcoal, wealthier households are less price sensitive. The latter also holds for kerosene response with respect to wood fuel prices.

Table 4 presents fuel demand elasticities with respect to total household expenditure. In all three cases, these elasticities vary substantially among population groups. Kerosene demand elasticities with respect to household expenditure are twice as high in rural Indonesia as in urban Indonesia, and are also inversely related to expenditure levels (rows 5, 6 and 7). All the estimates for kerosene are below the estimate of 0.78 obtained by Strout

[8]Uncompensated equiproportional increases in the prices of all fuels result in a proportional fall in expenditure on the three fuels of −0.020 for Indonesia as a whole.

Table 4
Total expenditure elasticities of household fuel demand (approximate standard errors in parentheses).

| | Kerosene | Charcoal | Firewood |
|---|---|---|---|
| 1. Rural Java | 0.545<br>(0.028) | 2.95<br>(0.215) | −0.379<br>(0.042) |
| 2. Urban Java | 0.225<br>(0.014) | 0.059<br>(0.071) | 1.848<br>(0.124) |
| 3. Rural outside Java | 0.539<br>(0.028) | 1.92<br>(0.160) | 0.392<br>(0.046) |
| 4. Urban outside Java | 0.366<br>(0.020) | 0.516<br>(0.094) | −0.016<br>(0.066) |
| 5. Rp 20,000 household expenditure | 0.588<br>(0.022) | 2.726<br>(0.176) | −0.176<br>(0.037) |
| 6. Rp 35,000 household expenditure | 0.386<br>(0.019) | 1.355<br>(0.111) | −0.417<br>(0.048) |
| 7. Rp 50,000 household expenditure | 0.307<br>(0.022) | 0.734<br>(0.114) | −0.603<br>(0.072) |
| 8. Java | 0.434 | 0.838 | −0.423 |
| 9. Outside Java | 0.486 | 1.200 | 0.349 |
| 10. Rural | 0.543 | 2.453 | −0.141 |
| 11. Urban | 0.265 | 0.181 | −0.681 |
| 12. Indonesia | 0.450 | 0.961 | −0.170 |

(1978) using 1969 SUSENAS cross-section and that of 1.0 (with respect to GNP) estimated by Summers (1979a) using aggregate time-series data.

Total expenditure elasticities of demand for firewood are negative, that is, firewood is an inferior good, in all geographic areas except rural outside Java. In Java as a whole the elasticity is −0.42, a value which suggests that continued income growth will aid substantially in alleviating the deforestation problem. Outside of Java continued income growth will increase firewood demand, although for Indonesia as a whole the expenditure elasticity is negative. This effect is offset to a slight extent by the relatively high total expenditure elasticity of demand for charcoal, particularly in rural areas.

Table 5 illustrates the subsidy effects of a 60 percent increase in the price of kerosene. The 60 percent figure was chosen because it was the proportional increase in kerosene's price at the most recent (January 1982) energy price adjustment.[9] A comparison of the official wholesale kerosene price of

[9]The substantial spatial variation in the price of kerosene has already been noted. However, even though the range in prices exceeds 60 percent, this is a fairly large price movement to study utilizing parameters estimated with cross-sectional data. In addition, nothing can be said about the speed with which consumers will adjust to new combinations of prices.

Table 5

Predicted changes in kerosene subsidies under alternative price regimes (rupiahs of subsidy per household per month).

| | 1978 total expenditure per capita (Rp/month) | April–June 1978 | | | May 1980[a] | | |
|---|---|---|---|---|---|---|---|
| | | Subsidy at actual prices | Subsidy with 60% price rise | Change in subsidy | Subsidy at actual prices | Subsidy with 60% price rise | Change in subsidy |
| Rural Java | 3,992 | 316 | 63 | −253 | 2,074 | 1,050 | −1,024 |
| Urban Java | 10,122 | 915 | 196 | −719 | 5,999 | 3,276 | −2,723 |
| Rural outside Java | 6,036 | 279 | 58 | −221 | 1,826 | 960 | −866 |
| Urban outside Java | 7,729 | 558 | 118 | −440 | 3,655 | 1,961 | −1,694 |
| Java | 5,113 | 426 | 87 | −339 | 2,791 | 1,458 | −1,333 |
| Outside Java | 6,358 | 331 | 69 | −262 | 2,173 | 1,150 | −1,023 |
| Rural | 4,734 | 302 | 61 | −241 | 1,981 | 1,016 | −965 |
| Urban | 9,222 | 778 | 166 | −612 | 5,099 | 2,771 | −2,328 |
| Indonesia | 5,568 | 391 | 81 | −310 | 2,561 | 1,343 | −1,218 |
| Elasticity of subsidy with respect to price of kerosene[b] | | −2.14 | −6.36 | | −1.28 | −1.51 | |

[a]May 1980 kerosene prices and subsidies per liter applied to April–June 1978 [Biro Pusat Statistik (1978, sub-round 2)] consumption pattern.

[b]Percent change in aggregate kerosene subsidy provided Indonesian households in response to a one percent increase in the price of kerosene.

Rp 25 per liter with a free trade price ex-Singapore for the April–June 1978 period as reported by the *Petroleum Economist* suggests an economic subsidy of Rp 22.50 per liter. The second column of table 5 provides estimates of actual subsidy per household per month for the period April–June 1978, the period covered by the SUSENAS 1978, sub-round 2 survey. These data clearly demonstrate the strong urban bias of the kerosene subsidy program. Urban households received more than two and one-half times the subsidy of rural households. Urban Javanese households received the greatest level of subsidy of all households, about Rp 915 per month, a level 3.3 times that received by rural households outside of Java. As a whole, households in Java received 28 percent more subsidy than those outside of Java.

The third column of table 5 provides estimates of the monthly subsidy per household implied by a 60 percent kerosene price increase. In April–June 1978, a 60 percent price rise would have resulted in a remaining subsidy of Rp 7.50 per liter. For Indonesia as a whole, the net kerosene subsidies provided households would fall nearly 80 percent as a result of this price increase. As the fourth column indicates, urban, and to a lesser extent Javanese, households would bear the greatest absolute loss in subsidy. The difference in the subsidy provided urban and rural households would fall from Rp 476 to Rp 106 per month.

The last three columns of table 5 are calculated in the same fashion as the preceding three except that they are based on the subsidy in effect beginning May 1980 and ending January 1982.[10] The fifth column of that table provides estimates of the monthly household subsidy resulting from that rate of subsidy but assuming the same consumption pattern of April–June 1978. The subsidy in May 1980 is estimated at Rp 147.50 per liter, and the effect of a 60 percent kerosene price increase is given in the sixth column. The average monthly subsidy of Rp 2561 is more than 6.5 times that of two years earlier. Note that while a 60 percent kerosene price increase reduced subsidy outlays by nearly 80 percent in April–June 1978, the same percent increase in price will reduce the subsidy by only 48 percent in May 1980. This reflects the much larger rate of subsidy per liter in 1980.

The effect of kerosene price increases on the total subsidy provided households is summarized by the elasticity of subsidy with respect to the price of kerosene, provided in the last row of the table.[11] This elasticity was $-2.14$ in April–June 1978, that is, a one percent increase in the actual kerosene price would have reduced the aggregate economic subsidy cost of

[10]Estimating the most recent economic subsidy provided kerosene is problematical because OPEC quotas are binding constraints on Indonesian export sales. Thus, a unit of petroleum product 'saved' domestically cannot immediately be converted into foreign exchange through trade. This was not the case in 1978 but may have been by early 1982.

[11]This elasticity is simply the own-price elasticity less the ratio of the subsidy-inclusive price to the subsidy per unit.

the Government by 2.14 percent. If the price had been 60 percent higher than it was (and the total subsidy cost 80 percent less as a result) a further one percent rise in domestic kerosene prices would have reduced the cost of subsidy to the Government by 6.36 percent. Note that in the May 1980 situation these subsidy elasticities are much smaller, reflecting again the much larger rate of subsidy per liter in effect at that time.

## 5. Conclusions

The analysis of these data conclusively rejects the deforestation argument for kerosene subsidy. The econometric results demonstrate that the demand for firewood with respect to the price of kerosene is very small in Java as would be expected given their very different end uses in rural areas. There is no basis to the claim that the kerosene subsidy alleviates the deforestation problem in Java.

We have also demonstrated that wealthier, urban households, for whom kerosene is the primary energy source, obtain a disproportionate share of total kerosene subsidy. In Indonesia as a whole, urban households constituted 18.5 percent of all households, accounted for 30.9 percent of total expenditure and received 36.8 percent of the kerosene subsidy provided households in 1978. Among Javanese households, the 18.2 percent that were urban accounted for 33.8 percent of total expenditure and 39.2 percent of kerosene subsidy. These facts would argue that the equity argument for kerosene subsidy cannot be strong. However, a definitive assessment of the distributional impact of ending kerosene subsidies depends on the distributional impact of alternative expenditures or tax reductions. Such an analysis is beyond the scope of this study. Nevertheless, poor households, who have no alternative to kerosene for lighting purposes, may bear a considerable burden if all subsidy is removed. This fact is not a sufficient argument for continuing a subsidy which is disproportionately captured by the non-poor. Certainly there are less expensive ways to aid poor Indonesian households, who are predominantly rural, than to subsidize a good consumed disproportionately by urban households.[12]

[12]Another consideration is the efficiency cost of the petroleum subsidy on productive activities. This question is dealt with at length in Pitt (1985).

## Appendix

Table A.1
Parameter estimates of the fuel expenditure equations (asymptotic standard errors in parentheses).

| | Kerosene | Charcoal | Firewood |
|---|---|---|---|
| 1. Constant | −1872.0 | −11936.3 | 4512.4 |
| | (1779.4) | (2773.7) | (4781.1) |
| 2. Log household size ($s$) | −716.58 | −1246.6 | 1335.7 |
| | (307.64) | (4589.6) | (827.6) |
| 3. Log members age > 10 years | −474.86 | 512.77 | −2150.4 |
| | (279.16) | (427.24) | (750.4) |
| 4. Log total expenditure ($m$) | 669.88 | 2818.7 | 945.82 |
| | (264.66) | (409.5) | (757.50) |
| 5. Urban | 18.082 | −948.37 | −1181.1 |
| | (210.38) | (290.41) | (526.6) |
| 6. Java | 163.66 | −223.94 | 7057.2 |
| | (173.44) | (263.10) | (495.3) |
| 7. Log price of kerosene | −1186.5 | −1583.7 | −5511.3 |
| | (390.40) | (634.8) | (977.0) |
| 8. Log price of wood fuels | 83.875 | −259.62 | −320.88 |
| | (188.84) | (295.49) | (480.02) |
| 9. Log size * log($m/s$) | 97.639 | 15.260 | −62.751 |
| | (28.792) | (44.566) | (76.64) |
| 10. Log members * log($m/s$) | 58.473 | −55.599 | 267.71 |
| | (32.320) | (48.082) | (87.78) |
| 11. Log expenditure * log($m/s$) | −52.432 | −170.29 | −184.35 |
| | (10.875) | (17.60) | (33.21) |
| 12. Urban * log($m/s$) | −28.910 | 83.670 | 205.01 |
| | (24.143) | (32.87) | (60.55) |
| 13. Java * log($m/s$) | 5.567 | 36.262 | −803.67 |
| | (20.00) | (29.553) | (57.73) |
| 14. Log price of kerosene* log($m/s$) | 135.47 | 161.012 | 663.77 |
| | (44.94) | (71.037) | (112.63) |
| 15. Log price of wood fuels * log($m/s$) | −3.663 | 37.328 | 25.417 |
| | (21.80) | (33.206) | (55.632) |
| 16. Sigma | 465.13 | 399.22 | 1,036.02 |
| Limits | 70 | 4,737 | 2,782 |
| Non-limits | 5,810 | 1,143 | 3,098 |
| Observations | 5,880 | 5,880 | 5,880 |

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