Market Transformation and Multiple Equilibria

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ABSTRACT

Current thinking on market transformation is that there is a market equilibrium where consumers make optimal choices with respect to energy efficiency technologies. The reason consumers don't make these optimal choices is because there are market barriers. The policy remedy is to remove these barriers. We suggest instead, that the market is at one of several possible equilibria.

Economic theory is rife with multiple equilibria; having a single equilibrium is a comparatively rare phenomena in theory and practice. Some of these equilibria will be stable equilibria that the market "falls into".

Viewed from a multiple equilibrium perspective, a good market transformation policy will move the market far enough away from the current equilibrium so that it moves to a different, preferred, equilibrium of it own volition. Policy recommendations under this framework are significantly different and warrant additional consideration.

Introduction

After considerable discussion and debate, the definition of Market Transformation has coalesced somewhere around the classic introductory microeconomic view of markets, with a downward-sloping demand curve, an upward-sloping presumably short-run supply curve, and one stable equilibrium not attained because of a "market barrier". Programs remove quantity constraints or price constraints, or they lower the transaction and uncertainty costs that are faced by buyers and sellers of relatively energy-efficient equipment. While it is possible to think about many of the things going on in markets and the function of programs with these tools, it does make it difficult if not impossible to describe some problems and programs. Words, concepts and images in very real ways bound in thoughts. Single market supply and demand is a simplification of reality and it may be too simple to handle the problems that we deal with in energy efficiency programs.

The objective of this paper is to help the reader break loose from the introductory microeconomic model that has become so prevalent and to move into a more mature understanding of markets. To accomplish this goal the first section of this paper will summarize the current theory of market transformation in the introductory microeconomic framework we are used to using. Then using the same tools we will illustrate how markets can work quite differently under some very common deviations of the ideal case. In particular we will show:

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- Multiple equilibria arise in a very important way.
- Outcomes are path-dependent.
- How policy choices are different when there are multiple equilibria

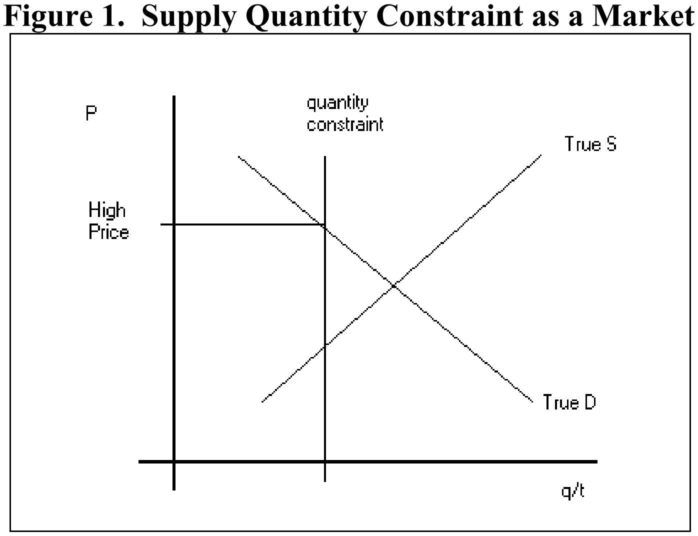
The paper will conclude with a summary and some program ideas that are viable in the multiple equilibrium framework.

What Is the Current "Theory" of Market Transformation?

The conventional theory of market transformation starts with a well-defined market that has a supply and demand function that yields an equilibrium price and quantity combination. This competitive equilibrium is efficient, but the problem is that we cannot reach it because there are market barriers. These barriers have names like "split incentives" and "hassle costs" and are easily depicted in one of two ways.

The first way barriers are depicted is as a quantity constraint. This is a common arrangement where there is an incentive on the part of retail suppliers not to put energy efficient equipment on the store shelves. A classic example is that grocery and drug stores, common suppliers of light bulbs, were unwilling to stock CFLs because they considered profit per foot of shelf space to be less than for incandescent bulbs (CFLs have lower turnover). The quantity of the efficient equipment on the shelf was less than it would be if that barrier did not exist. Figure 1 below depicts this. While manufacturers are willing to furnish True Supply, middle markets allow less. Because of the quantity constraint the equilibrium price of the efficient equipment is higher than it would be without the barrier.

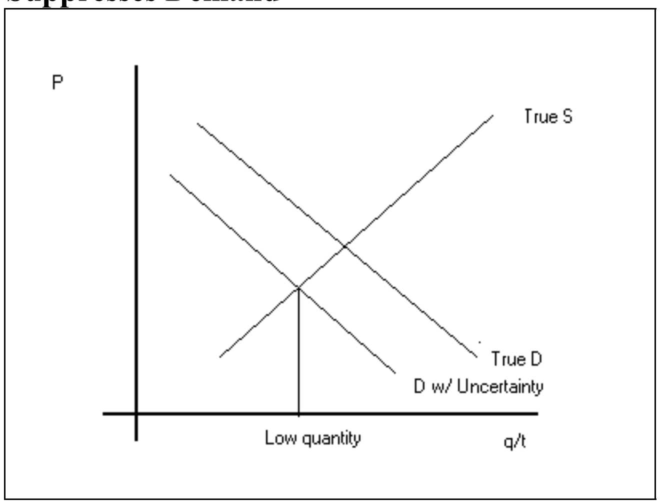
Figure 1. Supply Quantity Constraint as a Market Barrier



The second common depiction of a barrier is that there is another cost that is being born by either the buyer or the seller and that this results in an equilibrium with less of the energy efficient equipment sold. Figure 2 below shows this situation where the buyer bears the cost of uncertainty about the performance of the energy efficient equipment.

The extra uncertainty cost is shown as an adjustment to the demand function and the result is that there are fewer units of the energy efficient equipment sold. The usual subsidy program story in this depiction is that the subsidy pays the uncertainty cost of the buyer, shifting demand back up and increasing the number of units sold closer to the uncertainty-free competitive solution. The story for "barrier"-lessening programs (information, certification, standard lease agreement) is that uncertainty drops and demand approaches the True Demand.

Figure 2. Uncertainty as a Market Barrier that Suppresses Demand



These two archetypal examples have several underlying assumptions:

- There is one true equilibrium and that equilibrium is the efficiency ideal.
- By removing barriers, welfare and efficiency can be increased.
- It is possible to make small quantitative changes or apply small subsidies and have permanent changes.

None of these assumptions is necessarily true.

The One True Efficient Equilibrium Myth

Economics has never had the "one equilibrium assumption". It is frequently a simplification. The proofs of the existence of equilibrium are proofs that at least one exists and even then they rely on perfectly rational consumers and perfectly profit maximizing producers. In more complicated models of strategic interaction it is very common to have more than one equilibrium. Readers that are familiar with game theory will recall all the various refinements to Nash equilibria that are used to cut down the number of equilibria to a smaller subset.

Single equilibria are rare in anything more complicated than the toy models used in an introductory microeconomics course. Unique equilibria are often hard to demonstrate even in simple economies. To justify comparative statics for policy analysis, theoretical economists often stop at trying to prove local rather than global uniqueness of an equilibrium (Laitner, 2001), forcing them to confine policies to small changes. Kehoe (1998) gives an example where a simple exchange economy consisting of two neoclassically rational consumers and two exchange goods can have 3 equilibria.

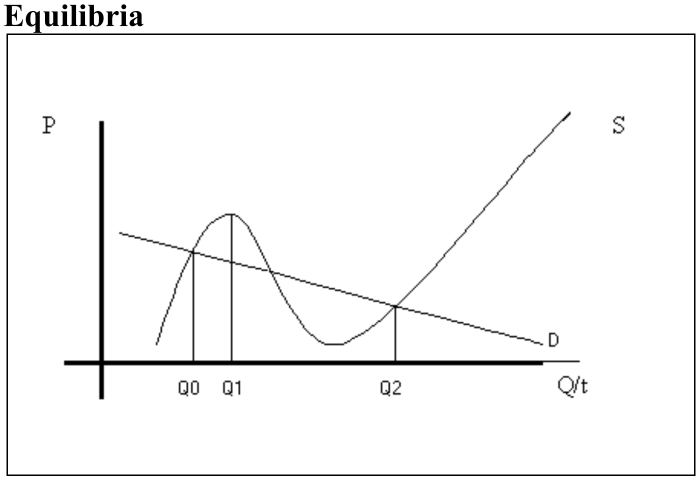
In the realm of strategic interaction more than one equilibrium is the rule rather than the exception. Modern bargaining theory considers the competitive solution to be just one solution- the one where the participants fail to come to an agreement. In other areas of strategic interaction non-uniqueness of equilibria is quite common. The "Folk Theorem," which governs repeated interaction between a finite number of firms says that any price between the competitive price and the monopoly price is a Nash equilibrium when there is repeated interaction.

Game theoretic explanations for multiple equilibria are only one path. Any time there is learning involved the order in which information arrives can induce profound changes on the end result. The most dramatic instances of this phenomenon can be seen in the natural world. Evolution, which is a remarkably efficient learning process, produces an amazing array of solutions to the same environmental problems. Simply imagining the unusual and unique creatures in Madagascar and Australia should confirm that even with similar climate and geographic conditions, multiple equilibria–different sets of species–can exist. In short, economic and ecological outcomes are path-dependent.

At any point in time, a path has been taken and some number of equilibria are possible. One can depict these multiple equilibria graphically using supply and demand curves as representations of possible price/quantity combinations, rather than strict mathematical functions. The supply curve becomes the locus of points representing, for each quantity, the lowest price at which producers are willing to sell their product. (A strict "supply function" – where quantity is a function of price – would preclude two possible quantities at one price.) A market equilibrium remains a point where supply is equal to demand (the two curves cross).

Supply and demand can cross in more than one point for several reasons. Figure 3 gives one example: a market where there are two scales of production technology, one that is cheaper when each firm is not producing very much and one that is cheaper when each firm is a producing a lot. In this case the supply curve can be bumpy. Up until Q_1, marginal costs increase as production includes more higher-paid night shift labor. Costs peak then drop at Q_1 with the purchase of new assembly machines. Costs again rise as the machines reach capacity and more labor shifts occur at night.

Figure 3. Bumpy Supply Curve Causes 3 Market Equilibria

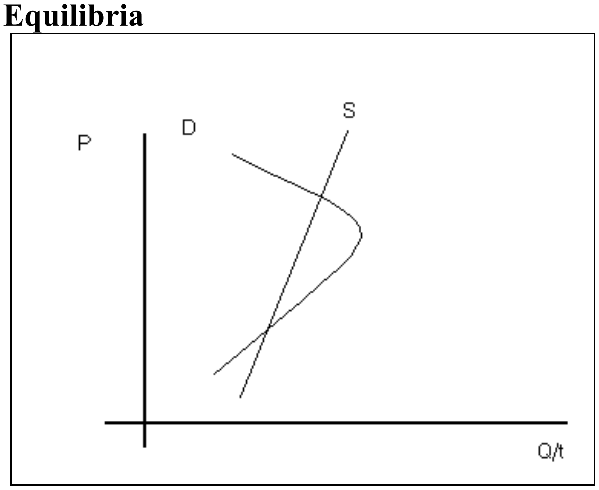


In this diagram there are apparently three equilibria - the first, at Q_0, where there are few transactions and all the firms use the small scale technology; another (unstable) equilibrium with more transactions to the right of Q_1, and an additional stable equilibrium at Q_2 where there are many transactions and all the firms use the large scale technology.

Interpreting this diagram gets to the point about why it is often hard to conceive of multiple equilibria. Economic activity always seems to take place about *an* equilibrium and we only observe one at a time. Markets do not exist in two states simultaneously so it is difficult to point to another equilibrium at any given time and it is difficult to infer the other equilibrium without observing the adjustment process. Someone markets their product at a price, consumers respond to the price, the supplier and competitors respond by adjusting production and asking price, and so on. If you start out near (in the attraction basin of) the low-production equilibrium, you'll end up at that equilibrium. If you start near high production, you'll end up with high production. It is difficult to infer the higher output equilibrium without observing the process.

In another example, demand may not be monotonic. This arises in the famous "lemons" story for the used car market, wherein consumers use price as an indicator of quality when they cannot directly observe quality. As a consequence, when prices are very low, few consumers will buy the good because most fear low quality. Thus in the low-price range, demand *increases* with price. As price rises, fear of lemons decreases, and at some point consumer demand begins to behave "normally," decreasing with increasing price. Figure 4 shows the case where there are two equilbria, one where prices are high and quality is perceived as acceptable and another where prices are low and quality is in doubt.

Figure 4. Fear of Lemons Causing a Backward-Bending Demand Curve, and 2 Equilibria



The point of this discussion is that multiple equilibria do exist and it is very difficult not to have them once you step just a little outside the strict assumptions of perfect competition: many small non-interacting firms, where everyone knows everything about the product, perfect rationality, and complete markets. Economics never had a single equilibrium assumption.

The Barriers and Correctible Market Myth

Given the image of a single equilibrium and the view that there are barriers that keep us from getting to the one true equilibrium it is rational that barrier removal and reduction will make people better off, i.e., increase welfare. There is even a theorem that when commonly translated says that if you remove a market distortion, like a tariff or other tax, welfare (the sum of economic benefits to producers and consumers) will increase. Hidden in the details of that theorem is the assumption that there is only the one distortion you're removing and there are markets for all goods.

The barriers paradigm is similar. The barrier distorts the energy efficiency market; the correction increases welfare by distorting the market back toward the competitive ideal. Even with a single equilibrium market, however, full correction of the barriers cannot bring market exchanges to their optimal level. They can only increase welfare to the private economic optimum – where each person makes all energy-saving deals that are to their personal advantage, given that they don't pay the economic costs of carbon emissions, nuclear wastes, and other environmental dangers.

A theoretical social economic optimum – where such externalities are internalized – would require more action. First you'd need to make people pay the environmental costs of energy usage. Second, you'd need a way to deal with the differences between individual risk and collective risk in efficiency investments. (If a new efficient appliance will save on average $100 in present value, net of costs, but with a standard error of $55 then a risk-averse individual may not invest, but a society of 10,000 people would face a $1 million net present value, with a standard error of $5500 and would choose for everyone to invest if the risk were shared. Risks might be shared through a perfect insurance market, except for the "moral hazard" that people insured against their energy costs use more energy.) Finally, even the social economic optimum is unlikely to be the long-term biological optimum, where diversity of life and ecosystem health are sustained even if it means less collective affluence for the present-generation humans in the particular market of study (often the United States).

The point of view that by removing barriers we can correct the market, if only we internalize externalities, is a consequence of the one, efficient equilibrium viewpoint from introductory microeconomics. We are trying to get the markets to approximate how we believe they would operate when there is perfect information and strong competition, i.e., all the usual assumptions about a competitive market. There are, however, some assumptions built into that efficiency claim:

- Market definitions will not change
- Technology will not change
- All markets (including all insurance markets) exist
- Production technology is "Smithian", i.e. non-decreasing marginal costs in the short-run.

When these assumptions hold, economists talk about introducing "first best" solutions to achieve efficiency. An example of a first best solution would be a tax on the consumption of gasoline to raise its price up to the "social cost." Then economists point out that first best solutions don't really exist, because the real world economy is full of distortions such as monopolies, tax and subsidy policy, externalities, and public goods. If you tax gasoline up to its marginal social cost, but railways are monopolies that don't charge their marginal cost, then the transportation market cannot reach efficiency, and it's not even sure that the tax on gasoline is more efficient than no tax.

Because the first best solutions are not always possible we introduce second-best solutions, energy efficiency programs, which are distortions from the competitive ideal. When we subsidize efficient equipment, for example, we are distorting the market for standard equipment by suppressing demand. In fact, any action on the market is a change from what it was before, a distortion of an already complicated and distorted economy. We are able to change to a degree just about any characteristic of the economy, if we are willing to devote enough resources to maintaining that.

In a multiple equilibrium system, at least when the equilibria are discrete and separated, almost no resources are needed to maintain the initial change. The markets themselves work to remain about whatever equilibrium is chosen by the policy makers. The many, potential, equilibria can have different characteristics. Some are more efficient, others have higher welfare. In this framework the true choices facing the policy makers are quite discrete:

- Is there an equilibrium that we would prefer to the one where we currently operate?
- Are the resources necessary to move to that other equilibrium available and do the benefits justify the choice?

How the Single-Equilibrium Approach Limits Our Thinking

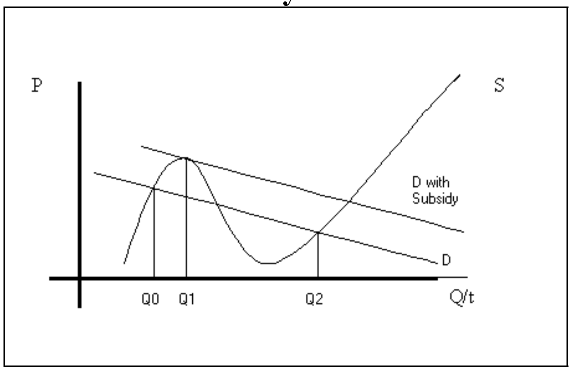
The single-equilibrium market barriers paradigm can be a useful metaphor at times, if only because it has led to a laundry list of problems to check for and address. Whether there are single or multiple possible equilibria regarding retrofit windows for older apartments, for example, the designation of differing landlord and tenant motivations as a "market barrier" to their joint self-interest can help us design a program that facilitates their economic collaboration. Whether a certification program, when it eliminates lemons fears, is viewed as unbending the demand curve or removing a lack-of-information barrier, it's an obviously useful market transformation tool. In these cases it is not the shape of demand and supply that drive program design; it's a good organizational study of the market actors and their decision-making processes. Still, there are times when the single equilibrium depiction limits our thinking too much. When markets have more than one equilibrium, and we study and understand those markets, new options for permanent market transformation may arise.

Return to the example of the market where there were two production technologies, a small scale and a large-scale technology. Suppose that before we begin our program, the low-quantity stable equilibrium holds with Q_0 units sold each month. In this case if we give a subsidy the demand curve will shift up as shown in Figure 5.

This will produce a temporary new equilibrium where the supply curve and the demand curve with the subsidy cross — sales are high and the suppliers are investing in large-scale production capacity. When the subsidy is removed, competitive pressure will force the equilibrium that was originally characterized by everyone using the large-scale technology, and Q_2 units are sold each period.

In this multiple equilibrium example it is possible to have a temporary program that produces permanent change, so long as the initial subsidy is sufficient to increase sales past the unstable equilibrium point Q_1. (Between Q_0 and Q_1, a supplier's cost of furnishing incremental units is more than the price that unsubsidized consumers will pay for them, suppliers stop furnishing them, and unsubsidized sales fall to stable equilibrium Q_0. Above Q_1 suppliers are willing to produce more units at the price that unsubsidized consumers are willing to pay, and they do, until sales rise to Q_2).

Figure 5. Bumpy Supply Curve, and Demand with Subsidy



Now, what's the minimum subsidy you can apply to get a permanent effect? Just enough to get Q_1+1 units sold. You could put a rebate on each of the first Q_1+1 units, just high enough to shift Demand-with-subsidy above the hump. Or, you could pay less by giving suppliers a lump sum subsidy just over enough to cover their losses in increasing production from Q_0 to Q_1 (or a golden carrot program that's worth that much in expected value). That's the area between the supply and demand curves from Q_0 to Q_1 and costs considerably less than a full rebate on Q_1+1 units. In contrast, a single-equilibrium view may have you subsidizing every unit sold[1].

The multiple equilibrium view suggests you devise a program that moves supply from a lower-production basin of attraction to a higher-production one. For this example, your most cost-effective program planning may involve studying production cost schedules and demand curves, and trying to find the minimum subsidy that will yield the desired permanent change, subject to your tolerable level of uncertainty. Or it may involve negotiations directly with manufacturers, where they accept subsidies in exchange for promises to move to a higher production level. (Your negotiation position will be strengthened, of course, if you precede negotiations by market studies.)

Options Available with Multiple Equilibria

In a multiple equilibria world, the organizing principle for market transformation programs should be: go back to the zeroth step of economic analysis, the basic assumptions about market definition, product definition and unit definition.

Changing market definitions generally have a market transforming effect, i.e., movement from one equilibrium to another. Market definitions often change because of evolving technology. For example, what I used to think of as my cable TV provider is now

[1] The authors admit that this square peg example has been beaten into the round hole of supply and demand analysis.

repackaging itself as a bandwidth provider, providing phone, cable TV and internet access. This kind of repackaging has also occurred in the natural gas pipeline industry. They are now providers of the rights-of-way that they have secured over years. Fiber optics companies need these rights of way and many are securing them by buying gas pipelines.

Besides combining markets, some markets may divide into several markets. Consider brokerage services. At one point, stockbrokers provided research and charged for transactions based a percentage of the sale. Now you can purchase through a full service broker or use a discount broker. The research component has been separated from the transaction component. While this is an excellent example of unbundling, or the removal of cross-market subsidies, it is also a good example of changing the pricing unit because many discount brokers have a fixed charge per transaction that is not based on the size of the transaction.

Some market transformation programs may operate by changing the pricing unit. Sticking with the general high technology spin to these examples, Internet service providers used to charge by connection time. They operated as if the priced unit in the market was a connection hour. The pricing system now is much different. People are not generally charged by the minute, but by the bandwidth, the maximum instantaneous capacity of the connection. The different pricing systems produced different incentives for modem and other technology. Would there have been such a big push for faster modems if the original connection charges were not by the minute?

These are all examples of the natural evolution of markets but there are also examples of policy decisions that had an effect on the zeroth step of the analyses. One of the most significant decisions made by the FCC was the 1968 Carterfone decision. The consequence of this decision is that you didn't have to rent your phone from AT&T any more. This may seem insignificant, but it created a new market for all kinds of phones and telecommunication devices. This was a small change in property rights that managed to produce several new industries and increase the use and variety of telecommunication-a true market transformation program.

Another interesting example is the creation in 1938 of Fannie Mae. While the main function of Fannie Mae was to fund mortgages, they also helped create a vigorous secondary market for mortgages. Having a secondary market reduced mortgage interest rates and helped increase the rates of home ownership. In 1970 they issued the first mortgage-backed security, which became extremely popular in the late 1980s as REMICs (Real Estate Mortgage Investment Conduit). The main reason for the popularity was because of The Tax Reform Act of 1986 (Pub. L. 99-514), which made the income taxable by the holders of the instruments and not the corporation. This securitization enabled further efficiencies in the secondary mortgage market. This change in property rights, the responsibility for taxes, had a phenomenal change on mortgage interest rates and homeownership – market transformation.

These two examples demonstrate how a small policy change, enforced by the self-interested behavior, will drive a market to a different equilibrium and then through further self-interested behavior, keep it there without additional cost. These still have the implicit assumption, however, that the market has a certain fixed state and that the policy change or program is going to alter that state. It ignores the idea that markets are changing all the time and that policy decisions will change the way that they grow and how they may change in the future. In other words, policy decisions which right now produce large increases in efficiency may, as the markets change, prevent policy changes in the future that will provide even greater benefits.

Early technologies can cause habits and uniformity that preclude later, superior technologies[2], or they can preclude earlier, environmentally superior technologies (consider the number of housing associations which forbid clotheslines as "unsightly" because clothes dryer technology early on created an association between wealth and lack of clotheslines). The structure of competition in a market may depend largely on who gets there first, under what rules, and with what production function. Markets with network externalities may depend heavily on what types of networks are set up first – which is why when we promote alternative vehicles we have to set up their fuel distribution network at the same time.

Most important for our purposes, the rules a market operates under can determine paths taken and final outcomes. For example, the United States chose not to regulate passenger truck and SUV size much, and not to penalize size with significant gas taxes. The result has been an arms race in SUV size, as people buy bigger and bigger to feel safe as they face potential collisions with other big SUV's[3]. Now, even if gas prices rise, many will choose high gas bills and buy big vehicles, just for perceived protection. In Europe, gas taxes are high, cars have stayed small, and people don't need size to feel safe. All the Europeans' safety money can go into smart car design.

The lesson from path dependence is twofold: First, every time we tweak the market or its governance structure (operating rules and regulations) we need to think about long-term effects. What networks and habits are we supporting or discouraging? What structure are we building into the economy? When we offer efficient air conditioner incentives, are we feeding a social expectation for air conditioning that precludes other interpretations of comfort? When we write a building standard that limits window space relative to wall space, do we just encourage higher ceilings for more wall space, defeating our purposes and creating at the same time an architectural trend toward bigger, more energy-consuming homes? Can we develop compensable property rights to sunlight for rooftop PV owners in a way that doesn't keep cities from building up, not out, so that we can still limit automobile use?

Second, can we use the lessons of this path dependence to design programs that will foster a move in the direction of more energy efficiency? Yes, early decisions are the most powerful, but they are also the ones made with the least amount of information. To see the ill effects of early action just look to your local asbestos removal contractor. Policy and program designs should do as little as possible to limit the breadth of innovation. It may be that there is one best technology to solve a problem right now, but to mandate its use is to kill the development of any other competing technologies.

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[2] For example, the persistence of the QWERTY keyboard developed for typewriter efficiency, instead of the DVORAK keyboard optimized for ergonomics.

[3] This is also an example of a coordination failure, individually rational behavior leading to socially undesirable results. Other examples of the same phenomena can be seen at sporting events with people standing, and some of the awkward, and life threatening plumage in some birds.

Some Energy Market Transformation Ideas

Based on these examples, here are some programs that could be introduced into the energy markets:

- Replacement of building energy standards by CAFÉ style standards with tradable offsets. This represents the addition of a helper market, much like the Fannie Mae case. Furthermore the offsets would enable more cost effective provision of energy savings.
- Separation of fixed connection, kW based load charges, and kWh based energy charges. This is much like the unbundling of brokerage services, and may provide for simpler regulation of the distribution provider, separate from the transmission and generation providers. While it could increase electricity use by lowering the marginal cost, it could decrease it by encouraging the user to choose technologies that keep him/her below a given kW ceiling.
- More flexible electricity pricing, so that it is possible to purchase X kWh an hour at a market rate and every kWh thereafter at a fixed rate. This is analogous to the deductible in insurance and may help provide a better risk management package for some users. While it may seem as if lowering energy price uncertainty would discourage energy conservation investments, Metcalf and Rosenfeld (1991) have argued that uncertain electricity prices cause people to *lower* investment in efficiency technology because they have an "option value" from holding their cash while they wait to see whether energy prices turn out to justify an irreversible capital investment.
- Public/private research partnerships where public subsidy helps get efficient technology developed, while the private party pays for their lowered investment cost and risk by limiting the economic rent they collect (patent rights, or prices, by agreement signed with the subsidizing agency). For example, a firm may agree that after 5 years, their patent goes into a semi-public domain, freely available to firms under a certain size (to allow the growth of a competitive market), but earning the inventor royalties from firms that have grown above that size.

The best and shortest summary of programs that change the market definition is not that they install efficient equipment, but that they provide good reasons to do so.

Conclusions

A single equilibrium view of energy markets limits our economic understanding of how they work, the possible policy objectives, and how we can transform them. Where behavioral and organizational studies are sufficient to inform good program design, that may be okay – so long as you think hard about paths the economy may take. But there are situations where an understanding of multiple equilibria allows you to optimize your efforts, by nudging the market towards the preferred equilibrium. With multiple equilibria permanent change can be shown to be permanent.

The multiple equilibria view also limits policy objectives. In the single equilibrium view you can always argue that by halving a subsidy you can always get some degree of permanent change. In the multiple equilibrium view this is not the case, the energy efficiency/ welfare combinations that are the true policy choices are separate and distinct. As a consequence it may not be possible to achieve the policy maker's desired mix of energy efficiency and welfare.

The multiple equilibrium view does, however, expand the possibilities of market transformation programs, by helping to break practitioners out of the implicit assumptions of the single equilibrium model. If anything it provides the hint that governance changing programs may be very effective means of achieving market transformation if they focus on:

- Combining formerly separated markets
- Separating bundled goods and services
- Changing the pricing unit
- Altering property rights
- Creating helper markets

The unifying concept behind these kinds of programs is to go back to the zeroth step of economic analysis, the definitions of the markets themselves, and consider what happens when those definitions are changed.

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United States Code TITLE 26: Subtitle A: CHAPTER 1 :Subchapter M: PART IV: Sec. 860A.