4

Impact of Policy Alternatives on Household Fuel Consumption

4.1 As Chapter 3 has shown, households typically use a subset of the available energy sources. This study modeled household fuel use accounting for two choices made by each household: (1) the selection of energy sources and (2) the decision regarding the quantity of each energy source to consume. The first choice is made from a finite set of alternatives and can be studied using a discrete choice model. The second choice is the continuous choice of the conventional kind. Because the continuous choice flows from the discrete choice, modeling requires their interdependence to be taken into account. In this study, the first choice was modeled using multinomial logit, and the second choice using linear regression with log-log specifications correcting for the self-selection bias. Details are given in Annex 2. The model is consistent with both sequential and simultaneous decision-making with respect to the two choices.

4.2 Only kerosene, LPG, wood, and electricity were examined (dung could not be included because information on the quantity consumed was not collected). Two models were set up to test the respective model's robustness. Model 1 categorized households on the basis of combinations of energy sources used, further subdividing kerosene according to its source: PDS or market. Model 2 categorized households according to which energy sources were used for cooking and lighting (see Annex 2 for how kerosene use was estimated), not subdividing kerosene as a function of source. Because model 1 utilizes fewer assumptions, its results are taken to draw conclusions; however, the results from the two models are compared first and omitted from further consideration if the results are both statistically different from zero and differ in sign. The explanatory variables were total household expenditures, household size, fuel prices, electricity price multiplied by access, social group, occupation, kerosene quota, state kerosene allocation divided by the number of PDS-kerosene-consuming households, median cluster expenditure, the 80th percentile of PDS kerosene consumption in the first sampling units, the number of kerosene dealers, the number of LPG dealers, and statewide per capita electricity consumption for noncommercial use.

Assumptions and Policy Scenarios Tested

4.3 The results of the modeling pointed to the difficulties of analyzing household fuel use patterns. The factors that contribute to the difficulties include the following:

- *Lack of quantitative information on the rationing of kerosene and LPG.* PDS kerosene is rationed, and there furthermore appears to be large-scale diversion of PDS kerosene to both the black kerosene market and the automotive diesel sector. As a result, many households in the survey did not seem able to purchase the full amounts to which they were entitled. With respect to LPG, there was also rationing in effect, taking the form of long waiting lists for the first cylinder, long turnaround time for cylinder refills, and, for some households, lack of local availability. No quantitative information is available on the actual rationing each household faced.
- *Lack of information on access to free fuels.* No information was collected in the survey regarding the availability of free biomass fuel. The only information collected was the mode of fuel acquisition; no data was collected regarding the distance to the closest source of free biomass, the time it takes to travel there, or other logistical information.
- *Lack of distinction between subsidized LPG and market LPG, and between black market kerosene and parallel market kerosene.* No questions were asked concerning the source of LPG or unit prices paid. Dividing expenditures by amounts did not yield results sufficiently consistent to draw conclusions about whether LPG was purchased from a public sector or private sector dealer. Similarly, it was not possible to distinguish between market kerosene and PDS kerosene diverted to the black market.
- *Lack of information on disposable cash income.* Commercial fuels have to be purchased with cash, so the amount of disposable cash income is an important determinant of household fuel choice. There are no reliable data on household income in India that are linked to household energy expenditures.
- *Uncertainties in the raw data.* The NSS is a general household survey and does not specifically investigate energy use. As such, the NSS questionnaire is not formulated to obtain reliable information on household energy use patterns. The monthly quantities of fuels used, especially with respect to LPG and biomass, are likely to carry large uncertainties (see Annex 1 for more detail). Estimates of imputed values of free biomass are especially problematic.
- *Extrapolation outside the data range.* In trying to simulate the impact of reducing or eliminating price subsidies, the model has to operate outside the range of the available data.

4.4 As a result of the above and other limitations of the data, modeling of this nature would not be expected to yield consistent results. This was true of this study. A number of

policy scenarios nonetheless were examined with the objective of assessing the effect of subsidy reduction or elimination and the corresponding mitigation measures:

- increasing the prices of subsidized kerosene and LPG by varying amounts, including complete subsidy elimination
- cash transfer, to the poor as well as to all households
- increasing the amount of PDS kerosene quota
- increasing the number of PDS kerosene dealers
- increasing the number of LPG dealers
- different combinations of the above scenarios

4.5 The scenario simulations tested, among others, two assumptions. The first is a set of assumptions about how the kerosene market operates, and includes the following:

- Kerosene is assumed to be supply-limited because of quotas and diversion.
- Rationing coupled with diversion raises the transaction cost of buying PDS kerosene.
- The effective price of PDS kerosene is the sum of the retail price and its transaction cost.
- Households buy market kerosene when the effective price of PDS kerosene exceeds the effective price of market kerosene (which also carries some transaction cost).
- Increasing kerosene allocation to each state should help make more kerosene (PDS and black market combined, since a portion of PDS kerosene is diverted to the black market) available.
- Increasing the number of kerosene dealers could also make kerosene more easily accessible by reducing the distance to the closest kerosene dealership.
- Some PDS kerosene is diverted to the black market, where the price is higher than that of PDS kerosene but lower than the price that would be attained under market conditions (otherwise supply would rise to match demand). One consequence is that the parallel market for kerosene, launched in 1993, cannot develop adequately because of competition not only from PDS but also from black market kerosene.
- Eliminating the kerosene subsidy (one of the policy scenarios examined) would eliminate the distinction between black market and parallel market kerosene. (Taking this elimination of distinction into account, however, is beyond the scope of this study.)
- Everything else being equal, increasing the price of market kerosene (a combination of black and parallel market kerosene in this study) should make diversion to the black market even more attractive. Conversely, increasing the

price of PDS kerosene would make diversion to the black market less attractive.

The second assumption is that LPG is also supply-limited; that the transaction cost of using LPG is high for a number of households; and that increasing the number of LPG dealers—making it more easily available in principle—is one way of lowering the transaction cost (this policy simulation did not yield consistent results).

4.6 Only those results where both models gave consistent results (that is, the same signs for statistically significant results), and where the predicted trends were not immediately counterintuitive on economic grounds are considered in the rest of this report.

4.7 The policy simulation results are presented in two tables. In the first table, the impact of increasing various parameters by 10 percent and making a cash transfer of Rs 100 per month to the bottom four deciles is examined. This set of scenario simulations helped to identify which explanatory variable changes did not give reasonable results as judged on economic grounds or consistency between the two models. The scenario simulations excluded on these criteria involved increasing the kerosene quota (defined as the amount of kerosene allotted to non-LPG-using households), the number of kerosene dealers, the number of LPG dealers, the price of electricity in rural areas, the kerosene quota, the amount of kerosene allocated to each state, and the number of LPG dealers in urban areas. In the second table, the impact of reducing the kerosene subsidy by two-thirds and eliminating the LPG price subsidy is considered as the starting case for dismantling the administered pricing mechanism. This scenario is compared to seven other scenarios, including the complete elimination of the kerosene subsidy; giving Rs 100 per month to households classified as being below the poverty line (BPL) as well as to all households; eliminating the kerosene subsidy only for households above the poverty line (APL); retaining the LPG subsidy for BPL households; increasing the number of kerosene dealers; and eliminating the LPG subsidy but retaining the kerosene subsidy. The government's definition of APL and BPL for each state, on the basis of per capita expenditure, was used for this purpose.

Modeling Results

4.8 Table 4.1 shows the results of increasing the total household expenditure; increasing the kerosene allocation (defined as the mount of PDS kerosene allocated to each state divided by the number of PDS-consuming households in the state); increasing the prices of PDS kerosene, market kerosene, and LPG; and giving Rs 100 per month per household to the bottom four deciles in rural areas. Predictably, increasing the total household expenditures has the greatest impact on the consumption of LPG and electricity. However, this also increases the consumption of firewood, indicating that, given greater resources, rural households would be likely to use even more firewood. Giving Rs 100 per month to the bottom 40 percent also increases energy consumption, but to a much lesser extent. In this study, results that show percentage changes within ±1 percent are considered not statistically different from zero. On this criterion, the only statistically significant increases in energy consumption are market

kerosene, firewood, and electricity. Importantly, with extra income the poor do not purchase more PDS kerosene but instead consume more market kerosene. The transaction cost of purchasing PDS kerosene seems high, if the poor are prepared to pay considerably more to buy market kerosene. Comparison of these two scenarios is not entirely consistent with the assumption of PDS kerosene being supply-limited, as richer households are seen to purchase more PDS kerosene as their household expenditures rise.

Table 4.1 Impact of a 10 Percent Increase in Energy Consumption in Rural Areas

Energy	*Total household expenditure*	*Rs 100 to bottom 40%*	*Price of LPG*	*Price of PDS kerosene*	*Price of market kerosene*	*Kerosene allocation*
Total kerosene	2.4	0.7	0.0	-1.6	-0.1	2.9
PDS kerosene	1.3	0.5	0.1	-2.0	0.7	0.6
Market kerosene	5.3	1.3	0.0	-0.5	-1.9	8.6
LPG	16	0.6	-7.4	0.5	0.8	0.9
Firewood	2.9	1.0	0.1	-0.2	-0.2	-3.6
Electricity	9.0	1.1	-0.1	0.7	-0.4	-3.7

Note: Percentage change relative to the base (1999–2000 actual) case

4.9 Increasing the price of LPG has the expected result of decreasing LPG consumption, but has no other impact. Increasing the price of PDS kerosene decreases the consumption of PDS kerosene. The impact of increasing the price of PDS kerosene is complicated to work out because of several considerations: it may or may not lower the transaction cost of procuring PDS kerosene, it lowers the effective income of households by reducing the amount of subsidy received, it makes diversion less attractive (thereby making more PDS kerosene available for household use), and as a result of lower diversion, the amount of black market kerosene available may be decreased. In the above result, price elasticity is seen to dominate.

4.10 Increasing the price of market kerosene should make diversion to the black market even more attractive, reducing the availability of PDS kerosene for purchase by households and increasing supply on the black market. The impact on diversion to the automotive sector is not clear unless the price of market kerosene is linked to the price of diesel, in which case diversion to the automotive sector also becomes more attractive. The model result gives a fall in the consumption of market kerosene and no statistically significant change in the consumption of any other energy source. The fact that higher retail prices of PDS and market kerosene lead to a decline in the consumption of both fuels suggests that the transaction cost effect is weaker than the direct price effects.

4.11 Increasing the allocation of PDS kerosene gives a somewhat surprising result. Everything else, including diversion, being the same, increasing kerosene allocation by 10

percent should result in a 10 percent increase in the consumption of PDS kerosene. In fact, the increase is statistically insignificant, indicating a near 100 percent leakage. If the numerically obtained figure of 0.6 percent (which is not statistically different from zero) is used to compute diversion, it still amounts to a leakage rate of 94 percent. While leakage may increase with increasing allocation, such a high leakage rate is unlikely and further points to problems encountered when trying to model household energy use in the face of so many uncertainties and limitations.

4.12 Table 4.2 shows the impact of reducing the kerosene subsidy by two-thirds and eliminating the LPG subsidy (under the scenario named "reduced subsidy"), and several variations on this reference case. Predictably, the reduced subsidy case has a larger impact on the consumption of PDS kerosene and LPG than on other energy sources. Eliminating the kerosene subsidy altogether (case A) further reduces PDS kerosene consumption. Eliminating the kerosene subsidy only for APL households and reducing it by two-thirds for BPL households (case B) has a comparable effect to that of case A. Keeping the same prices as in case A but giving Rs 100 per month to BPL families (case C) has little impact: there is a slight increase in the consumption of all energy sources relative to case A but the increase is very small compared to the difference with the base case. Giving Rs 100 per month to all households (case D) has a larger impact than case C, with more LPG and market kerosene being purchased. As expected, eliminating the LPG subsidy only for APL households in case E is no different from case A, because BPL families do not typically use LPG. Eliminating the kerosene subsidy but retaining the LPG subsidy actually increases LPG consumption, suggesting that higher-income rural households would switch from kerosene to LPG. If the kerosene subsidy is retained and the LPG subsidy is eliminated, the opposite happens: kerosene consumption remains the same as the base case and LPG consumption falls markedly.

4.13 The model outputs shown in Table 4.2 contain some problematic results. First, wood consumption in most cases is seen to fall. It is unlikely that rural areas, where about 60 percent of all households use free biomass, would see a fall in the consumption of firewood when the prices of kerosene and LPG are doubled. On the contrary, those households using kerosene and LPG for cooking would be expected to cut back on the consumption of kerosene and LPG and use more firewood. Both models gave results with the same sign, but this suggests that modeling is not robust with respect to firewood consumption. Second, electricity consumption increases in response to higher kerosene and LPG prices. This would not be expected on two accounts: (a) electricity is cheaper than kerosene for lighting, so whenever power is available, households prefer to use electricity if they are connected; and (b) households that are connected turn to kerosene primarily when electricity is not available due to power outages. Subsidy reductions are also equivalent to income reduction, with the result that through the income effect households may be expected to use less electricity. The output of the discrete choice model in fact shows that the number of households connected to electricity falls in the reduced subsidy case, but those who remain connected use more. This is difficult to explain, and suggests that the model is not robust with respect to electricity consumption.

Table 4.2 Percentage Change in Energy Consumption in Rural Areas

Energy	*RS*	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*A*	*B*	*C*	*D*	*E*	*F*	*G*
	Relative to the base (1999–2000 actual) case								*Relative to RS*						
Total kerosene	-11	-15	-14	-14	-13	-15	-15	0.2	-3.8	-3.1	-3.4	-2.4	-3.8	-4.0	13
PDS kerosene	-14	-18	-17	-18	-17	-18	-18	0.3	-4.7	-3.8	-4.5	-3.9	-4.8	-5.0	16
Market kerosene	-4.1	-5.7	-5.6	-5.0	-3.2	-5.7	-5.8	0.1	-1.7	-1.5	-0.9	1.0	-1.7	-1.8	4.5
LPG	-33	-32	-32	-32	-29	-32	5.7	-36	1.4	1.4	1.7	5.8	1.7	57	-4.1
Firewood	-0.9	-1.3	-1.2	-0.7	0.3	-1.3	-1.6	0.3	-0.4	-0.3	0.2	1.2	-0.4	-0.8	1.3
Electricity	4.8	6.3	6.2	6.8	10	6.3	6.7	-0.4	1.5	1.3	2.0	5.1	1.5	1.9	-4.9

RS (reduced subsidy) – PDS kerosene price increases by Rs 4 per liter and LPG cylinder price increases by Rs 124
A – PDS kerosene price increases by Rs 6 per liter and LPG cylinder price increases by Rs 124
B – PDS kerosene price increases by Rs 4 per liter for BPL, Rs 6 per liter for APL, and LPG cylinder price increases by Rs 124 for all households
C – Same as A but Rs 100 per month is given to BPL households
D – Same as A but Rs 100 per month is given to all households
E – PDS kerosene price increases by Rs 6 per liter for all households and LPG cylinder price by Rs 124, only for APL households
F – PDS kerosene price increases by Rs 6 per liter and LPG subsidy is retained in full
G – PDS kerosene subsidy is retained in full and LPG cylinder price increases by Rs 124

4.14 The corresponding tables for urban areas are shown in Table 4.3 and Table 4.4. In these tables, the scenarios reported are not the same as those for rural areas because different scenarios had to be excluded based on the two criteria discussed in paragraph 4.6. Comparison of Table 4.1 with Table 4.3 immediately points to marked differences between urban and rural households. Increasing the total household expenditure by 10 percent reduces kerosene and firewood consumption in urban areas; in contrast, their consumption in rural areas rises. Giving Rs 100 per month to the bottom four expenditure deciles gave no statistically significant changes. Increasing the price of LPG and the electricity tariff has the expected effect of reducing the consumption of these two energy sources. As in rural areas, increasing the price of PDS kerosene decreases its consumption, but increasing the price of market kerosene has no impact. Increasing the number of PDS kerosene dealers increases the consumption of PDS kerosene markedly and somewhat decreases firewood consumption, suggesting that this is one way of reducing the transaction cost of buying PDS kerosene. Assuming that PDS kerosene is diverted to the black market, one explanation for the increase in the consumption of market kerosene is that the lower transaction cost of obtaining PDS kerosene leads to greater diversion to the black market. It is not clear why electricity consumption should fall, given that the primary use of kerosene in urban areas is for cooking: using more kerosene to cook should not have an impact on electricity consumption. As before, the model may not be robust with respect to electricity consumption.

Table 4.3 Impact of a 10 Percent Increase in Energy Consumption in Urban Areas

Energy	*Total household expenditure*	*Rs 100 to bottom 40%*	*LPG price*	*Electricity price*	*PDS kerosene price*	*Market kerosene price*	*PDS kerosene dealers*
Total kerosene	-1.0	0.3	0.1	-0.5	-1.7	0.2	4.3
PDS kerosene	-1.2	0.0	0.2	-0.3	-2.4	0.8	6.1
Market kerosene	-0.7	0.8	0.1	-0.8	-0.8	-0.5	2.2
LPG	7.4	0.8	-8.1	0.4	0.8	-0.3	-0.5
Firewood	-2.0	0.2	0.1	-0.6	0.5	0.1	-1.0
Electricity	8.1	0.9	-0.3	-5.3	-0.1	-0.3	-2.8

Note: Percentage change relative to the base (1999–2000 actual) case

Table 4.4 Percentage Change in Energy Consumption in Urban Areas

Energy	*RS*	*A*	*B*	*C*	*D*	*E*	*G*	*H*	*A*	*B*	*C*	*D*	*E*	*G*	*H*
	Relative to the base case								*Relative to RS*						
Total kerosene	-14	-19	-18	-19	-19	-19	0.8	-9.8	-6.2	-4.9	-6.0	-6.1	-6.3	4.8	17
PDS kerosene	-19	-26	-24	-26	-26	-26	0.9	-14	-8.5	-6.6	-8.5	-8.8	-8.5	6.4	25
Market kerosene	-7	-11	-10	-11	-10	-11	0.6	-4.7	-3.8	-3.0	-3.3	-3.2	-3.8	3.0	8.7
LPG	-36	-35	-35	-34	-33	-33	-40	-36	2.0	1.7	2.3	4.1	3.6	-0.3	-6.2
Firewood	4.3	5.7	5.1	6.0	5.6	5.7	0.3	3.8	1.3	0.7	1.6	1.2	1.3	-0.5	-3.9
Electricity	-2.1	-2.1	-2.1	-1.7	0.1	-2.1	-1.4	-5.3	0.0	0.0	0.5	2.3	0.1	-3.2	0.7

RS (reduced subsidy) – PDS kerosene price increases by Rs 4 per liter and LPG cylinder price increases by Rs 124

A –PDS kerosene price increases by Rs 6 per liter and LPG cylinder price increases by Rs 124

B – PDS kerosene price increases by Rs 4 per liter for BPL, Rs 6 per liter for APL, and LPG cylinder price increases by Rs 124 for all households

C – Same as A but Rs 100 per month is given to BPL households

D – Same as A but Rs 100 per month is given to all households

E – PDS kerosene price increases by Rs 6 per liter for all households and LPG cylinder price by Rs 124 only for APL households

G – PDS kerosene subsidy is retained in full and LPG cylinder price increases by Rs 124

H – Same as RS, and in addition the number of PDS kerosene dealers is increased by 10 percent

4.15 Comparison of Table 4.2 and Table 4.4 shows that in the reduced subsidy scenario and in cases A–E, the fall in the consumption of PDS kerosene, market kerosene, and LPG is greater, and the increase in the consumption of wood much greater, in urban areas than in rural areas. The patterns with respect to kerosene and LPG may reflect the fact that a significantly greater proportion of households use kerosene and LPG in urban areas, and those

users who are not well off respond more to price increases. Although the fall in wood consumption in rural areas with subsidy reduction seems questionable, it is possible that wood consumption rises more in urban areas because of the greater reliance in these areas on kerosene and LPG for cooking, for which wood is a substitute. Comparison of case A and case C shows that the poor would not spend the extra Rs 100 per month on the purchase of fuel—a finding similar to that for rural households.

4.16 The only difference between the reduced subsidy scenario and case B is that in the latter APL households pay an extra Rs 2 per liter for PDS kerosene. Urban APL households respond to this additional price increase by increasing LPG consumption at the expense of kerosene. Comparison of case C and case D shows that APL households may spend a little of the extra Rs 100 on LPG, but not on kerosene. APL households would, however, use more electricity. Case H suggests that the effect of reducing the kerosene subsidy could be partially compensated by increasing the number of PDS kerosene dealers, although LPG consumption falls slightly.

4.17 The key findings of the modeling exercise can be summarized as follows:

- Increasing the prices of kerosene and LPG (by reducing subsidies) causes a greater reduction in the use of PDS kerosene, market kerosene, and LPG in urban areas than in rural areas, probably on account of the greater use of kerosene and LPG for cooking by low- and middle-income households in urban areas.
- With respect to possible compensatory measures, a cash transfer to the poor of Rs 100 per household per month did not much change fuel selection. Using cleaner fuels apparently is not a top priority of poor households, especially not of those that have access to free or cheap biomass.
- Increasing everyone's income by 10 percent resulted in an increase in the consumption of every energy source in rural areas, but a drop in the use of firewood and kerosene (in favor of LPG) in urban areas.
- If PDS kerosene is to be preserved, increasing the number of PDS kerosene dealers may be one way of lowering the transaction cost of buying PDS kerosene and of reducing leakage.

The hypothesis that the use of LPG may be limited by supply constraints, in addition to income and price considerations, could not be tested adequately because increasing the number of LPG dealers gave inconclusive results.