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Why public policies fail: Policymaking under complexity

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Abstract

The failure of public policies is ubiquitous. This paper ascribes this failure to the complex system nature of public policies. A key characteristic of complex systems is that they cannot be closely controlled or predicted. Yet the traditional approach to public policy is fundamentally based on both control and prediction, as it proceeds by comparing the expected costs and benefits of a postulated set of alternatives. In this paper I provide five pathologies of complex systems and show how they cause the failure of the traditional approach. If a public policy is recognized as taking place within a complex system, it is necessary to use instruments that can work within those informational and epistemological constraints. I provide several examples of the types of policies that meet these demands. But when dealing with complex systems, even with appropriate instruments it is nevertheless necessary to adjust the expectations of what can realistically be achieved.

JEL classification: D8; D04; D78; H5

Keywords: Public policy; Complex systems; Complexity; Policy failure

1. Introduction

The traditional approach to public policymaking involves listing possible states of the world given the set of possible choices, assigning a probability to each state, and calculating an expected outcome by considering costs and benefits. This approach works well in situations where the choices are well-known and where uncertainty can be quantified as risk. But both business and public policy often take place in complex domains where it is not possible to conceive of all the possible states of the world, much less to quantify probabilities and costs or benefits. Whether the interest is to create a new program or to improve public services, the systems nature of public policy means that prediction, evaluation and control (hallmarks of good policy-making) are difficult or impossible. The attempt to apply the traditional approach to such a domain often leads to unintended consequences or failure. And typically, things cannot not be made better by simply getting smarter experts, more data or larger budgets. Using the same approach that failed before, but doing it better, can only take you so far.

In this paper I describe five different "pathologies" of complex systems that often contribute to derail public policies. These are characteristics of the situation in which public policies are made and implemented, or of the relations they entail, that make it difficult to control, assess, evaluate, and predict what will happen when the planned actions are

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taken. The upshot is that it is no wonder that public policy fails so often when it is beset with so many obstacles. More importantly, policy fails when complex problems are addressed using standard linear and reductionist approaches that presuppose more knowledge and control than is ever possible in such situations.

This is a bleak message as it implies that the best that can be done in terms of policy-making is often much less than the high bar that we usually expect from government. But it does not mean that we are helpless and should not have public policy goals. Complex systems cannot be controlled or predicted, but they can be harnessed, influenced, constrained, tweaked, hedged and (at a certain level) understood. If we more realistically reassess how much we can actually control and manage complex policies, at the very least many of the most egregious policy failures can be avoided. Below I considers what kinds of policy approaches are applicable to complex problems. This is not a complete toolkit, but rather a set of examples that show the nature of some approaches to policy-making in complex domains that have proved useful. They do not allow for close control, first-best solutions and fine-tuning, but they can help to understand and, within the limits of the possible, to deal with the complex nature of the policy domain. In the end, however, it is still necessary to adjust our expectations about what public policy can actually achieve.

2. Examples of public policy failure

Ideally, we would like a complete dataset of comparable public policies from many different countries to assess the extent of policy failure. But policies are too diverse and a complete dataset does not exist. In addition, it is hard to even define what is a policy failure. Some pubic polices have the opposite effect of what was intended or so obviously cause harm that they can unambiguously be labeled as a failure. But in many cases, it is not so clear whether the policy has rightly failed. Many policies have different dimensions, so that some dimensions can meet their targets while others can miss. Furthermore, policy evaluation is hard to do properly so it may be unclear how well a policy has fared. Also, what is a failure to one person might be a success to another, as different people have different policy preferences and policies often lead to winners and losers. One definition due to McConnell (2015, p. 221) states that "a policy fails, even if it is successful in some minimal respects, if it does not fundamentally achieve the goals that proponents set out to achieve, and opposition is great and/or support is virtually non-existent."

My approach in this section will not be to try to be comprehensive or to pin down exactly what is or is not a public policy failure. The objective is simply to make the case that public policy often fails spectacularly by providing two examples of policies that have led to big conspicuous failures. Both examples are policies which were well-thought through and debated and which have many defenders, including academics, experts, politicians, and often public opinion. That is, they are not one-time slip-ups that were quickly perceived and abandoned or rectified with little harm or damage. Their inclusion here does not mean that all instances of these policies have failed, but rather that there have been many cases of failures and a general disappointment with the idea.

2.1. Microcredit

Microcredit is a policy of providing small loans to poor people (often women) who are typically illiterate, excluded and would not normally have access to official or private credit of any form. It is conceived to promote entrepreneurship and reduce poverty by giving the beneficiaries a foothold on which to build human, financial and social capital. The idea of microcredit as a developmental and antipoverty policy is attributed to Muhammad Yunnus who founded the Grameen Bank in 1983 in Pakistan. This initial model was highly praised by policymakers, academics, international organizations, donors, celebrities and public opinion. It was extensively copied and extended by other institutions across the world. In 2006 Yunnus was awarded a Nobel Peace Prize for the idea and the endeavor. The appeal of microcredit is evident. It addresses one of humanities most important problems, poverty. It is based on communities and is gender sensitive. Also, it is decentralized and scalable, and founded on the notion of individual entrepreneurship. The United Nations declared 2005 as the International Year of Microcredit and by 2009 there was an estimated 74 million people around the world holding a total of US$38 billion in microloans (UNCDF, 2005).

But despite this enthusiasm, as the policy matured and a track record became available to allow for proper evaluation, doubts arose if microcredit effectively had the purported impacts on its beneficiaries. As is often the case with public policy, it was not clear if the expected benefits for individuals and communities were actually materializing. Critics started portraying microcredit "as an interesting idea formulated by possibly well-meaning individuals, but an idea that

nevertheless went very wrong" (Bateman, 2014, p. 3). Also, a microcredit industry had developed that in some cases veered into profiteering and exploitation.

Microcredit as a public policy has attracted both defenders and detractors, so it is difficult to ascertain how well the policy has fared. Policy evaluation is hard to do rigorously and both sides have made claims based on anecdotes, poor data and flawed studies. Nevertheless, some rigorous evaluations have been performed. A study by Banerjee et al. (2015) uses careful empirical strategies that exploit randomness in the allocation of microcredit in a way that allows the identification of causal effects of microcredit on beneficiaries. The authors study six cases and are very careful to note the limitations of the tests and the possibility that other indirect and unmeasured benefits might have been realized. Nevertheless, their main conclusion is that:. . . there is little evidence of transformative effects. The studies do not find clear evidence, or even much in the way of suggestive evidence, of reductions in poverty or substantial improvements in living standards. Nor is there robust evidence of improvements in social indicators. (Banerjee et al., 2015, p. 13)

Although elsewhere the authors do find some "modestly positive, but not transformative, effects", this is still very little from a policy that was expected to be a game changer (Banerjee et al., 2015, p. 1). Whether one accepts the critiques or this more moderate view, microcredit has been, relative to expectations, a failed policy.

2.2. *Individual transferable quotas for fishing rights*

The collapse of fish stocks across the world is one of the great tragedies of the past fifty years. Overfishing and mismanagement of stocks has caused not only biological loss but also social and economic upheavals in communities that depend on fishing activity and produce. Worm et al. (2006) found that approximately 27% of the world's fisheries had collapsed by 2003 and extrapolated that if the same rate of decline continues, 100% will be collapsed by 2048. Economists and biologists have addressed the issue of fishery management at least as early as Hardin (1968); Gordon (1954), and Scott (1955). Many different public policies have been devised over the decades to address these problems.

One of the most popular, especially amongst economists, has been the policy of individual transferable quotas for fishing rights (ITQs). The method, first proposed by Christy (1973), recognizes that the essence of the problem is the lack of property rights to fish, which gives incentives for overfishing rather than careful husbandry, as a fish not caught today is up for grabs by others. ITQs create property rights to fish and a market in which these rights can be traded. The government determines the optimal economic sustainable annual yield for a given fishery and distributes rights to fish that amount amongst the eligible fishermen. Each holder of the ITQs can decide whether to effectively use their rights to bring in fish, or alternatively to sell the ITQs in the market. Similarly, fisherman can purchase additional rights to catch more than their initial share. This creates an opportunity cost to catching fish as a right that is used cannot be sold. The resulting market has the effect of allocating the permits to those fishermen that can catch the fish at lower cost. This is an allocation that command and control policy would probably never get right, given the difficulty in obtaining the information on each fisherman's costs and preferences. The beauty of the scheme is that it limits the annual catch to a sustainable level and assures that the activity is done in the least cost manner. In addition it provides incentives for innovation in organizational forms and technology.

Because of the theoretical elegance of the idea, ITQs have attracted many supporters. In 1992 an influential essay in the Journal of Economic Literature elected markets for permits as one of the main contributions that environmental economists had made in the previous years[1] (Cropper and Oates, 1992). Since then a great number of policy experiments using different formulations of ITQs have taken place across the world. According to Chu (2009), by 2008 ITQs were used in eighteen countries to manage the stocks of over 249 species. This form of management has thus become a major form of public policy.

How well have those policies fared? The answer is controversial, as there are both proponents of the policy as well as critics. In a paper published in *Science*, Costello et al. (2008) assemble a global database of 11,135 commercial fisheries out of which 121 used some variation on ITQs by 2003. They find that implementation of an ITQ reduced the probability of a collapse by 13.7%. Although this is less than could be wished, it is nevertheless a positive evaluation. Other studies reached even more mixed results. Chu (2009) found that of a sample of 20 fisheries where ITQs were used, only 12 showed any improvement in stocks. Acheson et al. (2015, p. 2) argue that "ITQs may be highly successful in ending the race for fish and increase revenues to fishermen, but their limited success in improving stocks is a

[1] They focused on markets for pollution emission, which are fundamentally similar to ITQs.

serious indictment." Branch (2009, p. 39) analyzed 227 papers that evaluated ITQs and found that 23% reported negative effects on fish stocks and 14% mixed effects. Bromley (2009, p. 280) criticized ITQs for effectively "free gifting to the commercial fishing sector of permanent endowments of income and wealth" and thereby increasing inequality.

3. The complex nature of public policy

Public policy fails for many reasons. Even a relatively simple objective, such as a vaccination campaign, requires myriad pieces of information and expertise, and involves the mobilization, cooperation and coordination of a great number of people and organizations that must act in certain ways at precise times. Many policies fail because the tasks are hard to do. Add to that the propensity for corruption, incompetence and political motivations, to which many public policies are prone, and it seems quite natural that things often do not turn out as expected. But although these evident frailties of the policymaking process are serious predicaments, they are problems that can in principal be dealt with. More effort, more information, better governance, smarter experts, more transparency and good will, all can do much to mitigate those problems and improve the delivery of public policy. Whole disciplines of economics, project management, and public administration provide theories, ideas and techniques for how to achieve better public policy results. Much improvement can certainly be achieved through such means. Better checks and balances on political organizations and improved accountability, for example, can surely do wonders to make public policy better serve the public interest.

The focus here, however, is on a different source of public policy failure. One that cannot be rectified by simply using better practices and more knowledgeable experts. The interest here is to understand the implication of the fact that public policies are embedded in complex systems. A complex system is one in which diverse agents linked in networks interact selectively following simple rules (that is, not necessarily optimizing) without centralized control, and from which emerges (often unpredictable) patterns, structures, uses and functionalities (that may be desirable or not), and do so continually, never settling on definitive equilibria, but always learning, adapting and evolving. In this section I explicitly describe how public policies fit this description of complex systems. More importantly, I stress why it is that these characteristics of the interactions that make up public policies imply that they are hard to control and are continually subject to failure. To set this up, consider the requirements of the standard approach to policymaking based on decision theory. A policymaker is tasked with solving a given problem. She collects information and enlists experts to determine a set of policy options. Each option is considered to determine the payoff it will entail in each future state of the world, taking in to account the probability of each possible contingency and possibly factoring in the strategic reaction of all relevant parties. From this analysis the option with the best net benefit is selected and implemented. Results are evaluated and the policy is fine-tuned if necessary. In many instances this approach works reasonably well. Yet, given the extent of policy failure, as documented in the previous section, in many other cases the approach fails.

I argue that the fundamental reason for this failure lies in the complex system nature of public policies. This section is setup in five subsections that each describe a 'pathology' of complex public policies that undermines the standard approach. Together these pathologies explain why it is that even when done with the best of intentions by the best experts, that is with no corruption or incompetence, public policies nevertheless tend to fail.

3.1. Public policies are non-linear and emergent

The thinking behind the standard approach to policy making follows the reductionist view that dominates much of science. Reductionism assumes that to understand a large and complicated matter one can break it into smaller and more easily understood components. Once these are understood, the pieces are put together to reveal the working of the whole. It requires the whole to be simply the sum of the parts. In other words, it requires the relationship between the parts to be linear.

Economic theory, on which public policies are generally based, is quintessentially linear. It was purposefully modelled on 19th century classical mechanics which was firmly constructed on reductionist logic. Linearity also conveniently makes the mathematics more tractable. An example of linearity in economic theory is the derivation of the market demand for a good as the simple summation of the demand of all individuals in society. This might be a suitable approximation in many cases, but requires the assumption that the individual demands are inde-

pendent, except through the effect of prices. In many real-world cases, however, this assumption is invalidated by phenomena such as imitation, fads, habit, hysteresis, and several types of externalities. That is, in these systems, people impinge on other people and adapt to what other people do across a many different margins (Schelling, 1978).

Linearity is also present in the way cause and effect is commonly modelled and tested in economic theory. In a linear causal relation, a unit increase in the cause x, yields the same magnitude of change in the effect y, for all levels of x. Much of econometrics is the estimation of the coefficients that capture these supposedly linear relationships. But in complex systems there is often no proportionality between cause and effect. Often large causes can have no impact, such a lake that receives considerable runoff from agriculture and other human uses, yet continues to be clear and sustain life. At some point the pollution passes a threshold level and the lake suddenly flips to becoming eutrophic, loosing attractiveness and life (Allen and Holling, 2012). The switch does not come about gradually, but rather in a punctuated manner. Complex systems are characteristically beset by such tipping points and public policies are mired in discontinuities.

The consequence of non-linearity is that the final effect of a public policy will not be the sum of the effect of its parts. Another way to say this is that the policy produces emergent phenomena, that is, results that cannot be easily predicted by looking at the constituent parts, but can only be gleamed and (possibly) understood by running the system. Emergence is the classic signature of a complex system.

3.2. *Public policies do not settle in equilibria and hard to predict*

Predictions are a fundamental requirement of the standard approach to public policies. All possible options must be mapped out and their cost and benefits considered in every possible future state of the world. This is a formidable requirement. In complex systems it is also an impossible requirement. As we have seen, the emergent phenomena that arise from the iterative interaction of multiple diverse agents is hard to foresee and can only be known by actually trying it out. Although many public policies often seem to play out as expected and settle on the anticipated results, this may be the temporary state of complex system. Stability and regularity might persist for long periods, but phase transitions can bring about unexpected change without warning.

But with complex systems, neither experience or experts are a guarantee of success. As noted by Watts (2011, p. 27) we are not only bad at predicting, but we also have trouble understanding what has already happened. Simply beefing up the science is not much of a solution. Science is currently in the throes of a credibility crises due to widespread lack of replicability, underpowered results and bias for positive results (not to talk of fraud) (Ioannidis et al., 2017; Maniadis et al., 2017). Economist have claimed that economics has undergone a credibility revolution in which sound empirical design has reduced the extent of the problem (Angrist and Pischke, 2010). Yet, although practices have improved and testing for policy treatment effects appears to have become the central activity of economists, most studies require natural or quasi-natural experiments which tend to provide little guidance for broader policymaking. As noted by Leamer (2010, p. 33), "since hard and inconclusive thought is needed to transfer the results learned from randomized experiments into other domains, there must therefore remain uncertainty and ambiguity about the breadth of application of any findings from randomized experiments."

Neither does it seem that the problem can be solved by getting more and smarter experts to get better understanding and better predictions. Although most real-world instances of public policy failures can probably be significantly ameliorated by having better people involved, this cannot solve the inherent problem of lack of predictability. In *Expert Political Judgement: How Good is it? How can we Know*, psychologist Philip Tetlock describes a twenty-year long experiment in which he collected prediction from 284 experts from all areas about a wide variety of events (Tetlock, 2006). The results showed that on aggregate experts' forecasting ability is only marginally better than dart-throwing monkeys (that is, marginally better than chance).

With public policies the task is even more difficult than anticipating a series of future scenarios. In complex systems it is not even obvious what you need to predict. Emergent phenomena might involve variables and dimensions that one would not even think of considering until the system takes that unexpected change (Watts, 2011). That is, you not only don't know what will happen, but you don't even know what can happen. And that makes pursuing public polices particularly difficult.

3.3. Public policies evolve and coevolve

In biological evolution what is being evolved is not the organism, but rather the information contained in the DNA for how to produce a new copy of that design. Evolution is an algorithm that works through variation, selection and replication. The result of this process applied over and over again is the rise and increase in population of those designs that are more fit than others given the constraints put forth by the environment. The unit of selection is the genome, or rather, the information contained therein.

Information in the form of culture, beliefs, institutions, norms and technologies, also changes through a process of variation, selection and replication. Public policies are crucially determined by culture, beliefs, institutions, norms and technologies, so if these things evolve according to the specific algorithm of variation-selection-replication, this affects which public policies arise, how they operate and the impact they have.

The first thing to note is that evolution does not optimize. It looks for fit design, which means design that replicates faster than competing design given the environment. Contrary to the world of standard economics, complex systems don't have a single global maximum, that is, one knowable best choice. Rather, they are composed of an unobservable rugged landscape of myriad peaks and throughs, so it is hard to even know what is the globally fittest solution. The result is usually for the design to get stuck on local maxima even when there are better solutions nearby. In the context of public policies this means that the problem to be addressed admits too many solution, most that cannot even be known in advance, and that once that design has been implemented it is difficult to change. That is, initial conditions matter and there is strong path dependence.

A second characteristic of evolution is that it cannot be easily steered, controlled, or predicted. In biological evolution variation comes about by recombination (sexual reproduction) and mutation. For any given environment there are many possibilities and most of them never get visited. In epistemic evolution there is intentionality by humans, as they try to achieve specific objectives. Nevertheless, the existence of purpose is subverted by accident, chance, unintended consequences, and serendipity, so that in the end the process is unpredictable and uncontrollable. Most medical discoveries, for example, are the result of luck or accident rather than purposeful knowledge (Taleb, 2012). Public policies in complex systems are similarly intendedly purposeful but subject to lack of control and predictability, often producing unintended results.

The isolated evolution of culture, beliefs, institutions, norms and technologies makes the public policy process elusive. But the situation is even more difficult than that, because each of these forms of information not only evolves itself, but in the process coevolve with each other. Coevolution takes place when a change in one evolving agent, say the design of a parasite, affects the fitness of a host. In this new environment, the host's old design is now less fit, so its ability to replicate diminishes. But this change in environment may also spurs the evolution of a new design for the host that allows it to better resist the parasite's attack. If this comes about, then the new design of the parasite is now less fit. The result of this coevolving relationship is that there is never a final stable equilibrium set of designs, rather each species must forever keep changing in response to the changes in the other, in a 'Red Queen's Race' where one must forever run faster and faster to stay in the same place (Carroll, 1871).

3.4. Public policies are subject to cognitive biases

Designing and implementing public policy requires creating incentives and constraints that will affect the choices and behavior of both the target public and those in charge of carrying out the policy. To get those incentives and constraints right it is necessary to have a good understanding of how people behave and respond to different stimuli. The model of human behavior that underpins the standard approach to policy making is rational choice theory, which describes agents as having a fixed set of preferences which strictly guide the choices they make. This is a reasonable approach in that people do seem to pursue their own self-interest, even when acting pro-socially. However, the theory also requires that preferences be consistent in terms of conforming to a series of characteristics (completeness, transitivity, logically ordered, etc.) and that they be fixed. If preferences are not well-behaved in this manner, many of the important results that arise from micro-economic theory, may not be assured, such as the existence, unicity and stability of a market equilibrium.

While rational choice theory may be a suitable template for many situations, especially to use as a benchmark or when dealing with large aggregates rather than small groups or individuals, in many other situations it can fail spectacularly. The recognition that deviations from full-blown rationality is not contained to a few amusing anecdotes,

but is rather deeply enmeshed in human societies has spurred the growth and acceptance of behavioral economics as a discipline (Ariely, 2010; Kahneman, 2013; Kahneman and Tversky, 1979; Thaler, 2015). If people are limitedly rational and subject to all sorts of cognitive biases, public policies become considerably harder to get right. Perfect rationality makes thing considerably easier as it makes very straightforward predictions of how people will act. But if instead actors are susceptible to a wide variety of biases, it becomes much harder to foresee how they will react to different incentives and constraints in different circumstances. A classic example of this is the failure of payment for blood as a policy to increase donations (Niza et al., 2013). Whereas rational agents would be expected to increase donations if offered economic incentives, in many cases payment was found to crowd out altruism.

3.5. Public policies suffer from reactivity and the Lucas Critique

A final cause of public policy failure addressed in this paper is the problem of reactivity. This is the fact that the groups and individuals subject to a policy are often aware of the fact that they are being manipulated and purposefully react, altering the impact of the policy in the process (Frey, 2017). Molecules or rats are unaware of the scientists' intent and therefore to not strategically react to the fact that they are being experimented upon. In the social sciences this is not the case, and with public policies it is most explicit. When a public policy is announced, those that stand to gain or to lose have incentives to strategically change their behavior to make the most of the situation. Policies are typically conceived taking the pre-policy behavior of the population as a guide. Therefore, when the policy is started it will already be operating on flawed premises as that behavior has changed in reaction to the knowledge that there is now a policy in operation. Even if policymakers try to foresee the strategic behavior and build it into the policy in game theoretic fashion, it is typically very difficult to cope with the tenacity and creativity of the subjects.

This problem is not new and has been recognized in several different areas. In economics it is known as the Lucas Critique, which caused a paradigm shift in macroeconomics in the 1970s by "criticizing the use of estimated statistical relationships from past data to forecast the effects of adopting a new policy, because the estimated regression coefficients are not invariant but will change along with agents' decision rules in response to a new policy" (Ljungqvist, 2008). Similarly, Goodhart's Law states that "When a measure becomes a target, it ceases to be a good measure" (Goodhart, 1981).

The implication of reactivity is that public policy often fails. It is hard enough to get right in normal circumstances, and much harder when those affected by the policy keep trying to second-guess the policy makers and keep changing their behavior. And although new methods like Big Data and Machine Learning might be able to give policymakers an edge, it is unlikely that this can solve the fundamental problem given people's creativity to pursue their own interest.

4. How to make public policies fail less

Although all types of policies fail, they do not all do so for the same reasons. Many policies fail because of incompetence, corruption, lack of resources, and/or bad governance, but could be set straight with more effort, resources and good will. Other policies also fail because of incompetence, corruption, lack of resources and bad governance, but even without these predicaments would still be highly vulnerable to failure. In this final section I consider how complex policies, could be approached to avoid or minimize the chance of failure. Ideally, we could classify each type of policy as being complex or not complex, to allow comparisons. But that turns out not to be an easy task, as almost every policy area seems to have many of the characteristics of complex systems. Consider the following list of policies: information policy, human resource policies, privacy policy, defense policy, economic policy, education policy, energy policy, environmental policy, foreign policy, forest policy, health policy, housing policy, macroeconomic policy, monetary policy, population policy, science policy, security policy, social policy, urban policy, transportation policy, and water policy. At this level of generalization and aggregation it is hard to point out a policy area that does not involve the multiple interactions of diverse agents that characterize complex systems. Perhaps a better level of analysis would be to consider more specific objectives within these broader areas. Then it might be easier to classify policy objectives along a continuum of complexity/non-complexity. Rather than attempting such a classification I will just claim that some policy areas have more attributes of a complex system than others and discuss what kind of approaches can be used for the complex policies. Those that are not complex, e.g. (perhaps) running national parks, may be hard and complicated, but they can be better designed and implemented in a straightforward manner by using more resources, more experts, more data, better governance, etc.

Complex policy areas can also benefit greatly from these straightforward remedies, but these do not address all the problems, risks and liabilities to which complex policies are prone. The reason is because the five 'pathologies' discussed above cannot be resolved with standard policy making based on decision theory, prediction and evaluation. These are situations in which the Hayekian impossibility of acquiring, processing and interpreting all the necessary information impedes considering and comparing all alternatives to trace out the best response (Hayek, 1945). They are policy areas where past experience is a poor guide for future action because of its non-ergodic nature. They are policy areas where "a mechanical application of generic rules that ignores these [local] particularities is an invitation to practical failure, social disillusionment, or most likely both" (Scott, 1998, p. 318).

If this is the case, how can public policy proceed in complex areas? Given that the fundamental cause of the intractability of these policies is their complex nature, any solution must be immune to the specific problems that complexity creates. This means that the solutions must not have unrealistic informational requirements, must not necessitate unreasonable prediction, and will probably involve little control and direct detailed intervention from policymakers. Note that any policy along these lines is quite different from the standard approach to public policies that seeks better results through more control, more information, and more prediction and evaluation.

There are several innovative approaches in business and in government that have characteristics that make them suitable for dealing with complex problems. Many of them use new information technologies to get around those obstacles and enable solutions to emerge, many times, from the bottom up. I describe some of these approaches below. Yet, though these solutions are promising and many times even astonishing, it is important to point out that they are usually not silver bullets that suddenly allow all policy goals to be magically reached. I argue that even when these complexity-compatible approaches are used, they usually only ameliorate some dimensions or aspects of the problem and not the entire policy concern. The fundamental complexity of the problem remains. Therefore, it is essential that in addition to using smarter and more appropriate tools and approaches, one realistically reassess what can be expected from the policy. Almost always, what can truly be achieved is much less than our expectations demand. Smarter approaches can greatly improve a complex situation, but they cannot transform a complex situation into a simple problem that can be controlled at will. Complex policy areas remain complex and some objectives simply cannot be achieved, so we should soberly downgrade our expectations.

In some cases, this means simply abandoning the intent to pursue that specific policy. It's just too complex, too risky and can fail in ways that do not compensate the risk. An example is a policy to forcefully promote democracy, rule of law and other liberal values into other nations. There is much evidence that such efforts have not fared well historically, and in some cases, has been disastrous, e.g. Iraq and Afghanistan (Diamond and Plattner, 2015; Hermann and Kegley, 1998). Most policies that fit this category are controversial for a lot of reasons, political, ethical, philosophical, etc. But even setting aside these ideological issues, policies like geoengineering, cloning, and new planned cities, are probably too complex and interdependent to ever get right.

In many cases the option to forego the policy area is not realistic and it has to be pursued. An example is health care policy. Health care has failed in most countries. It is a prototypical complex system (Bar-Yam, 2006; Lipsitz, 2012). It is an area that must have public policy guidance and coordination. But whatever that policy should be, the track record suggests that it will not be the current grand visions that require too much knowledge and control. Probably, whatever it is that can work, will be much humbler.

It is not in the scope of this paper to provide a comprehensive list of all the tools that have already been created and tried for dealing with complex policies. That is a topic for a paper of its own. Furthermore, my impression is that there are not that many examples to report yet.[2] There is a tendency to view methods like crowd-sourcing, sharing, prediction markets, big data, AI, machine learning, blockchain and others, as the solution to all of humanity's ills. That is not what I am suggesting here. Nor do I cover the many ways in which these approaches can improve the standard approach to public policies, making them faster, cheaper and more knowledgeable. Instead, I describe a small sample of new methods that can specifically address one or more of the 'pathologies' of complex systems reviewed above. This serves both the purpose of illustrating how complex public policies can be more properly conducted, and to reiterate the limits of what even these complexity-appropriate policies can achieve.

[2] D. C. Colander and R. Kupers (2014) book "*Complexity and the Art of Public Policy Solving Society's Problems from the Bottom Up*" presents a convincing indictment against existing policy approaches when the policy domain is complex. Yet, as noted by some reviewers, they were not able to find many examples to illustrate their claims (Squazzoni, 2014).

4.1. Methods that obviate prediction

In *Everything is Obvious Once You Know the Answer*, Duncan Watts forcefully makes the point that "there is a difference between being uncertain about the future, and the future itself being uncertain. The former is really just a lack of information—something we don't know—whereas the latter implies that the information is, in principle, unknowable" (Watts, 2011, p. 147). Although we tend to think of prediction as uncovering something that in a sense is already there, predetermined but not yet realized, in reality, what will happen is still to be determined and depends on a series of other things that are also not realized or certain, so the best we can do is to think in terms of probabilities. In complex systems, even that is hard to do. Not only is there little basis for making specific predictions, but we actually don't even know what it is we should be making predictions about. When designing policy in a given area there are not just a few easily distinguishable scenarios or options, each with a manageable number of variables for us to consider what can happen with probabilities that can be estimated. Instead, there are infinite possibilities and no way to know which are relevant or not.

Given the impossibility of prediction in complex systems, how can public policy be designed and implemented? It must be done without the need for prediction, at least by the policymakers themselves. One way to do this is through prediction markets, which try to capitalize on the wisdom of the crowds to get more accurate predictions than can be made by individuals or experts.[3] In prediction markets anybody with an insight or an opinion can 'put their money where their mouth is' and buy or sell a contract for a given pre-specified event, such as, who will be elected in a forthcoming presidential election. By aggregating information held by people with different perspectives and different outlooks, prediction markets offer an approach to deal with the Hayekian problem of the use of knowledge in society (Hayek, 1945). According to Williams (2011, p. 1) the markets have been used to forecast uncertain outcomes ranging from influenza outbreaks, to the spread of infectious diseases, the demand for hospital services, the box office success of movies, climate change, vote shares, election outcomes and the probability of meeting project deadlines at Google.

But although prediction markets are a smart tool that can certainly improve policymaking by allowing for better forecasts and more access to information, they do not solve the fundamental problem of complexity, in particular, the fact that in many cases you don't even know what it is you need to predict. Furthermore, different authors have run horseraces between prediction markets and other simpler models (such as using historical probabilities) and found that even when prediction markets do outperform the others, they do so by very small margins (Erikson and Wlezien, 2008; Goel et al., 2010). As noted by Watts (2011, p. 2) "predictions about complex systems are highly subject to the law of diminishing returns: The first pieces of information help a lot but quickly you exhaust whatever potential for improvement exists."

Another approach is to give up the pretension of prognostication and rely instead on experimentation and trial-and-error. Watts (2011, p. chap. 8) gives several examples of strategies for what he calls 'reacting to the present'.[4] The first is the strategy used by the Spanish clothing retailer Zara for deciding on future designs, styles, fabrics, etc. Instead of depending on the wisdom of stylists and couturiers to divine the fashions that the whims of consumers will favor in the upcoming season, Zara follows what they call a measure-and-react strategy, where they have a large number of agents across the world go to places where people gather and transit, to harvest ideas from what the man and women on the street are currently wearing. These inspirations are quickly designed and produced in small batches that are, in a short span of time and at low cost, tried out in stores across the world. Those that are well-accepted have their production expanded and further pursued, while those that fail are quickly abandoned. This strategy has made Zara (Inditex fashion group) the top fashion apparel retailer in the world (in 2017) and its founder, Amancio Ortega, the third richest man in the world (January 2018).

This strategy allows the design to emerge from the bottom up rather than being decided from the top. It could potentially be used for public policy purposes in those situations where it is hard to predict how the subject of the policy will react or what are their preferences. This would require, however, a change in society's and the government's mentality towards public policy, as the strategy necessarily involves error and failure. The traditional approach to public

[3] An example is Agur http://www.augur.net/, whose homepage boasts: "Welcome to the future of forecasting. Augur combines the magic of prediction markets with the power of a decentralized network to create a stunningly accurate forecasting tool - and the chance for real money trading profits."

[4] These are examples of strategies by private firms, but similar approaches could be used for policy purposes.

policy see's failure not as a means to learn and reveal information, but as incompetence and something that must be averted and punished.

Two other strategies in the same spirit are "bucket testing" and the "Mullet Strategy".[5] The first is used, for example by web companies that market through websites. The strategy involves running "two simultaneous versions of a single or set of Web pages in order to measure the difference in clicks, traffic, transactions, and more between the two. Bucket testing provided a great way to send a small amount of traffic (usually less than 5%) to a different user interface without negatively impacting the bottom line if our new design had unintended negative consequences."[6] It is thus similar in effect to running small randomized controlled experiments as a means to test different policy conceptions and applications.

The "Mullet Strategy" refers to the (vulgar) hairstyle of the 1980s, in which the hair is short over the forehead but long in the back; business up front and party at the back. This strategy is used, for example, by the Huffington Post (online news aggregator) to test new and potentially risky content from different contributors. This outlet uses both regular and eventual contributors, as well as user-generated material. Because too much content is generated through its extensive network, it is not possible to screen and edit all the material. But it would also be too risky to just publish without vetting what might be offensive, nonsense or wrong. The "Mullet strategy" involves putting this new material in the back pages of the website and promoting that which catches the readers whimsy, while dropping anything that is flagged as objectionable before it has enough exposure to cause any problems. In terms of policies this would once again involve experimentation in safe scenarios to test what works and what doesn't before committing the entire enterprise. While strategies like these are smart and can probably improve public policies even in complex areas, at the present they just seem to improve some tasks or dimensions of real world policymaking and not are not capable of radically substituting entire operations. More importantly, many of the fundamental difficulties that arise due to the non-linear, emergent, non-ergodic, evolutionary, reflexive and irrational nature of complex system remain unattended or might even be exacerbated.

4.2. Methods that economize on information and obviate control

Another margin on which to adapt policy to its complex nature is to design them so that command, control and constant hands on management are less needed. This is not a new idea. ITQ (individual transferable quotas) and much of mechanism design are attempts to set up situations so that the actors themselves make most decisions without the policymaker having to have all the relevant information or establish what actions the agent should take. While these approaches to policy making can yield good results in some cases, recall that in Section 2 I used them as examples of public policy failures, based on the poor record in real world applications. Quite possibly with new information technologies and more experience these approaches can fulfill their promise, as theoretically they do make clever use of information constraints. Their failure to generally do so thus far is indicative of the difficulties of applying many of the ideas being described here to real-world situations.

There are even other more radical proposals to address the fundamental problem that complex systems are hard to run and control. One of these is the notion of 'shared spaces' to deal with the problem of traffic in cities. Colander and Kupers (2014) describe the implementation of a scheme in the Netherlands that sought to deal with the damaging competition for space on city roads between vehicles, pedestrians, cyclists and other users, not by adding more signs, speed bumps, traffic lights, speed limits, etc., but on the contrary removing all rules and attempts to steer behavior. Counterintuitively, this slowed down average speeds, reduced traffic incidents and gave many areas a renewed liveliness. By forcing all users to negotiate the use of the road, instead of dictating behavior from above, a more amiable environment emerged. It is not clear, however, to what extent this idea is scalable or valid for other environments.

Several other schemes are already being tried that have the potential to greatly improve public policy. Bike sharing schemes using new technologies have already transformed several major cities, visually and in terms of accessibility. Today there are more than 1600 bike sharing schemes, and many new ones come on line every month (Economist, 2017). Colorful undocked bikes have, for example, taken over major Chinese cities. Most of these schemes are private rather than public but help to deal with problems that concern transport policy.

[5] See Watts (2011, p. chap. 8) for details.

[6] https://www.360logica.com/blog/what-is-bucket-testing/

Prizes are another scheme that have been increasingly used throughout the world to achieve specific policy goals with less direct governmental involvement. This strategy is not new. In 1714 the Longitude Act in Britain established a prize for devising a simple method for the precise determination of a ship's longitude at sea, worth £10,000, £20,000 or £30,000 (depending of accuracy). Napoleon offered a prize in 1795 for a method to preserve food to be used in battle. Today prizes are back in favor, used by governments, businesses, international organizations and philanthropists. An example is the Ansari Xprize which: "challenged teams from around the world to build a reliable, reusable, privately financed, manned spaceship capable of carrying three people to 100 km above the Earth's surface twice within two weeks. The prize was awarded in 2004 and along with it, a brand new private space industry was launched."[7] Among the hundreds of others prizes that a quick internet search uncovers are: to invent an affordable, accurate, fast and easy-to-use test for bacterial infections that will allow health professionals worldwide to administer the right antibiotics at the right time[8] ; creating solutions that advance the autonomy, scale, speed, depths and resolution of ocean exploration[9] ; the development of scalable, efficient and effective decentralized solutions to sustainability challenges which exploit the Distributed Ledger Technology (DLT) used in blockchains.[10]

The attraction of prizes is that they provide a low cost means to explore ideas distributed across diverse groups with different perspectives, providing a greater chance of finding innovative solutions than a centralized government effort would afford. In a sense they are equivalent to performing many simultaneous experiments to see what works best, yet with less control by the government or overseer about what is tried.[11]

These new approaches and technologies can be tantalizing and transformative. Some like blockchain still need to prove their worth for policy uses, but others like sharing have already made a mark. Nevertheless, the central point made above remains valid. When they do not address the fundamental nature of complex systems, the methods provide agility and expediency, but cannot eliminate the inherent pathologies of complex systems. Society's expectations for what public policies can realistically deliver should be prepared for this inherent and inalienable predicament.

5. Conclusions

On April 26, 2010 the New York Times printed a graph that had been presented to the leader of the US and NATO forces in Afghanistan, General Staley A. McChystal. The graph "was meant to portray the complexity of American military strategy, but looked like a bowl of spaghetti" (Bumiller, 2010). Hundreds of squiggly arrows linked dozens of nodes with labels such as; overall government capacity; tribal governance, popular support; insurgents; narcotics; infrastructure, service & economy; population conditions & beliefs; coalition capacity & priorities; among others. Each of these linked to dozens of other smaller labels in even finer print. The article went viral for bemoaning the use and abuse of Powerpoint even in the US military. The general is reported to have remarked "When we understand that slide, we'll have won the war" (Bumiller, 2010, p. A1).

The slide may have been ridiculed as the butt of a joke, but it was not an inaccurate depiction of the situation faced by the US and allied forces' operation in Afghanistan. The policy for delivering aid and reconstruction to this war-torn region has all the characteristics of a complex system and suffers from the pathologies that make it so hard to get things right. The same failures experienced by US and NATO missions were previously endured by British (1830s) and Soviet (1979–1989) incursions in Afghanistan (Loyn, 2009). It is possible to draw a simpler and more easily understood picture of the players, interactions and catalyzing forces that characterize the problem. But the reality of the policy problem will still be subject to the burdens of policy management inherent to complex systems.

Albert Hirschman coined the 'Hiding Hand Principle' to refer to tendency of policy makers to underestimate the complexity and challenge inherent in the projects they initiate, to get stuck when things don't work, but then, under a pinch, to become creative and find solutions or alternatives that would never had occurred to them without the unexpected complications (Hirschman, 1967). According to Hirschman (2011, p. 13) "the only way in which we can

[7] https://ansari.xprize.org/

[8] https://longitudeprize.org/challenge.

[9] https://oceandiscovery.xprize.org/

[10] https://ec.europa.eu/research/eic/index.cfm?pg=prizes

[11] I have focused on tools that are compatible with unpredictability, uncontrollability and the emergence-nature of public policies. An example of policies that are compatible with cognitive biases are those that use Nudge Theory (Thaler & Sunstein, 2008). For policies prone to evolutionary dynamics, an example are research funding strategies that are sensitive to serendipity (Editorial, 2018; Yaqub, 2018)

bring our creative resources fully into play is by misjudging the nature of the task, by presenting it to ourselves as more routine, simple, undemanding of genuine creativity than it will turn out to be." In one sense Hirschman's principle is very much in the spirit of this paper. It recognizes that many public policy initiatives are less predictable, controllable and understandable than what we usually presume. But in another sense, this paper has the opposite recommendation. Rather than embracing our ignorance and lack of true command over what the policy will achieve and how, I have stressed the importance of recognizing when a public policy has the characteristics of a complex system and adjusting both the expectation of what can be achieved, as well as the types of policy tools and instruments to pursue those ends. Flyvbjerg and Sunstein (2016, p. 984) study a much larger sample than Hirschman's 11 projects and found that rather than the benevolent version, a Malevolent Hiding Hand Principle was much more prevalent, "which also hides obstacles and difficulties, but in situations in which creativity does not emerge, or emerges too late, or cannot possibly save the day . . . it hides not only the initial obstacles and difficulties, but also the barriers to creativity itself." They recommend greater use of cost-benefit analysis to avoid such malevolent public policy outcomes, though they recognize that the very same unprecise expectations that are at the root of the Hiding Hand Principle may make these analyses hard to do properly. Public policies in non-linear, emergent, non-ergodic, evolutionary, non-ergodic and cognitively biased domains are even harder to get right and recognizing that fact, not misjudging it, is the first step to avoid failure.

References

Acheson, J., Apollonio, S., Wilson, J., 2015. Individual transferable quotas and conservation: a critical assessment. Ecol. Soc. 20 (4), http://dx.doi.org/10.5751/ES-07912-200407.

Allen, C.R., Holling, C.S., 2012. Discontinuities in Ecosystems and Other Complex Systems. Columbia University Press.

Angrist, J.D., Pischke, J.-S., 2010. The credibility revolution in empirical economics: how bette. J. Econ. Perspect. 24 (2), 3–30.

Ariely, D., 2010. Predictably Irrational, Revised and Expanded Edition: The Hidden Forces That Shape Our Decisions. HarperCollins.

Banerjee, A., Karlan, D., Zinman, J., 2015. Six randomized evaluations of microcredit: introduction and further steps. Am. Econ. J. Appl. Econ. 7 (1), 1–21.

Bar-Yam, Y., 2006. Improving the effectiveness of health care and public health: a multiscale complex systems analysis. Am. J. Public Health 96 (3), 459–466, http://dx.doi.org/10.2105/AJPH.2005.064444.

Bateman, M., 2014. The Rise and Fall of Muhammad Yunnus and the Microcredit Model. International Development Studies Working Paper Series.

Branch, T.A., 2009. How do individual transferable quotas affect marine ecosystems? Fish Fish. 10 (1), 39–57, http://dx.doi.org/10.1111/j.1467-2979.2008.00294.x.

Bromley, D.W., 2009. Abdicating responsibility: the deceits of fisheries policy. Fisheries 34 (6), 280–290, http://dx.doi.org/10.1577/1548-8446-34.6.280.

Bumiller, E., 2010. We Have Met The Enemy And He Is Powerpoint. The New York Times, p. A1.

Carroll, L., 1871. Through the Looking-Glass and What Alice Found There. Macmillan & Co., London.

Christy, F.T., Retrieved from University of Rhode Island, Kingston 1973. Fisherman Quotas: A Tentative Suggestion for Domestic Management.

Chu, C., 2009. Thirty years later: the global growth of ITQs and their influence on stock status in marine fisheries. Fish Fish. 10 (2), 217–230, http://dx.doi.org/10.1111/j.1467-2979.2008.00313.x.

Colander, D.C., Kupers, R., 2014. Complexity and the Art of Public Policy: Solving Society's Problems from the Bottom up. Princeton University Press, Princeton.

Costello, C., Gaines, S.D., Lynham, J., 2008. Can catch shares prevent fisheries collapse? Science 321 (5896), 1678–1681, http://dx.doi.org/10.1126/science.1159478.

Cropper, M.L., Oates, W.E., 1992. Environmental economics: a survey. J. Econ. Lit. 30 (2), 675–740.

Diamond, L., Plattner, M.F. (Eds.), 2015. Democracy in Decline. John Hopkins University Press.

Economist, T., 2017. The Bikes That Broke Free. The Ecoomist, December 23rd., pp. 99–101.

Editorial, 2018. The serendipity test. Nature 554 (7690), 5.

Erikson, R.S., Wlezien, C., 2008. Are political markets really superior to polls as election predictors? Publ. Opin. Q. 72 (2), 190–215, http://dx.doi.org/10.1093/poq/nfn010.

Flyvbjerg, B., Sunstein, C.R., 2016. The principle of the malevolent hiding hand; or, the planning fallacy writ large. Soc. Res. 83 (no. 4, Winter), 979–1004.

Frey, B.S., 2017. Reactivity in Economic Science. CESifo Working Papers, No.6593.

Goel, S., Reeves, D.M., Watts, D.J., Pennock, D.M., 2010. Prediction without markets. In: Paper Presented at the Proceedings of the 11th ACM Conference on Electronic Commerce, Cambridge, Massachusetts, USA.

Goodhart, C., 1981. Problems of monetary management: the U.K. experience. In: Courakis, A.S. (Ed.), Inflation, Depression, and Economic Policy in the West. Rowman & Littlefield, pp. 111–146.

Gordon, H.S., 1954. The economic theory of a common-property resource: the fishery. J. Political Econ. 62 (2), 124–142.

Hardin, G., 1968. The tragedy of the commons. Science 162 (3859), 1243–1248.

Hayek, F.A., 1945. The use of knowledge in society. Am. Econ. Rev. 35 (4 (September)), 519–530.

Hermann, M.G., Kegley, C.W., 1998. The U.S. use of military intervention to promote democracy: evaluating the record. Int. Interact. 24 (2), 91–114, http://dx.doi.org/10.1080/03050629808434922.
Hirschman, A.O., 1967. The Principle of the Hiding Hand. Brookings Institution.
Hirschman, A.O., 2011. Development Projects Observed. Brookings Institution Press.
Ioannidis, J.P.A., Stanley, T.D., Doucouliagos, H., 2017. The power of bias in economics research. Econ. J. 127 (605), F236–F265, http://dx.doi.org/10.1111/ecoj.12461.
Kahneman, D., 2013. Thinking, Fast and Slow. Farrar, Straus and Giroux.
Kahneman, D., Tversky, A., 1979. Prospect theory: an analysis of decision under risk. Econometrica 47 (2), 263–291, http://dx.doi.org/10.2307/1914185.
Leamer, E.E., 2010. Tantalus on the road to Asymptopia. J. Econ. Perspect. 24 (2), 31–46, http://dx.doi.org/10.1257/jep.24.2.31.
Lipsitz, L.A., 2012. Understanding health care as a complex system: the foundation for unintended consequences. JAMA 308 (3), 243–244, http://dx.doi.org/10.1001/jama.2012.7551.
Ljungqvist, L., 2008. Lucas critique. In: Durlauf, S.N., Blume, L.E. (Eds.), The New Palgrave Dictionary of Economics. Palgrave Macmillan, Basingstoke.
Loyn, D., 2009. In Afghanistan: Two Hundred Years of British, Russian and American Occupation. St. Martin's Press.
Maniadis, Z., Tufano, F., List, J.A., 2017. To replicate or not to replicate? Exploring reproducibility in economics through the lens of a model and a pilot study. Econ. J. 127 (605), F209–F235, http://dx.doi.org/10.1111/ecoj.12527.
McConnell, A., 2015. What is policy failure? A primer to help navigate the maze. Publ. Policy Adm. 30 (3–4), 221–242, http://dx.doi.org/10.1177/0952076714565416.
Niza, C., Tung, B., Marteau, T.M., 2013. Incentivizing blood donation: systematic review and meta-analysis to Test Titmuss' Hypotheses. Health Psychol. 32 (9), 941–949, http://dx.doi.org/10.1037/a0032740.
Schelling, T.C., 1978. Micromotives and Macrobehavior. W.W. Norton & Company, New York.
Scott, A., 1955. The fishery: the objectives of sole ownership. J. Political Econ. 63 (2), 116–124, http://dx.doi.org/10.1086/257653.
Scott, J.C., 1998. Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed. Yale University Press.
Squazzoni, F., 2014. Review of' complexity and the art of public policy: solving society's problems from the bottom up'. J. Artif. Soc. Soc. Simul. 17 (4), 2.
Taleb, N.N., Retrieved from 2012. Understanding Is a Poor Substitute for Convexity (Antifragility). http://fooledbyrandomness.com/ConvexityScience.pdf.
Tetlock, P.E., 2006. Expert Political Judgment: How Good Is It? How Can We Know? Princeton University Press. Princeton University Press, Princeton.
Thaler, R.H., 2015. Misbehaving: The Making of Behavioral Economics: W.W. Norton.
UNCDF - United Nations Capital Development Fund, 2005. International Year of Microcredit 2005: Final Report. New York. https://www.microfinancegateway.org/sites/default/files/mfg-en-paper-international-year-of-microcredit-2005-final-report-may-2006_0.pdf.
Watts, D.J., 2011. Everything Is Obvious: Once You Know the Answer. Crown Business.
Williams, L.V., 2011. Introduction. In: Williams, L.V. (Ed.), Prediction Markets: Theory and Applications. Taylor & Francis, pp. 1–3.
Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., Halpern, B.S., Watson, R., 2006. Impacts of biodiversity loss on ocean ecosystem services. Science 314 (5800), 787–790, http://dx.doi.org/10.1126/science.1132294.
Yaqub, O., 2018. Serendipity: towards a taxonomy and a theory. Res. Policy 47 (1), 169–179, http://dx.doi.org/10.1016/j.respol.2017.10.007.