Lee Kuan Yew School of Public Policy
National University of Singapore

469C Bukit Timah Road
Oei Tiong Ham Building
Singapore 259772
Tel: (65) 6516 6134 Fax: (65) 6778 1020
Website: www.lkyspp.nus.edu.sg

Lee Kuan Yew School of Public Policy
Accepted Paper Series

Coping with the Cold: Space Heating and the Urban Poor in Developing Countries

Wu Xun
Lee Kuan Yew School of Public Policy
National University of Singapore
Singapore
Email: sppwuxun@nus.edu.sg

Julian Lampietti
Europe and Central Asia Region, the World Bank
Email: jlampietti@worldbank.org

Anke Sofia Meyer
Europe and Central Asia Region, the World Bank
Email: asmeyer@attglobal.net

May 01, 2004

Accepted Paper No.: LKYSPP13-11

Abstract

While providing affordable warmth to the urban poor is among the main challenges facing many developing countries, so far there has been no empirical work on the demand for space heating for the urban poor in developing countries. One explanation for this gap in the literature is that the urban poor often use a mix of fuels and it is virtually impossible to separate this mix into end uses such as heating, cooking, and lighting. This paper exploits a natural experiment in household survey data collected in three countries — Armenia, Moldova, and Kyrgyz Republic — to model household demand for space heating, and then derives policy implications for designing appropriate heating strategies to provide affordable warmth to the urban poor.

JEL code: G41

Key words: space heating, affordable warmth, and the urban poor

Please Cite as:

Wu, Xun, Julian Lampietti, and Anke Meyer. Coping with the Cold: Space Heating and the Urban Poor in Developing Countries, *Energy Economics* 26(3), 2004.

Introduction

Warmth – it is as essential as food and shelter for survival in many developing countries but, despite the potentially large public benefits associated with its provision, it does not receive much attention from policy makers. Inadequate warmth increases the likelihood of cardiovascular and respiratory disease, directly contributing to excess winter mortality. Yet you can't buy warmth, you can only buy the fuel, appliances, and housing necessary to create and contain it.

This paper investigates the demand for space heating in Europe and Central Asia and derives public policy implications of providing affordable warmth for the urban poor. Providing affordable warmth for the urban poor is important for three reasons. First, as regional energy prices are brought into line with world market prices households without access to inexpensive substitutes must spend an ever larger share of their income on heating. Second, there may be substantial negative environmental and health externalities associated with the burning of inexpensive substitutes such as wood and coal. Third, the combination of low energy prices and central planning resulted in ubiquitous infrastructure for heating, which is district heating networks, with low fuel efficiency, further complicating the design of cost recovery measures that are part of energy sector restructuring everywhere.

In the last decade, international organizations such as the World Bank and the European Bank for Reconstruction and Development have focused on providing financing for rehabilitating district heating systems. Experience in restructuring these systems, for example, in Poland and the Baltics has shown that, through a combination of investments, institutional improvements and sector reform, those district heating systems can be modernized—approaching the efficiency, cost and service observed in Western and Northern Europe. However, this experience may not be fully applicable in countries with large numbers of poor households. For example, even though district-heating systems can be the most cost-effective heating mode given a high heat load, their high ratio of fixed to variable costs may make them prohibitively expensive when only a small amount of heat is demanded. A better understanding of the demand for space heating is therefore crucial for designing appropriate policy for the urban poor in developing countries.

While household energy demand has been an active research area in the past two decades (Dubin and McFadden, 1984; Baker, Blundell and Micklewright, 1989; Baker and Blundell, 1991; Assimakopoulos, 1992; Poyer and Williams; 1993; Vaage, 2000), there have been only a few studies on the demand for space heating (Nesbakken, 2001; Leth-Petersen and Togeby, 2001; Liao and Chang, 2002), and to our knowledge, there is no published empirical work on the demand for space heating in developing countries. We postulate two reasons. First, leading household modeling strategies require large—and sometimes historical—data that are typically not available in developing countries. Second, households consume a mix of fuels and it virtually impossible to separate this mix into end uses such as heating, cooking, and lighting.

The classic approach to identifying heat consumption is to use norms to net out basic needs, and then to study the residual, but the drawback is that it obscures the variations in consumption and spending patterns that are of interest here. This paper exploits a natural experiment in household survey data collected in three countries—Armenia, Moldova, and Kyrgyz Republic—to model household demand for space heating. In these three countries, district heating has become quite unreliable or has not been supplied at all in many locations, and therefore households have resorted to alternative sources of heating. The analysis is limited to urban households because they are more constrained in their heating choices and thus the welfare effects of public policies are expected to be larger. The model provides new insights for governments and the international donor community on how to provide poor households with affordable warmth.

The rest of the paper proceeds as follows. The next section presents the main characteristics of space heating in Eastern Europe and Central Asia during the period of transition from planning economy to market economy. Section 3 describes data and presents our empirical findings, and Section 4 extends our analysis by focusing on issues regarding the differences between the poor and the non-poor in heating consumption, expenditure for heating, as well as in price and income elasticity. In the last section, we conclude the analysis by discussing policy options for space heating for the urban poor.

Space Heating in Eastern Europe and Central Asia

Heating is a critical issue for people's livelihoods in Eastern Europe and Central Asia. Urban areas in the region have three unique features that distort patterns of development and limit household choices when it comes to living conditions. The first is the region's cold climate, which necessitates high spending on heating, winter clothing, and food. The second is the legacy of central planning, which provided almost universal access to infrastructure services— many of which are rapidly deteriorating. The third is the drop in household incomes over the past 10 years. These factors influence profoundly how heat can be provided in the future for the urban poor in Eastern Europe and Central Asia.

The cold weather. Average temperatures in the region are well below those in most other regions. During the coldest winter days temperatures often drop below minus 20^{o} Celsius in many places, and as a result heating is required for five to seven months in most places. People at the same income level as in other regions are worse off in Eastern Europe and Central Asia because additional expenditures on heat, warm clothes, and food are necessary to survive during the cold winters.

The crumbling legacy of central planning. Under central planning, the region's governments provided almost universal access to infrastructure services. For example, close to 100 percent of households have electricity connections. In urban areas, space heating and in many cases domestic hot water supply were also a part of the cradle-to-grave centrally planned system. In the 1950s large, centralized district heating became the system of choice because it had the potential of efficiently using the waste heat recovered from power generation through combined heat and power (CHP) plants.

Users of district heating systems had no influence over when and how much heat was provided. They could be reasonably assured, however, that heat would be provided for free as soon as outside temperatures dropped below 8° Celsius for at least five days. Heating systems would then be operational until temperatures were above 8° Celsius for at least five days. Rooms would be heated to at least 20° Celsius most of the time and, lacking individual controls, consumers would respond to overheating by opening windows—even in the winter.

Even before the 1990s, district heating systems suffered from a lack of maintenance and financing. In the early 1990s, financial difficulties created by the collapse of the centrally planned economies were aggravated by the increase in primary energy prices in these countries. The costs of providing heat began to soar, and one government after another decided to raise residential heat tariffs closer to supply costs. Higher heat tariffs coincided with the lower household incomes caused by the contraction in economic activity.

While not having control over the amount of heat consumed may have been acceptable when heat was essentially free of charge, it became untenable as prices rose. Coupled with late or nonpayment of salaries and pensions as well as a loss of entitlements, many households responded by not paying their heating bills, falling behind in their payments or switching to less expensive heating fuels, all of which contribute to the further deterioration of the district heating systems.

Falling household incomes. Between 1991 and 1996 real incomes dropped by 14 percent a year in Eastern Europe and Central Asia. Between 1996 and 2000 real incomes grew slightly, by just under 1 percent a year. Such changes have been accompanied by increasing income polarization, and in many countries urban poverty has reached alarming levels.

While real incomes have stabilized, real energy prices have continued to rise.

Governments have been eliminating energy subsidies, pushing utilities to raise prices in an attempt to improve cost recovery. Many of the price increases have been substantial—for example, between 1991 and 2000 the price of electricity jumped by an average of 177 percent throughout Eastern Europe and Central Asia[1]. The changes in energy prices and incomes between 1991 and 2000 are shown in Figure 1. The figure separates price changes in clean (liquefied petroleum gas, electricity, district heat, natural gas, and kerosene) and dirty fuels (coal, wood, and diesel). The price of clean fuels rose much faster (110 percent between 1991 and 2000) than that of dirty fuels (45 percent). Thus energy, particularly from clean fuels, has become a relatively more expensive component of consumption, and households, especially the poor, are faced with an increasingly difficult choice of how much money to spend on what kind of fuels.

Figure 2 shows the heating fuel choices of households not on district heating networks, based on 1999 household survey data for Armenia, the Kyrgyz Republic, and Moldova. When free to choose, the poor are more likely to use dirty fuels such as wood (Armenia) and coal (Moldova), while the non-poor rely on clean fuels such as electricity and central gas.

These patterns have important implications for heating interventions. First, as incomes fall, people buy dirtier heating fuels. Second, while cash transfers may offset the welfare effects of higher heating prices, they will not stop households from using dirtier fuels if the prices of those fuels are not raised as well. Thus thought should be given to designing heating policies that take into account the social costs of burning dirty fuels. These include the health costs associated with not having enough heat and the resulting productivity losses**,** the health costs associated with burning dirty fuels, the environmental costs associated with deforestation, and the opportunity costs of time spent collecting heating material—especially wood.

[1] These data cover Armenia, Azerbaijan, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Tajikistan, and Uzbekistan.

Estimating Demand for Space Heating: Data and Results

Data and Estimation Approach

We use household survey data from Armenia, Kyrgyz Republic and Moldova in our estimation of the demand for space heating. The survey data from these three countries are selected because they include sufficient information on household energy consumption and expenditure patterns. Information on some variables that are not included in the survey data but essential for our modeling, for example, temperature, are collected from additional sources.

Although these survey data contain significant amounts of information on energy consumption in general and heating in specific, separating the demand for heat from nonheat energy is difficult because households consume a mix of fuels for a variety of purposes. For example, one household may use wood for heating and cooking in the winter and LPG for cooking in the summer. Another may use electricity for heating and gas for cooking in the winter and electricity for air conditioning and gas for cooking in the summer.

To solve this problem, we developed a new approach to estimating heat demand. The approach relies on two sub-samples: households that are connected to the district heating network and report that district heating is their only source of heat, and households that have no central heat. For the first group, all non-central heat energy consumption is only for nonheat purposes such as lighting and cooking; for the second group, energy consumption includes not only consumption for nonheat purposes but also for heat. Comparing the total energy consumption (not including central heat) of these two groups of households makes it possible to isolate the energy used for heating. A scatter-plot illustrating this relationship for the three countries is presented in Figure 3. We exploit this natural experiment in our data to develop and estimate a nested heat demand model.

Model Specification

We start with the following reduced form equation:

$$q_i = \alpha_0 + \alpha_1 income_i + \alpha_2 p_i^{nh} + \alpha_3 hhsize_i + \alpha_{4i}(1 - DH_i) \quad (1)$$

where energy consumption (q_i) for household (i) is a function of income, price of nonheat energy (p^{nh}), and whether or not the household is on the district heating network (DH_i). For households with district heating (DH_i=1) the equation becomes:

$$q_i = \alpha_0 + \alpha_1 income_i + \alpha_2 p_i^{nh} + \alpha_3 hhsize_i \quad (2)$$

This actually becomes the estimation equation to determine the energy consumption for nonheat consumption because q_i for households with district heating account for nonheat consumption only. We assume that the demand for nonheat consumption is determined by income level, price of nonheat energy and household size.

For households without district heating (DH_i=0) equation (2) becomes

$$q_i = \alpha_0 + \alpha_1 income_i + \alpha_2 p_i^{nh} + \alpha_3 hhsize_i + \alpha_{4i} \quad (3)$$

Since households with district heating do not consume other fuels for heating, the difference between the two equations, or α_{4i} , can be interpreted as a measurement of heat consumption for households without district heating. Therefore,

$$q_i^{heating} = \alpha_{4i} \quad (4)$$

Suppose that the demand function for heating can be specified as

$$q_i^{heating} = \beta_0 + \beta_1 income_i + \beta_2 p_i^{heating} + \beta_3 room_i + \beta_4 apartment_i + \beta_5 temperature_i \quad (5)$$

where $p^{heating}$ is the price of heating fuels. Other than the price of heating fuels, the number of room (room), type of household (apartment=1 if the household lives in an apartment; apartment=0 for all others) and mean temperature during the heating season for cities where the households reside ($temperature_i$) are other variables that determine the level of household heating consumption.

Notice that (4) and (5) share the same left-hand side, so that:

$$\alpha_{4i} = \beta_0 + \beta_1 income_i + \beta_2 p_i^{heating} + \beta_3 room_i + \beta_4 apartment_i + \beta_5 temperature_i \quad (6)$$

Since we don't know α_{4i}, equation (6) cannot be estimated directly. However, the coefficients for equation (6) can be estimated by linking (6) with (1) through α_{4i} .

Substituting (6) into (1) yields the following new equation:

$$
\begin{aligned}
q_i &= \alpha_0 + \alpha_1 income_i + \alpha_2 p_i^{nh} + \alpha_3 hhsize_i + \alpha_{4i}(1-DH_i) \\
&= \alpha_0 + \alpha_1 income_i + \alpha_2 p_i^{nh} + \alpha_3 hhsize_i \\
&+(\beta_0 + \beta_1 income_i + \beta_2 p_i^{heating} + \beta_3 room_i + \beta_4 apartment_i + \beta_5 temperature_i)(1-DH_i) \\
&= \alpha_0 + \alpha_1 income_i + \alpha_2 p_i^{nh} + \alpha_3 hhsize_i \\
&+\beta_0(1-DH_i) + \beta_1 income_i(1-DH_i) + \beta_2 p_i^{heating}(1-DH_i) \\
&+\beta_3 room_i(1-DH_i) + \beta_4 apartment_i(1-DH_i) + \beta_5 temperature_i(1-DH_i)
\end{aligned}
$$

which can be estimated directly, and the coefficients for demand function for heating are coefficients for the dummy variable ($1-DH_i$), and interaction terms such as $income_i(1-DH_i)$, $p^{heating}(1-DH_i)$, $room_i(1-DH_i)$, $apartment_i(1-DH_i)$ and $temperature_i(1-DH_i)$, respectively.

Empirical Results

The nested heat demand model fits the data well in all three countries and the results are reported in Table 1. F-statistics are highly significant and the R-square is in the range of 0.4 to 0.5. All of the variables, except temperature[2], have the expected sign and are statistically significant at the 5 percent level. Energy consumption increases with both income and household size and it decreases with energy price. Households with district heating consume less energy than those without, and finally, households with more rooms consume more heat and households living in apartments consume less heat than in houses.

With the regression results, household heat consumption can be calculated and a household demand function for heating can be drawn based on our data for the three countries studied. We expect a heat demand function to be kinked, sloping steeply around the minimum

[2] The temperature variable shows the correct sign and is statistically significant for the model estimation for Moldova; however, it has the wrong sign for models for Armenia and Kyrgyz republic, albeit statistically insignificant. There are several explanations for the mixed results for the coefficients of the temperature variable. First of all, we used mean temperature during the heating season (November through February) instead of the number of heating days to measure temperature as it is only available for us for the three countries. The mean temperature variable may reduce the variation in the data. Second, the majority of household in our data come from a few cities and there is no variation in temperature for households living in the same cities.

amount needed for survival and then rapidly leveling off as the quantity of heat goes from necessity to luxury. Identifying the location of this kink is important empirically because at prices above it demand is inelastic and welfare losses are large—while at prices below it demand is more elastic and welfare losses are smaller.

A scatter plot of household heat consumption against price per kgoe[3] for Armenia, the Kyrgyz Republic, and Moldova suggests a demand curve of precisely this shape (see Figure 4 for details). There is a steep downward slope below 250 kgoe and above $0.2 per kgoe followed by a rapid flattening out. It appears that households alter their heating strategies quickly in response to price changes in the range of $0.01–0.20 per kgoe— and that for households without substitution opportunities, welfare losses will be greater when the price rises above $0.2 per kgoe (equivalent to $0.017 per kWh). In these cases it will be particularly important to design policies that cushion the blow of energy price increases on the poor.

Space Heating and the Urban Poor

The model results can be used to analyze the relationship between space heating and the urban poor. In particular, we focus our attention on two questions: 1) how much heat do poor households consume? 2) how much do poor household spend on heating?

How much heat do poor households consume? While there is not much differentiation in living area because commercial real estate markets are not well developed in the sample countries, larger (poor) households tend to consume more energy than smaller (non-poor) households. However, the poor consume less energy than the non-poor on per capita basis. Figure 5 presents a comparison between the poor and the non-poor in energy consumption on a per capita basis. The figure reveals that in all three countries the poor consume less heat per capita than do the nonpoor.

---

[3] Comparing energy consumption patterns requires converting different fuels to equivalent energy values. Conversions to kilograms of oil equivalent (kgoe) are based on mean values of fuel energy content relative to oil, so the exact heat content of a given fuel will vary depending on its quality and efficiency in combustion. This paper uses the following equivalence values: 1 kilowatt-hour of electricity=0.085 kgoe; 1 cubic meter of central gas=0.833 kgoe; 1 kilogram of LPG=1.059 kgoe; 1liter of kerosene=0.824 kgoe; 1 kilogram of wood=0.376 kgoe; 1 kilogram of coal=0.541kgoe. The source is the International Energy Agency.

The calculation shows that annual nonheat energy consumption ranges from 50 kgoe per capita in Armenia to about 125 kgoe in the Kyrgyz Republic, and annual heat consumption ranges from 40 kgoe per capita in Armenia to 175 kgoe in Moldova to 180 kgoe in the Kyrgyz Republic.

Thus heat consumption accounts for 40–60 percent of total energy consumption. Differences across countries in heat consumption are mainly driven by differences in climate and energy pricing. For example, Armenia is the “warmest” country of the three and has the highest energy price level.

How much do poor household spend on heating? To calculate heating expenditures, we multiply heat consumption by the price of a household’s primary heating fuel. The results are reported in Figure 6. These calculations indicate that heating accounts for 5–10 percent of household spending and for 20–40 percent of energy spending. On average the poor spend almost twice as much of their household budgets on heating as do the nonpoor. In absolute terms nonpoor households spend $30–50 a year on heating and poor households spend $25–40.

These results are important for three reasons. First, that the poor spend a larger share of their budgets on heating suggests that it is possible to design a heating subsidy that benefits them more than the nonpoor. Second, that heat is a large share of energy spending suggests higher heating prices will considerably reduce household welfare unless inexpensive substitutes are available.

Third, poor people are unlikely to pay for heating systems that cost more than $25–40 a year because they can find less expensive ways to heat themselves. They might, however, be willing to pay slightly more for heating systems that are substantially more convenient.

Policy Implications and Conclusion

The results of the paper shed light on the choices of policy options for designing heating strategies for the urban poor in developing countries. First of all, in the countries studied, poor people cope with unreliable or non-functioning district heating and rising energy prices by substituting less expensive dirty energy, including wood, coal, and kerosene. But there are private and social costs associated with poor people's heating choices. Private costs include the opportunity cost of the time spent collecting heating material (especially wood) and illnesses and labor productivity losses associated with insufficient heating. Social costs include air pollution from the burning of dirty fuels and the environmental costs associated with deforestation. These costs must be taken into account when evaluating the economic implications of alternative heating policies and investments. It will be particularly important to design policies that cushion the blow of energy price increases.

Second, in the countries studied, nonpoor people obtain heat at a cost of between $30 and $50 per year while poor people spend between $25 and $40 a year. Although the absolute cost differences are small, proportionally the poor spend almost twice as much of their household budgets on heating as do the nonpoor. This suggests that heating policy or investment interventions that result in higher costs than those of existing systems will face substantial implementation resistance among the poor. Unless there is a significant improvement in heat quality, poor people are unlikely to pay for heating systems that cost more than $25–40 a year because they can find less expensive ways to heat themselves. Any cost recovery strategies must take into account consumer perceptions of system quality, which is a function of cost and convenience.

Third, consistent with the expectation that the poor already have cut heat consumption close to the minimum needed to avoid very serious health problems and chosen dirtier fuels to further save money, the survey data show that the poor are less income and less price elastic than the nonpoor. This implies greater proportionate welfare losses to the poor and a more active search for substitutes if heating prices increase. This suggests the possibility of designing price-based heating subsidies that benefit the poor more than the nonpoor. However, in targeting subsidies, subsidy design must be based on an understanding of income-linked access rates to clean energy networks. If the poor lack network access, the bulk of network-based subsidies would be captured by the nonpoor and therefore subsidies for non-network solutions might result in better poverty targeting.

Finally, our analysis shows that household demand for heating becomes much more elastic at prices below $0.20 per kilogram of energy equivalent (equal to $0.017 per kWh) and the consumption level of about 500 kgoe (equal to 5880 kWh). Because the long run marginal cost of clean energy sources is everywhere above that cost and unlikely to fall, network heat suppliers recovering full costs will be operating in an inelastic portion of the consumer demand curve. The inflection point will vary by country, but is useful to estimate because it provides policy guidance on the price above which consumer welfare begins to drop quickly and complementary interventions to address this drop may be needed.

What do these results imply for the type of heating technologies to be supported? While this paper does not go into details of different technologies, their costs and institutional challenges (for this see "Coping with the Cold", World Bank Discussion Paper 2002), several requirements are obvious.

First, heat needs to be provided in a flexible way, meaning that heat consumption must be controlled and metered at the household level and billed accordingly, so that households can choose the level of heating and heating expenditures that is affordable for them.

Second, households need to have a greater choice of available heating technologies and providers. Currently, most governments and heating sector experts in Eastern Europe and Central Asia are still fixated on district heating as the only heating system worthy of public support. District heating is a local monopoly and tightly regulated and controlled by municipalities. Based on the survey results, it appears that for many years to come household incomes in many localities will not be sufficient to pay for the level of heat that district heating systems are designed to deliver. With substantially lower consumption and accordingly lower payments, many district heating systems will not be viable. Governments and regulators should therefore consider opening the heating sector to new players under a set of new rules that are restricted to ensuring safety and environmental performance. Those new players could, for example, provide improved fuel stoves or set up small boilers under contracts with a small number of buildings. Some initial public support through financing, business development, etc. should be considered.

Third, more importance needs to be paid to improving residential buildings. In Eastern Europe and Central Asia most buildings consume two to three times as much heat as buildings in comparable climates in Western Europe. Improving the tightness of the building shell lowers the requirements for heating and thereby the costs of achieving a minimum or desired comfort level. Poor households would however need some financial support to be able to afford those investments.

Reference

Assimakopoulos, V., 1992, Residential energy demand modeling in developing regions, Energy Economics 14, 57-63.

Baker, P., R. Blundell and J. Michlewright, 1989, Modeling household energy expenditures using micro data, Economic Journal 99, 720-738.

Dubin, J. and D. McFadden, 1984, An econometric analysis of residential electric appliance holdings and consumption, Econometrica 52, 118-131.

Lampietti, J. and A. Meyer, 2001, Coping with the Cold: Heating Strategies for ECA's Urban Poor, World Bank Discussion Paper.

Leth-Petersen, S. and M. Togeby, 2001, Demand for space heating in apartment blocks: measuring effects of policy measures aiming at reducing energy consumption, Energy Economics 23, 387-403.

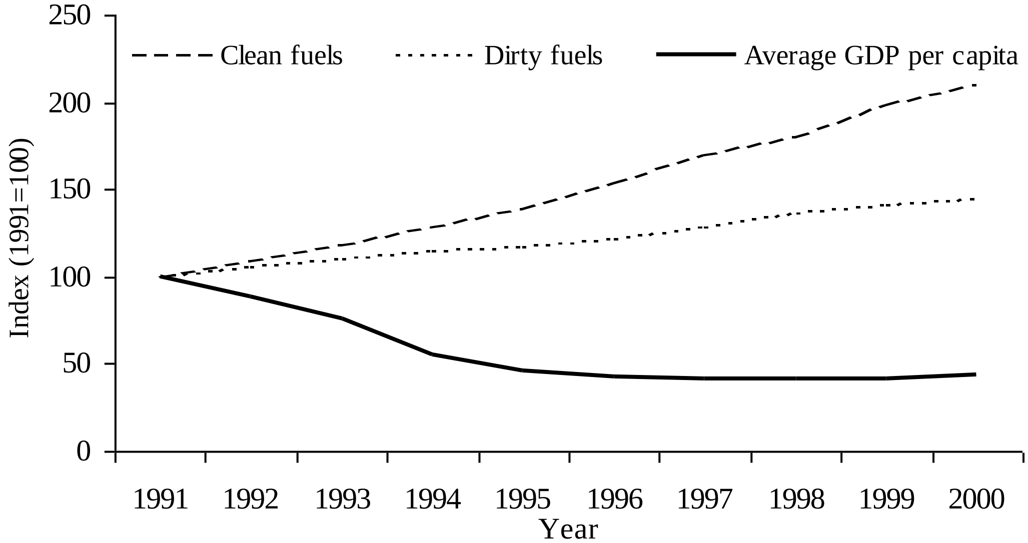
Lian, H. and T. Chang, 2002, Space-heating and water-heating energy demands of the aged in the US, Energy Economics, 24, 267-284

Nesbakken, R., 2001, Energy consumption for space heating: a discrete-continuous approach, Scandinavian Journal of Economics, 103(1), 165-184

Poyer, D., and M. Williams, 1993, Residential energy demand: additional empirical evidence by minority household type, Energy Economics 15, 93-100.

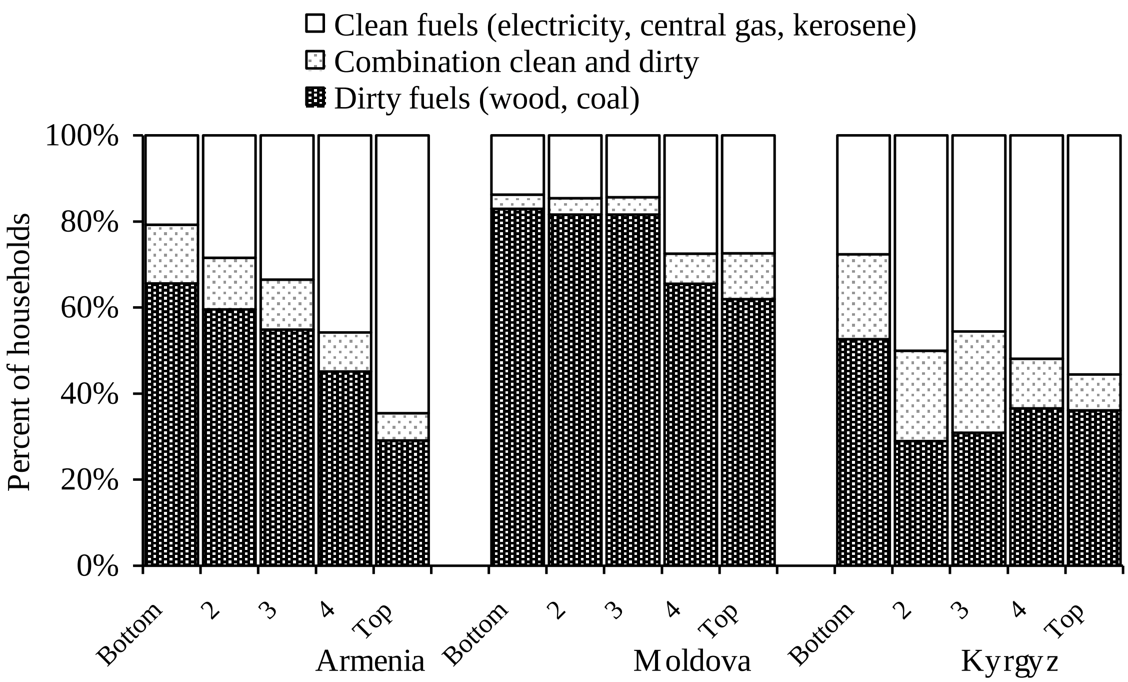
Vaage, Kjell, 2000, Heating technology and energy use: a discrete/continuous choice approach to Norwegian household energy demand, Energy Economics 22, 649-666.

Figure 1 Relative changes in energy prices and incomes in Eastern Europe and Central Asia, 1991–2000



Source: Author's calculations from International Energy Agency data and World Bank data.

Figure 2 Urban household heating fuel choices by income quintile

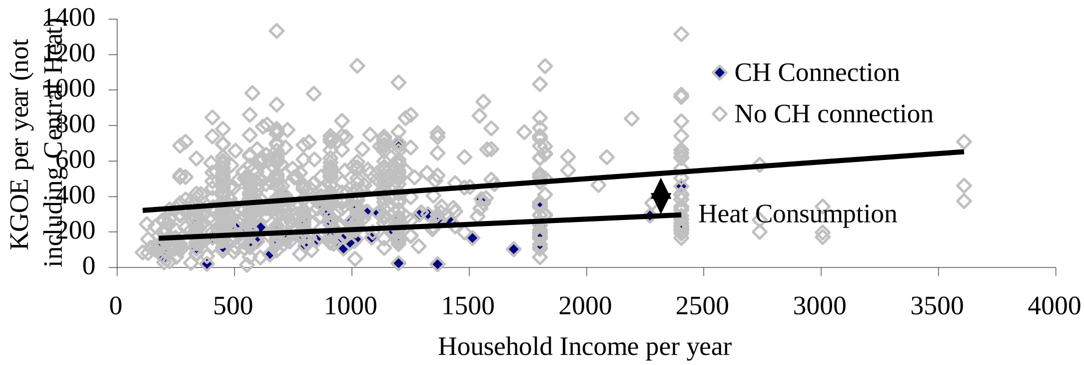


Note: Excludes district heating.

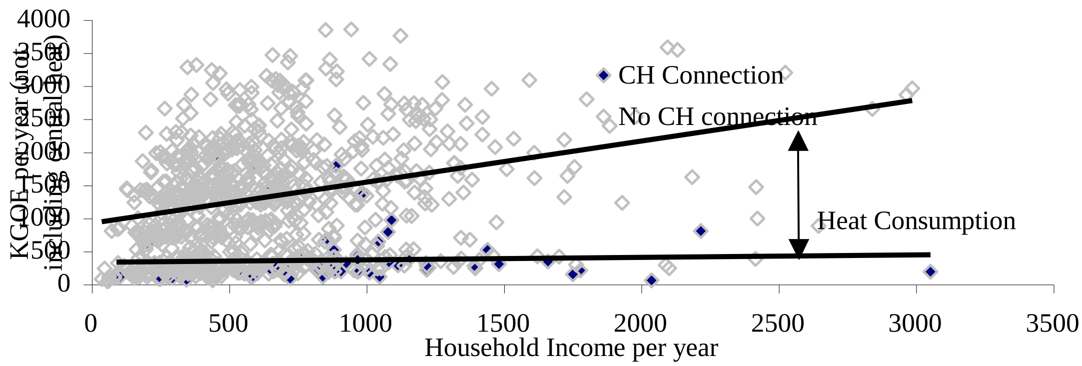
Source: Author’s calculations from 1999 household survey data.

Figure 3 Satterplots for Energy Consumption

A. Armenia



B. Kyrgyz



C. Moldova

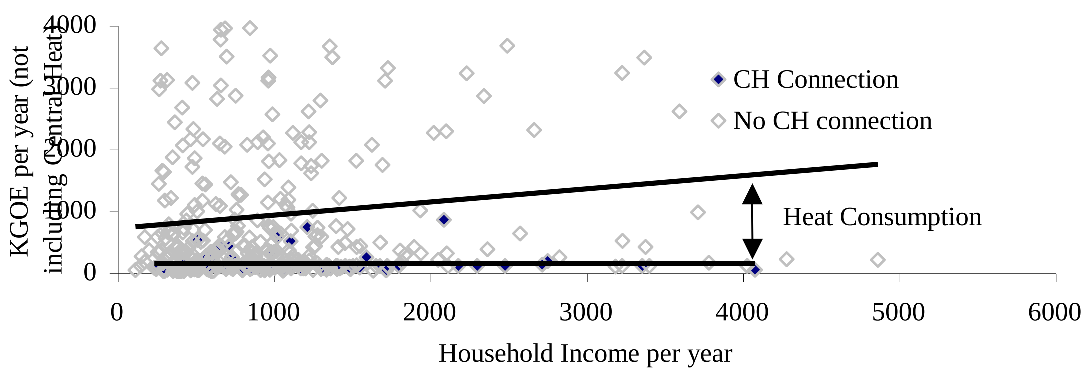
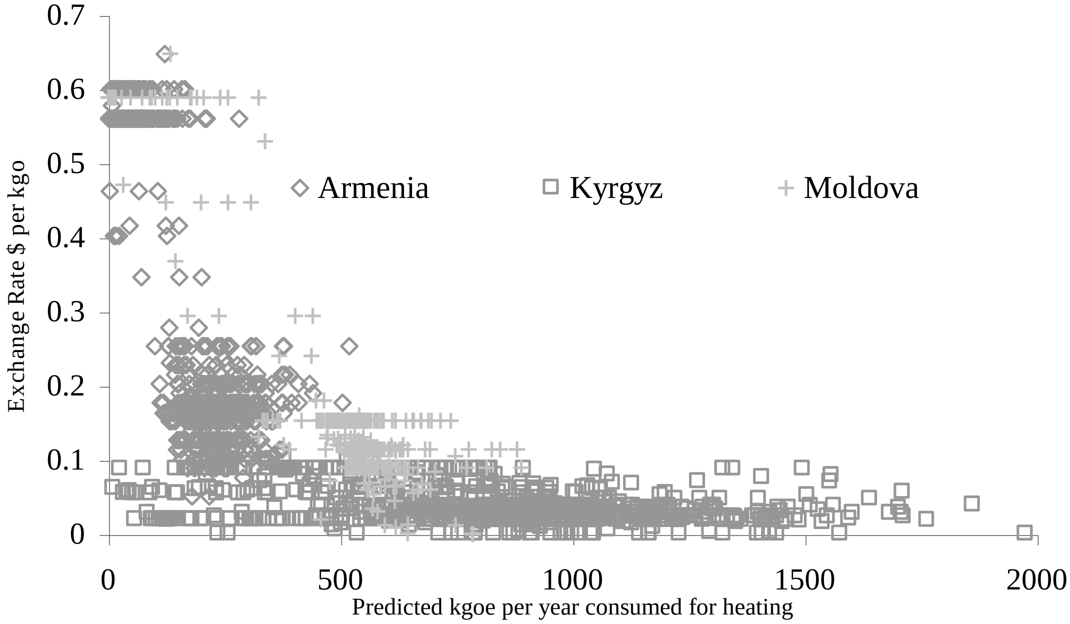


Table 1 Heat demand estimation results

Description	Armenia Coef.	Armenia t-stat	Kyrgyz Coef.	Kyrgyz t-stat	Moldova Coef.	Moldova t-stat
Per capita expenditure Quintiles	17.59	2.91	54.03	2.01	17.52	0.36
Non-heat energy price index	-125.73	-2.42	-3485.1	-6.01	-1291.2	-13.04
Household size	17.69	4.2	69.14	4.23	18.87	0.48
1-DH (DH=1 for households with district heat)	196.88	5.27	377.37	2.65	576.25	3.03
(1-DH) x per capita expenditure	0.06	3.87	0.31	3.51	0.14	1.45
(1-DH) x price of primary heat fuel	-445.03	-9.62	-6123.7	-6.87	-1443.3	-3.49
(1-DH) x number of rooms	34.64	5.27	166.18	8.45	74.75	2.19
(1-DH) x apartment	-67.33	-4.89	-512.62	-6.63	-40.52	-0.12
(1-DH) x Mean temperature	3.74	1.34	13.84	0.69	-108.37	-2.83
Constant	146.07	2.98	317.35	1.89	730.01	2.74
R^2	0.5		0.47		0.41	
F	F(9, 734) = 81.69		F(9, 904) = 90.24		F(9, 399) = 30.72	
N	744		914		409	

Source: Author's calculations.

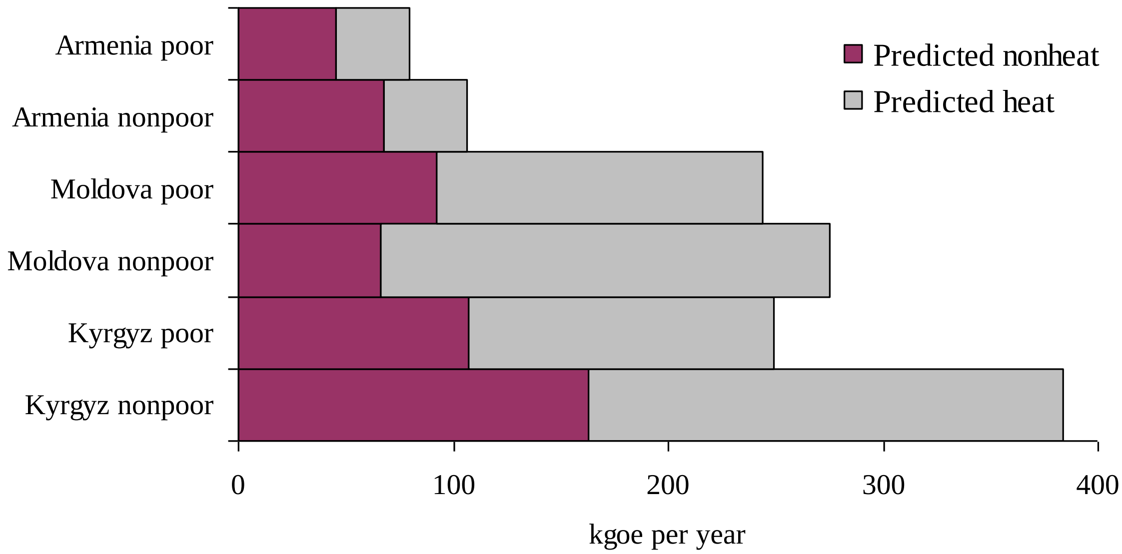
Figure 4 Demand for heat in selected countries



Note: Excludes district heating.

Source: Author's calculations.

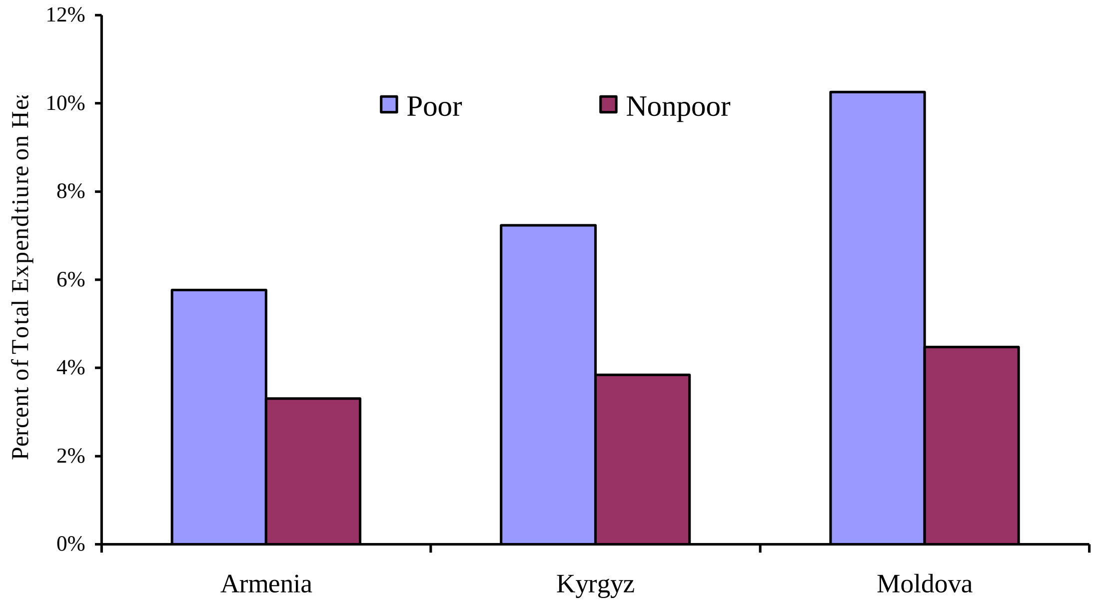
Figure 5 Predicted per capita heat and nonheat energy consumption in selected countries



Note: Excludes households on district heat.

Source: Author's calculations.

Figure 6 Predicted heat expenditure as a percentage of household expenditures



Note: Excludes households on district heat.

Source: Author's calculations.