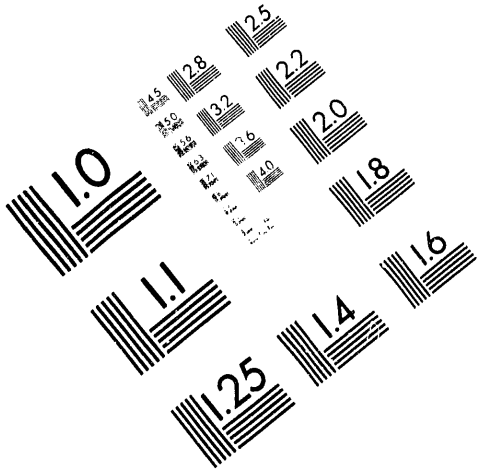

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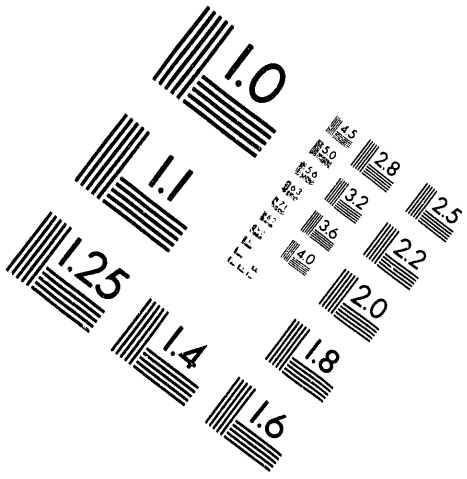

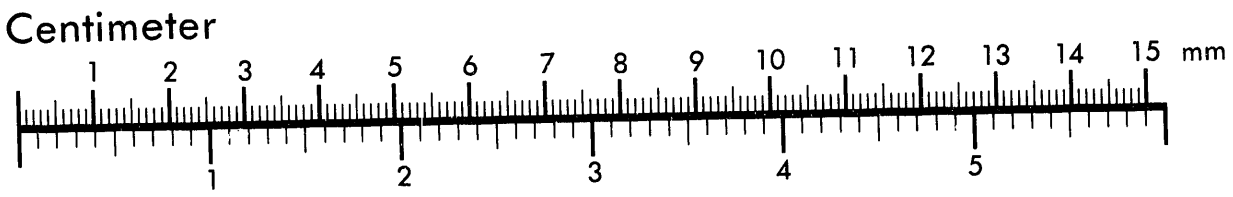

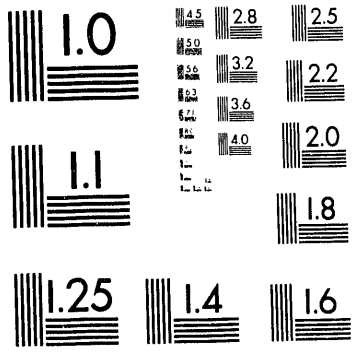

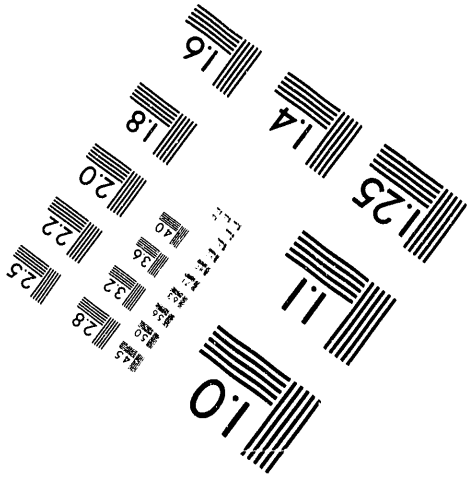

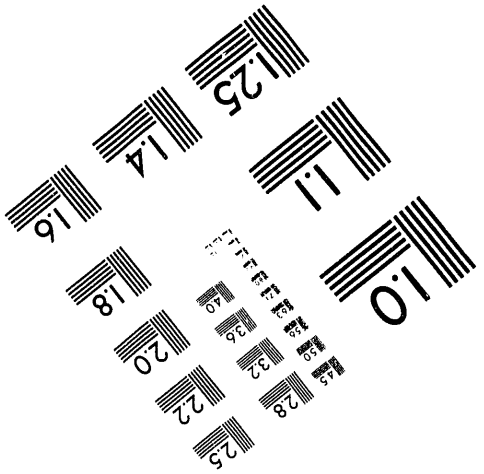

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On the Economic Analysis of Problems in Energy Efficiency: Market Barriers, Market Failures, and Policy Implications

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Abstract

In his recent paper in *The Energy Journal*, Ronald Sutherland argues that several so-called "market barriers" to energy efficiency frequently cited in the literature are not market failures in the conventional sense and are thus irrelevant for energy policy. We argue that Sutherland has inadequately analyzed the idea of market barrier and misrepresented the policy implications of microeconomics. We find that economic theory, correctly interpreted, does not provide for the categorical dismissal of market barriers.

We explore important methodological issues underlying the debate over market barriers, and discuss the importance of reconciling the findings of non-economic social sciences with the economic analysis of energy demand and consumer decision-making. We also scrutinize Sutherland's attempt to apply finance theory to rationalize high implicit discount rates observed in energy-related choices, and find this use of finance theory to be inappropriate.

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More than other scientists, social scientists need to be self-conscious about their methodology.

-Milton Friedman

1: Introduction

In a provocative recent paper, Ronald Sutherland (1991) examines one of the central ideas in the literature on energy conservation and efficiency, the concept of "market barriers." He aims, in particular, to demonstrate that several of the barriers to energy-efficient investment frequently cited by efficiency analysts are not "market failures" in the sense of neo-classical microeconomics and are thus inappropriate targets for the economic analysis of energy-related markets. He also argues that certain ideas of finance theory can be used to explain behavior observed in the markets for energy investments. Finally, he derives from his analysis several recommendations regarding the appropriate scope and nature of government intervention in energy-related markets.

The proper economic and policy analysis of problems in energy efficiency has long been and continues to be a focus of controversy. Accordingly, Sutherland's paper merits attention in that it expresses what are presumably widely-held, if often implicit views on this subject. He has made a useful contribution in questioning the definitions of terms that are frequently (but not always carefully) used by efficiency analysts and in attempting to articulate the issues involved within the framework of microeconomics.

As we will show, however, the issues involved in evaluating the question of market barriers and analyzing their potential implications for policy are considerably deeper and more complex than Sutherland suggests, and neither theory nor evidence warrants the dismissal of such barriers as important phenomena for energy policy. Broadly, there are four areas in which Sutherland's account is inadequate: 1) he has not given an adequate description of the idea of market barrier and the attendant evidence; 2) he has not correctly presented the broad policy framework provided by microeconomic theory for the study of failures or imperfections in energy-related markets; 3) he has oversimplified the problems of risk in energy investments, and mis-applied the ideas of finance theory thereto; and 4) he has ignored the methodological problems involved in competing accounts of the phenomena described by the term "market barrier." In view of these problems, Sutherland's analysis must be greeted with skepticism, and his dismissal of market barriers rejected.

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In this paper we will examine each of these areas and aim to provide a more accurate and complete account of the problem of market barriers and its relation to economic analysis. We begin with an overview of the literature on market barriers, followed by a summary of Sutherland's key points and conclusions. We then discuss the theoretical background underlying the market failure doctrine that Sutherland uses to dismiss the idea of market barrier. Next, we examine the problems in his attempt to apply finance theory to the analysis of energy investments, and continue with a discussion of changing theoretical perspectives on decision-making by individuals and within firms and the implications for energy analysis. We then discuss briefly the problems of methodology ignored by Sutherland. We continue with a description of the special case of market barriers to energy efficiency in new buildings, and close with several concluding observations.

This paper is most closely related to the paper of Fisher and Rothkopf (1989) on market failures and energy analysis. We will, in part, extend their discussion of the theory of market imperfections and its policy implications, particularly in light of Sutherland's rejection of their application of the market failure concept to a variety of problems in energy efficiency.

Finally, we note that, while Sutherland refers to several papers in the literature on energy efficiency, his primary focus is the report by Carlsmith et al. (1990). Our aim here is not to defend that work in particular, a task we leave to its authors. Instead, we will discuss themes that appear in that report as well as in a variety of other works in the hope of providing a reasonable overview of the most common and important ideas therein from the standpoint of economic analysis.

2: The Meaning of "Market Barrier"

Although Sutherland refers to the categorization of market barriers employed by Carlsmith et al., he provides little description or discussion of the research that has led so many analysts to conclude that these barriers are important factors in determining energy demand. For detailed treatment and a further guide to the literature, the reader may refer to the papers cited by Sutherland (Blumstein et al 1980, Hirst 1986, Vine and Harris 1989, Carlsmith et al. 1990, Fisher and Rothkopf 1989). To provide a framework for our discussion, however, we will begin with an overview of the idea of market barrier and several key examples.

In general, the term "market barrier" refers, as Sutherland notes, to factors creating unexploited opportunities for increased cost-effectiveness in the provision of energy services in specific applications. Discussions of market barriers, however, form part of the larger body of work on unrealized possibilities for increased economic efficiency in the use of energy. At the broadest level, the case for such increased efficiency is made as follows. There is a continual process of technological innovation in the area of energy efficiency and consequently a steady emergence of possibilities for more cost-effective use of energy in a range of applications. There are, however, inevitable gaps between innovation, commercial application, the development of new markets, and the adoption by individuals and firms of new products and practices. In general, the term "market barrier" is used to refer to conditions or factors contributing to these gaps between innovation and application, that is, slowing or preventing the attainment of the most cost-effective provision of various energy services.

There are thus two central themes in the market barriers literature: 1) problems in the development of new markets for products or services incorporating efficiency-related technological innovation and 2) factors that may impede efficiency in such markets once

they are established. In addition, "market barrier" has been used to denote both economic factors and social or behavioral influences that may impede cost-effective outcomes. In the case of economic "barriers," different observers also distinguish the role of prices in decision-making from such factors as the decision rules used in making investment choices. Finally, analysts of market barriers have examined both energy related capital investment, such as the purchase or replacement of equipment, and behavior, such as thermostat management and other actions aimed at conservation.

Studies of market barriers draw upon technical evidence. These studies typically infer the existence of such barriers from examples of efficient technologies that are perfect substitutes for more common technologies, that use less energy than those technologies, and that save energy at a cost less than the price of energy. These examples are based on engineering calculations using a *typical* building or appliance. Such calculations and the use of them to infer market failures can suffer from three generic shortcomings (Koomey, 1990): 1) hidden costs, 2) incorrect parameter specification, and 3) time lags.

Market barriers are implied by engineering calculations when a device based on proven technology saves energy at or below the price of energy and is not being adopted after being on the market for years. In addition, there must be no hidden costs, and the input parameters used for the calculation must capture the range of possible physical situations and usage characteristics existing throughout the economy.

An example (from Koomey 1990) that suffers from none of these problems is the case of the efficient core-coil fluorescent ballast for use in commercial buildings (as compared to the standard core-coil ballast). The efficient core-coil ballast was on the market throughout the 1980's. It delivers equivalent service and reliability as the standard core-coil, with the exception of energy use and lifetime, where it delivers superior service. It saves electricity at a cost of 1.4¢/kWh (roughly 1/5 of the current price of electricity to commercial customers), assuming 2600 hours/year of operation[1]. Fluorescent ballasts are used in virtually all commercial buildings. In spite of the cost effectiveness of the efficient core-coil ballast, it would have been chosen by only 10% of the purchasers in 1987, had not laws been passed prohibiting their use in certain states (Geller and Miller, 1988).

It is legitimate to infer from this example that the resulting technology choice is far from the economic optimum. However, such calculations are only the first step in assessing the existence of market barriers. They do not indicate what those barriers are, only that some such barriers probably exist.

Analysts of market barriers have consistently drawn upon research on social and behavioral determinants of energy demand, and this research constitutes an important part of the literature on market barriers. Thus, there is now a sizable body of evidence on the workings of the various factors subsumed under the rubric of "market barrier." This evidence is in a variety of forms, including statistical analyses, surveys, and ethnographic studies. It has been gathered by researchers from universities, utilities, and laboratories among others. A particularly important source has been evaluations of so-called "demand-side management" programs undertaken by utility firms.

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[1] the lowest plausible number of operating hours for commercial buildings is around 1300, which would yield a cost of conserved energy of 2.8¢/kWh, still 1/2 of the electricity price. These calculations assume a real discount rate of 6% and other parameters as specified in Koomey 1990.

Social factors: A variety of studies have shown that such factors as cultural norms and family structure may override financial considerations in efficiency and conservation decisions. An example is the influence of social and cultural factors and intra-family relationships on the decision to weatherize a home (Wilk and Wilhite 1987). (Much of this research is summarized in Stern and Aronson 1984, and Lutzenhiser 1992);

Behavioral and managerial factors: These include both economic and apparently non-economic types of influence on decisions. A number of studies have documented that consumers may de-emphasize or ignore completely financial and cost considerations in favor of other factors (Stern 1986). One particularly important area of research has been discount rates implicit in consumers' and firms' efficiency investments; numerous studies have shown these discount rates to be unusually high, calling into question the model of life-cycle cost minimization frequently used to describe investor behavior (Hausman 1979, Meier and Whittier 1983, Train 1985, Geller and Miller 1988). Another important finding is foregone efficiency investments due to a perception of risk on the part of managers. In addition, there is research showing directly that consumers use decision rules to make efficiency investments that differ fundamentally from those that would be used by an "expert" individual (Kempton and Montgomery 1982), including a focus on initial costs without considering returns to the investment. Many researchers have interpreted various findings on consumer decision-making in this context as evidence of "bounded rationality;"

Problems of market structure: Among the problems that have been identified are misplaced incentives for energy efficiency in buildings, that is, situations in which gains from efficiency do not accrue to the investor; absence of information regarding efficiency possibilities; failures in capital markets; codes and standards impeding cost-effective efficiency investments; limitations on supplies of equipment incorporating innovations in efficiency. An example of research in this area is that of Ruderman, Levine, and McMahon (1987), who estimated inefficiency at the market level.

3: A Summary of Sutherland's Arguments

Sutherland's argument against market barriers is based on a certain view of economic theory and the policy prescriptions that derive from it. The fundamental "theoretical" result is, as he states it, that

> "...private markets under perfectly competitive conditions tend to allocate resources efficiently. Under such conditions...interference with the market would introduce inefficiencies and lower output...When private markets fail to be efficient, government involvement potentially can improve efficiency and output. The technically correct economic basis for government involvement in conservation is a market failure in this market."

According to Sutherland, a "market failure" is "a condition in any market that results in an inefficient allocation of resources," while the term "market barrier" refers to "market conditions that discourage energy-efficiency investments relative to an estimated cost-effective level." Thus,

> "[t]he issue...is whether the market barriers that have been identified in the conservation literature are in fact market failures as defined in the economics literature. If so, then these barriers are true sources of economic inefficiencies and should be the focus of government policy. However, if market barriers are not market imperfections, then by default they must be benign characteristics of well-functioning markets."

Sutherland goes on to survey a number of putative market barriers, primarily following the typology of Carlsmith et al. and argues in each case that the barrier in question is not a market failure. The recurrent theme is that the "barriers" cited by efficiency analysts are, in some sense, merely "natural" economic phenomena. Regarding the perceived riskiness of energy-efficiency investments, for example, Sutherland reasons as follows:

> "The issues with respect to risk are whether risk constitutes a market failure and whether risk discourages investment. A simplistic view of perfectly competitive markets assumes perfect knowledge and perfect foresight. However, in actual markets, all investments are characterized by a future return that is subject to some risk. This normal business risk certainly characterizes highly competitive markets and does not constitute a market failure."

Similarly, although he acknowledges the possibility that information problems may affect investments in energy efficiency, Sutherland states that

> "In the simple economic model of competitive markets, information is assumed to be widely available and free. More realistically, information is a commodity that has a positive supply price. Competitive markets supply information to the extent that is of sufficient value to cover costs. Private markets do not supply complete information about every product because the costs would exceed the willingness of consumers to pay for it. Almost all decisions that consumers and investors make are characterized by...uncertainty that results from imperfect information. However, these decisions may be economically efficient."

In the same vein, he concludes that the so-called "misplaced incentives" barrier to energy efficiency in buildings "is not a barrier to investment but merely a characteristic of the normal functioning of private markets," essentially because the buildings market reflects the "normal" competitive situation of producers constructing buildings and consumers purchasing them. Sutherland also interprets the "high initial cost" barrier as indicating no more than that individuals or firms are unable to make certain purchases within their budget constraints, and therefore as also being simply a mis-identification of a normal economic state-of-affairs.

We will scrutinize Sutherland's analysis of riskiness in energy-efficiency investments, and his application of the Capital Asset Pricing Model to this problem, in more detail in a later section. At this point, we note simply that he applies this and other ideas of investment theory to conclude that the high implicit discount rates observed in energy-related markets are "rationalizable," that is, he interprets them as a rational response to conditions of risk and other common economic conditions.

Having dismissed the above-mentioned, as well as several other, market barriers as not qualifying for market failure status, Sutherland concludes that none of these phenomena should be of concern to policy makers. He goes on to specify what he views as examples of "legitimate" energy-related market failures: environmental externalities, information arising from research on conservation--a public good--and national security problems associated with dependence on imported petroleum. These failures justify several interventions on the part of the government: sponsorship of energy research and development, action to adjust prices to take account of externalities, and planning for contingencies in petroleum supply.

4: Comments

It may be worth noting first certain points of apparent agreement between Sutherland and analysts of market barriers. Certainly, proponents of energy efficiency and conservation in general support the goal of marginal cost pricing, the policy of adjusting prices to internalize environmental costs, and the idea of federal support of energy-related R&D as a risk-reduction measure. In addition, the importance of closing information gaps is a consistent theme in the market barriers literature.

What, then, is the basis of his dismissal of the idea of market barrier? With the exception of his discussion of high discount rates, Sutherland has not confronted directly the evidence regarding market barriers. Rather, he has adopted a strategy aimed at avoiding consideration of this evidence altogether. As we sketched above, his main argument is categorical: only market failures are relevant for policy; most so-called market barriers are not market failures; therefore, these barriers do not affect economic efficiency and so should be ignored by policy-makers. In effect, he argues that the claimed barriers *cannot in principle* have any effect on economic efficiency. We observe that this view is not universally held among economists who have considered the problems. As the economist Quigley (1986) put it, commenting on Stern's paper on the importance of social and behavioral factors in energy demand,

> "...few economists...will be shocked or offended by the argument put forward by Stern. Economic concepts and characterizations do not explain all of human behavior or all of the behavior of individuals as consumers of energy...Markets do not function perfectly. Information is costly to acquire and expensive to process. Consumers are differentiated by factors other than income. These other factors are surely important in explaining or forecasting demand behavior."

Because Sutherland claims that economic theory, in particular, the theory of market failure, simply obviates the consideration of market barriers, it is important to scrutinize this theory and his application of it. We undertake this in the following section.

5: Microeconomic Theory and its Policy Applications

As we have seen, Sutherland is not particularly explicit about the theoretical background upon which he bases his position, referring merely to the "important result" that "private markets under perfectly competitive conditions tend to allocate resources efficiently." The content of the theory to which he alludes and its application to policy--upon which Sutherland's paper is implicitly based--are, however, central to his argument against market barriers. As we will show in this section, there are serious problems in the position that Sutherland takes, with respect to both the broad implications of microeconomic theory and its application to specific examples related to market barriers.

Sutherland's policy position is based on what the economist Schultze (1977) terms the "rebuttable presumption" that the economy should be taken to be operating efficiently unless otherwise demonstrated, so that a burden of proof lies with those advocating government intervention in economic affairs. While this framework has roots in classical political and economic theory, it is generally thought to find theoretical justification in the modern general equilibrium theory commonly credited, in its basic form, to Arrow and Debreu (Arrow 1953, Debreu 1959). The two fundamental results are the so-called "first and second theorems of welfare economics," which describe in a highly stylized, mathematical setting the basic relations between decentralized economic decision-making and economic efficiency. While the exact statements of these theorems require the appropriate mathematical terminology and notation, they are generally interpreted as

follows. The first theorem states that, under appropriate conditions, an economic equilibrium achieved through the independent decisions of individuals and firms using a system of prices is a "Pareto optimum," that is, a state-of-affairs in which no individual can be made better off except at the expense of another. The second theorem states that, again under the appropriate conditions, any such Pareto optimum can be achieved as a competitive equilibrium given the proper re-allocation of initial endowments of consumers.

Sutherland's policy positions are based on the traditional theory of market failure. This theory forms the conceptual core of modern welfare economics and provides a concise statement of the manner in which a decentralized economy might fail to allocate resources efficiently. This theory was developed by Samuelson (1947,1954) and Bator (1958) in particular, who were concerned with, as the latter author put it, "those phenomena which cause even errorless profit- and preference-maximizing calculation in a stationary context of perfect...information and foresight to fail to sustain Pareto-efficient allocation." In this tradition, the allowable "failures" of market-based allocation are externalities, public goods, and non-convexities--such as increasing returns-to-scale--which may cause, in a theoretical sense, a breakdown in the nexus between Pareto optimality and competitive equilibrium, providing a rationale for government intervention. Challenging the "rebuttable presumption" on the basis of this formal framework requires identifying one of these three market failures.

These traditional examples of market failure are important in analyzing in a stylized setting the logic and the limits of the theory within which they arise and are defined. This theory as a whole is universally recognized as one of the landmark achievements of contemporary economic thought. It provides a modern mathematical expression of ideas regarding private markets and resource allocation dating to Adam Smith two centuries ago, setting forth idealized conditions under which decentralized decision-making could result in (suitably defined) optimal outcomes. That it does not, however, provide a model of the economy we actually have has been emphasized repeatedly by several of its chief architects as well as many other commentators (Arrow 1985, Hahn 1970, Blaug 1980). Consequently, many economists have questioned the extent to which the Arrow-Debreu theory provides a theoretical justification for an economic policy framework based on the assumption of market efficiency, that is, the logic of the "rebuttable presumption." As the economists Nelson and Winter (1982) note,

> "[the] problems with the competitive organizational solution are viewed as partially remediable with ancillary organizational machinery to spur competition as much as possible, make demand effective for public goods, control externalities, and aid the needy. It is this patched-up system, with admitted flaws, that Western economists tend to support and advocate. It should be apparent that such advocacy cannot rest much weight of argument on modern welfare economics."

A central problem is that the theory is fundamentally static; it focusses on equilibrium states even in its treatment of intertemporal allocation. It therefore provides no explicit account of the dynamic adjustment mechanisms which have long been thought central to the working of a capitalist economy (Hahn, 1970). For the analysis of market barriers, this is particularly troublesome, for, as we described in Section 2, the rationale for these barriers is based on the observation of delays in the adjustment to energy-related technological innovation. In a deep sense, this problem of the absorption of innovation is not even addressed by the theory to which Sutherland appeals, and so in this respect the theory cannot be used to analyze, let alone dismiss, the phenomena associated with market barriers.

A further problem with Sutherland's analysis is his ignoring of categories of market "imperfection" larger than the traditional market failures. Key among these is the problem of "transaction costs," which, although given various definitions in the literature, can be thought of as costs associated with carrying out the market transactions that are assumed to be costless to participants in the basic general equilibrium theory; colloquially, they are the "costs of running the economic system." The prima facie case for transaction cost problems in energy-related decisions is particularly strong inasmuch as these decisions generically require a great deal of information gathering and computation for gains that, while real, may represent a relatively small fraction of the decision-maker's income. From the individual's perspective, the costs of making optimal decisions regarding energy efficiency may outweigh the gains to be had. The aggregate effect of many such decisions, however, may be significant departures from economic efficiency. In the case of appliances, for example, energy efficiency standards, which can be promulgated at relatively low cost, may be the most effective way of overcoming the transaction cost problem.

The problems of risk and uncertainty are associated both with the descriptive accuracy of the theory and with more general examples of market imperfections. Given the central importance of risk, uncertainty and intertemporal decision-making in problems of energy efficiency (freely acknowledged by Sutherland), it is necessary to take into account the complete Arrow-Debreu theory, which includes a complete system of markets over time and states of nature, that is, complete "futures" and "contingent" (or "risk") markets. A central reason for the skepticism of many economists regarding the descriptive accuracy of this theory is the absence in the real world of many of the required markets, and thus the failure of the real economy to satisfy certain key hypotheses or boundary conditions required for theorems concerning competitive equilibrium and Pareto optimality. Indeed, the problem of incomplete markets is the focus of one line of current research in general equilibrium theory; even maintaining all of the standard assumptions except the completeness of markets, the conclusions attained are substantially weakened--the theory is by no means robust with respect to this condition (Magill and Shafer, 1989). Thus, while it is obvious, as Sutherland states, that risk and uncertainty are "normal" conditions of business (as well as consumer) decision-making, it is simply incorrect to imply as he does that this fact can be addressed with no more than a nod toward "theory."

A theoretical example of the potential problems that uncertainty poses for energy-related decision-making is given by Howarth and Andersson (1992), who construct and analyze a model of consumer choice of energy-using devices in a dynamic competitive environment characterized by uncertainty regarding technological innovation. They show that, in this setting, consumers purchase technologically and economically inferior devices even when it is in their interest to choose an improved device, that is, the uncertainty inherent in the dynamic process of technological innovation results in choices that do not maximize the benefits available to consumers themselves. An example of the problem of missing markets is given by Sutherland himself: the absence of a secondary market in energy-efficient devices may bias consumers against investments in such devices.

There are parallel problems in Sutherland's treatment of the economics of information. Over the past several decades, research on various aspects of this topic has proceeded rapidly. While this body of work does not cohere as neatly as the standard neo-classical theory, the general picture that is emerging differs in fundamental ways from the more traditional view. The public goods aspect of information mentioned by Sutherland is only one part of problem. It is inaccurate to suggest, as he does, that the classical view of perfect markets can be maintained by simply absorbing information as another commodity (Stiglitz 1979). Here again, it is obviously true that imperfect information is a common characteristic of real economic situations. The implications of information problems in

theory, however, are so fundamental that the traditional view of the merits of competition is, in effect, turned on its head: the classical view of perfect competition and optimality is no longer a reasonable first approximation, but rather an extremely special limiting case (Stiglitz 1984,1991). Among the problems that can arise in the presence of information imperfections are breakdown of equilibria, multiple prices in equilibrium, and the disjunction between equilibrium and Pareto optimality (Stiglitz and Weiss 1981). In general, the "folk theorem" that, once the costs of information are taken into account, equilibrium and optimality are restored--some version of which is implicitly drawn upon by Sutherland--has been replaced by the conclusion that, given pervasive information problems, there are fundamental departures from optimality (Greenwald and Stiglitz 1986).

One important idea in information economics that pertains to energy-related markets is the problem of *asymmetric information*; this idea underlies several of the barriers related to energy efficiency in buildings that Sutherland dismisses, including "misplaced incentives" and the "landlord/tenant" problem. For a builder or landlord to invest in efficiency-related improvements, for example, she must know that these improvements will be observable and verifiable to the tenants in order for the investment to be recoverable through rents. Many if not most energy efficiency features--from improved insulation to heating and cooling systems--are either not readily observable or have operating characteristics that are difficult to verify. Knowing this, the builder or landlord may forego such investments, even though they would benefit both the builder or landlord and the tenant; the asymmetry of information between the two parties to the transaction results in an economically inefficient outcome. Standardized building energy rating systems may be the efficient solution in this case (Vine et al., 1987). A related example is the case in which a landlord or owner pays energy bills, but cannot monitor the use of energy-using devices within the building controlled by tenants or occupants. In this case, an instance of the so-called "moral hazard" problem, there is no incentive for investment by either party in measures that would result in economic benefits to both.[2]

In summary, it is not the case, as Sutherland claims, that energy efficiency analysts have ignored "the conditions under which the private market allocates resources efficiently." Rather, they--in the company of most economists--recognize that we do not live in an Arrow-Debreu world, and that problems of economic policy--including those specific to energy efficiency--cannot be addressed by naive appeals to ill-specified notions of "perfectly competitive markets." Indeed, as we have indicated, the implications of much of contemporary economics are contrary to those suggested by Sutherland. Commenting on recent work on incomplete markets, information, and game theory, Hahn puts the matter quite succinctly: "Certainly, the 'fundamental theorems of welfare economics' do not apply to the world that we are beginning to explore" (Hahn 1989).

In what the economist Stiglitz calls the "new new welfare economics," the policy framework based on the "rebuttable presumption" yields to a point-of-view in which various market imperfections are recognized as pervasive; Smith's "invisible hand" is seen as rather "palsied." The central task for policy is then not the justification of intervention

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[2] While most of Sutherland's arguments regarding the workings of energy-related markets are conceptual, he does refer to another paper in which he claims to have cast statistical doubt upon the hypothesis that efficiency in buildings is related to owner occupancy because of such problems as information asymmetries between builders and buyers or landlords and tenants. We note that the survey from which he drew his data could not, by its design, obtain information regarding the proportion of a building actually occupied by its owner (EIA 1986), and so it is questionable whether his interpretation of his statistical results is correct.

through the identification of market failures, but rather the analysis, in the presence of a given failure or imperfection, of what mechanisms might promote increased economic efficiency. This requires, inter alia, the comparative analysis of the workings of different means of organizing economic activity (Friedman 1981,1984), a problem that is suppressed in the traditional framework. In the case of market barriers, what is required is not still more discussion of problems in energy markets but instead the design of efficient instruments for increasing energy efficiency. Contrary to Sutherland's view, in which such mechanisms as codes and standards, for example, are likely to impede economic efficiency, these mechanisms, while certainly no panacea, may if well-designed promote economic efficiency in energy-related markets.

6: Energy Efficiency and the CAPM

We have seen that Sutherland's attempt to dismiss the problem of risk in efficiency investments by appealing to the market failure doctrine may be questioned on several grounds. In this section, we turn to Sutherland's related attempt to apply finance theory--specifically the Capital Asset Pricing Model (CAPM)--to provide a more micro-level rationalization of certain evidence concerning these investments, notably the observed high discount rates implicit in energy-related consumer choices. We will draw in part upon the paper of the economist Lind (1982), whose superb discussion of the issues of risk and discounting in energy policy includes a treatment of both the utility and shortcomings of the ideas underlying the CAPM.

Lind's overall theme is the theory and application of the idea of social discount rate and the proper treatment of risk in energy investments in what he acknowledges to be the "second-best" world we inhabit. He describes a fundamental insight of modern finance theory, reflected in a variety of models, including the CAPM, that the "rational" view of risk is, roughly speaking, not based upon variance (as in the common perspective) but co-variance. Thus, for example, in the context of a portfolio of investments, the risk associated with a given investment is defined not in terms of the variance of returns on that investment but rather in terms of how returns on that investment co-vary with returns on other items in the portfolio. Even though the given investment may have extreme variability of returns--that is, large variance--and thus be "risky" in a naive sense, it should not be considered risky if, in particular, it would tend to "pay off" in exactly those states in which the rest of the portfolio "lost." Thus, apparently risky investments may have the characteristic of insurance, in which expected payoff is negative but which is desirable from the standpoint of risk-reduction. This point-of-view gives rise to the important idea of diversification in investing; Lind applies this analysis to argue that federal support for certain energy-related research and development is justified both from a public-goods and from a risk-reduction standpoint.

In his policy recommendations, Sutherland repeats Lind's point on the risk-reduction and public goods aspects of federal support for work in, at least, energy supply problems. Sutherland also wishes, however, to "rationalize" the observed high discount rates in energy investments--frequently cited as a market barrier--using the idea of CAPM and the conception of risk embodied therein. In order to understand the problem with this application, we quickly review the CAPM.

The CAPM is a general equilibrium model of asset prices. In its basic form, it is built on assumptions that are numerous and stringent; among them are: investors are risk averse and have quadratic utility functions and homogeneous expectations; the time-scale involved is a single period; investors rationally choose a portfolio from among all assets, including human capital; capital markets are perfect, i.e., information is freely available, there are unlimited opportunities to borrow at a risk-free rate, and there are no transaction

costs. A central analytic conclusion of the model is that, in equilibrium, asset prices reflect riskiness of investments in terms of their covariance with the market portfolio of all assets, rather than in terms of the variance of their returns.

It is not the case, as Sutherland claims, that this model "suggests" any particular conclusion regarding energy efficiency investments. Rather, Sutherland wishes to apply the CAPM to such investments. However, by his own logic, consumer choice in this instance is characterized by, among other things, transaction costs and an inability to diversify, that is, to invest in a portfolio consisting of all assets. Thus, in this case, several of the key boundary conditions for the model are not met, or in other words, the model does not apply; in fact, under this condition, the CAPM, based as it is on a concept of diversification, is singularly unsuitable. In citing risk, liquidity problems and high transaction costs, he is in fact proposing a different model. His claim that high consumer discount rates are "consistent with the CAPM" is therefore meaningless. The liquidity constraints in question result from missing markets, while the idea of transaction costs, as we have described, is a fundamental problem in the application of the apparatus of welfare economics. In short, Sutherland's rationalization of high discount rates in consumer energy-related decision-making depends in part on market imperfections or failures.[3]

In the case of firms, as Lind discusses, the problems of applying the CAPM are if anything more severe. Chief among the difficulties is the fact that the CAPM is a single-period model, and, as he notes and as Myers and Turnbull (1977) have studied in the context of corporate investments, the generalization to longer-term horizons is by no means straightforward. It is not possible, for example, to theoretically derive precise estimates for the risk premia that should be assigned to discount rates in multiple-period decisions, so that "explaining" high discount rates is in some sense an empty exercise. In addition, the problems associated with empirically estimating parameters in the more general (multi-period) portfolio model are so large as to preclude its systematic use as a decision-making tool. Thus, Sutherland's assertion that the CAPM is "equally applicable to capital budgeting" conceals a host of problems.

Finally, Sutherland's use of the term "risk" reflects inattention to contrasting meanings of that term as it is applied in the market barriers literature. Technically, decision-making under conditions of risk has to do with choice over lotteries, that is, choice in the context of known, objective probability distributions. The "perceived riskiness of energy investments" cited by market barrier analysts frequently refers, by contrast, to reports--particularly by managers of firms--of reluctance to invest in new technology whose operating characteristics are unknown. Thus, the appropriate modeling framework is not decision-making under risk but decision-making under uncertainty. This brings us to the more general problem of the modeling of rational decision-making and its application to energy problems.

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[3] We note here that essentially the same argument regarding high consumer discount rates was previously made--with considerably greater succinctness--by Chernoff (1983), who, however, simultaneously sought to "explain" these high discount rates and to argue that consumer choice in this case doesn't involve discount rates at all.

7: The Decision-making of Individuals and Firms

In our discussion in Section 5, we described the problems in Sutherland's representation of the broad policy implications of microeconomic theory, particularly with respect to the treatment of uncertainty and information problems. As we indicated, a central theme in recent microeconomic research is that in the presence of such problems, the workings of a decentralized economy may differ substantially from the classical picture of the "invisible hand." It is important to note that the research from which this conclusion emerges typically assumes economic agents equipped with the substantial powers of information processing and computation characteristic of older neo-classical models. That is, economic inefficiencies may result from such problems as transactions costs and information asymmetries even in the presence of agents who are perfectly rational in the conventional sense.

Equally significant for the analysis of market barriers to energy efficiency is the broad problem of limited expertise or "bounded rationality" on the part of consumers and managers making energy-related decisions in a changing technological environment. Underlying both Sutherland's invocations of the neo-classical competitive model in general and his attempt to apply the CAPM in particular is the assumption of complete rationality on the part of both individuals and firms. Specifically, his assumption is that both carry out some form of--possibly risk-adjusted--expected value calculation in making energy-investment decisions. He has avoided altogether any discussion of one of the central themes in the literature on market barriers, the idea that energy-related decisions reflect pervasive bounded rationality. This phrase, while often used, is given various definitions. In the case of market barriers, it refers in particular to individuals' or firms' apparent failure to minimize expected costs when making energy efficiency decisions.

The case for bounded rationality in this context is strong. Detailed studies of energy-related decision-making have consistently revealed that consumers do not routinely employ purely economic criteria in making these decisions (Kempton and Montgomery 1982, Stern 1986). Both efficiency analysts and several economists who have studied the problem have concluded that the high implicit discount rates in efficiency choices are evidence of some anomaly (Hausman 1979). This finding is consistent with one of the central themes in the more general literature on consumer choice, consumers' inability to process the information required for completely "rational" choices and their use of simplifying heuristics in the face of complex decision tasks (Bettman, Johnson and Payne 1991).

Economists are increasingly recognizing the importance of phenomena of bounded rationality (Kreps 1991, Machina 1991). A large part of the impetus for their consideration of alternatives to the neo-classical model of rationality is the steady stream of work over the past several decades by cognitive psychologists demonstrating systematic departures from this model in individual decision-making (Tversky and Kahneman 1986). The expected utility model, whatever its normative appeal, is on increasingly uncertain ground as a descriptive model of behavior, with some decision theorists having concluded that it has been decisively falsified (Schoemaker 1982).

The point here is two-fold. First, the basic model of behavior which Sutherland seeks to apply to the idea of energy efficiency choices is increasingly being questioned by economists and decision theorists. Second, research on energy efficiency choices provides not only a set of apparent examples of boundedly rational behavior but also a natural setting for its further study.

The issue of bounded rationality in energy-related decision-making is also critical for evaluating policies based the provision of information, such as appliance labelling. Sutherland's view of information problems in energy-related markets is, as we have noted, limited to the public goods aspect of information, so that any sub-optimality in, for example, consumer appliance choices could be rectified by government-sponsored labeling. This view is questionable given both research on the effect of labeling and results of such programs in practice (Robinson 1991, McNeill and Wilkie 1979), which demonstrate that labelling has quite uncertain effects with respect to consumer decision-making. Labelling does not free the consumer from the frequently complex calculations required in, for example, life-cycle cost minimization, and evidence such as we have cited indicates that most consumers cannot make such calculations even if supplied additional information. Here we see the appeal of a policy such as appliance standards: it may facilitate decisions that consumers themselves would make were it not for the difficulty of the task.

Related considerations hold for the problem of studying energy-related decision-making on the part of firms. In the strict neo-classical framework to which Sutherland adheres, firms are profit-maximizing or cost-minimizing "black boxes," assumed to make optimal decisions. There is a growing trend among economic theorists, however, toward examining the internal workings of firms and the characteristics of their decision processes (Nelson and Winter 1982, Kreps 1991). In the case of firms' reactions to risk and uncertainty, for example, Lind notes and other researchers have concluded that firms do not in general employ strictly "rational" rules of investing such as portfolio techniques based on the CAPM and its variants (Lind 1982, Ross 1986, March and Shapira 1987). There are an increasing number of tools available for the economic analysis of how firms adapt to changes in the technological environment, which is central to the analysis of market barriers.

8: Problems of Methodology

As we noted earlier, Sutherland does not directly respond to most of the evidence regarding market barriers. He thus avoids several of the most vexing methodological problems in evaluating market barriers: the reconciliation of economic analysis with the modes of inquiry used in other social sciences and the appropriate formulation, interpretation and verification of economic models. For example, should the life-cycle cost models of engineering economics and the decision rules studied by anthropologists arising from the "folk quantification of energy" be considered competing hypotheses? If so, what kind of evidence would be required to compare them? More generally, if findings on market barriers to energy efficiency are to be applied, how can they be compared with the conclusions derived from more conventional economic analysis? How can the various perspectives be integrated in a manner that informs energy policy? We note that such questions arise even if the economic analysis departs from strict neo-classical utility maximization modelling in favor of some sort of bounded rationality approach, for there remains the problem of reconciling interpretive and formal descriptions of behavior.

In the context of policy, analogous problems arise even with respect to economic modeling per se. We will briefly explore one such quandary, the interpretation of the kind of "rational" model proposed by Sutherland. As we noted earlier, some analysts of market barriers argue that such rational models (based on minimization of expected costs) are inaccurate descriptions of the processes used by consumers in making energy decisions. Against such arguments, a standard line of defense for this kind of modeling is derived from the usual "as if" justification, following the widely-adopted methodological position put forth by Friedman (1953). That is, whatever decision rules are being used by consumers in this context, the result is equivalent to that which would be obtained by an

idealized, fully rational (in the technical sense) and completely informed consumer computing risk-adjusted net present values.

This approach to modeling was justified by Friedman in part by the dictum that the aim of economic inquiry was solely the "prediction" of phenomena. Failing that, the use of "falsified" models of economic behavior has also been justified as providing insight into the logic of rational choice or the consequences of certain axioms of rationality (Kreps 1991). It is apparent, however, that Sutherland's aim is neither prediction of events nor the elucidation of rational choice but rather ex post rationalization for the purpose of justifying a certain policy stance. The problem is that the "as-if" point-of-view loses its rationale in the context of policy; the choice situation *as seen by the decision-maker* has substantial implications for the design (or obviation) of policy interventions. The importance of this issue has been discussed by Kunreuther (1976) and by Friedman and Hausker (1988); we will illustrate it with a germane example.

Consider the following characteristic situation: a person choosing an appliance has the choice between a basic model and a model that is otherwise identical but is, in addition, more energy efficient. (This is precisely the case studied by Meier and Whittier (1983).) For a premium that is a relatively small fraction of purchase price, the energy efficient model is expected to yield savings on energy costs over the lifetime of the appliance, and it is observed that, at some "reasonable" discount rate, the net present value of the additional investment and corresponding returns is positive. If the person does not choose the efficient model, how should this action be interpreted? The "Friedmanesque" approach might offer the following story: the consumer has acted as if she had weighed the expected benefits against the required premium, determined her--possibly risk-adjusted--discount rate, computed an expected net present value for the incremental cost of the efficient appliance, found this value to be negative, and rejected this investment. Now, in this simple situation, the consumer may actually have carried out such a procedure, that is, the "as if" story may in fact be a reasonably accurate description of the consumer's behavior. On the other hand, she may have ignored altogether the future returns on the efficiency premium and simply decided she did not wish to spend the extra money for the efficient appliance. Or, she may have mentally compared the (undiscounted) returns over a short period in the future and found these not to outweigh the initial extra expense. The point is that, *from knowledge of the outcome alone, we cannot distinguish among these or other possibilities.* More generally, econometric estimation of data arising from an aggregate of such purchases allows no such interpretation.

This problem is also illustrated by the suggestions of several economists who have studied consumer energy choices and have concluded that the discount rates implicit therein are "suspiciously high" (Hausman 1979). They have suggested that government intervention to provide greater information may thereby be warranted. But what information should be provided, and what effect could it be expected to have? If, for example, consumers actually use very short payback times to evaluate savings, then improved information about these savings may be useless. There is something of a slippery slope here; it is not hard to reach a reductio ad absurdum in which the government undertakes the education in basic engineering economics of consumers upon their arrival at the department store appliance section.

Thus, while the sort of ex post rationalization offered by Sutherland may find justification in Friedman's strict positivist methodology for scientific inquiry, this methodology does not allow us to question or evaluate such a rationalization in such a way as to guide the formation of policy regarding energy efficiency.

This is only one example of the problems of methodology that arise in considering the problem of market barriers, and of their importance for the design of policy. Sutherland's failure to consider such problems in his analysis of the economic perspective on market barriers renders his account incomplete.

9: Summary and Conclusions

We have argued that microeconomic theory, properly understood, does not provide for the categorical dismissal of the phenomenon of market barrier. On the contrary, from the point-of-view of recent developments in economics and allied fields such as decision theory, many of the instances of market barrier may be explicable using economic tools and concepts. This will require, however, increasing attention to the problem of articulating methods, concepts and empirical data from disparate fields of social science (as well as engineering). From a policy standpoint, what is needed is increased focus on modes and costs of intervention in the face of pervasive inefficiency, rather than continued argument over whether or not energy-related markets are "working." The recent work of Howarth and Andersson (1992) and Bhattacharjee et al. (1991) provides exemplars of the sort of theoretical economic analysis that will facilitate this effort, while Koomey (1990) has provided a precise framework for identifying situations in which intervention is warranted and for designing corrective policies.

Various debates over the economics of energy use and the influences of social and behavioral factors in the formation of energy demand have been ongoing over nearly two decades, with few signs of convergence among the various points-of-view. In light of renewed concerns over global climate change and the economic and policy analysis of such measures as carbon taxes, it has become if anything more important to find the balance between economic and other policy perspectives. From this view, Sutherland's attempt to simply dismiss the body of knowledge that has developed regarding market barriers is quite unhelpful. What is needed at the very least is analysis that draws upon the insights and strengths of different fields and aims to frame the results in a manner that promotes understanding in the context of public discussion. Sutherland's paper, based as it is on little more than one hand waved at theory and the other at evidence, does neither.

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