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Ali Shamsavari

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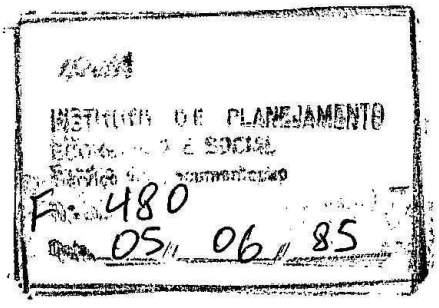
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A CRITICAL LOOK AT THE THEORIES OF HOUSEHOLD DEMAND FOR ENERGY*

Ali Shamsavari

Rio de Janeiro Junho 1982

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*As opiniões expressas neste trabalho são pessoais, não devendo ser encaradas como a posição oficial do IPEA

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PART I

INTRODUCTION

The past ten years have witnessed a growing interest in research on demand (whether industrial, commercial or residential) for energy (1), on the part of both scientists and public policy-makers. This trend was primarily set in motion by the large increases in energy prices in the early 70's due to a four-fold oil price like by the Organization of Oil-Producing Countries (OPEC). Industrialized countries which are major users of energy, especially those amoung them, which depend heavily on imported oil (West European Countries and Japan) responded to this major price rise by putting a great deal of emphasis on energy-saving and conservation as well as attempting to look for new, alternative sources of energy. This adjustment to new prices, besides the search for alternative sources, took two basic forms: 1) By raising the prices of oil derivatives and products using these derivatives for their users, the quantity demanded of these products declined and 2) By efforts to improve the efficiency of energy using equipment and changes in consumption habits some economy was achieved in energy use.

These developments have naturally put the question of the responsiveness of demand for energy on the agenda for scientists, policy-makers and the public. Obviously the effectiveness of public policy in energy saving and conservation depends to a large extent upon the effectiveness of price variable as a policy tool

in bringing about desired changes in levels of energy consumption. That is why the main focus of the studies on demand for energy has been on the price elasticity of demand.

Another important question that has received a lot of attention, especially in more recent times, is the possibilities of inter-fuel substitution. Thus besides (own) price elasticity of demand for one form of energy the responsiveness of that demand to the price of alternative forms of energy (as measured by cross-price elasticity) has been a subject of research and investigation. It is clear that even if total energy consumption may not be responsive to changes in the average price of energy (and, therefore, the possibility of economizing on total energy consumption may be nil), in case different forms of energy can be easily substituted for one other, an economy in the total energy cost can be effected through a shift form more expensive fuel to the less expensive.

Thus the two fundamental issues that have attracted growing attention in the past ten years can be stated as follows:

i) The responsiveness of demand for energy to changes in the price of energy.

ii) The extent of interfuel substitution by various users of energy.

Of course, besides the above two issues, there are a number of other questions that we find discussed and analyzed in the literature on demand for energy. Among these we can mention the

following items:

i) The responsiveness of demand for energy to income. This issue, like others mentioned before, is very important from the view-point of policy-makers. For example, if energy demand is income-elastic and the country is growing economically, energy consumption will grow proportionately more than income.

ii) The effect of social, demographic and geographic factors such as urbanization, population growth and climatic conditions, has also received a lot of attention. (2)

iii) The price of household appliances has also been found to affect energy use in the residential sector.

In what follows we will first question the validity of the current definitions of household demand for energy and raise certain critical issues in this connection, which I believe are very important for proper research on household demand for energy, especially from a public policy point of view (Part II). In Part III we will highlight the complexity of the relationship between price and income elasticity, on the one hand, and their determinant on the other. Finally in Part IV we will deal with the question of interfuel substitution.

PART II

THEORETICAL PROBLEMS IN THE DEFINITION OF DEMAND FOR ENERGY

Demand for energy has been universally defined as derived demand. However, this manner of defining is not free from theoretical ambiguities. Furthermore, there are two problems, not related to the above-mentioned type of definition which also beclouds the proper definition for energy. In this parte we will discuss these problems in the hope of gaining more clarity about the nature of demand for energy.

1 The 'Derived Demand' Definition

The widely accepted definition of demand for energy in the literature is based on the concept of 'derived demand'. This concept ev l ed in Economics in relation to the problem of the nature of demand for productive inputs by firms. Economists who were studying demand for factors of production needed a concept which would capture the specificity of this type of demand in contradistinction to consumer demand for goods. This is how the phrase 'derived demand' was coined with the intention of adequately distinguishing demand for factors of production from demand for consumer goods. Since the word 'demand' had been traditionally used to designate consumer demand, economists were averse to the idea of using the same word in another context. Thus demand for factors of production was predicated by the adjective 'derived' to mean that demand for factors of production is ultimately demand for consumer goods, i.e. it is the demand for consumer goods, which ultimately justifies demand for factors of production. Thus

in this conception, no autonomy is accorded to production and the latter is presumed to be based entirely on consumption. (3) We may trace this conception to the idealogical problematic of the entire neo-classical school, which amounts to the primacy, or if you like, 'sovereignty' of consumer (i.e. household or private consumer).

We do not want to get involved in these theoretical and ideological issues. Our purpose is simply to pinpoint the problems associated with the concept of derived demand.

When researchers on demand for energy began their investigations it was only natural that they characterized demand for energy as derived in order to highlight the particularities of demand for energy. It seemed 'obvious' that energy is demanded by consumers (households) not for its own make but for the uses it has in processes that yield satisfaction to them.

> Electricity does not yield utility in and of itself, but rather is desired as an input in to other processes (or activities) that do yield utility. The demand for electricity is thus a derived demand, derived from the demand for the output of the processes in question.
>
> (Taylor, 1975 , p.80)

This is how Taylor, a major figure in energy-demand studies, defines household demand for energy. (4) In his definition, the 'derived demand' nature of demand for energy is stated strongly and unambiguously. The anolgy implied is clear enough: energy is demanded by households as an input into processes that yield utility in the same way as productive factors are demanded by firms to yield an output.

The difficulty with the above definition is that it suggests a distinction between goods that are directly consumable (and thus a source of direct utility for consumer) and goods that are used as inputs in processes (activities internal to household) whose output is directly consumable. We have no quarrel with the fact that such a distinction can be made, but with the implications of applying such a distinction consistently and universally. Apart from the fact that the holderline between what is directly a source of utility and what is not is hard to draw, and the fact that sometimes the activity itself is a source of utility in addition to its output, a great majority of consumer goods would readily qualify as candidates for 'derived demand' definition. Thus raw meat, spices, dog food, etc., and even items like furniture (so far as they are viewed simply as articles to be put to a practical use, ignoring their aesthetic aspects) would easily be classified as 'inputs into other processes that yield utility'. All these items, it can be claimed, are not desired for their own make but for the utility that their use in a certain household process (activity) yields.

We see that the application of the notion of 'derived demand' to an item of personal consumption is not as easy as it seems at the first sight. But let us assume, for the sake of argument, that this analogy between consumer demand for energy and producers' demand for productive fators is true. If we take this assumption seriously then consumer demand for energy must be treated as a

a truely derived demand, in which case, like the producers' demand for productive inputs it must be not only a function of the price of the input (in fact, the relative price of this input compared to other substitutable inputs) but also a function of the price of output (for which the equivalent, in consumer demand, would be the price [utility] of the good which is produced with the aid of the said input at home).

However, we have not seen any attempt on the part of researchers to model demand for energy in such a way that makes it dependent on the price or cost of the goods or services 'produced' at home using energy as an input. Obviously this price or cost depends on many other prices besides the energy cost. This is not to say that no attempt has been made to take into account the costs of home processes using energy. In fact, researchers in this area have been quite aware of one aspect of these costs, i.e. the price of household appliances using energy. But, obviously, this is not enough. Thus consumers may respond to changes in energy prices not simply by changing the quantities of their stock of household appliances but also by finding alternative ways of satisfying the needs for energy-using goods and services without changing the quantities of these stocks or simultaneously with changing them.

Thus the price of appliances using energy is but one aspect (or one component) of the total price of energy-using goods and services. The interesting feature of this total price is that it relates demand by consumers for energy at home to their demand for energy outside home. (e.g. if this price goes up due to higher energy prices, consumers may find it more economical to use energy outside home. But this may mean that the overall response of the

consumer use of energy is not as big as indicated by the elasticity measurements based on home consumption).

Furthermore, there is another problem associated with the 'derived demand' definition, which we should point out. This definition ignores an asymmetry between consumers' and producers' demand for 'inputs'. This asymmetry consists of the fact that when producers' output increases (e.g. due to an increase in the demand for their output) their demand for energy input increases, while in the case of consumer an increase in the price (output, utility) of energy-using equipment leads to a decrease in 'household' demand for energy.

Having discussed the problems associated with defining demand for energy as derived demand we now turn to some other theoretical issues connected with the definition of demand for energy.

2. Problems of defining the scope of Demand for Energy

One would naturally assume that when researchers talk about household demand for energy what they mean is the Consumption of energy taking place strictly at home (within the household) or through the use of personal means of consumption (such as driving of a personally-owned car). Thus it does not include energy consumption that occurs when consumers use public transportation or eat at a restaurant (or, in some countries take baths at public bath-houses). However, this assumption may not be correct as we can see from the following quotation from a study by Fisher & Kayson. The latter state that according to their findings income elasticity

of household demand for energy in the United States depends on the degree of urbanization, i.e., the more urban an area the higher the responsiveness (elasticity) of demand to changes in income. As a justification for their conclusion they say:

> The richer urban states have a more varied use of appliances of a "luxury" nature such as smaller cooking appliances and air conditioners. Moreover, the "necessary" appliances are, to a larger degree, constant-use appliances. Further, in urban states activities outside the home which compete with the use of electricity in the home, e.g. restaurants, movies, laundries, etc. are widely available. A rise in income, therefore, probably tends to mean more use of electricity both inside and outside the home in urban areas .....(5)

It is obvious from the above quote that Fisher & Kayson are thinking about energy consumption by consumers 'both inside and outside the home' in their justification of the higher income elasticity of household demand for energy. This thought, although very interesting because it highlights the complexity of defining household demand for energy (without really problematizing it), raises serious problems for both the theory and the measurement of this demand. Where do we draw the line between household demand and other types e.g. commercial or industrial, of demand for energy? And how are we to measure consumer demand for energy '<u>outside</u> the home?'

It is clear that for both theoretical reasons and measurement purposes household or consumer demand for energy should be restricted to what is consumed at home or directly by consumers.

If we were to include energy consumption by consumers outside the home (use of public transportation, going to movies, eating out, use of public baths, etc.) we might as well include their consumption of energy through using goods that are manufactured with the help of energy (which, today, includes almost all consumer goods). Thus consumers, by demanding manufactured goods and services, are demanding energy. Therefore, directly and indirectly, all energy use may be reduced, in the last analysis, to consumers' demand for energy.

This is precisely the point where this confusion in theory and measurement links up with the definition of household demand for energy as derived demand. We pointed out in Section 1 of this Part that this definition is, ultimately, based on the primacy or sovereignty of consumers. This problematic, as we remarked earlier in Section 1, denies any autonomy to other varieties of demand besides consumer demand and, thus, leads to confusion of the type we are dealing with in the present Section, i.e. the confusion of consumers' direct use of energy with their <u>indirect</u> use occasioned by their consumption of goods and services (both 'inside and outside the home') which require energy use for their production.

However, an idea suggested by these confusions, should not be missed and left unheeded, i.e., the fact that consumers' response to changing energy prices may involve the substitution of publically produced energy-using goods and services for privately produced ones.

The point mentioned above is very important from public policy point of view; e.g., suppose we wanted to reduce personal consumption of energy because of rising costs of energy imports. If we assume that consumers respond to an increase in the price of energy by using less energy at home without increasing their purchases of energy-using goods and services we might reasonably conclude that a price rise will result in an X - amount of energy saving. However, if consumers adjust to changing energy prices for household consumption by switching to public goods and services the expected saving may not result or may not prove to be as large as expected.

3. Concluding Remarks

We would like to conclude this part by highlighting the main points raised by the preceding commentaries on the problems of defining household demand for energy.

a) If the 'derived demand' definition of household demand for energy is accepted, a great number of articles of consumption would equally satisfy this definition and, thus, the demand for them may be characterized as 'derived demand'. The problem with this definition is that it sets up a false analogy between production and consumption and thus blurs the specific distinction between these two spheres of social economy.

b) In the 'derived demand' definition of household demand for energy the total cost of energy-using home-produced goods and services is ignored, although certain researchers have paid attention to some elements of this cost (primarily the price of energy-using household appliances or their user-cost)

c) Researchers on household demand for energy have looked, for the most part, at individual, 'home' use of energy, ignoring the shifts in the 'modes' of energy consumption by individual consumers. For example, an increase in the price of energy may reduce consumers' demand for energy, at the home, even in the short run. But this may not be taken as an overall decrease in demand for energy by consumers because their demand for energy may have changed its 'mode' of satisfaction from private use to public use. Unless it is determined that as a result of this price increase the overall demand for energy has diminished it cannot be claimed that consumer demand for energy has decreased.

d) In the literature on household demand for energy the question of consumers' adjustment of their demand for energy to changing energy prices, especially in the long run, has been conceived in terms of stock adjustments only. No attention has been paid to the adjustment in the 'mode' of consumption, e.g. the shift by consumers from private to public energy use.

e) All the points above point to the fact that consumption is not a strictly private matter. They point to both the 'technology of consumption' and the 'socialness of consumption'.

This point will become clearer after the discussion in Part III. At this point we may say that the problems and difficulties associated with a proper definition of demand for energy are related to the fact that consumption is generally viewed as a

as a private matter and therefore the possibilities of public consumption is largely ignored.

PART III

THE DETERMINANTS OF THE ELASTICITY OF DEMAND FOR ENERGY

In this part we will review some of the findings on the elasticity of household demand for energy and try to shed some light on the major factors determining it. We will focus mainly on (own) price and income elasticity, postponing the discussion of cross price elasticity until the next part which is devoted entirely to the question of interfuel substitution.

1. The Evidence on Income and Price Elasticities

The evidence on price and income elasticity show that household demand for energy is responsive to changes in incomes and prices especially in the long-run. These points are very well summarized by Taylor in his 1975 survey of the literature on demand for electricity:

> a) The price elasticity of demand for electricity for all classes of consumers, is much larger in the long-run than in the short run.
>
> b) This also holds for the income elasticity of demand.
>
> c) The long-run price elasticity of demand is indicated to the elastic.
>
> d) The evidence on the magnitude of the long-run income elasticity is much more mixed.
> ..... (Taylor, 1975, PP. 101-02)

Taylor's 1977 survey, which covers studies on demand for many other forms of energy besides electricity, basically confirms the above findings. Taylor's major conclusion is that "the price of energy is an important determinant of the amount of energy that is consumed and the form in which it is consumed ... Energy consumption is not simply a matter of income and lifestyle". (Taylor, 1977p. 37)

These findings seem reasonable. The point about higher elasticity of demand in the long run can be explained by the fact that demand for energy is tied up with investments in household appliances whose stock can be varied only in the long-run.

What we are interested in is not the fact that demand for energy is responsive to changes in income and energy price, which has been established by most of the studies on demand for energy, and which is a significant result of these studies. Our primary interest is in the magnitude of these elasticities and their determinants. The existing literature has addressed this question without reaching a consensus. We now turn to this question.

In a study by Fisher & Kaysen the problem of determinants of income and price elasticity is explicitly posed. They find that the degree of economic maturity and also the degree of urbanization affect the magnitude of price and income elasticities. They conclude that:

> The implication..is thus that as the economies of all states mature, short run household electricity demand will become even less price sensitive that it now is.

Furthermore:

> .....The more urban states have significantly higher income elasticity than the less urban states. (6)

As a justification for the last point they point out that firstly "there are significant differences in the composition of white goods stocks as between rural and urban states". In poorer and less urban states 'necessary' appliances such as freezers are more consistently used, while in richer and more urban states the use of 'luxury' appliances such as air-conditioners is more prevalent. Finally, in urban states energy consumption outside the home is larger because of the availability of public facilities such as restaurants, cinemas, etc.

It is on the basis of such studies that Taylor concludes that income and price elasticities are positive functions of the level of income and the degree of urbanization (Taylor, 1975, p.105), i.e., the higher the level of income and degree of urbanization the greater is the responsiveness of demand to changes in income and price.

These conclusions which are mostly based on studies of demand for energy in the United States and Canada cannot be

generalized. The results of a study by the Nordhaus, which is a comparative study of energy consumption in a number of industrialized countries, contradict the above conclusions. In this study both the long-run and the short-run income elasticities of demand for energy have an inverse relationship with the degree of economic development, while price elasticities behave curiously in that price elasticity for both high-income countries such as the U.S.A. and low-income countries such as Italy are higher than that of medium-income countries such as the U.K. (Nordhaus, 1977, pp. 253-254)

These findings suggest that at high levels of income energy consumption by households reaches a saturation point and thus income elasticity is low. On the other hand, at low and medium levels of income the elasticity is higher, i.e. larger incomes lead the consumers to consume relatively more energy. As far as the price elasticity is concerned both high and low income countries show higher responsiveness of consumer demand for energy than the medium income countries.

2. <u>The Complexity of the Relationship between Demand Elasticities and their Determinants</u>.

In view of contradictory results, mentioned above, it seems to me that the relationship between demand elasticities on the one hand, and the level of income and the degree of urbanization, on the other hand, is much more complicated than what is claimed by Taylor, namely, a direct relationship. The following remarks are intended to show the complexity of the relationship.

At low levels of income consumers are just in the process of getting used to energy-using equipment and they are not 'hooked' to energy consumption through the mechanisms of habit formation. A rise in energy price at this stage may easily lead to a very reduced level of consumption of energy. This is not to suggest that consumers' overall use of energy necessarily declines. The point is that in low income countries people have still the opportunities of either going back to traditional sources of energy (e.g. firewood) or switching to traditional public facilities still available (e.g. public baths in the Middle East). Because of these circumstances demand for energy may be price elastic for upward changes in the price of energy. However, a price decrease would substantially encourage the use of the newly acquired energy-using household appliances or the acquisition of such appliances. Therefore, demand would be price-elastic for downward changes in price. Thus, we encounter an asymmetry between elasticities with respect to increases and decreases in price, at this level of income.

At an intermediate level of income where a majority of consumers are used to energy-using household appliances and where, because of this circumstance, traditional sources of energy and traditional public facilities are not available an increase in price of energy will not lead to a drastic reduction in energy consumption. On the other hand, if energy price falls consumption will be encouraged because of the ownership of energy-using appliances and the process of habit formation. Thus for a downward change in

energy price, demand will be price-elastic.

At high levels of income consumers have already acquired the necessary, 'contant use' appliances and are purchasing more 'luxury' equipment. At this stage an increase in energy prices will lead to a reduction in 'luxury' energy consumption at the home (but may increase energy consumption outside the home). At high levels of income public facilities that can satisfy consumers' demand for energy-using goods are available and, in this sense, there is a comparison between high income and low income countries. In the latter we find traditional sources of energy (including human labour) as well as traditional public facilities available for use. In the former, modern public facilities have replaced the traditional facilities. But the existence of these facilities in high income countries make the demand for energy price-elastic (like the case of low income countries) with respect to an upward change in energy price. On the other hand, a fall in energy price will lead to higher levels of energy consumption, i.e., demand is also price elastic with respect to downward changes in energy price.

The discussion above makes it clear that there is no linear and simple relationship between income and price-elasticity of demand. Besides the asymmetry between demand response to a rise and a fall of energy price at certain levels of income, we see that higher incomes do not lead to higher price-elasticities in a smooth, direct or linear fashion.

In the discussion above we touched only the question of the relationship between the level of income and the price-elasticity of demand for energy. However, the question of the relationship between income and income-elasticity of demand is as imprtant. Rather than going into a complicated discussion of this issue we would like to suggest the follwoing idea.

The relative significance of the price and the income variable in explaining demand for energy depends on the level of economic development, income and urbanization.

At low levels of income, economic development and urbanization consumers are not as 'price-conscious' as at higher levels. At these levels price variable is a much less significant determinant of consumption than at higher levels because of the predominance of household 'production' and self-sufficient economy. The major part of 'income' earned by consumers in underdeveloped countries is not 'price-dependent'. Thus under these circumstances income is the most significant explanatory factor in demand. Adequate income and living in more urban areas mean that consumers have enough income to buy household appliances and that dwellings they reside in are 'wired' or 'piped' so that energy consumption is at least 'possible'.

Price variable becomes determinant only under the conditions when i) the basic needs are met and energy consumption becomes a matter of choice between higher or lower levels of utility at the home and ii) the availability of different appliances using different sources of energy and the availability of public sector uses of

energy-using services are presupposed. All this presupposes higher levels of income, urbanization and economic development.

We conclude that, in spite of the empirical findings that show a direct relationship between price and income elasticity on the one hand and the levels of income and degrees of urbanization on the other hand, no such simple, linear relationship exists. Rather, the degree of economic development, urbanization and the level of income tend to reverse the sole of income and price variables, in the determination of demand for energy.

3. Some Important Aspects of the price Elasticity of Demand for Energy

Obviously the (own) price elasticity of demand for energy depends on two main considerations:

i) The possibility of the substitution of non-energy goods and services for energy.

ii) The possibility of the substitution of one form of energy for the other (inter-fuel substitution).

We will leave (ii) for the next part and for the moment focus on point (i). The point that the price elasticity of demand for energy depends on the possibilities of the substitution of non-energy goods for energy has not been missed by the existing literature. Since energy is considered as an input purchased by households to aid them in producing goods and services at home (in the same way as firms buy energy or other inputs is order to

produce goods for sale), again the anology with the firms' demand for inputs is naturally extended to the problem of the substitution of non-energy goods and services for energy by households. Let us look at this issue more closely.

The evidence on industrial demand for energy shows that there is no possiblity of substitution of non-energy inputs for energy, although some substitution of human labour for energy is possible. Thus, we are left primarily with the possibility of interfuel substitution, which in industry requires, normally, changes in technology.

Now if we look at household demand we see that the situation is somewhat different. Consumers facing increased energy prices have the following choices (besides interfuel substitution, which, as in the case of industry, depends on changes in 'technology', if we interprete the latter as changing the stock of household appliances):

i) Consumers can substitute non-energy goods for energy, i.e., they can buy goods and services satisfying their demand for goods that are at present met by using energy (although there are limits to this substitution, for example energy use for heating and lighting at home can be reduced but not completely discontinued). However, the problem with this substitution is that it may not lead to energy saving at the level of the entire economy because the

substituted non-energy goods require energy for their production.

ii) the consumers can substitute public consumption of energy for private use. This depends on the availability of public facilities. This kind of substitution involves the same difficulty as we saw in the case (i) above.

iii) consumers can substitute some human labour for energy.

I believe that these important points have not been raised or adequately dealt with in the existing literature on household demand for energy. It is only through research on the ways and means available to consumers to deal with changes in energy prices, i.e., the opportunities, open to them, for the substitution of non-energy goods or non-privately used energy for private use of energy, that the magnitude and behaviour of price elasticities in different conditions can be explained. Furthermore, multi-sector models that include all major energy-using sectors in the economy are more useful, especially from policy point of view, in determining the responsiveness of demand for energy to changes in energy prices. The discussion in this part has shown that there are complex interactions between energy use in difficult sectors and this is why, I believe, multi-sector models are more relevant for energy demand research.

PART IV

THE QUESTION OF INTER-FUEL SUBSTITUTION

As was pointed out in Part III the (own) price elasticity of demand for energy partly depends on the possibility of the substitution of one type of energy for other types. This poses the question of interfuel substitution and cross-elasticity of demand for energy.

The point that various forms of energy are substitutable for one another is a universally recognized fact. Furthermore, it has been generally established that interfuel substitution depends to a large extent on changes in the type of energy-using household appliances owned by consumers. But what has been largely ignored is the point that besides the problem of the necessity of changes in the type of household appliances when interfuel substitution is contemplated by households, there are definite limits to this substitutability.

In general, researchers have assumed that different types of energy are readily substitutable for each other provided that appropriate changes are made in the type of equipment and appliances used. The following quotation from Taylor is typical:

> The consumption of natural gas has a number of characteristics in common with electricity ... Secondly, natural gas and electricity share many of the same uses and thus are directly competitive forms of energy.
>
> (Taylor, 1977, p.10)

The problem, however, is that given the present technology there are many areas of non-substitutability between electricity and natural gas. And, therefore, gas and electricity may not be 'directly competitive forms of energy' in many instances. This is the reason, I believe, why cross-price elasticities of demand for e.g. electricity, is negligible, especially in the short-run. (Taylor, 1975, p.105)

Most researchers have approached the problem of interfuel substitution by the inclusion of the price of the alternative form of energy in demand equations. This, however, has led to poor results and, as a consequence, researchers have attempted other approaches. I will explain below why this way of approaching has led to bad results and based on that analysis I will suggest other alternatives.

Electricity and gas as forms of energy are substitutable for each other in certain uses by household, but this substitutability has certain conditions and limits. In the first place, since energy-using household appliances and equipment are designed to use only one form of energy, substitution of one form for another depends upon switching from one type of appliance to another. For this reason cross-price elasticities are negligible, especially in the short-run. Secondly, there is an asymmetry between demand for gas and demand for electricity, which has gone unnoticed in the literature on household demand for energy. This asymmetry is due to the fact

that while electricity is a substitute for gas in all household uses of gas (namely, cooking, water heating and winter heating) gas is not a substitute for electricity in all the uses of the latter (it is a substitute only in uses mentioned above). Obviously, demand for gas is sensititve to the price of electricity, especially in the long-run, because, given sufficient price advantages, consumers may decide to substitute electricity for gas. On the other hand, if we consider that part of the demand for electricity which can be satisfied by gas (confined to the above-mentioned uses) it will be sensitive to the price of gas. However, since the total demand for electricity may be much larger than the part confined to uses where it is competitive with gas, demand for electricity is not sensitive to the price of gas.

Because of this asymmetry between demand for electricity and demand for gas I think that these two kinds of demand should be approached asymmetrically. More specifically the following functional forms for these two types of demand may be contemplated:

Quantity demanded of electricity =
F (Income, Price of Electricity & X)

Quantity demanded of gas = F (Income, Price of gas, Price of Electricity & X), where X stands for a set of explanatory variables besides income and prices.

In these forms of equations the asymmetry mentioned above is reflected in the fact that the price of electricity appears as an argument in the demand function for gas, while the price of gas does not appear as an independent variable in the demand function for electricity. This approach is one way of getting around the problem of non-substitutability of gas for electricity. Another more effective way would be to estimate equations of the following type (similar equations have been estimated in some studies in the past, for example, see Chern and Lin 1977, pp 60-74):

Fraction of residential consumers using electricity for cooking (or water heating) = F (Price of Electricity, Price of Gas, Income, Price of Appliances & X)

Or:

Ratio of Electricity using appliances to gas using appliances = F (Price of Electricity, Price of Gas, Income, Price of Appliances & X),

Where X stands for a set of other explanatory variables. The same type of equation can be estimated for gas.

The purpose of the estimating equations above is to estimate demand for each type of energy indirectly through demand for appliances which use that form of energy. The advantage of this method lies in the fact that in attempting to focus on demand for energy relating to comparable and competitive forms it offers a more reasonable approach to inter-fuel substitution.

Of course, if we can somehow isolate that part of demand for electricity which may be satisfied by using gas from total demand for electricity we will be able to approach the problem directly. This is an idea that is well worth pursuing.

FOOTNOTES

1. Throughout this paper whenever we mention demand for energy without specifying its type we mean 'household' demand for energy.

2. The list of various explanatory variables used by different researchers of household demand for energy, besides the traditional price and income variables, is quite extensive. I have discussed some of these variables in my Progress Report No.1 IPEA, July, 1981. Extensive discussions of models using these variables can be found in ERPI (1976),Taylor (1975) and Taylor (1977)

3. Of course this idea is not new, and is not confined to Neo-classical Economics. Classical political economy used the expression 'productive consumption' to designate the use of products by industry in contradistinction to personal consumption of products.

4. This definition by Taylor is Typical. For example we find the following definition in Erdmanne & Gobet (1977) pp 183-85:

> The analysis begins from the fundamental proposition that the demand for energy is a derived demand: users do not demand energy because of any intrinsic utility it possesses but rather because it is

> essential for the provision and consumption of goods and services. This characteristic of energy demand is readily recognized in end-use sectors such as the industrial sector, where energy is used as an input into the productive process..... The inherently derivative nature of the demand for energy, however, is no less characteristic of any end-use.

The analogy could not be put more perfectly. It seems as if, in energy, economists have found a perfect 'prototype' of a good that satisfies 'derived demand' definition both ways: energy is an input in industry and in household sector. But this manner of definition defies the whole inport and intent of the 'derived demand' concept. This concept has been used to distinguish productive demand for inputs from personal demand for consumer goods. But now, in the case of energy, we are faced with a situation in which a derivative concept is 'reflected back' onto its source. In a way, using the concept of 'derived demand' to designate any type of consumer demand is a contradiction in terms.

5. Quoted in Taylor, 1975, p.87

6. Quoted in Ibid, pp. 86-87

BIBLIOGRAPHY

1. Electric Power Research Institute (EPRI) (1976) Long-range Forecasting Properties of State-of-the-Art Models of Demand for Electric Energy, Palo Alto.

2. Chern Wen S. (1978), Aggregate Demand for Energy in the United States, in Maddala, G.S., Chern, Wen S. and Gill, Gurmukh S., (eds.) Econometric Studies in Energy Demand and Supply, Praeger, N.Y. 1978

3. Chern, Wen S & Lin, William W.(1978) Energy Demand for Space Heating in the United States, in Maddala, et.al., op.cit.

4.Erdmann, R.W. & Gorbett, F.W. (1977), Energy Demand Projections for Canada: An Integrated Approach, in Nordhaus, William D. (ed.) International Studies of Demand for Energy, Amsterdam, 1977.

5. Gill, Gurmukh S. & Maddala, G.S. (1978), Residential Demand for Electricity in TVA Area, in Maddala, et.al, op.cit.

6. Jorgenson, Dale W. (1977) Consumer Demand for Energy, in Nordhaus, op.cit.

7. Khazzoom, Daniel D. (1977), An application of the concepts of free and captive demand to the estimating and stimulating of energy demand in Canada, in Nordhaus, op. cit.

8. Nordhaus, William D. (1977), The Demand for Energy : An International Perspective, in Nordhaus, op. cit.

9. Taylor, Lester D. (1975), The Demand for Electricity: A Survey, Bell Journal of Economics, 6(1) Spring 1975.

10. Taylor Lester D. (1977), The Demand for Energy: A survey of price and income elasticities in Nordhaus, op. cit