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A Market Failures Framework for Defining the Government's Role in Energy Efficiency

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EXECUTIVE SUMMARY

This paper examines the role of government in a market economy, with specific emphasis on the activities of the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE).[1] Its purpose is to identify lessons from the market-failures literature that can support decision making within EERE. The analysis focuses on opportunities to improve economic efficiency by adopting cost-effective policies in circumstances where markets fail to reach outcomes that are measured to be desirable by consumer's preferences.

To do this, a critical review of the traditional and emerging literature on market failure is presented. Traditional literature divides the causes of market failures into externalities, public goods, decreasing-cost industries, and institutional barriers. This literature tends to examine circumstances in which market prices fail to provide sufficient information or incentives to achieve Pareto optimality, assuming the context of a perfectly competitive economy. Pareto optimality exists when gains from trade are exhausted and when the situation prevails that no individual's well being can be improved without a worsening of some other individual's well being.

Emerging literature focuses on failure caused by insufficient information. The information topics considered include a general lack of information, information asymmetries, and price signaling. This literature draws upon recent advances in economic thinking that focus on incentives provided by distributions of information that are less than perfect, but which are arguably commonplace. In contrast to traditional literature, which assumes that market participants are always fully informed, this literature argues that participants are virtually never perfectly informed. Studies from this field typically rely on gross simplifications of interactions between individuals and draw upon game theory to control the information available to different market players. They also draw upon new developments in economics that allow greater testing of behavior, which are referred to as experimental economics or behavioral economics.

There are a number of solutions to traditional market failures, including direct regulation, taxes on undesirable activities, tradable permits, and subsidies to desirable activities, which provide candidates for policy measures. These are discussed in some detail. Here a distinction between first-best and second-best policy remedies is included. First-best solutions return an economy to Pareto optimality. Second-best solutions correct some, but not necessarily all, market failures and cannot guarantee Pareto-optimal outcomes. Examples of first-best policies are taxes on consumption of (say) imported oil and which send price signals to users and producers of imported oil that lead to less consumption of imported oil and numerous other behavioral impacts. For example, consumers may change their habits in using products that use imported oil in the short run and buy more efficient products in the

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long run. Producers may expand domestic oil exploration. Auto manufactures may search for ways to produce more fuel efficient cars or cars that use alternative fuels.

Examples of second best policies are actions that "short circuit" the general equilibrium outcomes of the market. An example of a second-best policy is an R&D program to improve the quality or performance of energy efficient technologies. Such policies are incomplete in the sense that they fail to signal to consumers that imported oil is scarcer and fail to signal to auto manufacturers that there are competitive gains to be made from successful fuel efficiency innovations.

Information policies are treated separately. For example, one type of information issue, information asymmetries, assumes that a party with superior information will use it to best advantage when dealing with a party having less information. If this were true, consumers might assume that government information programs were being strategically implemented and either discount them, or require additional incentives to accept the information at face value.

It is argued that, of necessity, virtually all EERE programs are second-best policy solutions. This is because of the existence of multiple sources of failure, an inability to levy taxes, clear instances of lack of information, and clear instances of information asymmetries. In this case, theoretical policy solutions provide options whose benefits must be verified through empirical analysis. In other words, a policy solution must be demonstrably superior to other solutions, including inaction, before its adoption is justified. It also suggests that more latitude in developing policy options is required than would be the case if one or a few market imperfections were evident.

Finally, a general critique of the overall market failures framework is presented. This includes the validity of using a "perfect market" as a benchmark, the reliance on willingness to pay as a measure of efficiency when it is conditioned by income levels and distributions, the apparent confusion between positive (predictive) and normative (optimal) behavioral analysis, and the general lack of a firm empirical basis for identifying and correcting market failures.

To pursue this latter point, two studies of CAFE (corporate average fuel economy) standards are reviewed—one by the General Accounting Office and one by Resources for the Future. Both conclude that increasing miles-per-gallon targets may reduce rather than increase well-being, termed here social welfare. However, uncertainties in value estimates embedded in the studies and questions of issue framing lead to significant uncertainties in the robustness of their results. Nevertheless, even though these studies fail to reach definitive conclusions, by employing empirically based models that follow the market failures paradigm and make all key inputs transparent, these studies unquestionably shift the burden of proof to critics. They provide strong incentives for program developers to present their arguments in a similar manner.

The principal conclusions of this analysis are that EERE should consider:

- organizing its analytical foundation for developing R&D and information programs around the market failure literature,
- extending its definition of market failures to include information issues,
- investing in additional empirical studies to verify assumptions and conclusions from the market failures literature, and
- applying net-benefit tests to policy alternatives by using empirically based behavioral models that embed the technical attributes of EERE technologies and information programs.

Because of uncertainties in estimating social values and in framing issues, these models and studies should be constructed to provide a wide range of alternative assumptions about values and tradeoffs.

Finally, the range of available options is broad and will require policy guidance beyond that likely to arise from pure analysis. Hence, a clear and consistent approach to R&D portfolio development and information program development, with explicitly articulated policy inputs, should prove the most defensible and, ultimately, the most successful policy management strategy.

1.0 INTRODUCTION

1.1 Purpose

This paper presents a review of the traditional and emerging literature that describes and evaluates the role of government in a market economy. It is specifically concerned with decision making within the Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE).

The paper's principal purpose is to present a framework for identifying where EERE should invest to improve the quality of its decisions and strengthen its justification for those decisions. Its secondary purpose is to describe a path to more uniform R&D portfolio development practices across EERE.

The intended audience for the analysis is the EERE senior policy official who must make and justify decisions concerning EERE priorities and choices, particularly in energy technology R&D and in the promotion of these technologies (a function sometimes referred to as "market transformation"). Methods underlying decision making and justification are changing due to new business practices employed by the Office of Management and Budget (OMB).

1.2 Background

The paper builds upon an earlier study that examined recent developments in economic analysis and interpreted these developments as to their impacts on EERE programs (Bjornstad 2003). These developments include new theories of investment, the emergence of experimental methods to test the behavioral content of theories, and incentive effects of differing states of information.

The paper also considers the institutional framework for decision making within EERE and the types of requirements this framework places on EERE. Beginning with the FY 2004 budget process, a management system termed the Program Assessment Rating Tool (PART) was used to assess how well Executive Branch programs were meeting their goals, with specific emphasis on sound management practices and program performance.[2] The specific PART initiative that influences EERE is termed Better R&D Investment Criteria, an initiative that DOE helped develop. PART is a questionnaire-based approach, whereby agencies fill out their own ratings and OMB reviews them. A major goal of the activity is to tie budgets to performance in a consistent and quantitative manner that complements the requirements of the Government Performance and Results Act (GPRA).

One aspect of the initial questionnaire of particular relevance to this study was the question "Is the Federal Role Critical?" Agencies concluded that this question was subjective and that inter-program comparisons were difficult. OMB agreed, and temporarily removed the

[2] Various documents describing this tool can be found at http://www.whitehouse.gov/omb/budintegration/part_assessing2004.html, accessed 10-24-03.

question, commenting that the question was nonetheless important and would be addressed further (Daniels 2004). This paper should provide input to this continuing discussion.

1.3 Organization of Paper

The remainder of the paper is divided into three sections.

Section two presents the rational for a market-based role of government. It first examines what we term the traditional approach to the role of government. Here, externalities, public goods, decreasing-cost industries, and market barriers are discussed. Next we turn to what is termed the emerging approach to the role of government. Here asymmetrical information topics and signaling are discussed. Finally, a discussion of the interpretations of market failure and available policy instruments to deal with it are presented, and a distinction between first-best and second-best solutions is provided.

Section three examines two studies that seek to interpret applied choices as to government's role using welfare economics. Each examines the costs and consequences of CAFE (corporate average fuel economy standards) and makes policy recommendations.

Section four presents the conclusions and recommendations.

2.0 MARKET-BASED ROLE OF GOVERNMENT

2.1 Traditional Approach

The role of government in allocating resources in a market economy has its traditional basis in a series of papers that describe the circumstances under which prices can coordinate efficient choices in consumption and production and the general departures from these circumstances that reduce efficiency.[3] Starting from the conclusion that, under reasonable conditions, a market economy generates efficient outcomes (sometimes referred to as the First Theorem of Welfare Economics), departures from this norm are examined. These departures are termed market failures.

Traditional generalizations of market failure that have special relevance to energy efficiency include externalities, public goods, decreasing-cost industries, and institutional barriers to the transmission of clear prices signals. Other failures include common property resource management, the assignment and defense of property rights, and non-competitive markets.[4]

2.1.1 Externalities

Externalities are costs (or benefits) that are conferred on third parties by the principals to some separate transaction, over which the third parties have no control. For energy sectors, these costs can include local pollution from using energy products, regional pollution from electrical generation, climate change costs, and costs due to reduced energy security from oil imports. Other types of energy-related environmental externalities include water and ground contamination from petroleum leaks from vessels and underground storage tanks. Sources of renewable energy present specific environmental externalities as well, such as fish kills from hydropower, avian mortality from wind power, and particulate air pollution from biomass combustion. In principle, each of these external costs represents an impact for which there is an optimal level of abatement, and there are a variety of mechanisms to measure this level.

In a sense, externalities can be thought of as "missing markets." Pollution imposes a cost on those who experience damages, and damaged parties have a willingness to pay to avoid the damages, but have no market mechanism in which to express this willingness. Typically, willingness to pay is least for small amounts of pollution and increases as increments of pollution, and damage, increase. At the same time reducing pollution is costly. Typically, it is least costly per unit to remove the largest increments of pollution and most costly to remove the smallest increments. Depending on the specific externality, this can be thought of as leading to a downward sloping curve that represents demand for environmental quality and an upward sloping curve that represents the supply of environmental quality. Were there a market, polluters and affected parties could interact and arrive at terms of trade, such that the

[3]Early discussion of market failure can be found in Bator (1958), with summaries of refinements to the theory in Burkhead and Miner (1971), Oakland (1987), and Cowen (1988). Fisher and Rothkopf (1989) summarize the implications of market failure theory for the energy sectors. Brown (2001) reviewed market failures and barriers pertaining to energy-efficient and renewable energy technologies.

[4] These failures and corresponding policy remedies are treated in any number of textbooks and other writings on welfare economics, market failure, and choosing policy instruments. See, for example, Sterner (2003), Baumol and Oates (1975), and Bohm and Russell (1985).

per-unit resources expended in removing the last increment of pollution would just equal the per-unit willingness to pay to have the increment removed.

Once optimal abatement schedules are determined, there is no justification for polluters to escape penalties for their actions. To the extent that a clean environment is a property right held by society at large, society could logically assess the pollution costs previously external to the polluter and assign them to the polluter's cost schedule. Doing so would force the polluter to internalize the cost. The result would be reduced pollution, higher costs for the goods produced, a lower level of consumption in response to the higher costs, and any number of subsequent adjustments to related markets as the consequences of regulating pollution work themselves out. How this may be done is discussed below. However, it is notable that if those impacted by pollution are aware that they may not be liable for making abatement payments, they may overstate their (hypothetical) willingness to pay.

Fisher and Rothkopf (1989, 399) suggest that, of the market failures, externalities are probably the easiest to understand and accept, particularly those related to environmental quality. However, there are other externalities, not all of which give rise to easy consensus.

One is the oil vulnerability externality, first examined by Plummer (1981) and subsequently studied by a number of analysts (see, for example, Greene and Tishchishyna 2001). Plummer suggests measuring impacts due to oil supply disruptions, overdependence on oil imports (including impacts due to monopsony buying power), and depletion of natural resources. Oil markets also inflict unpriced national security costs. Under relatively tight market conditions, the physical concentration of oil reserves in a relatively small number of countries generates the potential for physical and price-setting supply disruptions. These market conditions impose national security costs by reducing foreign policy flexibility and complicating military strategy, especially during periods of rising oil demand and tightening world markets.

An emerging concern lies in the production of greenhouse gas, particularly carbon dioxide from burning fossil fuels. In this case, assigning value weights to carbon abatement is particularly challenging because the costs of abatement accrue to the present generation, but the benefits accrue to future generations. Hence, efficiency considerations, based on willingness to pay, give rise to equity considerations, based on "fairness" and, even more challenging, equity considerations that arise between generations. More generally, the role of government in the literature focuses on the efficiency of matching resource scarcity to willingness to pay in a way that generates the greatest economic welfare for any given level and initial distribution of economic resources. Equity, the notion of fairness or moral obligation to provide for those with fewer initial resource endowments, is not considered. In contrast, the political process pays considerable attention to equity concerns.

Finally, energy is typically valued not for its own sake but rather for the services it enables. Hence, fuel oil is valued because home heating is valued, and gasoline is valued because auto services are valued. However, regulating auto fuel changes the auto usage, which can generate additional external impacts. As we discuss below, factoring in changes in auto use

occasioned by fuel policies can have an impact on external costs due to congestion or accidents, but may not affect key pollutants.

In sum, there is clear consensus that private actions can have an impact on common resources, but there are many attendant concerns over the costs and benefits that these actions occasion and further concerns over the tradeoffs that should be considered fair game. Measurements of externalities and the public's willingness to pay to abate them are difficult to make, and there is little consensus over which values should be considered best estimates. There is also disagreement over which tradeoffs are valid. To some, the nexus between (say), (1) higher fuel economy leading to reduced global warming and (2) higher fuel economy leading to higher vehicle use and greater highway congestion is a clear and appropriate tradeoff. But to others, casting greater highway congestion as a cost of controlling greenhouse gas emissions is inappropriate. Thus, for externalities, and for other market failures, issues of values and framing remain.

2.1.2 Public Goods

A distinction can be drawn between private goods, which the private sector will supply because profits can be earned, and public goods, which will generally not be supplied because profits cannot be earned. Public goods have two defining attributes: (1) "exclusion from consumption" is not readily possible, so that potential purchasers can "free ride" without paying, and (2) consumption by additional parties does not reduce the quantity of the good available to others, so that, at the margin, the socially optimal price is zero. In contrast, private goods have well-defined property rights (so that exclusion is possible), and are characterized by increasing marginal costs. Hence, markets can provide optimal allocations of private goods but not public goods. Again, for public goods, serious measurement issues for willingness to pay arise because there is an incentive for consumers to understate willingness to pay, thereby free-riding on those who accurately state willingness to pay.

These conditions characterize a number of valuable products, including national defense and much social infrastructure. They also characterize basic research into foundational topics needed to create more efficient energy-using products and more cost-effective renewable energy options. As a result, the private sector will typically not undertake basic research and, for this research to be undertaken, government support is required.

To examine the "exclusion from consumption" condition, suppose that developing a new energy-using product would require an advance in fundamental materials science. A firm undertaking this basic research would find that, if the critical discovery were made, other firms would quickly identify the discovery and incorporate it into their own products. These firms could then compete with the initial mover and could price their products without having to recover the costs of developing the advance. Thus, the initial mover would likewise be unable to recover development costs and would have no incentive to undertake the basic research in the first place.

There are, however, some methods for restricting use of "ideas" that might protect the firm undertaking basic research. As an example, patents can create intellectual property rights that

allow developers to recover costs. The question is: Where should the line be drawn between those ideas that are protected by patents and those that are not? To return to the zero marginal cost condition, any one firm using the idea would not diminish the amount of knowledge available to other firms and one could argue that the marginal cost of knowledge used (ignoring sunk costs) is zero. This leaves a bit of a quandary in that, without patent protection, virtually all R&D would be left to the government and the non-profit sector. However, it is also commonly accepted that firms have greater expertise than government in meeting market needs efficiently, so that it is desirable for firms to undertake the applied R&D that brings private goods to market.

This provides general, but still rough, guidelines for patent policy. Patents are not issued for ideas. They are issued for developments that are unique, have direct utility in application, and are non-obvious; in other words, for advances that produce practical results and advance the state-of-the-art in a meaningful way. In exchange for patent protection, the inventor must provide a written description that teaches others how to use the advance. When it is used in the manner described in the patent's "scope claims," the inventor is entitled to compensation, and when it simply adds to the general body of knowledge, the inventor is not. Precise applications of patent law vary from product to product and are the result of legislation, case law, Executive Branch patent rules and regulations, and trade and other government policies.

Based on this reasoning, the general guideline is that the more fundamental the inquiry, the more likely it is that government support will be required. The closer the inquiry is to developing a marketable product, the less will be the need for government support and the greater will be the private interest. All of this assumes that the private sector judges the new products to be marketable.

The public goods nature of education and training is also an important rationale for government involvement in energy-efficiency and renewable energy programs. Investments by employers in creating a well-educated, highly trained workforce, for instance, are dampened because of the firm's inability to ensure that the employee will work long enough for that firm to repay those costs. The difficulties of selecting and installing new energy-efficient equipment compared to the simplicity of buying energy may prohibit many cost-effective investments from being realized. This is a particularly strong barrier for small- and medium-sized enterprises. In many firms (especially with the current trend towards lean firms) there is often a shortage of trained technical personnel who understand and can explain the ability of energy-efficient technologies to generate a stream of cost savings that more than pay for any up-front installation premium. Government programs that pay university engineering faculty and students to conduct energy audits of industrial plants can help overcome this barrier by training the next generation of energy professionals, while delivering energy diagnostics and audit recommendations to plant managers (Martin et al. 1999).

2.1.3 Decreasing Costs

Decreasing-cost industries are characterized by technologies for which marginal costs decline up to a scale at which a single facility can meet the needs of an entire market. As an example,

it was once argued that electric power systems experienced lower marginal costs as the scale of operation increased. In this case, a monopolist could potentially provide service at lower unit costs than could a number of competitive operating systems with higher average costs. However, the corollary to this argument was that regulation would be required to ensure that the monopolist would pass along the cost savings to its customers. This situation was referred to as a natural monopoly and was argued to characterize electrical generation, electrical transmission and distribution, oil and gas pipelines, and other operations for which there were significant economies of scale.

These arguments are currently less important for energy markets than they once were because, with the restructuring of electricity markets, there are potentially larger markets and thus more competition than before. Moreover, there is a literature that suggests that through joint ownership arrangements, it would be possible to construct an efficiency-sized facility, such as a pipeline, and still provide sufficient competition to control monopoly rents. (See Coursey, Isaac, and Smith [1984] for examples.)

It may also be possible to characterize the gathering and dissemination of information as a natural monopoly, insofar as, once collected, the marginal cost of dissemination is essentially zero. We defer discussion of information until a later section.

2.1.4 Institutional Barriers

In addition to the classic market failures discussed above, it has long been argued that the special circumstances of some energy markets fail to provide consumers with clear price signals or sufficiently fungible choice sets to allow buyers and users of energy-using products to make optimal choices. We review several of these here.

2.1.4.1 Electricity Pricing

One clear-cut instance of market failure lies in household electricity pricing practices. The demand for electricity is characterized by a highly variable load that experiences cycles over seasonal, weekly, and daily time periods. Seasonally, the demand varies due to heating and cooling requirements. Weekly, it varies according to the needs of industry and commerce. Daily, load variance occurs as routine practices (like raising the indoor temperature upon arising, taking showers before breakfast, cooking at the dinner hour, washing dishes following the dinner hour, and the like) reinforce effects due to the changing of day and night. To follow these loads, utility companies employ a series of practices that includes bringing on line generators with different "cycle times" and correspondingly different cost structures. Typically, base-load plants have the longest cycling times and the lowest average costs; peaking plants have the shortest cycling times and the highest average costs; and intermediate-load plants have intermediate cycling times and costs.

The consumer, however, is not generally aware of the time of day/week/season cost schedule to which he or she is subject. Instead, the consumer sees a monthly electricity bill, often for billing periods of different lengths, that is essentially an average monthly cost. To avoid billing spikes in high-usage months, some companies

even allow customers to average costs over entire years, so that no price variation is seen. Thus, the price of electricity in most retail markets today does not reflect the real-time costs of electricity production, which can vary by a factor of ten within a single day (Hirst and Kirby 2000).

The result from these pricing practices is that the consumer experiences incentives to over-consume during peak periods and under-consume during slack periods. Most analysts agree that economic efficiency would be served by showing the consumer marginal costs of meeting load through time-of-day pricing. But would this reduce overall electricity consumption? This is unclear. Time-of-use pricing would reduce consumption at current peaks, but it would not necessarily shift these reductions to other time periods. On the other hand, the consumer would, on average, face lower prices due to increased efficiencies from shifting loads from more expensive to less expensive generators. The first effect might reduce consumption while the second might increase it.

2.1.4.2 Misplaced Incentives

A second clear-cut example of market barriers lies in misplaced incentives. This is typically labeled the "principal-agent problem" in the economics literature.[5] This problem occurs when an agent has the authority to act on behalf of a consumer (the principal), but does not fully reflect the consumer's best interests. Examples of this failure are numerous:

- architects, engineers, and builders select equipment, duct systems, windows, and lighting for building occupants;
- landlords purchase appliances and equipment, while tenants often pay the energy bills;
- industrial buyers choose technologies that manufacturers use in their factories;
- specialists write product specifications for military purchases;
- fleet managers select the vehicles to be used by others; and
- new car buyers determine the pool of vehicles available to buyers of used cars.

The involvement of intermediaries in the purchase of energy technologies limits the ultimate consumer's role in decision making and could lead to an under-emphasis on life-cycle costs.

The landlord-tenant relationship is a classic example of misplaced incentives. If a landlord buys the energy-using equipment while the tenants pay the energy bills, the landlord has little incentive to invest in efficient equipment. When the landlord pays the utility bills the landlord does have an incentive to purchase energy-efficient equipment, but the tenant has no incentive to conserve. About 90 percent of all households in multifamily buildings are renters, which makes this barrier particularly problematic in this segment of the market.

[5] We discuss issues of agency further below under "Information Asymmetries."

Commenting on this predicament, Fisher and Rothkopf (1989, 403) suggest that if utilities find that conservation practices are less costly than meeting the increased load, arrangements that allow the utilities to make conservation investments through rate-based financing might be optimal. Unfortunately, the restructuring of electricity markets has all but rendered this suggestion obsolete.

Misplaced incentives can also involve significant time lag. For instance, new car purchasers have a dominant influence on the design decisions of automakers. Yet they are not representative of the entire driving public, many of whom purchase their vehicles secondhand. In particular, new car purchasers are usually wealthier than average drivers, an attribute that skews their purchase preferences away from fuel economy and towards ride quality, power, and safety.

Brown (2001) summarizes a variety of other barriers to consumers achieving energy cost effectiveness in their purchases. Producers often bundle energy attributes in ways that blur distinctions between energy-using attributes and other attributes. Autos, for example, fail to offer equal performance for different engine/efficiency/price combinations. R&D capabilities offering innovative energy-saving features vary significantly by sector, such that the buildings sector sees less innovation than the auto sector. More generally, energy purchases are typically a relatively small proportion of income or total cost, and energy-consuming agents may not have sufficient incentives to overcome the transactions costs of making optimal energy purchases.

2.1.4.3 Markets for Capital

Although, in theory, firms or households might be expected to borrow capital any time a profitable investment opportunity presents itself, in practice a number of institutions restrict abilities to make the long-term commitments required for capital purchases. For example, firms are often observed rationing capital—that is, imposing internal limits on capital investment. The result is that mandatory investments (e.g., required by environmental or health regulations) and those that are most central to the firms' product line often are made first, while other, perhaps cost-effective, investments go unfunded. While not unique to energy investments, the set of institutional issues creating disincentives for the purchase and use of EERE technologies provides a potential target for policy.

Different energy producers and consumers have varying access to financial capital, and at different rates of interest. In general, energy suppliers can obtain capital at lower interest rates than can energy consumers, resulting in an "interest rate gap." Differences in these borrowing rates may reflect differences in the knowledge base of lenders about the likely performance of investments as well as the financial risk of the potential borrower. At one extreme, electric and gas utilities are able to borrow money at low interest rates. At the other extreme, low-income households may have essentially no ability to borrow funds, resulting in an essentially infinite discount rate for valuing improvements in energy efficiency. In intermediate cases, households may face a range of interest rates for different types of purchases, with relatively low

mortgage rates and relatively high consumer credit rates. Arguably, the highest rate faced is the marginal rate the energy-saving investment must confront. As we discuss below, financial institutions may also ration lending funds while setting interest rates below market clearing levels.

Differences in the cost of capital between electricity suppliers and purchasers may also introduce distortions. The broader market for energy efficiency (including residential, commercial, and industrial consumers) faces interest rates available for efficiency purchases that are also much higher than the utility cost of capital (Hausman 1979; Ruderman et al. 1987; Ross 1990; Levine et al. 1995). Thus, while society may find it cost effective to substitute energy conservation for energy production, market signals lead to the opposite result.

Firms may also hedge in undertaking internal decisions. DeCanio (1993), for example, has shown that firms typically establish internal hurdle rates for energy-efficiency investments that are higher than the cost of capital to the firm. Information gaps, institutional barriers, short time horizons, and non-separability of energy equipment all contribute to this gap. Each barrier could potentially be amenable to policy interventions.

Firms also face uncertainties over internal rates of return from energy-saving investments and may adjust internal hurdle rates accordingly. Energy prices, as one component of the profitability of energy-saving investments, can be subject to large fluctuations. Performance of innovative, but untested, technologies may provide additional uncertainty. Firm performance may be a third. Hassett and Metcalf (1993) and Sanstad, Blumstein, and Stoft (1995) have examined the role of price uncertainty in capital investments related to energy efficiency and have found support for this argument. Ross (1986) has shown that internal hurdle rates may vary for different types of projects, with small projects especially penalized.

Jones, Bjornstad, and Greer (2002) analyze capital markets for buildings and find that pressures to reduce first costs may militate against adopting energy-efficient systems with significant capital costs. Lovins (1992) shows how this pressure to reduce first costs can result from the fee structures for architects and engineers. Interviews with more than fifty design professionals and analysts showed that the prevailing fee structures of building-design engineers provide incentives to control the capital cost of the project. Such fee structures tend to reduce energy efficiency, because additional first costs are typically needed to enable the installation of superior heating, ventilation, and air-conditioning systems that reduce operating costs.

2.1.5 Information Issues

One of the traditional strengths of the market model is its ability to accumulate and distribute information regarding the relative scarcity of economic resources in producing products and the relative value placed on these products by potential buyers. Hence, a carpenter in Kansas need not concern himself with the timber harvest in Washington or with the likelihood that a

continued building boom in Phoenix will make lumber unavailable for the houses he plans to build. He can simply go to the lumber yard and price out wood products for local delivery and, based on these prices, make plans as to housing designs that will meet local needs and market conditions. If the boom continues, lumber will be available at higher prices and adjustments to blueprints may be required to meet local conditions. If demand for Washington lumber in Tokyo softens due to weakness in the Japanese economy, prices may rebound lower. All of this information is reflected in the market equilibrium price with the details virtually irrelevant in Kansas. Any additional required information is assumed to be equally available to all market participants, and in a sense, equally irrelevant. When this is the case, market prices plus the market environment reflect all the information needed to make socially optimal choices.

In fact, it is well understood that information is not equally available to all markets and that, within markets, individual participants may have unequal levels of information to use strategically. A literature has emerged in the last few decades that addresses these and other information questions. We now turn to a more extensive discussion of information issues.

2.2 Information Economics and Market Failure

Information economics has emerged over the last few decades as a challenge to the assumption that markets are fully informed by price signals and by the underlying "market environment." As was noted above, under fully informed conditions, and absent market failures, a market economy reaches a Pareto-efficient state, such that no individual could be made better off without making some other individual worse off. This efficient state can be compared to alternative states that are subject to market failures and policy instruments to restore efficiency can be applied. For each initial resource endowment, a unique, but equally efficient, distribution of resources will be obtained. While it is generally recognized that this set of arguments greatly simplifies the real world conditions facing a modern economy, the models resulting from it provide a first approximation of reality and a firm basis on which to develop policy.

Information economics responds to this conclusion by asserting that information is always imperfect and that, as a result, the initial states assumed by the classical analysis cannot typically be considered Pareto optimal. While not rejecting the substance of the classical market-failure arguments, information analysts argue that the solutions from those analyses are often incomplete or misleading. The result has been a proliferation of special-case models in which specific information topics are examined and basic models are extended. Here we divide this very large body of literature into three general categories that provide some insight into issues relevant to energy-policy analysis. In each case, we provide an overview, but far from an in-depth analysis, of a much larger body of thought.

We consider three categories of information breakdowns. The first issue is the notion of *information asymmetries*. For simplicity, we use the example of the simple two-party case. One party is referred to as the principal, and the principal, by definition, is the party that offers a "contract" to a second party, referred to as the agent. One of the two parties has information that is valuable to the contract, but which is withheld from the other party. Both

principal and agent have separate objectives, and the challenge is to improve the efficiency of the contract and allocate the distribution of gains that greater efficiency implies.

The second category discussed is the overall *information character of the market environment,* which we define as the information available to any party seeking it, but at a cost. Whereas the first category dealt with strategic relations between two parties with unequal information endowments, this case deals with the choice by a single individual as to how much information to gather when the gathering process is costly. Here, we consider how much information is enough, and illustrate the issue using the case of investment under uncertainty and bounded rationality.

The third consideration is *insufficient price signals,* which occur when some markets use prices as mechanisms to accomplish ends other than market-clearing. In this case, prices signal something other than resource scarcity. We illustrate this using interest rates and their relation to credit rationing.[6]

2.2.1 Information Asymmetries

The broad literature of information asymmetries can be simplified to how to structure a contract between two individuals. The contract seeks to improve efficiency and distribute efficiency gains from improvements accruing to a transaction between the two individuals, one of whom has better information than the other. As noted, a principal offers a contract to an agent, and the agent can choose to accept or reject the contract. When the principal, who offers the contract, is the better informed party, the model is called a *signaling model.* When the principal is the uninformed party, the resulting model can take one of two forms. When the principal is uninformed about how the agent will *behave*, the model is called a *moral hazard model*. When the principal is uninformed about the *attributes* of the agent, the model is termed an *adverse selection model*. In general, the analysis of these models seeks to guide the principal in structuring contracts that provide incentives to improve the outcome relative to efficiency and distribution. The literature contains many permutations about the number of principals and agents, the order of deal making, the role of uncertainty, sequential bargaining, and the like.[7]

R&D decisions can provide an example of a simple moral hazard problem. Here, the principal (for example, EERE) hires a research specialist agent to carry out a study. The reason for hiring the agent is because the agent possesses special expertise that the principal does not. The problem is to write an R&D contract that provides incentives for the agent to solve the R&D problem as efficiently as possible. For example, a fixed-price contract provides the incentive for the agent to solve the problem quickly, and, once a contract is let, provides the greatest incentives for efficiency. The agent bears all of the risk. If the agent

[6] The modern theory of non-cooperative games applied to economic behavior provides a rigorous formation through which to examine these and other information topics. Rasmusen (1989), for example, describes information conditions as perfect or imperfect, certain or uncertain, symmetric or asymmetric, and complete or incomplete, and describes the implications of each. Alternative (but consistent) treatments can be found in any number of sources.

[7] There is a broad literature on information economics. One exhaustive series is being prepared by Laffont and Martimort (2002 and forthcoming).

knows the cost of fulfilling the contract exactly, the agent can assess the profitability of the contract and accept or reject the price based on profitability. In general, there are a large number of *mechanisms* available to identify prices that divide the gains from efficiency between the principal and the agent.

In contrast, the costs of solving the R&D problem may be highly uncertain; there may not even be a solution. In this case, the agent may reject any fixed-price contract. To provide an incentive for the agent to do the work, the principal may offer a cost-plus contract, wherein the agent is reimbursed for costs plus some level of appropriate profits. Such a contract provides no incentives for efficiency. Moreover, the principal bears all of the risks due to uncertainty. An alternative contract might contain elements of fixed costs and cost-plus provisions. In this case, there are greater incentives for efficient behavior and the benefits from this efficiency, as well as the costs due to uncertainty, are divided between the two parties.

An example of a simple adverse selection problem deals with the case where the EERE issues a call for cost-sharing R&D proposals. Assume, for example, that in this case, the government would pay for some share of the R&D. After seeing this offer, a firm might be less willing to share its best ideas, and would prefer to come forth with more risky, less potentially marketable projects. EERE, in contrast, would wish to select the least risky, most potentially marketable projects. As the party offering the contract, EERE might choose to increase its own cost share to provide incentives for the private sector to come forth with more attractive projects.

Another information asymmetry is signaling. Here the principal is the better-informed party and moves first. One example of signaling is the case of a principal offering a used car for sale. In this case, the principal knows the condition of the car, and the prospective buyer (the agent) does not. The principal could price the car fairly and do nothing else. The agent might in this case assume the car is inferior (why else would it be for sale) and reject the fair price, interpreting the offer as a case of adverse selection. To remedy this, the principal could undertake any number of actions to suggest that the car is of high quality and fairly priced. For example, the principal could wash and wax the car (to signal fastidious care), could clean up the garage and park the car in it during the sale period (to signal the car has been protected), or could assert a reputation for offering fair deals. The principal could also offer a contingency contract providing a warranty. However, by doing so, the principal could potentially induce the buyer to use the car irresponsibly (moral hazard) such as not maintain the car properly. Hence, the contract would have to provide balance between providing evidence of the car's condition and promoting responsible use by the buyer, presumably through a risk-sharing arrangement.

The basic lesson from asymmetrical information theory is that when parties to economic transactions have different amounts of information and different objectives they will behave strategically. Both parties will typically know (or suspect) who has the superior information and will assume that the better informed party will use this information to his/her best advantage. This situation constitutes a market failure in the sense that, were equal information available to each party, a socially superior bargain could be struck. Failing this, a

large number of mechanisms are available to promote efficient behavior and divide gains from it among the parties.

2.2.2 Information and the Market Environment

Joseph Stiglitz (2002) has argued that, because there is only one way for information in a market environment to be perfect and a virtually infinite number of ways that it can be imperfect, one should expect market failures due to information inequities to be the norm. Certainly, this would be true for emerging energy technologies because they are new, unfamiliar, and to some extent untested.

One reason that agents may be less than fully informed is that gathering and processing information is costly. Under this circumstance, consumers may trade off the benefits of making better decisions by using better information against the costs of gathering better information. One approach to this topic has been proposed by Simon (1955), who suggests that consumers "satisfice" rather than optimize. They gather information until they can make acceptable decisions, an approach that is also sometimes called bounded rationality. In other words, they make decisions that are privately rational, given their knowledge base and the costs of adding to it, but that are less than socially optimal, because with information about (say) emerging energy technologies, they might rationally choose these technologies more often.

One response to boundedly rational decisions that are individually optimal, but socially inferior, might be for the government, recognizing the information deficiency, to undertake an information expansion program. Such a decision could be based on the argument that information provision is a decreasing cost industry, that information can be considered a public good, or simply due to the difference between private and social optimality.

However, there are also reasons, based on asymmetrical information theory, to believe that a government program of this sort would be less than fully effective (Bjornstad 2003). Under such a program, the initial condition would be one of information asymmetry. The government would have superior information and the consumer would have inferior information. Under these circumstances, both parties would have incentives to behave strategically. The party with superior information would have an incentive to take advantage of its information position to meet its goals, in this case to promote the purchase and use of energy-saving products. The party with the inferior information would recognize this incentive and discount the information accordingly.

To deal with these perverse incentives, the party with the superior information (in this case the government) might need to take some action to demonstrate the validity of its position. For example, government could develop a superior reputation through repeated interactions with the public, or it could take steps to demonstrate its confidence in the reliability of its information (as the National Energy Policy [2001] does by requiring agencies to use the products that EERE is promoting). Conversely, the parties with inferior information could require some sort of contingency agreement in the event the information is not fully reliable. This topic is not addressed in the literature, but may have merit.

A second, and related, reason that consumers may not adopt new innovations as rapidly as is socially desirable is that they perceive that the performance characteristics of the new technologies as uncertain. However, with the passage of time, these uncertainties will abate costlessly. That is to say that the prospective consumer pays no direct price for the information but endures the opportunity cost of foregoing the benefits from the new technology while waiting to receive the "costless" information. Uncertainty may derive from any number of sources, including energy prices, product reliability, or product performance. As was noted above, deferring investment until uncertainty abates may present itself to observers as the firm or consumer setting an internal hurdle rate above the opportunity cost of capital, whereas the firm in fact is adding a risk premium to the opportunity cost of capital.

Finally, one might ask: What if some individuals, due to bounded rationality, or other reasons, make decisions that are patently not in their best interest? Should government intervene? Specifically, if cost-efficient, energy-saving investments are not purchased, should government take steps to correct what are sometimes termed "negative internalities"? We argue below that it is proper to separate normative and positive economic analysis, giving the benefit of the doubt to consumer rationality. Nevertheless a literature is developing to help frame these issues and offer alternative perspectives as to when government might properly adopt a "paternalistic" stance. (For a review, see Camerer et al. [2003].)

2.2.3 "Inefficient" Price Signals

Stiglitz (2002) and others have argued that under some market circumstances prices are used as signals rather than as instruments to clear markets. One example of this is the credit market, where interest rates are the relevant "price," and there is adverse selection, because prospective borrowers know more about their own creditworthiness than do lenders.

The issue is this: If a borrower knows that he or she will be certain to repay a loan, he/she will only agree to borrow at a low rate. In contrast, a less worthy borrower, knowing that he/she may not repay the loan, will be less concerned about a higher interest rate. Thus, banks cannot attract credit-worthy customers by offering interest rates at average levels that balance off good credit risks and bad credit risks. The bank, then, offers an interest rate that is lower than the market clearing rate, and rations its loans by choosing the most qualified borrowers. More risky buyers are thus shifted to other lending markets.

Such an analysis is relevant to the frequent criticism that members of disadvantaged minority groups and small businesses have inadequate access to capital markets. Fisher and Rothkopf (1989, 403) note that it is commonly assumed that the poor have limited access to capital funds for purchasing cost-effective energy equipment and that this access is often used to justify low-interest or zero-interest loan programs. The issue, of course, is not the likelihood that the investment will repay the borrower, but whether the borrower will repay the lending institution. In this case some alternative, such as adding electricity-saving investment costs to power bills, might reduce non-payment, lowering the credit risk and therefore providing greater access to capital markets. The effect of this transaction would be to assign savings

from energy-efficient investments directly to the electric utility, but would also assign the performance risk of the investment solely to the borrower.

2.3 Market Failure and Policy Instruments

2.3.1 Market Failure

Thus far we have been vague about the definition of a market failure, beyond stating that it is a departure from the market equilibrium that would have been obtained in its absence. To some, it is a departure from the equilibrium that a fully informed, yet benevolent and empowered, central planner could restore. Finding departure from a Pareto-optimal equilibrium, in which no party could be made better off without making some other party or parties worse off, provides a rationale for government intervention in market outcomes.

An alternative approach would suggest that these departures provide guidance as to the potential role for government, but are by themselves insufficient to justify government activity. They are, in other words, necessary but not sufficient. Sufficient conditions would require the identification of a set of policy instruments and implementing institutions that would generate an expected net benefit with an acceptable distribution of benefits and costs. Harold Demsetz (2002) has articulated this as a choice between an idealized state (the perfect market) and an imperfect alternative institution. Anne Krueger (1990) has characterized it as a choice between market failure and potential government failure. There is also consideration of first-best and second-best policies. A first-best policy would succeed in restoring a disturbed Pareto equilibrium to its original state. A second-best policy might fail to reach full Pareto equilibrium because of multiple market failures. The theory of the second best argues that corrections to suboptimal states based on partial equilibrium analysis (i.e., correcting one of several aspects of suboptimality, such as insufficient R&D, but ignoring the others) may even leave an economy *worse off* rather than better off. In the case of a second-best policy, either further analysis or additional policy instruments might be required to reach a Pareto-superior end state.[8] We deal with analyses of this type in the following section. Policy instruments are treated immediately below.

2.3.2 Policy Instruments

Sterner (2003) provides a taxonomy of available policy instruments that include: direct regulation (sometimes termed command-and-control); quantity instruments such as tradable permits; price instruments, such as taxes; deposit refund schemes; subsidies; property rights; and information enhancement policies. We deal with these briefly here, noting that many others have prepared exhaustive treatments.

2.3.2.1 Direct Regulation

Direct regulation can take the form of performance standards, building or production codes, prohibitions, and/or admonitions to take some specific action. As an example, the DOE's Appliances and Commercial Equipment Standards Program develops test

[8] For a seminal discussion of this topic, see Lipsey and Lancaster (1956). The review by Parry and Oates (1998) emphasizes that analysis may require extensive studies of other linked markets as well, such as labor markets.

procedures and minimum energy-efficiency standards for residential appliances and commercial equipment. Many environmental protection programs take a similar approach to controlling pollution. The essence of command-and-control regulation is the application of a single metric to all similar applications.

Most economic analysis suggests that command-and-control regulation is inferior to other forms of regulation that are structured to take into account more information about the individual circumstances of the polluter or the bearer of pollution damages. Exceptions to this principle are found in Kahn (1995), who suggests that direct regulation may be appropriate when optimal levels of pollution are near zero, when monitoring costs are high, or during unusual circumstances such as emergencies, when relationships between costs, values, and damages change abruptly. Other rationales might include sensible working relationships between a small number of regulated firms and knowledgeable authorities.[9]

The principal criticism of command-and-control regulation is that, by treating each firm identically, it fails to consider that some firms can abate pollution at lesser cost than others, and that alternative forms of regulation, by taking this into account, could reduce pollution at lower costs. Tietenberg (1984) once estimated, in a comparative cost analysis of air pollution control, that using command-and-control policy tools, rather than market-based ones, could significantly increase (by two to twenty-two times) the cost of meeting abatement targets. Nevertheless, the command-and-control approach remains a dominant aspect of energy and environmental regulation, partly because of its simplicity and undoubtedly due to its acceptability in our culture.

2.3.2.2 Quantity and Price Instruments

We treat price and quantity instruments together because they are theoretically symmetrical. An authority can, in principle, calculate an optimal level of emissions, issue tradeable permits equal to that quantity, create a permit trading system, and arrive at a price for the permit that would be identical to a tax on pollution emissions that generate the same quantity of emissions permitted by the trading system. The principal theoretical difference between the two is esoteric and relates to uncertainty in cost or benefit functions and related price sensitivities (Weitzman 1974). The practical difference arises from the uncertainty about market resources in a dynamic environment; to a policy maker the issue is if it is more important to be confident in the quantity of pollution that is discharged or in the marginal cost of pollution control.

The efficiency gains from both price and quantity instruments derive from two sources. First, in a static sense, when firms are heterogeneous they will typically have different cost schedules to abate similar amounts of pollution. Both instruments allocate pollution control in such a way that the firms with least-cost abatement do the

[9] There is some anecdotal evidence that firms over-comply for the purpose of developing "reputations" with regulators. This occurs because the pace of regulation often lags behind the pace of private-sector development, and to wait for extended regulatory proceedings might be to miss windows of opportunity. Under this approach, a given firm might construct and operate a facility in anticipation of regulatory approval, with the permission of regulatory authorities. See Brännlund et al. (1996).

greatest amount of abatement, but are compensated for doing so. Hence, a firm with relatively low abatement costs that held emission permits could sell permits to firms with higher abatement costs. Both firms would benefit from this, as would society, which would spend less overall on pollution abatement.

The second source of efficiency from price and quantity instruments comes from general equilibrium adjustments that result from cost and price adjustments following the enactment of new policies. Take, for example, a new tax on (say) gasoline. The tax would increase the cost of auto travel per mile. Auto users, in the short run, would have incentives to use their cars less and in more efficient ways (as by carpooling). In the longer run, they would purchase more energy-efficient autos. Auto manufacturers, seeing the demand for more fuel efficient autos, would invest in fuel efficiency research. Ultimately a new equilibrium would be reached.

In general, whenever one adds a tax to some product, one reduces its attractiveness relative to substitutes. Thus, if the goal were to reduce carbon emission, a tax on carbon emissions would accomplish this. Alternatively, one could determine the allowable amount of the product and create a property right to produce (emit) that amount.

2.3.2.3 Subsidies

Subsidies are the opposite of taxes. Rather than adding to the cost of some activity, they reduce the cost of it. Thus, while taxes are useful policies to reduce undesirable activities, subsidies are useful to encourage desirable activities.

The government uses a variety of subsidy schemes to promote its energy policies. For example, tax credits for solar energy, insulation, and other energy-conserving practices have long been used. As such, these policies affect end use directly. Current policy subsidizes the purchase of certain fuel-efficient vehicles and certain renewable energy technologies, such as wind-generated electricity. EERE has a large energy-efficiency R&D program that subsidizes the development of technologies and knowledge that reduce energy use.

Depending on their use, subsidies can be less attractive than alternative policies. As an example, an R&D subsidy to produce energy-efficient auto technologies is a second-best policy because it fails to address energy end-use prices. Hence, if there were an externality, say, due to external costs of imported oil, a more desirable policy would be to tax imported oil. Failing to tax would mean that a suite of market signals driving toward lower gasoline use would not be sent, and the policy would be less effective, per unit of social resources used. More specifically, the subsidy to autos would send consumers a signal that certain fuel-efficient autos were available, but not the message that imported fuel should be viewed as more scarce, as would a tax. The policy would also fail to distinguish between domestically produced oil and imported oil.

It can also be argued that certain subsidies that reduce uncertainty by providing warrantees against uncertain outcomes, such as non-performance by an unproven technology, may be more effective than simple price subsidies (Bjornstad, 2003). Examples of these would be lease programs, buyback programs, and performance guarantees.

2.3.2.4 Information Programs

We have discussed information topics at length above. If one accepts the results of the new theory, market failures due to information inadequacies characterize virtually all markets. Some information issues arise from ignorance: consumers are unaware of the availability of desirable products. Some problems are due to matters of strategy. If I know that you are better informed than I and have your own agenda, how should I respond? Others deal with the information content of prices. If prices signal information other than resource scarcity (bank credit or quality of products), are these market failures?

2.4 General Criticisms

The economic approach to defining a role for government has also been criticized as subject to a number of weaknesses. These include:

- market mechanisms that may not exist,
- a limited empirical foundation,
- reliance on willingness to pay, which under-values the views of citizens with lower incomes, and
- confusion between positive and normative conclusions

One criticism of the economic approach is that it posits as a benchmark a market mechanism that may not actually exist. If the Pareto-efficient baseline is a chimera, do the analysis and the conclusions that stem from its use as a criterion retain validity? We would argue "yes," because even while failing to capture fully the interactions of economic agents in the U.S. economy, it provides a vehicle to generate insights about economic efficiency that can be subjected to empirical study and refinement. We know, apart from economic theory, for example, that most people judge pollution to be undesirable. The question is how to deal with it, and the theory provides insights as to efficiency implications of different choices. It points out that the optimal level of pollution is a value judgment, but is influenced by the costs of pollution abatement. It demonstrates the symmetry between price and quantity policies. It highlights tradeoffs. It reinforces the fact that there are costs to every action, and that not all desirable consequences will be judged affordable. In other words, theoretical analysis provides understanding that would not arise through causal observation. It helps avoid drawing false conclusions from valid premises, and it helps focus attention on the validity of premises. In other words, it provides a framework within which to identify and evaluate the costs and benefits accruing to alternative choices. There is no available dominant alternative.

A second criticism of market failure analysis is that it rests on a thin empirical foundation. As an example, Cowen and Cramption (2002) argue that little of the information economics

toolkit rests on data-based analysis. As evidence, they supply a series of papers that use experimental economics to demonstrate that economic agents do not always follow strict interpretations of their dominant strategy when they make economic decisions. Elizabeth Hoffman (2002), for example, demonstrates that the free rider principle is less prevalent in the experimental laboratory than theory would suggest. Isaac et al. (2002) demonstrate that group size is less of an impediment to collective decision making than was previously thought. More generally, the field of behavioral game theory (see Camerer 2003) is arising as a combination of logic and empirical verification. It should not be remarkable to suggest that logic, supplemented with empirical analysis, provides more information than logic alone.

A third criticism of market failure analysis is that outcomes rely heavily on value judgments, measured as willingness to pay. Such analysis tends to neglect the desires of those with limited income and thus limited ability to pay. This criticism is valid, but limited. The power of preference-based decision making is that, if correctly executed, it identifies feasible solutions and allocates resources toward activities that, in the aggregate, are more valued. There is little point in proposing policy solutions that cannot be sustained, and only the programs for which constituents are willing to pay are sustainable. However, it is also true that society values equity concerns. Thus, even though failure to invest because of restricted access to capital markets by disadvantaged social groups may be a reasonable market response, it may still be valid to implement a program targeted at these groups.

A final criticism of market failure analysis lies more in the inferences drawn from the analysis than in the analysis itself. This can be summarized by the statement that policy sometimes confuses positive conclusions and normative conclusions concerning "economic man." Specifically, much guidance given policy makers implies that not only *do* individuals make marginal tradeoffs between alternative choices, including service flows from energy-saving capital investments, but that they *should* behave this way. The conclusion is that a failure to do so is a market failure, justifying government intervention. The positive analysis, in contrast, says only that rational economic behavior can be used to predict real world outcomes; it does not hold that rational economic behavior should be imposed.

As an example, current policy seems to assume that individual consumers do or should view capital purchases in a manner akin to purchases of financial investments and substitute between them. Yet, even studies of purely business markets, such as commercial buildings, show that it is the financial markets that impose pressures to reduce first costs, rather than embrace larger first costs for life-cycle reasons (Jones et al. 2002). The assumption that households would borrow to reduce future costs is akin to assuming they buy stocks on margin, a risky prospect at best that must be evaluated relative to ones entire asset portfolio. Establishing an empirical basis for such assumptions is critical. The asymmetrical paternalism literature, discussed above, provides a framework within which to address these issues.

In sum, market-failure theory provides a logical framework that informs real world analysis. This framework also provides a basis for measuring the importance of key variables and behavioral tendencies. But when the empirical measures do not perfectly track the theoretical predictions, using the theory to reject the data is ill advised. Finally, taken together, these

analyses can provide evidence of sustainable program acceptability, where sustainability is judged by willingness to pay even while providing a basis to evaluate the distributions of these outcomes among the members of society. With this information, value judgments as to final policy choices can be made.

3.0 EXAMPLES OF ANALYSES

This section examines two studies (Portney et al. 2003; Austin and Dinan, 2004) that address the issue of CAFE standards using the market-failure framework just discussed. The fact that they use this framework in no way predetermines the conclusions they reach: the large numbers of specifications and parameter choices that must be introduced leave wide latitude for different results. Despite this, the two studies do reach similar conclusions, and they do introduce a vocabulary and format that could serve as a model for discussing policy alternatives relevant to any number of EERE programs. Hence, EERE may wish to consider the implications of similar analysis of its programs.

Briefly, CAFE requires each manufacturer of new vehicles sold in the U.S. market to meet a single, sales-weighted fuel-economy standard. For autos, this standard began at 18 miles-per-gallon (mpg) in 1975 and increased to 27.5 mpg in 1985 and the years that followed.[10] In 1979, a similar program for light-duty trucks was set in place with the mpg floor at 20.5. Manufacturers have always had the option to pay a penalty of $5.50 per vehicle sold for each 0.1 mpg by which they fail to meet this standard. Domestic manufacturers have arranged to just meet this floor and have never paid penalties, while some foreign manufacturers of luxury or performance vehicles have routinely paid penalties.

In general, manufacturers have a number of options for meeting this standard. They can adjust fuel efficiency through technology, they can reduce the weight of the vehicles, or they can vary the relationship between fuel economy and performance by some combination of actions. Ultimately, given the right market conditions, they can adjust the mix of prices of the different elements of their fleet so that buyers of heavy, less fuel-efficient cars pay premium prices and buyers of smaller, more fuel-efficient cars receive subsidized prices, leaving the overall product mix at or above the standard.

Thus, CAFE is a second-best solution because it addresses fuel consumption through constraints on the available vehicle stock. Note, however, that a fuel-efficient car reduces fuel costs per vehicle mile traveled and hence provides an incentive to drive more and thus use more fuel (the rebound effect) than a simple analysis of percentage changes in fuel economy would suggest. In contrast, a fuel tax would provide an incentive both to drive less and to purchase more fuel-efficient cars.

The question addressed by both studies is whether the current level of CAFE serves the nation well. Should CAFE be raised, lowered, or left the same? The answer to this question could be posed in a way that would seem obvious: "Of course higher fuel economy is better." This response, however, ignores the fact that higher fuel economy comes at an opportunity cost. For any given technology, a higher level of fuel economy can be achieved by reducing vehicle performance. Reducing vehicle weight increases fuel economy but reduces safety. Increasing fuel economy encourages more driving, which takes back some fuel savings, increases congestion, and leads to more accidents. Interestingly, increasing fuel economy does not lead to less carbon monoxide or hydrocarbons, because current regulatory practices

[10] This discussion draws on material presented in Portney et al. (2003).

control these at the tailpipe, per mile driven. Thus, tightening CAFE standards could increase the outputs of these pollutants, as it increases miles driven.

The analysis presented in Portney et al. (2003) centers upon the control of externalities within a static context. First, the authors consider, but ultimately reject, inclusion of a Pigouvian price for oil price shock impacts.[11] They do this by arguing that the interconnectedness of the world oil market would still send shock waves throughout the U.S. economy even if the United States reduced its fuel consumption. They next examine the impact on the U.S. economy of reducing oil imports due to U.S. monopsony power.[12] They draw upon a National Research Council study (2002) that sets a tentative additional cost of 12 cents per gallon for this effect. To estimate the environmental externality tax, they again draw upon the National Research Council study (2002) and arrive at a tax of 12 cents per gallon for carbon reduction. They also note the lack of other environmental benefits (as noted above). Finally, they consider a number of other potential externality taxes, but ultimately reject their inclusion. Thus, in total, each gallon of fuel saved, saves 24 cents in welfare costs. Finally, they note that these charges exclude existing taxes and that the current combination of Federal and state taxes, which average about 40 cents per gallon, more than offset the externalities.[13] Based on these findings and assumptions, raising CAFE standards would result in welfare losses, rather than gains.

There are also unintended consequences. The rebound effect leads to more driving as fuel economy increases. They assume that with such effects (a 15-percent rebound effect, a cost of 3.5 cents-per-mile congestion cost, 3.0 cents-per-mile accident cost, and an average fuel efficiency of 20 mpg), there would be a cost of 19.5 cents per gallon. With adjustments due to rebound effect for the CAFE standards and other effects, this value is strikingly similar to the externality welfare gain.

The authors suggest that a simple analysis of these numbers indicates that raising CAFE standards would create a welfare loss. They also note that the resolution of the uncertainty associated with many of the values (such as the costs of global warming) could change best estimates greatly over time.

Austin and Dinan (2004) address the same fundamental problem with the same analytical paradigm, but employ a much richer analytical framework. Their approach is to model the market for new vehicles and to integrate additions and subtractions to the vehicle stock over

[11] A Pigouvian price is the tax, normalized against the control instrument (in this case gallons of gas), that balances the supply and demand of the control target externality (in this case reduction of costs to the economy due to oil price spikes).

[12] Monopsony power suggests that, because the United States is such a large buyer of oil in world oil markets, reductions in U.S. demand will lower the average price of oil. In this case the savings is the sum of the reduction in oil spending plus the effect of the lower price on oil that is still consumed.

[13] This observation is actually an assumption that could be subjected to further analysis. For example, most fuel taxes supply funds for road building and maintenance, which in themselves encourage more driving, but, in general, decisions to build more roads ignore the impact on additional accidents that would accrue to greater numbers of passenger miles traveled. Moreover, studies that measure willingness to pay for further reductions in pollutants related to vehicle miles traveled are conducted against a backdrop of existing taxes, and sorting out their influence on willingness to pay may deserve further comment.

time until the effects of the new standard are fully reflected in the vehicle stock, a period they take to be fourteen years. Using this approach they are able to examine assumptions about the mechanism the auto industry uses to implement the standard; the effects of consumer preferences working against these mechanisms; and a number of other effects, such as the organization of the industry. They are also able to compare the efficiency effects of the CAFE with those from taxes, and with CAFE combined with credit trading.[14] Their work assumes similar costs due to externalities as Portney et al. (2003), but does not examine the impacts of congestion or accidents due to rebound effects. In general, their work provides a more sophisticated treatment of the auto market than did earlier work.

Perhaps not surprisingly, given the common assumptions about costs due to externalities, the general conclusions by Austin and Dinan (2004) are very similar to those by Portney et al. (2003). They conclude that, given current gasoline tax levels, further increases in CAFE standards reduce economic welfare. If the goal were to reduce gasoline use, as among these instruments, the gasoline tax is the most efficient, the CAFE with credit trading the next most efficient, and the CAFE the least efficient.

[14] Credit trading permits a more efficient distribution of the burden of achieving the CAFE standard among firms, much like emissions permit trading.

4.0 GENERAL CONCLUSIONS

This paper has reviewed the rationale for government intervention into markets from the perspective of economic efficiency. Its goal has been to gather insights to guide investments into ways to select and justify choices concerning the makeup of EERE R&D programs and efforts to promote their products.

The failure of markets to supply adequate information and incentives to achieve Pareto optimality forms the basis for rationalizing government interference in market allocations of goods and services. In general, there have been relatively few changes in the basic arguments surrounding market failure since the oil embargo of the early 1970s. Market failures include externalities due to an imperfect world oil market, pollution and other environmental impacts, concerns with monopoly power, decreasing-cost industries, and barriers specific to individual markets in which energy and energy-using products are bought and sold.

The principal recent insight added to this literature has been the role of information, and especially asymmetrical distributions of information, on market behavior. Information topics add considerable complexity to the analysis of market failure, and have not been fully integrated with the traditional theory.

A second change since the early 1970s has been the general recognition of the complexity of intervention in markets and the importance of documenting the net benefits from proposed government interventions. In general, analysts now examine whether or not there would be apparent gains from the best possible manner of interventions, typically tax or quantity measures, and then compare these to the impacts from politically acceptable "second-best" policies. To the degree possible, analysts also try to examine the specific institutions that would implement programs. The trend is toward greater testing of underlying economic assumptions. This is due, in part, to the influence of such emerging fields as behavioral economics and behavioral game theory, and of experimental methods for studying them.

Examining two similar studies of CAFE standards provides a clear example of how economic welfare analysis can improve policy deliberations. Both these studies used a market-failures framework, paying particular attention to economic behavior and embedded technical relationships into economic models.

Evaluating these models means reexamining the assumptions that underlie their specification and parameterization. Is it reasonable to frame models to trade off highway deaths due to increased driving against future impacts due to climate change? Superior analyses will be structured to permit comparison of numerous tradeoffs so that policy makers can choose which to include, which to exclude, and which simply do not matter.

Uncertainties will always qualify model results. Ultimately, policy will focus more on the value of impacts than on the impacts themselves, but value estimates will provide a point of departure—rather than a terminal point—for policy deliberation. Increasingly, costs will be valued in market terms as opportunity costs, rather than as avoided costs, or other measures

of impact. In the studies examined, the question was not how much energy is saved, but rather, how does the market value the sacrifices required to save energy.

EERE necessarily operates largely in an environment characterized as the "theory of the second best." For the most part its activities take place in the absence of appropriate energy price signals. Its principal activity is to conduct R&D to improve the science base and to improve the quality of the technologies that derive from science. To a lesser extent it conducts activities to promote these technologies. However, a clear concept of benefits is required to conduct economic benefits analysis, as is a clear concept of economic costs.

Clear concepts of benefits and costs could help produce a better integrated approach to research management from which EERE could gain. The market failure literature provides insight into the government role for R&D and the government role for reducing energy-related externalities. It also provides a potential role for information theory and underscores the need for empirical work. For instance, consider the two studies examined here. The Austin and Dinan (2004) analysis assumed that fuel-efficiency data posted on the windows of new cars sufficed to provide an informed market environment. In contrast, Portney et al. (2003) reduced realized fuel economy to compensate for expected differences between bench tests and road experience.

Clear concepts of benefits and costs will not necessarily lead to accurate estimates of benefits and costs. Dowlatabati, Boyd, and MacDonald (2004) chide the modeling profession for producing inaccurate estimates and suggest the need for new ways to improve estimates and new mechanisms to factor them into policy. More generally, it should be understood that all analysis is analysis under uncertainty. Developing decision-theoretic approaches for evaluating the information content of data and estimates for answering specific policy questions would add confidence that EERE is drawing the best possible arrows from its quiver as it seeks to defend its program choices.

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