EVOLUTIONARY AGENT-BASED POLICY ANALYSIS IN DYNAMIC ENVIRONMENTS

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Abstract

This is an interdisciplinary research project to design and to evaluate public economic policies by means of evolutionary agent-based computation. A simple and robust model of economic evolution is built where behavior evolves by imitation in a social network. Numeric agent-based simulations are used to investigate the evolutionary process under different environmental dynamics. And environmental policies are formulated and evaluated that explicitly take the evolution of economic behavior into account.

In order to build an objectively simple evolutionary mechanism, we introduce Relevance Estimation and Value Calibration, a numerical method that measures the minimum amount of information needed to tune an evolutionary algorithm to a desired level of performance. It also measures how this performance depends on the tuning of individual algorithm parameters. When applying the method to an array of conventional evolutionary algorithms we find that the tuning of the mutation operators—which maintain diversity—has the highest impact on algorithm performance. This general result is confirmed for models of economic evolution, where agents have to adapt under complex dynamics of climatic and technological change.

We proceed to build a simple evolutionary mechanism with only one free parameter for the diversity of strategies, and study the welfare effect of changing this diversity parameter under different environmental dynamics. Examples of dynamic environments include technological and environmental change. We find that the level of diversity that leads to a welfare distribution which is socially optimal—in terms of constant relative risk aversion—is different for different environmental dynamics. We formulate policy advise on the socially optimal level of diversity when the dynamics are unknown. In general, a higher degree of risk aversion calls for a higher degree of diversity.

We then include this evolutionary mechanism in a model of global warming where the policy maker wants to replace fossil energy, which has a negative environmental impact, by renewable energy, which is environmentally neutral yet less cost-efficient. Numerical evaluation of a regulatory tax on investments in fossil energy reveals that the level at which a regulatory tax convinces evolutionary agents to abandon fossil energy is significantly higher than what can be concluded from a model with rational and representative agents. We design and evaluate two novel public policies—*prizes* and *advertisement*—that selectively increase the probability of environmentally friendly strategies to be imitated. Numerical evaluation shows that the effect of *prizes* on welfare and global warming is similar to that of a regulatory tax, while being easier to enforce. *Advertisement* works well only when the cost difference between fossil and renewable energy is small, but has the unique advantage that it does not depend on enforcement.

We conclude that a model of economic evolution can be designed that is simple and robust in an objective way, and that the simple evolutionary mechanism of such a model is sufficient to allow a community of agents to adapt well to different environmental dynamics, even when their rational capabilities are bounded and their information is limited. Such models do not only lead to different predictions with regard to established policy tools like a regulatory tax, but they open the door for new policy instruments that regulate the selective advantage of economic behavior.