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Shaping the Evolution of Complex Societies

John Gowdy, Mariana Mazzucato,
Jeroen C. J. M. van den Bergh,
Sander E. van der Leeuw, and David S. Wilson

Abstract

This chapter calls for an approach to economic policy that takes evolutionary and complex systems theories into account. Such an approach alters the way that economic policy is framed and how policy co-depends on understanding markets as outcomes of nonmarket interactions, incomplete information, path dependency, and coordination failures. Using several illustrative examples, the chapter explores the application of evolutionary and complexity thinking to policy criteria, goals, instruments, and policy assessment. These examples—the transition to a low carbon economy, using multilevel selection to inform group design in various human organizations, policy making as shaping and creating markets, government failures in Greek farm policy, and protecting the Sudd Wetland in South Sudan—are used to identify key issues for an evolutionary and complexity approach to public policy.

Introduction

Economists have long acknowledged the importance of complexity and evolution. For example, over one hundred years ago, Alfred Marshall (1920:19) advised the economics profession that "the Mecca of the economist lies in economic biology…its key-note is that of dynamics, rather than statics." And in 1898 Thorstein Veblen asked "Why is economics not an evolutionary science?" Despite this history, modern economics, at its core, is very non-evolutionary. Its perceived scientific foundations focus generally on narrow concepts of representative agents or average behavior (vs. populations of diverse behaviors in evolutionary approaches), equilibrium (vs. innovation, surprise, and selection dynamics) and markets (neglecting social networks of nonmarket interactions between agents). Economists' research often focuses on efficiency

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in a static allocation framework, assuming that institutions, norms, and culture are outside the purview of economic analysis. By the middle of the twentieth century the common definition of economics had become the science of the allocation of scarce resources among alternative ends (Robbins 1935). Issues of formation (i.e., how institutions, norms, and culture develop and how allocative mechanisms feed back onto them) received some consideration, but they were generally to be found at the margins rather than at the center of analysis. Their marginalization led to some quite spectacular shortcomings of economic models, such as their failure to consider, much less predict, the possibility of catastrophic financial crises (Colander et al. 2009).

Here, we are concerned not with economic theory and methodology per se, but rather with policy: how economic policy is framed and how this is dependent on the way in which market processes and underlying interactions are understood. In policy considerations, modern economists have strongly focused on allocation mechanisms, with far fewer formation mechanisms than called for by evolutionary theory and complex nonequilibrium dynamics. Our fundamental argument is that economics should focus more on those formation mechanisms.

Surprisingly few studies have systematically and comprehensively addressed public policy from an evolutionary and complexity perspective. The last chapter of Nelson and Winter (1982), *The Evolution of Public Policies and the Role of Analysis*, is perhaps the first explicit attempt to outline an evolutionary perspective on public policy. While subsequent studies in the literature on evolutionary economics and innovation addressed technology policy (Dosi et al. 1988; Metcalfe 1998; Cantner and Pyka 2001; Fagerberg 2003), broader treatments of public policy from an evolutionary–complexity framework are rare (for notable exceptions, see Witt 2003; Moreau 2004; Schubert 2012; van den Bergh and Kallis 2013; Wilson and Gowdy 2013; Colander and Kupers 2014; Waring et al. 2015).

The starting points for our discussion are two assumptions at odds with the canonical model of Walrasian economics: static equilibrium and strict rationality. Here we begin from the accepted insight in evolutionary and complexity economics that economic systems are frequently out of equilibrium. To the extent that they are stable, they are stabilized by complex interactions among economic actors. In addition, human preferences are not adequately represented by the axioms of standard consumer choice theory. In view of this, Bowles and Gintis (2000:1441) call for an expansion of the subject matter of economics:

> Two basic tenets of the Walrasian model, behavior based on self-interested exogenous preferences and complete and costless contracting have recently come under critical scrutiny. First, social norms and psychological dispositions extending beyond the selfish motives of *Homo economicus* may have an important bearing on outcomes, even in competitive markets. Second, market outcomes depend on strategic interactions in which power in the political sense is exercised. It follows

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> that economics must become more behavioral and more institutional. We can return to these themes of the classical tradition, now equipped with the more powerful mathematical tools developed over the past century.

From an evolutionary point of view, perhaps the most problematic assumption of the strict Walrasian model is the assumption of self-regarding agents. It is well-known that the Walrasian general equilibrium model is unstable. Gintis (2007) argues that this is due to the assumption that prices are "private"; there is no dynamic interaction among economic agents. When interaction among agents is allowed, a stable general equilibrium model cannot be constructed.

We believe that public policies should be formulated and judged on real-world behavior and their effectiveness in the face of nonmarket interactions among agents, incomplete information, incomplete contracts, and pervasive market and government failures. Explicitly considering complexity and evolution in public policy gives rise to a rich field of inquiry, embracing diversity, bounded rationality, social interaction, path dependence, and self-organization. Admittedly, replacing the rational agent by a more general, satisfactory alternative is difficult as behavior has so many dimensions.

What does evolutionary and complexity thinking about the economy imply for policy criteria, goals, instruments, elements, and policy assessment? Witt (2003) argues that both positive and normative dynamic aspects of evolutionary approaches improve upon the comparative-static interpretations of policy, as in public choice theory, economic policy-making theory, and social philosophy. Moreau (2004) considers evolutionary policy as a means to maintain the flexibility and diversity of the economic system so as to prevent it from becoming locked into undesirable trajectories, to create incentives for exploration activities, and to establish institutional structures that can react to what has been learned. Wegner (1997) calls into question the "Impossibility Theorem" of Hayek, who had a distinct evolutionary view on the economy. Although Hayek used an evolutionary approach, he used it to argue for the virtues of unregulated markets: "The state cannot be considered as more efficient than the market process for solving the coordination problem among individual decisions with the information disseminated among market participants." Van den Bergh and Kallis (2013) explore the meaning of evolutionary policy from normative and positive angles. The former concerns policy design informed by evolutionary thinking, whereas the latter regards policy making and politics as an evolutionary process (as studied in political science). They compare evolutionary policy with policy advice coming from two dominant schools of policy analysis: neoclassical economics and public choice theory. Mazzucato (2013a) argues for an evolutionary approach to public policy that goes beyond correcting "market failures" and actively creates and shapes markets, channeling the direction and pace of economic change. This builds on Polanyi's emphasis on market processes themselves as deeply shaped by policy (Polanyi 1944/2001)

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and Keynes' view of policy as actively and directly affecting the outcome of the system, rather than tinkering on the sidelines (Keynes 1926).

There are many reasons why sociocultural evolution does not automatically lead to progress nor to a continuous increase of complexity: Selection is a local search process. Adaptations are often compromises between different implicit or explicit "objectives." There is resistance to change in ideas, institutions, behaviors and technologies because of historical constraints (different literatures use different terms for this: path dependency, lock-in, Baupläne limits, or development constraint, "structural inertia" and "imprinting"). Not all evolution is adaptive microevolution. Randomness and drift, coevolution, multilevel selection, and niche construction mean that the environment is not constant and exogenous to the individual species' evolution, but rather influenced by it. Evolution as improving species or their fitness does not imply improving the welfare or quality of life for each individual. In fact, an important role for public policy in evolutionary human social systems is to counter inequality tendencies.

Van den Bergh and Kallis (2013) argue that evolutionary thinking suggests that the well-known Arrow paradox, according to which aggregation of individual rational preferences into internally consistent ("rational") social preferences is impossible, understates the problem of constructing a social welfare function. As economic preferences reflect bounded rationality and are evolving due to external forces, notably advertising and social interactions (Witt 2003; Norton et al. 1998), there cannot be any constant static social welfare function. One alternative is to focus on evolutionary progress. However, there are different interpretations or criteria of "progress" (Gould 1988; Potts 2000), including increasing diversity and increasing complexity, extended division of labor, new ways of transmitting information, population growth, adaptation to the environment, and increasing efficiency of energy capture and transformation (Schneider and Kay 1994). Taking several of these into account while assuming or testing for a degree of consistency would be a way to go forward. When different indicators sketch different pictures, one can add weights to make clear choices or trade-offs.

Evolution introduces the elements of system complexity, including uncertainty about the future, novelty, surprise, irreversibility, and limited social and policy control. This suggests two possible directions for choosing a policy goal:

1. A focus on effectiveness: better to inefficiently reach a target than efficiently miss it.
2. A focus on risk aversion: some form of the precautionary principle (e.g., operationalized via "minmax regret") or portfolio approaches.

From an evolutionary angle, cost effectiveness could be broadened to include the cost over time of maintaining sufficient diversity to improve selection outcomes, avoid lock-in, and keep options open. In innovation studies, understanding complexity has been approached through the notions of national and

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regional systems of innovation considering a broad set of innovating actors, such as governments, research institutes, private companies and NGOs, as well as their networks (Edquist 2005).

Public policy typically draws on many theoretical perspectives, including but not restricted to economic theory. Often there is no formal theoretical perspective, just the experience, interests, and judgments of policy makers. There is frequently a severe "silo effect" (i.e., a separate community forming around each policy issue). Against this background, it is important to develop a policy framework that can be applied to a diversity of policy issues—now more than ever, given the problems of our age (extreme inequality, the prospect of disruptive climate change, the loss of biological and cultural diversity). A combination of complexity theory and evolutionary theory has the potential to provide this general theoretical framework.

Complexity and evolution are different concepts that need to be related to each other; they are overlapping yet distinct. Complexity is characterized by self-organization, fractals, basins of attraction, and sensitive dependence on initial conditions. Complex systems may also be characterized by "control without hierarchy" (Gordon 2007), a concept showing the interplay between evolution and complexity. Highly evolved complex societies, like ant and termite colonies, and contemporary human societies function "as if" they were characterized by centralized control, yet there is no central authority. Such societies seem to be controlled by an "invisible hand," yet it is very different than the kind envisioned by Adam Smith (Wilson and Gowdy 2015). Important concepts from evolutionary theory include multilevel selection, the distinction between proximate and ultimate causes, gene–culture coevolution, and discontinuous major transitions (Maynard Smith and Szathmáry 1995). A growing literature suggests that complex social systems evolved through multilevel selection (Henrich 2004; van den Bergh and Gowdy 2009; Gowdy and Krall 2015).

Standard economics focuses on allocation, and policies are typically designed from this perspective. The complexity approach emphasizes formation and policies that affect formation, although it also allows for analysis of given policy instruments, but using different assumptions than standard economics. Standard economics has focused on the narrow concept of welfare; maximizing real output is measured using standard accounting methods. Complexity focuses more on measures that go far beyond simple economic measures.

Illustrative Examples

Here we present several case studies that incorporate complexity and evolution. Real-world applications give a dimension not present in theoretical papers. When it comes to solving practical problems, policy makers make little reference to abstract theory, but this does not mean that policy makers are not interested in complexity. Complexity involves both a notion of complex

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theories and also a complex vision of how the economy works. Colander and Kupers (2014) advocate an engineering methodology using science, but also allowing for intuition, gut feelings, guess and other “nonscientific” considerations. Good engineering is a creative effort that uses any means at its disposal to come up with a workable solution (Colander, this volume). In this spirit, the case studies below can be described as applying an *educated common sense* methodology.

Climate Policy and the Transition to a Low Carbon Economy

According to the Intergovernmental Panel on Climate Change (IPCC), there is broad scientific agreement on the climate getting warmer and that this is being caused by anthropogenic emissions. The mechanisms of climate change as well as the physical, biological and socioeconomic impacts have been mapped out in detail, the results of which have been summarized by the IPCC (2014). A precautionary perspective emanating from this is that we should avoid a rise in global average temperature beyond 2ºC. This poses an enormous challenge in terms of designing and implementing policies that steer our economies away from high carbon production, consumption, and transportation. Several studies claim that we may need to reduce the carbon intensity of output by more than 80%, depending on global economic growth and population scenarios (Jackson 2009; PWC 2012; Antal and van den Bergh 2014).

The dominant economic view on climate policy is that we need to regulate carbon dioxide and other greenhouse gases through market mechanisms such as carbon taxes or emissions trading. Theoretical support for this comes from environmental economics, which conceptualizes the problem as a market failure, in particular as an environmental (greenhouse gas) externality. The underlying policy goal is to increase social welfare by correcting this market failure. An important point is that the aim is not to minimize the level of environmental externalities. Indeed, since externalities are pervasive, the latter would imply reducing the size of the market economy up to the point of eliminating it. The central policy insight of this externality welfare approach is that price instruments will result in equal marginal costs of abatement (emissions reduction) among all polluters, giving rise to a minimization (in theory) of the total sector costs, or even economy-wide costs of abatement (Sterner 2002). Another element of climate policy is some (implicit or explicit) form of subsidizing technological innovation that similarly has a theoretical basis in market failures theory, in this case motivated by positive knowledge externalities that arise from R&D. Policy instruments like setting standards and providing information are also seen as relevant but tend to be less clearly supported theoretically. Such policies have a more pragmatic basis (driven by, e.g., sociopolitical feasibility) or are founded on other theoretical considerations (e.g., transaction costs, ease of monitoring) within the traditional framework.

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Does an evolutionary and complexity perspective change this policy picture? Here are some suggestions. From an evolutionary angle, two issues may be stressed: creating or maintaining technological diversity (e.g., in renewable energy options) and escaping or avoiding carbon lock-in (Unruh 2002). With regard to the first issue, one may strive for a desirable level of diversity in terms of an optimal trade-off between scale advantages of focusing on a single technology (namely, increasing returns to scale, as explained below) versus diversity benefits associated with keeping options open and allowing for spillovers and recombinant innovation (van den Bergh 2008). Here, diversity is best seen as multidimensional (following Stirling 2007), comprising variety (number of distinct types in a population), balance (in terms of distribution of the types), and disparity (some measure of distance between the types). Optimal diversity can thus be seen to blend elements of traditional and evolutionary economics to rationalize decision problems about uncertain future options.

The second evolutionary (and complexity) notion is carbon lock-in. It is the outcome of a long history of investing and innovation in fossil-fuel based combustion engines, in electricity generation and transport. Increasing returns to scale on both the demand and supply sides of markets are responsible for lock-in as they increase the net benefits of certain options beyond their intrinsic benefit merely because of scale effects. As a result, early dynamics coincidentally lead to a scale advantage for one option and this matters for long-term outcomes. Examples are economies of scale; learning, informational and network externalities; and complementary technologies, including infrastructures. To escape from carbon lock-in, specific policies compensating for (or countering) increasing returns to scale have been suggested, such as setting a clear future goal (e.g., California's zero emission vehicle program), creating semiprotected niches (e.g., with public subsidies), and public procurement (governments buying green products or investing in eco-efficient public buildings to help create new markets). Additional, potential "unlocking strategies" that have received less attention include restricting advertising (e.g., of cars with oversized combustion engines), stimulating status seeking (e.g., of hybrid car or solar panels on roof tops), and discouraging innovation in undesirable dominant technologies (e.g., in the internal combustion engine by car manufacturers) (van den Bergh et al. 2007). Furthermore, hybrid solutions are empirically suggested to possibly offer a way out of a lock-in situation (e.g., the Toyota Prius). This is supported by evolutionary model studies showing that a transition to a low carbon economy can occur along a path starting with hybrid, recombinant innovations (Zeppini and van den Bergh 2011).

A complexity perspective suggests the importance of identifying and accounting for undesirable indirect effects of climate policies that are—to a large extent—avoidable. Related insights can improve the effectiveness of these policies. Important categories of such indirect effects are (a) energy rebound (e.g., more energy use through more intense use, re-spending, diffusion), (b) carbon leakage (relocation of polluting industries or shifts in international trade due

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to policy differences between countries), (c) green paradox (unwanted oil market responses to renewable energy subsidies), and (d) environmental problem shifting (e.g., reducing greenhouse gas emissions through biofuels resulting in biodiversity loss and pesticide runoff). These four types of indirect effects have been referred to as "escape routes," arising from a narrow focus on single environmental problems, single countries, or single technological options (van den Bergh 2012). To identify effective solutions, assessment through models and indicators require a broader, more complete systems perspective that sufficiently reflects economic and environmental complexity.

In addition, by adopting a complex systems angle one can further reframe climate policy as an opportunity. This has already been done in the young area of sustainability transition studies (Grin et al. 2010). This employs a multidisciplinary approach to understand major transitions in the past and future, focusing on stages and levels (niche, regime and landscape) of change. Approaches include "innovation systems" (Jacobsson and Bergek 2011), the "multilevel perspective" (Geels 2002), "strategic niche management" (Kemp et al. 1998), and complex systems analysis (Rotmans and Loorbach 2009). The separation of various approaches is not very sharp (Markard and Truffer 2008) and, in fact, combines various elements of complex systems theory, innovation studies, and evolutionary economics. Explicit evolutionary models (both multi-agent systems and sets of dynamic equations) have been employed to study policy packages aimed at stimulating a sustainability transition (see overview by Safarzynska et al. 2012). Traditional equilibrium markets are here replaced by coevolutionary populations of firms and consumers, naturally integrating innovation (R&D) strategies in the market behavior of firms and social interactions (notably imitation/diffusion or status seeking) in consumer market behavior. Such models tend to account for multiple selection factors, associated with input and output markets, financial investment conditions, government regulation, and public opinion. The result is an approach that allows for testing a wider range of policies within a single framework than traditional equilibrium models can do. This involves a consistent comparison of price incentives, standards, subsidies, and information provision (Safarzynska and van den Bergh 2010; Nannen and van den Bergh 2010). This full range of climate policy instruments cannot be easily compared in traditional approaches, whether in economics or other social sciences, as they focus either on markets or social interaction networks, but rarely on their combination. In this respect, such complex evolutionary models present progress on climate policy analysis.

Going one step further, one might deal with the complexity associated with climate policy in a wider macroeconomic setting. This raises questions about macroeconomic transition strategies aimed at reducing the strength of positive feedback mechanisms (the role of GDP information), or combining climate and employment goals (Antal 2014). Other issues associated with complexity can be briefly mentioned without going into much detail. Uncertainty plays a role in every phase of the cause–effect chain from greenhouse gas emission to

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socioeconomic and welfare effects. Thinking more deeply about these uncertainties is crucial for policy effectiveness and may affect the choice between policy instruments. Comparing top-down versus bottom-up mechanisms is another and is relevant in choosing between local climate solutions versus a regional or global climate agreement. By setting up a diversity of local "transition experiments," lessons can be drawn and a variety of important issues can be studied (Grin et al. 2010). But what is perhaps most interesting about an evolutionary approach is that it can rigorously study the combination of top-down (regulation through price incentives supported by an international climate agreement) and bottom-up (triggering prosocial behavior, local experiments) initiatives in terms of policy effectiveness. Finally, an evolutionary framework with diverse agents is capable of studying inequitable impacts of climate policies in terms of income or spending power distribution. The relevance of this is great, among others, as inequality may present a barrier to a transition because diffusion of green products will be hampered by individuals who are too poor to be green.

The previous suggestions are not meant to deny that traditional economics recognizes certain aspects of complexity and evolutionary thinking. First, diversity is essential to the core policy insight of environmental economics as price incentives are seen as minimizing total abatement costs by equalizing marginal abatement costs among *heterogeneous* polluters, even though it represents a static and exogenous view of heterogeneity (diversity). In addition, the complexity of the numerous interactions between all goods, services, and production factors is captured and translated into the idea that correcting prices of energy or carbon will affect all other prices in the economy and thus alter incentives in favor of less carbon-intensive purchases, factor uses, and technology innovation and diffusion. One might say that the use of price incentives represents a form of complete systems control, assuring that carbon emissions reduction is achieved most effectively without any leakages. Finally, environmental economics now has well-integrated insights from (evolutionary) innovation studies and fully supports (e.g., Jaffe et al. 2005) the idea that we need a policy package consisting of carbon pricing and subsidizing promising but still expensive technologies (e.g., certain forms of renewable energy).

Evolutionary and complexity perspectives do not necessarily imply that the traditional emphasis on the importance of carbon pricing is wrong. For instance, from a complex systems angle, a decentralized price incentive structure, rather than hierarchical control by norms and standards, to stimulate behavioral changes of all agents (consumers, producers, investors, and innovators) makes sense. In other words, the alternative view can confirm or reinforce existing policy insights, indicating their robustness against distinct methods. Finally, the main conclusion to be drawn from these examples is that an evolutionary-complexity perspective on climate policy, rather than suggesting a radical change in policy design, mainly refines and complements current insights about particular instruments.

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Multilevel Selection Theory and the Practical Design of Groups

To function well as a group, members must perform services for each other at some cost in terms of time, energy, and risk. These prosocial efforts are vulnerable to exploitation by more self-serving individuals. The inherent disadvantage of prosociality makes it difficult to see how it can evolve by a Darwinian process, but there is an inherent advantage that also needs to be taken into account: groups of highly prosocial individuals have a competitive advantage over groups crippled by selfishness. Prosocial behaviors can win the Darwinian contest, but only if selection among groups in a multigroup population is strong enough to prevail against selection among individuals within groups (Wilson and Wilson 2007; Wilson 2015).

The same potential conflict between prosocial and disruptive self-serving behaviors occurs at all rungs of a multitier hierarchy. What's good for me can be bad for my family. What's good for my family can be bad for my clan. All the way up to what's good for my nation can be bad for the global village. The general rule is: Adaptation at any level of a multitier hierarchy requires a process of selection at that level and tends to be undermined by selection at lower levels. Another point is that the balance between levels of selection is not static but can itself evolve. When mechanisms evolve that suppress the potential for disruptive self-serving behaviors within groups, the group evolves to be a highly cooperative unit: a veritable superorganism.

These statements summarize multilevel selection theory, which has wide-ranging implications in the biological and human social sciences. Many of these implications bear upon human, animal, and environmental welfare, which brings multilevel selection theory into the realm of public policy. The public health risk of cancer provides an outstanding example. Countless cell divisions take place within our bodies. Every division carries a risk of mutation and some mutations cause cells to proliferate at the expense of neighboring cells, forming a tumor. This is a process of natural selection among cells within a single organism: tumor cells outcompete neighboring cells but they are seldom good for the organism. Eons of natural selection at the between-organism level have resulted in an arsenal of physiological mechanisms that keep mutations to a minimum and kill or contain tumor cells when they arise. These mechanisms are not perfect, however, so malignant tumors still occur. Environmental factors that increase mutation rates or impair the immune system can increase the incidence of cancer. Every cancer death illustrates the logic of multilevel selection theory; in this case, adaptation at the level of the whole organism requires a process of selection among organisms and tends to be undermined by selection among cells within organisms (Pacheco et al. 2014; Horne et al. 2015).

The same example can be used to illustrate the distinction between disruptive and benign competitive processes. Natural selection among multicellular organisms favors any cellular interactions that cause the organism to survive

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and reproduce better than other organisms. Some of these interactions look cooperative in human terms but others are competitive, such as nerve cells competing for attachment sites or the B-cells of the immune system differentially proliferating on the basis of the antibodies that they produce. Competition among cells within an organism is not bad as long as it is orchestrated, and natural selection among organisms is required for the orchestration.

Another practical application of multilevel selection theory is animal and plant breeding (Denison 2012). In the poultry industry, hens are housed in cages. Imagine that you are a poultry breeder who wants to select for egg productivity. You monitor the productivity of all the hens and select the most productive hen from each cage to breed the next generation of hens. To your surprise, egg productivity goes down and hen mortality goes up. An ounce of multilevel selection thinking provides the answer: By selecting the most productive hen within each cage, you selected the most aggressive hens that achieved their status by suppressing the productivity of the other hens! The wiser strategy, and the one followed by the poultry industry, is to select the most productive cages rather than the most productive hen within each cage to breed the next generation (Goodnight 2011).

It is easy to think of workplaces as cages inhabited by coworkers who advance by interfering with the productivity of other coworkers. The comparison is funny but also worth taking very seriously. It is important to stress that there is more to evolution than genetic evolution. The psychologist B. F. Skinner coined the phrase "selection by consequences" to stress that the outcome of operant conditioning is much like the outcome of natural selection (Skinner 1981). Create a social environment where a selfish option delivers a higher payoff than a prosocial option and people will gravitate toward selfishness. Create a social environment that favors prosociality and people will become prosocial. Genetic evolution hasn't occurred, but something that is roughly equivalent in terms of behavioral outcomes has. Evolutionary game theorists make the same point with their phrase *replicator dynamic*. Any process that causes the most successful strategy to become more frequent during the next iteration of the game counts as an evolutionary process and results in roughly the same behavioral outcome as if the trait was evolving by genetic evolution (Gintis 2009b). Finally, cultural change operating over decades, centuries, and millennia is increasingly being studied as an evolutionary process, complete with its own inheritance and transcription mechanisms (Turchin 2005, 2010). Multilevel selection is taking place all around us, at all timescales, and every timescale has implications for public policy formulation.

Starting with genetic evolution, most primate species are cooperative to a degree but members of the same group are also their chief rivals. Even cooperation usually takes the form of alliances that compete against other alliances within the same group. In our species, mechanisms evolved that largely suppressed self-serving behaviors within groups, causing between-group selection to become the main evolutionary force (Boehm 2012). Teamwork in small

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groups became the signature adaptation of our species. Teamwork included physical activities such as childcare, hunting, gathering, defense against predators, and defense and offense against other human groups. Teamwork also included mental activities such as communicating with a shared inventory of symbols and transmitting learned information across generations. Nearly everything distinctive about our species can be traced to teamwork in small groups. This is in stark contrast to the economic conception of people as lone operators who care only about maximizing their own utilities.

Recognizing small groups as a fundamental unit of human social organization, in which teamwork takes place most spontaneously, has policy implications all by itself (Wilson et al. 2013). Mechanisms that promote teamwork in small groups tend to break down in larger groups. For larger groups to function well, culturally derived mechanisms are required that interface with our genetically evolved mechanisms. Multilevel group selection favoring larger and larger polities has been taking place since the advent of agriculture, including but not restricted to direct competition (warfare). It is often opposed by cultural evolution within polities, causing them to collapse due to factionalism at a variety of scales (Turchin 2005, 2010). Human history provides a fossil record of multilevel cultural evolution and our current nations, institutions, and cultures reflect the current balance between levels of selection. One policy implication of this view is that history matters. Cultures can vary greatly in their capacity to function at a large scale and the specific coordination and policing mechanisms that happened to evolve in one culture but not others. This is in contrast to orthodox economic theory, which often does not take history into account. Multilevel selection theory is equally relevant at the timescale of a single human generation.

Healthy child development requires an enormous amount of nurturance on the part of parents and other caretakers (Biglan 2015). The adage "it takes a village to raise a child" needs to be taken very seriously, given what we now know about small human groups as a fundamental unit of social organization. A fascinating literature on childhood in hunter-gatherer societies and other traditional cultures shows how children grow up in mixed age groups with light supervision by adults. Learning takes place by child-motivated practice and play, and teachers are typically older children rather than adults. Mixed age groups tend to inhibit disruptive competition among the older children and the bullying of younger children. A 14-year-old in a group of 14-year-olds behaves differently than a 14-year-old interacting with 8-year-olds and 18-year-olds. These and other insights provide a new lens for viewing child development and education in our own societies (Ellis et al. 2012; Gray 2013).

Finally, multilevel selection theory is relevant to decisions that we make on a daily basis. All species have evolved to be phenotypically plastic; that is, to change their behavior in response to their immediate circumstances. A snail pulls into its shell when it senses danger and reemerges when the danger passes. In the same way, people self-protectively avoid prosocial activities when

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they sense that their efforts are likely to be exploited but willingly become team players when they trust those around them (O'Brien and Wilson 2011). Trust is based not only on the trustworthiness of one's social partners but also on mechanisms that prevent disruptive self-serving behaviors and contain them when they take place. Human groups need to be protected against cancerous social strategies, no less than multicellular organisms (Wilson et al. 2013).

This brief overview shows how a theory that applies to the evolution of social behavior in all species can be used to understand human social behavior and how the new basic scientific understanding can be used to accomplish positive change in a practical sense. Some insights from multilevel selection theory are already appreciated by policy makers but many others are not. As Einstein said, the theory decides what we can observe.

Markets as Outcomes and Policy Making as Shaping or Creating

Markets are not given—putting pressure on actors—rather they are outcomes of interactions between different types of actors, both public and private. These actors can be understood as being part of a "social ecosystem." Policy making can then usefully focus on the characteristics of the agents in that ecosystem (the characteristics of the companies, e.g., shareholder/stakeholder, and what type of public institutions, e.g., simply spending on market failures or also investing strategically) and the nature of the dynamic interactions between them (e.g., how rewards are shared). In this sense, an ecosystem view of markets is useful.

As for the public side of the ecosystem, it is important to understand the degree to which public policy not only fixes market failures (the usual lens) but actively shapes and creates markets (Mazzucato 2013a, 2015a). This point builds on key insights from the work of Polanyi (1944/2001:140), who emphasized the way that markets are deeply shaped and created by policy:

> The road to the free market was opened and kept open by an enormous increase in continuous, centrally organized and controlled interventionism…. Administrators had to be constantly on the watch to ensure the free working of the system.

While Polanyi wrote seventy years ago, the visible hand behind the market is more relevant today than back then (when Keynesian policies were yet to spread). Indeed, it is precisely looking at hotbed areas of modern capitalism, like Silicon Valley, that the visible hand of policy is most evident. Most general-purpose technologies (e.g., the Internet, nanotech, biotech) were fruits of active policy making by agencies like NASA, DARPA, National Nanotech Initiative and the National Institutes of Health (Block and Keller 2011). Mission-oriented public investments (Mowery 2010) have not only been important for the "public good" (market failure) part of the innovation chain (i.e., upstream basic research), but also many parts downstream, including early-stage funding of firms (Mazzucato 2013a). In this process, public investments

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not only "de-risked" the private sector, but actively "took on risk," directly financing new areas that did not previously exist. The high uncertainty behind this process is evident by the fact that with each success, there are many failures. Key to understanding this dynamic is the recognition that Keynesian "animal spirits" (guiding private investment) are determined by private expectations of where new technological and market opportunities lie. Such opportunities have been deeply shaped by active public policy that created and shaped new market opportunities.

Such a "market shaping" (vs. just fixing) lens would also affect how we understand intellectual property rights. Rather than see them in terms of knowledge ownership, we can view the policies around such rights (which were fundamental for developing the boundaries of markets) as being key to the knowledge governance of the system. This takes emphasis away from "intervention" and moves it toward shaping the core of the system. Put another way, it takes emphasis away from the dynamics of "imperfect competition" (in which innovation is usually understood due to the need for appropriability mechanisms to have knowledge not freely accessible) toward a different view of the competitive process itself. Indeed, this was Schumpeter's core insight (Schumpeter 1934).

Having an understanding of who the different actors are, and what they are doing to co-create the market, also helps to connect risks and rewards. If government is investing in high-risk areas, is it realistic to think that it can get back a return simply via tax? Should it think of its investments through a portfolio approach and make sure it not only absorbs the downside risk but also some of the upside success so that the losses can be covered, and the next round funded equally? Asking these questions will help policy makers create a more mutualistic and sustainable (over time) innovation ecosystem in the future, rather than the current one where we socialize the risks but privatize the rewards (Mazzucato 2015b).

This case study will build, therefore, on the following properties of innovation ecosystems: (a) they are collective (different types of public and private actors interacting), (b) the outcomes are highly uncertain (with most failing), and (c) markets do not stand separate from policy but rather emerge as a result of public and private interactions. A fourth complex characteristic that is crucial here is the cumulative and path-dependent nature of innovation. As argued by Lazonick and Mazzucato (2013), the fact that innovation today builds on innovation yesterday means that "returns" to innovation build on each other, allowing some latent actors to potentially capture a large share of rewards beyond their own contribution. This makes it essential for policy makers to build policies (including tax policies) that stem from a representation of the collective nature of the ecosystem and the role that each actor realistically plays in the distribution of both risks and rewards. For further discussion on the implications for policy, see Mazzucato (this volume).

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Policy Failure in Greek Farming

This case study highlights how severe environmental degradation was caused during the period of 1950–2000 by a partial and myopic economic perspective, which focused on immediate problem solutions. It also shows how an evolutionary complex systems approach could have mitigated some of the issues concerned by taking into account dimensions of the overall system that were not accommodated in that partial perspective.

The main elements of the story are as follows (van der Leeuw 1998:281–324). In the 1950s, during a period of important migration of rural populations to urban environments, the Greek government instituted substantial subsidies to keep young farmers active on the land. At that time in Greece, most people (whether living in rural areas or cities) owned a "family" plot of land. The new subsidies were insufficiently communicated to the rural population and, in the Argolid at least, the urban notables (bankers, notaries, lawyers, dentists, etc.) grabbed this opportunity to apply for the subsidies. To qualify, they had to argue that they were effectively farming. To reduce the time spent on that activity, a number of them chose arboriculture, in particular, apricot or orange cultivation.

This had two unintended consequences: the citrus crop required substantial irrigation and demanded more water than was sustainably available, and the financial success of the early citrus farming seduced others into adopting that crop, thus rapidly increasing the surface of citrus groves and the total volume of water needed.

Irrigation water was pumped up from an underground aquifer, initially by means of combustion-engine-driven pumps. These could only pump water up to a depth of ten meters, from the uppermost of the three aquifers under the Argolid valley. Once that aquifer had been exhausted, salt water came in from the sea, and whatever could be pumped up was too salty for agricultural use. Deeper drilling was the result, and electric pumps were installed in the boreholes to pump the water up from the second and third aquifers. Ultimately this source of water was also exhausted, and the Greek government proceeded to capture fresh water offshore, coming from a different drainage basin, and build a canal to provide irrigation for a limited number of farmers in the area. The inequality in access to water, of course, exacerbated the wealth differentials in the valley.

The most affluent and up-to-date farmers replaced flood irrigation with drip irrigation, but that process was still far from complete in the early 1990s, when fieldwork was conducted (van der Leeuw 1998). In the meantime, the draining of the upper aquifer caused the marshy area on top of it, in the center of the valley, to dry out as well. That marsh had kept the surface air from freezing during the winter. Once the water disappeared, part of the orange crop was attacked by night-time frost. To compensate, farmers installed "air mixers," essentially engine-driven windmills which kept the air around the oranges just above 0ºC.

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The windmills, however, were expensive to install and run, thereby driving up the cost of the oranges.

These costs were bearable as long as the EU subsidized agricultural exports to other EU countries. But these subsidies were discontinued in 1992 and replaced by subsidies for export to Russia. Even with the subsidies, the Russians could not afford the best oranges and thus settled for second-rate ones. What to do with the best? Juicing factories were built, and the remainder of the best crop was buried after harvest. Thus, the pesticides used on crop ended up in the groundwater in the center of the valley, where the soil had salinized and become unsuitable for cultivation. At the periphery, the groundwater table descended several hundred meters.

There are many other elements that could enrich this story, but its essence is clear: due to short-term and myopic economic thinking, every single time a "solution" had been found to a challenge, "unanticipated problems" emerged, which led to the adoption of new techno-fixes to keep the system going. Ultimately, this cascade of unanticipated challenges and technological solutions made the area unsuitable for cultivation.

An evolutionary complex systems approach would have been able to avoid some of these challenges by taking from the start a wider, generative, and *ex ante* approach to assessing the potential paths forward. What would that have entailed, and how could some of the emergent challenges have been avoided?

First, it would have required a much more complete map of the systemic interactions in the wider socioenvironment of the area involved, including but not limited to technological, economic, political, and arboricultural aspects. Having a map of that system would have enabled farmers to at least anticipate some of the consequences of their actions, and it would have changed the calculus behind their decision making by internalizing into the system some of the externalities they did not perceive.

To improve such anticipation, it would have been helpful to have insight into the longer-term path-dependent history of the system dynamics, and how it led to the destructive lock-in that made large areas unsuitable for agriculture. Many of the unintended consequences of the system played out with different temporal rhythms, and awareness of how interacting with the environment would transform the risk spectrum of the socioenvironmental system by removing known frequent risks and replacing them with unknown longer-term risks would have enabled stakeholders to make different choices, and in particular emphasize the precautionary principle.

It would also have been helpful to have some insights from multilevel selection, as the emergence of the orange groves was highly destructive of the local social network: in a community-based lifestyle, these developments led to individuation, competition, and social differentiation, in effect destroying village life. Knowledge of how the shift from collective information-sharing and well-being to one of individuation would affect the environment and the

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society could have mitigated the difficulties, as is clear from much of Ostrom's work on similar small-scale societies (e.g., Ostrom 1990).

One of the contributions of a complex systems perspective would have been that second-order change (the change of change) might have been taken into account in dealing with the system. This is maybe the domain in which the (dynamic) equilibrium approach of much economic policy making is the most directly relevant to what happened in the area. A population that for centuries had to live with the (short- and long-term) consequences of its decisions and the risks this entailed, and had developed complex ways to do so, was exogenously seduced (or driven) to search for short-term solutions that ignored the longer-term ontological uncertainty of the complex system involved.

Evolutionary theory as well as anthropological theory could have contributed awareness of the heterogeneity of the conditions under which the farmers were living, of the differences between them in the perception of these circumstances, and thus of the choices and decisions they have made and would make under changing circumstances. Hence, the populations would have been understood as highly diverse, and the interactions between the diverse actors seen as the dynamic that drives the system.

Network thinking would have contributed a tool to help understand the ways in which the society would implement the spread of technological innovations through the social relations of the "gatekeepers" (i.e., those people in a society who enjoy the trust, respect, and admiration of others) and might therefore have helped initiate other choices. But this perspective would also have been able to elicit a number of the societal barriers to innovation.

From a historian's point of view, it is vain to speculate what might exactly have happened if these elements of a combined evolutionary and complex systems approach had impacted the evolution of the system. But had these tools for thought been available to conceptualize the evolution of the complex dynamics of the Argolid agricultural system, we argue that a much more effective and balanced approach to policy in the valley could have been designed, taking into account how the farmers concerned would have reacted to changes in the area's conditions, as well as the environmental dynamics, the economic externalities, etc. By means of a range of different agent-based models, different realistic scenarios could have been explored for any of the main decisions that the farmers faced at different times, whenever their personal and family conditions or the wider economic and environmental conditions changed. The main lesson would have been that before one starts changing complex socio-environmental dynamics (e.g., by initiating subsidies), one needs to consider that the situation in which one intervenes is the result of a long process of balancing out different choices and actions, and that rapid action is likely to have unanticipated consequences that do not necessarily conform to the intent of the policy action.

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The Case for an Evolutionary Development Path: The Sudd Wetland[1]

The Sudd Wetland in South Sudan is one of the world's largest and most unique intact ecosystems. It is home to a number of endemic species, vibrant human cultures, and perhaps the largest animal migration on Earth. The Sudd is threatened by a variety of development pressures including a plan to almost completely drain the wetland to increase the flow of the Nile for agriculture downstream. The case of the Sudd illustrates how a broader and more refined concept of "value" can enrich our understanding of the importance of large ecosystems to human welfare and environmental stability and point the way to more balanced, nuanced government policies.

A major threat to the Sudd is a proposed canal that would make the White Nile bypass the Sudd to send more water downstream to Sudan and Egypt for agriculture. Excavation of the canal began in 1978. The project was two-thirds completed when a Southern People's Liberation Army missile disabled the digging machine in 1983. Construction was halted and today the excavated portion of the canal has been partly reclaimed by nature.

If completed, the canal would increase water flow to the south by 20 million cubic meters per day, an increase of about 5%. As originally planned, the first phase of the project would shrink the wetlands by about 40% and the second phase would completely dry out the wetlands. The government of South Sudan would receive a substantial sum from selling the water rights to Sudan and Egypt. But substantial costs would fall on the people of South Sudan in terms of loss of grazing lands, fisheries, hunting and seasonal farming in the Sudd, and perhaps a destabilization of the microclimate (De Villiers 2001).

An alternative to the canal would be the carefully planned use of the wetland for integrated sustainable development, including sustainable fisheries, timber harvesting, and ecotourism. If done properly this would generate a dependable flow of income out into the distant future. The process of defining and implementing a plan for the sustainable use of the Sudd could bring together diverse ethnic groups to work toward a common shared goal. The Sudd could become a symbol of South Sudan National unity much as the Serengeti/Masai Mara and its wildlife has become a source of pride and a national symbol for Tanzania and Kenya. Preserving the wetland would be a major top-down initiative requiring considerable resources, but formulating and implementing a sustainable development plan would be a bottom-up undertaking with the potential to harness all sorts of economic and cultural dynamics. Sustainable development of the wetland could be a catalyst for ethnic unity and nation building.

[1] Based on a project of the United Nations Environment Program (UNEP) and the Evolution Institute, "The Future of the Sudd," conducted by John Gowdy and Hannes Lang; see https://evolution-institute.org/project/future-of-the-sudd/outputs/ (accessed March 1, 2016).

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The choice between letting the destruction of the Sudd continue as dictated by the whims of market forces or to preserve its unique environmental and cultural features for the benefit of society is clearly framed by the Jonglei canal proposal. A business-as-usual approach will result in the destruction of a unique and irreplaceable piece of the natural world that could enhance the well-being of the citizens of South Sudan for generations to come. To avoid this outcome requires active intervention on the part of policy makers. Such an intervention need not destroy the creative power of individual and community initiatives. Government policy could set the top-down parameters within which market forces work and then let bottom-up creativity work within that framework.

Traditional cost-benefit analysis would simply calculate the benefits of the canal in terms of the discounted present value of selling the water downstream, and possibly the potential for increased agriculture (probably monoculture) in the drained area of the Sudd. The costs would include the environmental damage and cultural disruption caused by draining the wetland. It is quite possible that a comparative static cost-benefit calculation would favor diverting the water and draining the wetland since the monetary benefit could be quite large and immediately available. The benefits of not draining the wetland are likely to play out over a long time period and are much more difficult to calculate. In general, the discounted present value criterion of standard analysis favors projects with immediate benefits over those whose benefits are smaller but spread out over time. A large but declining amount of money in the present is worth more than a smaller amount that lasts longer.

The alternative of preserving the wetland for future sustainable development would keep and harness the evolutionary potential of the Sudd in terms of its future contributions to the economy, society, and environment of South Sudan. The overarching public policy would be the top-down mandate to preserve the wetland. Given that mandate, ecosystem, cultural, and economic diversity would be preserved and allowed to shape the specific adaptations to future economic and environmental changes.

The two scenarios for the Sudd clearly illustrate the importance of considering evolutionary diversity and complexity in environmental policy (Gowdy 2014). The cost of diverting the Nile includes not only traditional economic costs but also the costs of destabilizing wetland ecosystems and losing their "supportive" services, including provisioning, regulating, and cultural services (Millennium Ecosystem Assessment 2003). A policy dedicated to the sustainable use of the wetland must consider the dynamic unfolding of its economic, cultural and environmental potential. Sustainable development requires active public intervention and planning. Limiting policy to greasing the wheels of the market economy is likely to lead to the severe degradation of the wetland and result in social and environmental disruption. The loss of economic, cultural and environmental diversity would greatly diminish the evolutionary potential of South Sudan to adapt to future social and environmental changes.

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Key Issues for Policies Based on Evolution and Complexity

Recognizing that the economic world is characterized by complexity and evolutionary dynamics is hardly a new insight, although in many ways it has been eclipsed by the economic paradigm that is currently dominant. Our concern here is how to navigate this complexity to assure effective public policy. Table 18.1 presents some of the assumptions about human behavior, the nature of markets, and evolutionary processes that distinguish the evolutionary–complexity approach to public policy from the standard economic approach. These differences are apparent in the examples given in the previous section, and they underlie some major considerations in public policy formation.

Heterogeneous Economic Actors Versus Homogeneous Actors

Within economics, a main functional role of diversity is to ensure competition that contributes to the efficient production and allocation of goods. Within evolutionary and complexity theory, diversity (differences in types) and variation (differences within a type) play a different set of functional roles (Page 2010, 2015). In these systems, both variation and diversity contribute to system robustness and enable system evolvability by providing the seeds of innovation. Changes in levels of variation can signal shifts in regime or equilibria, while a flattening peak produces less selective pressure (Scheffer et al. 2009). As another example, diversity contributes to the collective intelligence of a group (Hutchins 1995; Page 2007). It is also important to stress that diversity per se is not necessarily adaptive. Cancer cells contribute to the diversity of multicellular organisms but not in a way that contributes to collective survival and reproduction.

These other contributions of diversity (some positive, some negative) can enhance economic enquiry. For example, governmental decisions on whether to allow mergers traditionally focus on maintenance of competition and prevention of monopolistic power. An evolutionary and complexity perspective would suggest that policy makers should also be concerned with maintaining a

Table 18.1 Differences between the evolutionary–complex and standard economic approaches.

Evolutionary–Complexity Approach	Standard Economic Approach
Heterogeneous economic actors	Homogeneous actors
Bounded rationality	Perfectly rational agents
Other-regarding preferences	Self-regarding preferences
Centralized and decentralized planning	Decentralization is almost always best
Multilevel selection	Naïve group selectionism
Major transitions are critical	Continuity is assumed
Markets are myopic	Markets are forward looking

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diversity of types of technologies as well. This can give rise then to a trade-off between benefits and costs of diversity in order to arrive at a desirable level of diversity (van den Bergh 2008).

Bounded Rationality Versus Perfectly Rational Agents

If we assume rational, optimizing agents, then cognitive load (i.e., the computational and informational demands that we place on individuals) is irrelevant from a policy perspective. But if we construct more realistic models of agents, then the cognitive requirements of policies may undermine their effectiveness. Cognitive load effects could take many forms and lead to suboptimal decisions. For example, under conditions of scarcity, people make systematically different decisions than under conditions of abundance (Mullainathan and Shafir 2013). They could also influence the choice over institutions as some behaviors may be easier to induce because they are similar to existing behaviors (Bednar et al. 2010). Through evolutionary approaches one can give attention to individual and social learning through interactions in social networks (Boyd and Richerson 1985; Jackson 2010) which substitutes to some extent for individual cognitive load.

Self-Regarding Preferences Versus Other-Regarding Preferences

At the core of Walrasian economic theory is a mathematical proof of the ability of competitive markets to promote the public good. This idea is so important that it is called the First Fundamental Theorem of Welfare Economics. A key assumption necessary for this proof is that preferences are self-regarding. It is true that economists have constructed utility functions that incorporate many assumptions about preferences and well-being. But the mathematical proof of the efficiency of competitive markets—and thus a key intellectual argument for laissez-faire policies—breaks down if preferences are other-regarding (Wilson and Gowdy 2015). This is a major reason why there is such resistance to behavioral economics from conservative schools of thought (Gul and Pesendorfer 2008; Camerer 2008). A large body of evidence has established the fact that humans are unique among mammals as to the degree of their sociality, and this should be taken into account in public policy formation (Henrich 2004; Boehm 2012).

Centralized Versus Decentralized Planning

Under which circumstances should public policy be formulated as dynamic/constant or centralized/decentralized? Should policy aim at steering diversity for innovation and welfare? Evolution and complexity imply an active role for public policy in shaping the direction of innovation, resource use, distribution, etc., but this need not imply micromanaging. How can the innovative and

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self-organizing properties of a decentralized socioeconomic system be harnessed in a framework of active management? A top-down approach can create space for bottom-up innovation. A top-down approach can also help address the problem of institutional inertia and undesirable technological lock-in. Such inertia can preclude needed fundamental institutional change and limit policy choices to those compatible with the status quo. Using climate change as an example, according to some commentators, risky technological fixes (geoengineering) fitting in a top-down approach now seem more likely (socially and politically feasible) than fundamental changes in consumer behavior and energy infrastructure involving many bottom-up, including evolutionary type of, processes (Hamilton 2013).

Multilevel Selection Versus Naïve Group Selectionism

Naïve group selectionism is a term used in biology to refer to the assumption that nature and human society are functionally organized at all levels, from individual organisms to ecosystems and nations. It can be traced historically to the Christian view of a world created by a beneficent and all-powerful god, but it persists as an unquestioned assumption in economic conceptions of the invisible hand (Gowdy et al. 2013; Wilson and Gowdy 2015) and in some conceptions of complex adaptive systems (Wilson, this volume). In contrast, multilevel selection theory shows that functional organization can evolve at higher levels of a multitier hierarchy of groups, but only when special conditions are met. This had a major impact on evolutionary thinking, starting in the 1960s (Williams 1966), but has yet to have a comparable impact in the human social sciences and policy formulation.

Major Transitions Versus Continuity

One of the most important implications of multilevel selection is that a higher-level unit, such as a social group, can become so functionally organized that it literally becomes an organism in its own right. The venerable idea of a society as an organism has a stronger scientific foundation than ever before. Higher-level selection processes have been central to the evolution of complexity (Martínez and Moya 2011). Evolutionary history can be understood as a series of major discontinuous transitions to higher levels of complexity (Maynard Smith and Szathmáry 1995; Margulis 1998; Wilson and Wilson 2007). Michod (1999:60) writes: "The major transitions in evolutionary units are from individual genes to networks of genes, from gene networks to bacteria-like cells, from bacteria-like cells to eukaryotic cells with organelles, from cells to multicellular organisms, and from solitary organisms to societies." The question for economic policy is: Can major transitions be managed or even directed to achieve a soft landing from one quasi-equilibrium to another? An example is the transition from a fossil-fuel economy to a low carbon-emission economy.

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Can major transitions be anticipated and guided? The new field of sustainability transitions deals with these issues.

Institutional and technological lock-in can hinder transitions and create discontinuous jumps when the locked-in system finally breaks down. Again using energy as an example, the world's economies are dependent on a massive infrastructure and institutional inertia based on cheap fossil fuels and this, so far at least, has made it nearly impossible to address the issue of climate change. Selection at the level of the market economy has created barriers to needed change at higher levels of organization—human society as a whole and the natural world that supports all life. A key point of multilevel selection is that lower levels can undermine higher levels. But higher levels can also shape lower levels, and this is the key to active public policy in an evolutionary framework. It suggests policy design in accordance with a systems approach that takes into account the direct and indirect effects of policy on the various system levels.

Myopic Versus Forward-Looking Markets

Just like natural selection, economic selection cannot see ahead. For example, the market system has an incredible ability to find demand for its outputs and the resources necessary for production. Price signals call forth technology to "solve" the problem of energy scarcity. But with climate change, almost no signals are yet present. Almost nothing has happened yet to indicate to the market that climate change is a concern. In the myopic view of the market, climate change might even be good to the extent that damages have to be repaired and this creates economic demand. But this problem also plays out at the local scale, as is illustrated by the Greek agricultural case and the Sudd Wetland discussed earlier.

Humans are unique in the degree to which they imagine the consequences of their actions into the distant future. Cultural evolution need not be myopic. But it requires active management of present-day actions that determine the evolutionary time paths of cultural change into the future.

Conclusion

We argue for a shift away from the currently dominant economic paradigm toward a new paradigm based on evolutionary and complex systems theory. In some respects, this new paradigm would represent a return to the roots of economic thinking, as voiced by Marshall and Veblen in the passages quoted at the beginning of this chapter. Modern evolutionary and complex systems theories provide a powerful set of theoretical and methodological tools to realize this vision. The integration of evolutionary theory and complex systems theory is itself a work in progress, and both are only beginning to be applied to address real-world problems. Thus, it is premature to say that a new paradigm

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for economics based on evolutionary and complex systems theory has already arrived. We do think, however, that the *need* for the new paradigm has been established. Our arguments in this chapter point the way to how the new paradigm can be used to address real-world problems.

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