The Poverty of Applied Policy Analysis

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"We always plan too much and think too little We resent a call to thinking and hate unfamiliar argument that does not tally with what we already believe or would like to believe "

- Joseph Schumpeter, (1947, pg xi)

Introduction

My objective today is to put forth a call for each of you to rethink how we do applied policy analysis. I plan to justify the need for this rethinking using a variety of arguments. Some of my arguments will be familiar to most if not all of you, others may be unfamiliar to most if not all. I claim no originality for the basic theoretical arguments, they all appear in the literature. What I hope you find to be original and useful is the synthesis of these arguments. Furthermore, though in places I will point out the need for additional theoretical work, my primary goal is to convince practicing agricultural policy analysts to become more comprehensive in their analyses. In the grand tradition of presidential addresses, my remarks cover a rather broad range of issues at the expense of depth on any one issue. Nevertheless, I hope that my remarks will stimulate discussion and thought about how we as agricultural economists do applied policy analysis.

Let me begin by providing a quick overview of my remarks. As previously stated, the purpose is to address what I believe to be major limitations in the way that we as agricultural economists perform applied policy analysis. Specific issues to be addressed include: (1) the limits of static efficiency arguments and the need to systematically address equity issues, (2) our failure to recognize the pervasiveness and import of rent seeking behavior, (3) a lack of attention to the potentially dominate role of dynamic considerations, and (4) the limitations of neoclassical theory for analyzing uncertain, dynamic systems.

Inadequacies of Static Efficiency

Static efficiency is inadequate as the sole policy analysis tool for at least three reasons. First, there are a number of important limitations or caveats associated with any finding of efficiency that often are unrecognized or go unacknowledged. Second, public policy is generally concerned primarily with equity rather than efficiency considerations. Third, static efficiency is an equilibrium condition and thus a very limited measure of efficiency.

Limitations of Pareto Optimal Solutions

Let me turn first to the limitations of static efficiency analyses. First, as we are all well aware from our welfare theory training, Pareto optimal solutions are not unique. They clearly depend on the initial endowments and property rights as can be demonstrated using an Edgeworth Box analysis in exchange societies or by using production possibility frontier and Scitovsky indifference curves in a production economy[1]. Furthermore, as a result of the dependence of Pareto optimal solutions upon the original endowments and specification of property rights, efficiency and equity are nonseparable.

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Recognizing this dependency, Just, Hueth and Schmitz (1982, pg. 29) observe, "One cannot solve the problem of efficiency and distribution in two stages, by first maximizing the value of social product by correctly allocating resources and then distributing the product equitably."

Despite these well known limitations, common practice is to take the existing distribution of resources and property rights as given, and then analyze "gains" or "losses" in efficiency from that point. This practice contributes to the tyranny of the status quo which arises from four key factors. First, by implicitly accepting the status quo distribution as optimal, we treat efficiency as an "objective truth value" (Bromley, 1990). Bromley defines objective truth value as "an accepted behavioral norm that allows the economist to offer up an efficient outcome as both evidence of a 'good' thing and - more importantly as proof of the *scientific objectivity* of that particular finding of goodness" (pg. 87, original emphasis). Economists that rely solely on a finding of efficiency, are in effect hiding behind a bogus sense of objectivity.

Use of the Pareto criterion also clearly favors the status quo distribution. As Just, Hueth and Schmitz (1982, pg. 31) observe, "From a policy point of view, the Pareto criterion favors the status quo since the range of choices that represent Pareto improvements depends critically on the initial distribution of income". In effect, a large number of alternative outcomes lying on higher Scitovsky indifference curves are ruled ineligible under the Pareto criterion.

The status quo also affects the framing of problems in terms of "losses" and "gains". "Because the value function is steeper for losses than for gains, a difference between options will loom larger when it is framed as a disadvantage of one option rather than as an advantage of the competing option." (Tversky and Kahneman, pg. 456). Thus, from a marketing standpoint a cash discount is more palatable than a credit surcharge. Similarly, if beneficiaries of the status quo are able to frame potential impacts as "losses", these will be valued more heavily than an equivalent amount of "benefits" to be received by beneficiaries of the proposed policy. Thus, for example, the "costs" of environmental regulation loom larger than the foregone "benefits" of cleaner water.

Finally, the existence of uncertainty, provides a mechanism through which those favored by the status quo can delay changes (Bromley, 1994). Commonly, the full costs and benefits of a proposed policy will be uncertain. Those favored by the status quo will often call for more study, at taxpayer expense, to ostensibly reduce the uncertainty. The burden of proof and thus the transactions costs fall on those currently bearing unwanted costs.

Recent actions related to efforts in South Florida to restore the Everglades provide an example of how the existence of uncertainty can be used as a delaying tactic. The original environmental legislation, known as the settlement agreement or the Marjory Stoneman Douglas Act was scheduled to take effect in January 1992 and mandated that specified water quality standards be achieved by July 2002. This Act, required agricultural industries to implement specified BMPs and implemented a per acre tax to fund offsite clean up activities. Agricultural interests filed 36 separate lawsuits, challenges and appeals to the settlement agreement. New legislation, known as the "Everglades Forever Act" was passed in 1994 in response to the various lawsuits and challenges. The new legislation requires that the industry implement BMPs and assesses an "agricultural privilege tax" of approximately $25 per acre for a period of 20 years. However, the industry was able to delay the beginning date of the legislation by two and one-half years, and the date that water quality standards have to be met by four and one-half years. The Everglades Forever Act also mandates additional research be done at taxpayer expense. Meanwhile, the regional water management agency responsible for implementing the legislation, spent over $6.5 million on litigation related expenses over the period, October 1988 - July 1993.

Equity as the Primary Policy Objective

The second major reason that static efficiency analysis is inadequate as a policy tool is that not only is efficiency not unique and nonseparable from equity considerations, generally efficiency isn't the key policy issue. Public policy is about the incidence of impacts, redistribution of wealth or economic opportunity is generally the objective, not efficiency (Bromley, 1994). In fact, government's power arises from its ability to reassign resources by taxing or passing laws. Despite this obvious government function, there seems to be a great reluctance among economists to consider equity issues. In noting this reluctance, Castle (1993, pg. 279) observed, "I have been disturbed by the unwillingess of many economists to consider the philosophical underpinnings of our discipline. The consequence has often been either the rejection of economics or its rigid application. Either approach results in too narrow a view of policy making." Clearly, in order to participate effectively in policy debates, agricultural economists need to become better equipped to deal with equity issues. We can begin by becoming more familiar with the various concepts of social justice including social welfare or utilitarian philosophy (e.g. Bentham (1791), Samuelson (1947), Rawls (1971)) and Kantian philosophy of absolute rights (e.g. Buchanan (1954) and Nozick (1974)). The recent changes in Washington, D.C. may underscore the policy importance of understanding alternative philosophical positions and their implications.

The profession also needs to move more aggressively to formally integrate equity and efficiency considerations into our policy analyses. Chavas' (1995) pioneering work provides a beginning. His framework is based on Rawls' concepts of fairness as lack of envy (as formulated by Pazner in his fairness equivalence concept), original position and the veil of ignorance. Chavas' framework allows the analyst to explicitly analyze equity - efficiency tradeoffs.

As policy analysts, we also need to be more cognizant of the pervasiness of rents and rent seeking behavior and the role they play in policy making. As Mueller (1989, pg. 238) observed, "Few issues illicit greater agreement among economists than the proposition that society's welfare is maximized by competitive markets and free trade, yet tariffs, quotas, regulations abound; one suspects that the allocative efficiency gains from competition and free trade so obvious to the economist have been sacrificed to provide the equally obvious rents and redistributive gains that restrictions engender." I'll return to this issue of rents and rent seeking in a moment.

Static Efficiency as an Equilibrium Condition

Third, static efficiency is inadequate since it is an equilibrium condition and thus a very limited measure of total efficiency. Social, as well as environmental and natural resource systems are characterized by change. Castle (1993, pg. 280) argues that one of the fundamental conditions for successfully managing natural resource systems currently missing in the literature is "the need to recognize that the natural environment and social systems are in constant change." Capitalism in particular is defined by change as Schumpeter observed, "Capitalism then is by nature a form or method of economic change and not only never is but never can be stationary." (1947, pg. 82). Before pursuing this issue of dynamics, let me first return to the importance of rents and rent seeking.

Rent Seeking

Rent seeking is a relatively recent addition to economic theory dating from Tullock's seminal work in 1967, followed closely with works by Stigler (1971), Krueger (1974), Buchanan (1980) and others. This theory has not fully penetrated applied agricultural and resource policy analysis.

There are a number of key characteristics of rents and rent seeking that are important to keep in mind in the context of applied policy analysis. First rents can arise as a result of government policy or from private activities (e.g. access to Ricardian inputs, technological change). Second, as Tullock (1967) pointed out, we need to clearly differentiate between good rents and bad rent seeking. Rents can be good in that they play a crucial role in stimulating innovation. Rent seeking behavior on the other hand, leads directly to socially wasteful expenditures, as "people jockey at the trough". (Rauch calls this the "parasite economy".) Third, politicians can extract rents by creating Stiglerian rents or by extorting existing private or previously generated public rents (McChesney, 1988). Fourth, it is important to remember the iron rule of rent seeking, "Wherever a rent is to be found, a rent seeker will be there trying to get it." The key lesson for our purposes, is that the rent seeking literature has demonstrated that nearly all forms of government activity have the potential to create or redistribute wealth and thus are likely to stimulate rent seeking behavior, including economic incentive mechanisms which textbooks commonly treat as pure transfers (Lee, 1988).

Rent Seeking in the Everglades Controversy

Evidence of rent seeking is widespread in the debate over how best to restore the Everglades ecosystem in South Florida. On one hand, are the agricultural interests who clearly have incentives to protect existing rents arising from government import restrictions. Estimates vary, but values in excess of $200 million per year ($450 per acre) have been common in recent years. A March 1993, *Florida Trend* article (Hagy) reported that the industry had spent an estimated $15 million on legal fees, contributed millions more to political campaigns, spent $100,000s on public relations, and had 30 lobbyists in Tallahassee representing the industry's interests during deliberations on the Everglades Forever Act.

On the other hand, some environmentalists have viewed Everglades restoration as an opportunity to secure environmental benefits at industry or other's expense. Thus environmental groups lobbied for much higher taxes on agriculture than the approximately $25 per acre figure that was included in the Everglades Forever Act. The $25 figure is based on a relatively narrow application of the polluter pays principle. Environmental interests also proposed a ballot measure that would have implemented a penny a pound tax on sugar production with the proceeds used for environmental restoration. (In a routine review, the Florida Supreme Court ruled that the proposed amendment violated established restrictions on content and struck it from the ballot.)

A recent environmental proposal seeks to utilize existing industry rents in an innovative manner. Under this proposal, environmentally sensitive lands currently in sugar production would be purchased from growers at market price. Simultaneously an agreement would be forged with the Federal government to allow the state to import at the world price, an amount of sugar equivalent to the normal production from the purchased acreage. The imported sugar could then be sold at the U.S. domestic price and the difference used to pay off the mortgage on the land purchase.

In the middle of the two main competing interests, is the South Florida Water Management District who is primarily responsible for managing water in South Florida. Over the past decade the District's budget has tripled from $97.1 million in 1986 to $293 million in 1995 and the staff increased 60% from 1037 to 1651 FTEs. This evidence suggests that District might also be susceptible to rent seeking behavior.

Implications for Policy Analysis

The pervasiness of rent seeking behavior has important implications for policy analysts. As a start we need to be more cognizant of the importance of rents and rent seeking. Second, as policy analysts, one of our tasks is to design institutions that allow and encourage those forms of competition that create rents by creating additional consumer surpluses and discourage competition designed to gain and retain existing rents. Third, we need to avoid what I call the "naive analyst risk", where economic efficiency arguments are embraced or worse yet manipulated as a weapon to support particular rent seeking positions.

Naive analyst risks can arise in a number of contexts. First, as Sonstelie and Portney have argued, calculating the costs in benefit-cost analyses is much more difficult than many people acknowledge. Cost estimates are often subject to rent seeking manipulation by the impacted industry since the industry has asymmetric access to information as well as an incentive to bias cost estimates. Second, consultants may be hired to justify preestablished positions. This may happen when the client is a private entity, as well as when the client is a government entity. Smith (1994), Bromley (1994) and others have recently waged a lively debate on this and related issues. Suffice it to say that at times we're part of the rent seeking problem - sometimes naively - other times, and more disturbingly, deliberately. Finally, colleges of agriculture are susceptible to rent seeking which leads both to sins of commission (i.e. doing research to support established industry positions) as well as sins of omission (i.e. not doing "controversial' research).

Dynamic Considerations

Let me now turn to my third major topic, the potentially dominate role of dynamic considerations. My intent here is not to argue that dynamic efficiency as opposed to static efficiency is socially optimal. Dynamically efficient solutions are equally as dependent upon the prevailing property rights and endowments as are static efficient solutions. Furthermore, dynamic efficiency considerations raise additional concerns about the appropriate rate of discount and how to reflect preferences of future generations. My intent is merely to argue that dynamic adjustments to policies may well offset the estimated static impacts and that these dynamic considerations deserve more careful consideration by policy analysts.

The difference between a static and a dynamic analysis is in some ways equivalent to the difference between a zero-sum and a positive sum game. In a static, zero-sum world, regulation is perceived to inevitably lead to reduced competitiveness. When competitiveness and the environment is framed in this way, the tradeoff ignites a distributional power struggle which can consume enormous resources. As an example, a 1992 Rand study reported that 88% of superfund payments were spent on transactions costs, only 12% was used to clean up contaminated sites.

It is also important to realize that in general, static efficiency is not a necessary condition for dynamic efficiency or as Schumpeter (1947, pg. 83) observed, "A system that at every given point in time fully utilizes its possibilities to the best advantage may yet in the long run be inferior to a system that does so at no given point in time, because the latter's failure to do so may be a condition for the level and speed of long-run performance."

Innovation Offsets

Michael Porter, the Harvard Business School expert on competitiveness has focused attention on the key role of innovation and dynamic adjustments. He argues that the old comparative advantage and economies of scale paradigms for competitiveness have been largely superseded by globalization and new information technologies. The new paradigm of international competitiveness is based on innovation.

In extending the competitiveness paradigm to the consideration of the relationship between environmental regulation and competitiveness, Porter and van der Linde (1994) have focused attention on the critical role of innovation offsets. Innovation offsets reflect dynamic adjustments induced by a regulation that ultimately result in lower costs of compliance than static analyses would suggest. Innovation offsets can arise from the discovery of lower cost compliance procedures, the development of better production processes or products, and possibly the spinning off of new environmental industries spawned in response to the regulation.

Porter's arguments have lead to what has become known as the "Porter hypothesis", that increasingly stringent environmental regulation leads to improved economic performance (i.e. competitiveness) rather than to the conventional tradeoff implicit in static analyses. Based on my reading of Porter and van der Linde, I'm not convinced that Porter would accept this hypothesis as a hard and fast rule. I believe that Porter and van der Linde are trying to make three key points. First, that dynamic considerations may dominate static concerns. Second, that producers are not Panglossian dynamic optimizers, they sometimes need to be induced. And third, that properly formulated regulations can provide the necessary incentives to generate innovation offsets.

Furthermore, I believe that Porter would argue that tests of the "hypothesis" are premature in the U.S. since we haven't designed environmental policies or regulatory processes with dynamic efficiency objectives in mind. Nevertheless, there have been a number of studies examining the Porter hypothesis. Porter and van der Linde provide descriptions of a number of case examples to illustrate the range and potential impact of innovation offsets. There have also been a few studies that have attempted to test the hypothesis econometrically. However, difficulties arise in measuring both regulatory stringency as well as competitiveness. Lanjouw and Mody (1993) using international data, found a positive relationship between environmental compliance costs and patenting of environmental technologies. Jaffe and Palmer (1994), using U.S. panel data found mixed results. They found a positive relationship between environmental compliance expenditures and overall research and development expenditures. However, there was no significant relationship between environmental compliance expenditures and successful patent applications.

Desirable Properties of Environmental Regulations

Porter and van der Linde (1994) developed a set of eight properties for environmental regulations and a set of three characteristics of regulatory processes that would enhance the potential for innovation offsets. Desirable properties of environmental regulations include: (1) focus on outcomes not technologies, (2) change products and production processes, don't treat wastes, (3) use market incentives, (4) regulate as late as possible in the value chain, (5) provide phase-in periods, (6) lead international standards, but don't get too far ahead, (6) harmonize or converge associated regulations, and (8) balance liability exposure. Desirable characteristics of regulatory processes include: (1) predictability and stability to minimize option values (See Pagano, et al. 1995), (2) promote industry - regulatory interaction to minimize "struggles", but be careful to avoid capture, and (3) improve regulatory efficiency by minimizing overlaps and conflicting regulations and thus reducing the transactions costs associated with compliance and enforcement.

Implications for Policy Analysis

I think it is clear that environmental regulation does not inevitably lead to enhanced competitiveness. Equally clear however, is that induced innovations can offset static impacts, and that regulations should be designed to foster this potential. In a similar vein, economic impact assessments typically overestimate compliance costs because they fail to systematically account for induced innovation offsets.

Recognizing that pollution is generally a residual byproduct of the production process (Georgescu-Roegen, 1971), suggests that the opportunities for generating innovation offsets may be more prevalent than we might think. The key is to focus on modifying the production process, not residual treatment.

Experience with implementation of environmental regulation of dairies near Lake Okeechobee provides some evidence of the potential impact of innovation offsets[2]. The purpose of the regulations was to reduce phosphorus runoff into Lake Okeechobee. The regulations have induced dairies to reduce the phosphorus content of dairy rations, install feed barns which not only facilitate manure handling and recycling but also reduce cow stress and feed waste, and design new rotational grazing systems which minimize manure handling and concentration. The regulations also stimulated development of a privately marketed wastewater treatment system that has been used for swine as well as dairy operations. A study examining the economic impact of these innovation offsets is currently underway. Preliminary econometric evidence suggests that the physical productivity impacts have been significant. Since implementation of the regulations, average milk production per cow in the affected area has been increasing at 150 percent the rate of increase observed in the rest of Florida.

Limitations of Neoclassical Theory

Finally, let me offer a couple of observations regarding the limitations of the neoclassical theory of growth and innovation. Neoclassical growth theory indicates that perfect competition will direct an economy towards its optimal constant growth path. Thus, static efficiency which is implied by perfect competition is a necessary condition for dynamic efficiency. But clearly, economic growth is anything but constant over time. Real business cycle models were developed to help explain variations in economic growth. However, these models rely on random productivity shocks and convex preferences to generate output fluctuations. Neither neoclassical growth theory nor real business cycle models provide any insights into the sources of or the processes that generate innovation.

Schumpeter was one of the first economists to systematically recognize the essential dynamic aspect of capitalism which he called the "process of creative destruction" (1947, pg. 82). He described this process as, "The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates."

Schumpeter also recognized the crucial need for rent appropriation as an incentive for innovation - a condition inconsistent with textbook perfect competition and growth theory. Once innovation is considered endogenous to the system, rather than exogenous as in neoclassical theory, static efficiency is no longer a necessary condition for dynamic efficiency.

The ability to appropriate rents plays two critical roles in the innovation process. First, it provides an incentive for firms to invest in research and development and second it provides funds for research and development. The sugar industry in South Florida may be a case in point. As a result of government import restrictions, this industry has earned significant rents. Contrary to neoclassical arguments regarding competitive pressure and x-inefficiency, the industry has generated very high rates of growth in productivity. The increase in productivity is due to the industry's high rates of investment in research and development which have lead to new varieties, new harvesting techniques, and new milling technologies. As a result, the Florida industry is now considered by many industry analysts to be the low cost producer of sugarcane in the western hemisphere and cost of production studies indicate that Florida's cost is below the world average (Landell Mills, 1991).

Only recently, with the development of advanced game theory and mathematics, have Schumpeter's insights begun to get more formal theoretical analysis by mainstream economists (Thompson, 1993). However there is still a long way to go before we have a satisfactory dynamic theory.

Complex, Adaptive Systems Models

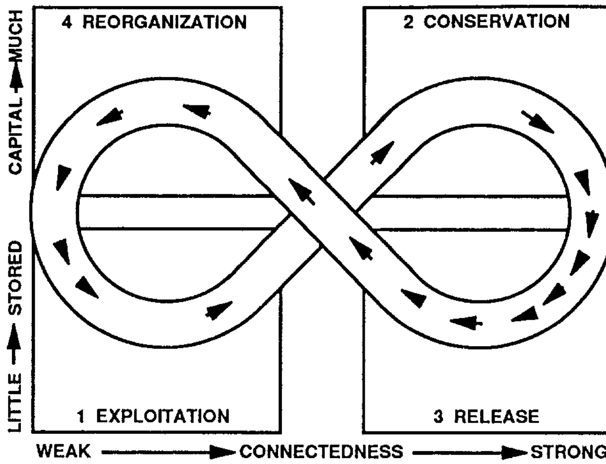
An alternative approach, that may have potential to improve our understanding of dynamic economic systems, is what is becoming known as complex, adaptive systems models in the broader scientific literature. Three fundamental insights underlie these models. First, change is not continuous and gradual, but punctuated or episodic. This is in contrast to neoclassical growth theory and the related Clementsian ecological view of succession and climax. Second, spatial and temporal attributes are not uniform, they are patchy and bunchy. Third, systems do not have a single equilibrium with functions controlled to remain near it. Rather multiple equilibria exist and systems move between them.

C.S. Holling (1992), an ecologist, has developed a four quadrant model based on empirical analyses of complex adaptive systems (Figure 1). The four quadrants (i.e. exploitation, conservation, release and reorganization) represent the four stages or phases of ecosystem dynamics. The two axes measure the degree of storage/capital accumulation and connectance/stability in the system. Finally the circular flow path and arrows illustrate the pattern of movement between the stages. The frequency of the arrows represents the relative speed of movement. Thus, systems tend to spend relatively long periods in the conservation stage and relatively short times in the release stage.

Briefly, the dynamics are as follows. Starting in the exploitation stage (e.g. after a fire in an ecosystem, or after a war, discovery of a new frontier or technological change in a social system) the system rapidly exploits the available resources and growth is very rapid and opportunistic. Over time opportunities to exploit available resources become limited and the system moves into a relatively long conservation stage. This stage is characterized by relative stability and predictability. The combined exploitation and conservation phases would correspond to the traditional Clementsian ecological model of succession and climax as well as the neoclassical growth model in economics.

However, observations of both ecosystems and social systems suggest that during this conservation phase systems tend to accumulate capital and become strongly connected. As connectance grows the system becomes brittle and susceptible to disturbances that could previously be absorbed. Thus, ecosystems find that the prevalence of a single climax species makes the system more susceptible to pest outbreaks and similarly the buildup of biomass makes systems more susceptible to fire (e.g. Yellowstone National Park). Similarly,

Figure 1. Holling's Four Stage Model of Complex Adaptive Systems.



social systems tend to become more homogenous and bureaucratic and thus less flexible and more susceptible to disturbances. These disturbances can be both internal (e.g. bureaucratic break-down) or external (e.g. technological change).

A case in point for social systems may be related to Mancur Olson's observation that, "Stable societies with unchanged boundaries tend to accumulate more collusions and organizations for collective action over time." In other words, interest groups come, but they rarely go. The result being government calcification or demosclerosis to use Rauch's term. Olson goes on to argue that interest groups "usually survive until there is a social upheaval or other form of violence or instability".

As systems succumb to disturbances, there is a rapid release of capital resources and a break-down in structure. The system then moves into a reorganization phase characterized by relatively large amounts of accessible resources and little connectance. The combination of release and reorganization corresponds closely to Schumpeter's process of creative destruction which he argued defined capitalism. The lack of structure in the reorganization phase leads to a chaotic environment. The current Washington political scene provides a useful example. Chaos theory has provided some initial insights into the dynamics of reorganization. One of the key insights being that relatively small well timed or even random events can have major impacts on the future structure of the system.

Holling argues that systems cycle through these stages, but the fundamental nature of the system can change each time through, depending upon the dynamics of the reorganization phase. Thus, a conifer forest might burn and ultimately reestablish itself or be replaced by a hard wood forest. The dynamics of social systems would appear to be similar with one key difference. The existence of purposeful behavior in social systems enhances feedback effects that can compound the connectance problem (e.g. fisheries exploitation, secondary disease outbreaks, Everglades drainage), as well as provide the potential for adaptive management. Adaptive management requires focusing on ecosystem resilience (sustainability) rather than subsystem enhancement and stability which eventually leads to rigidity and increased susceptibility to disturbances.

In a related development, Common and Perrings have attempted a merging of economic and ecological concepts of sustainability to derive an ecological economics concept of sustainability. They use the Solow/Hartwick concept of intertemporal price efficiency to reflect the economic component and the Holling concept of ecosystem resilience to reflect the ecological component. Holling's distinction between ecosystem stability (rigidity) and ecosystem resilience (sustainability) reflects the fundamental physical feedbacks or dynamics that characterize ecosystems. Common and Perrings show that the Solow/Hartwick and Holling sustainability concepts are largely disjoint. That is, an efficient price path is not necessarily incompatible with ecological sustainability of the system, but on the other hand, it clearly is not a necessary condition. Their results also suggest that the problem of ecological sustainability has to be solved at the level of preferences and technologies and thus these factors need to be made endogenous in economic models of sustainability. Furthermore, they argue that ecological sustainability requires abandonment of the principle of consumer sovereignty as the driving economic force. Ecological economics of sustainability implies an approach that explicitly recognizes system dynamics and privileges the requirements of the system above those of the individual.

In a different context, Stanford economist, W. Brian Arthur (1990) and colleagues (Anderson, et al. 1988) at the Sante Fe Institute have pioneered the application of complex adaptive systems to economic systems that exhibit increasing returns as opposed to the common neoclassical assumption of decreasing returns. Characteristics of increasing returns systems include multiple equilibria and extreme sensitivity to random events and event timing. Arthur has used nonlinear random-process theory to model increasing returns systems. One of his key illustrative examples is the competition between competing VHS and Beta VCR technologies. His models illustrate how fortuitous circumstances and early corporate maneuvering allowed VHS to achieve an early market share advantage that allowed it to capture virtually the entire VCR market, despite expert claims that the Beta technology was technically superior. Arthur uses mathematical simulations of this competition and similar systems using nonlinear, random process mathematics to illustrate how multiple solutions can emerge from the same initial conditions and to study the probabilities that a particular solution will emerge under a certain set of initial conditions.

Though still in their infancy, efforts to apply complex adaptive systems models to study social systems show promise. The exploitation and conservation phases have many parallels with neoclassical growth theory. The creative destruction (i.e. release) and renewal stages reflect the uncertain dynamic components that are ill defined in neoclassical theory. Formal recognition and examination of these stages may allow for better understanding of the processes of innovation and change and a deeper understanding of sustainability.

Summary

In summary, let me leave you with the five main points that I hope you will take away from this address. First, as policy analysts we need to explicitly recognize that efficiency is not an objective truth value. As Bromley (1990, pg.106) put it, economists have been "hiding behind a bogus and quite irrelevant facade that makes us feel good and look bad". In this respect we need to begin by explicitly recognizing the nonuniqueness and nonseparability of efficiency analyses and work to extend our analytical frameworks to jointly consider efficiency and equity. Chavas has provided a promising start in this direction.

Second, in policy circles, redistribution of wealth or economic opportunities is often the objective, and rent seeking is endemic. Economists who fail to recognize this are naive and subject to either being ignored as irrelevant or worse yet manipulated to support particular rent seeking positions. In our analyses we need to more carefully reflect the important role that rents play in the innovation process as well as the real costs associated with rent seeking behavior.

Third, dynamic adjustments often offset static impacts. Furthermore, in general static efficiency is not a necessary condition for dynamic efficiency. Fourth, environmental regulation is not necessarily a zero-sum game. But neither does it inevitably lead to innovation and enhanced competitiveness. Policies need to be designed to foster innovation offsets and economic impact and cost benefit analyses need to more carefully address these issues.

Finally, neoclassical growth theory is inadequate in its understanding of uncertainty and the dynamics of innovation, growth, and sustainability. Complex, adaptive systems theory provides a promising alternative framework for beginning to understand uncertain, dynamic systems.

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Endnotes

1. See Just, Hueth and Schmitz, Chapter 2 for detailed discussion.

2. See Boggess (1993) for a case study description of environmental regulation of dairies in the Okeechobee area.