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COMPLEXITY THEORY AND ECONOMIC INEQUALITY

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ABSTRACT

We analyze the potential for complexity theory to produce insights that elucidate the evolution of socioeconomic inequality and point toward effective policies. We position complexity theory as a complement to more traditional economic approaches. Economic models of inequality can fall into four broad categories: models based on individual attributes and technologies, social interaction models, intergenerational models of transfer, and models of institutional and social structure. Within each of these categories, complexity theory can enhance traditional theory. It is of particular value in helping to distinguish between bottom-up systemic and top-down structural causes of inequality. Complexity theory can further enrich our understanding of economic inequality by adopting a complex adaptive system of systems approach in which economic, social, political, and psychosocial systems interact with one another and with institutional and social structures to produce robust inequality, particularly on racial lines.

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Introduction

In this chapter, we describe four categories of models that attempt to provide causal explanations of economic inequality. We then interpret these models through the lens of complexity science. Our modest overarching goal is to call attention to how the core ideas from complexity science can add to our understanding of inequality and aid in the development of policies and interventions that might reduce it.

Our specific contributions are fourfold. First, we show how the connections between the four common classes of inequality models overlap with complexity theory. Second, we highlight a distinction between bottom-up *systemic* causes and contributors to inequality and (mostly) top-down *structural* causes. Third, we argue that our understanding of inequality could be improved by adopting a *complex adaptive system of systems* approach that more deeply interrogates the interdependent effects of economic, political, educational, health, environmental, and psychological systems on inequality (Page and Zelner, 2020). Last, we suggest that the addition of a complexity lens can result in better policies.

The concern with inequality is hardly new. The standard objectives of economic policies have long been efficiency, growth, and equality. Ideally, an economic system produces goods and services efficiently and then allocates both relatively equally, or at least with limited envy across individuals, with an understanding that the need to incentivize effort often results in differences in allocations.

Economists care about growth for good reason. Increases in productive capacity over time have enormous implications for individual and social well-being. A mere 3% annual growth over a century produces a sixteenfold increase in the output.

Producing efficient outcomes—both static and temporal—along with equality has historically been thought to involve tradeoffs (Okun, 1975; Meade, 1975). While it is true that some policies that reduce inequality can reduce growth, there is no necessary tradeoff. A standard example involves education, where increases in supply of skills, as produced by expanding educational opportunities, can be growth enhancing and inequality inducing; the complexities of these dynamics underlie the work of Claudia Goldin and Lawrence Katz. A second important example involves the effects of reductions in discrimination on growth. Hsieh

et al. (2019) argue that 20 to 40% in increase in per capita market output in the United States since 1960 may be attributed to increased opportunities for women and African Americans.

Complex systems represent one class of environments in which one can formally model evolving sectional distributions to understand how efficiency, growth and inequality coevolve, and by implications reveal what sorts of interventions produce tradeoffs and what sorts do not. One example of how systems thinking reveals novel ways to promote equality and efficiency is demonstrated by Lu Hong and Scott Page (2001, 2004), who show how diverse groups can outperform homogeneous ones; (Page, 2017) provides a broad synthesis of these ideas. These findings imply that reductions of inequalities in the compositions of groups can be efficiency enhancing. As such, they speak to broad issues in what Durlauf (2002) and Durlauf (2006) has called the memberships theory of inequality, which captures the general role of socioeconomic segregation as a fundamental source of contemporary inequalities.

Inequality remains a pressing issue because nations have not been successful at reducing it. Internationally, much of the story of post-World War II economies is one of growth. In Western Europe, the United States, and Canada, per capita gross domestic product has increased sixfold, so the advanced economies have sustained growth. In Eastern Europe and South America, country-level increases vary from four- to sixfold, and in East Asia, increases have been more than tenfold. Africa is a more complicated story, where much of the postwar period has involved stagnation.

Progress on inequality has been far less impressive. Economists measure inequality by dispersion of income, lifetime earnings, or wealth across a population; sociologists often focus on occupations. These inequality measures are typically calculated nationally, although some focus on differences at regional levels. Global inequality has always been a concern as well, though it is more difficult to measure given differences in purchasing power and variations in market penetration across countries.

Over the past forty years, inequality in Europe and the Americas has not lessened. Nor, in the postwar period, does one find that national per capita income inequalities between the developed and developing economies are converging (see Johnson and Papageorgiou, 2020, for an overview of the evidence). Such regularities, of course, mask important heterogeneities. For example, extraordinary growth exhibited by

East Asian economies coexists with persistent differences between Europe and China. Paul Johnson and Chris Papageorgiou illustrate the nuances of measuring inequality by the fact that while countries may not be converging, population differences between countries are such that, at the individual level, income inequality has been declining worldwide.

Human well-being can also be measured by social connectedness, income, wealth, health status, life expectancy, or life satisfaction. These measures also vary substantially across peoples and places. Some people live socially integrated lives while others live in isolation; some people earn millions per year in salary while others live in poverty; and some people can expect to live healthily into their 80s or 90s whereas others are fortunate to reach 70 years of age (Gee and Ford, 2011).

Empirical analysis of economic inequality reveals clustering by place and differences across racial and ethnic groups. While we should expect some variation to arise due to differences in natural capacities, effort, luck, and circumstances, the extent of variation and its spatial concentration within particular communities suggests the presence of compounded disadvantages that limit the prospects for many (Perkins and Sampson, 2015).

Compounded disadvantages create *system of system effects*. Each disadvantage reinforces others: An unsafe environment contributes to poor health, which in turn contributes to worse performance in school; high school dropouts are more likely to be unemployed and to lead less healthy lifestyles (Last et al., 2018). In addition, people suffering from poor health and poor economic prospects are less likely to place trust in government and social services, contributing to a system of forces that make life difficult.

Within these systems, we can distinguish *bottom-up systemic* forces that operate on features relating to interactions across individuals and/or their outcomes that generate population-level patterns from more *top-down structural* forces that result from features embedded in institutions, laws, or social structures that influence the preferences, beliefs, and constraints of individuals' choices. For example, healthcare provided by employers as opposed to the government is a structural feature that produces systemic effects: Poorer health among the unemployed leads to less ability to find and hold a job and reduced educational performance. On the other hand, the fact that racial wealth gaps contribute to racial differences in educational performance

is a systemic feature that can have structural effects. White parents pulling their children from increasingly diverse but lower-performing schools (a social, systemic effect) results in segregation in both schools and communities. In turn, this can lead to less funding for schools (a structural effect).

This example, and others like it, demonstrates the complex dynamics that link equality and efficiency and how policy outcomes can depend upon the contexts in which they are implemented. As we have just suggested, if initial conditional conditions are unequal, then well-intended movements toward structural fairness could amplify systemic disparities.

Systemic thinking about inequality also has important normative implications. Institutional structures that are *prima facie* fair will not necessarily reduce inequality if the contexts in which they are placed exhibit systemic and structural forces. These can combine to make inequalities robust. Consider meritocratic college admissions and firm hiring policies. These can exacerbate existing inequalities if winners of these competitions receive sufficiently high rewards and then pass on these benefits to their children by giving them more opportunities to excel (Jayakumar and Page, 2021). As a result, their children become the likely winners of future competitions (Markovits, 2019). Complexity science refers to this as a *positive feedback*. Ironically, it is one with negative consequences. Durlauf (2008) argues that these forces need to be accounted in intertemporally efficient admissions and hiring rules. Doing so changes the meaning of merit in ways that can break claims that meritocracy and equality work at cross purposes.

Neoclassical and Complexity Economics

The motivation for this chapter was to explore what complexity has added or can add to our understanding of inequality. Scholars at the Santa Fe Institute have been thinking of the economy as a complex system for more than thirty years. Early proponents of complexity economics highlighted the stark differences between its assumptions and those of neoclassical economics. Those comparisons painted neoclassical economics as making unrealistic assumptions about the world: optimizing, homogeneous agents interacting at a single place in a single moment in time in well-defined, separable strategic environments who always achieve equilibria.

In stark contrast, complexity economics makes far more realistic assumptions: diverse agents who learn are situated in networks and interact over time in environments rife with systems effects and externalities. In complex-systems models, macro-level patterns emerge from the bottom up. These patterns include stock market crashes, technological clustering, and segregation by race and income. These patterns become relevant parts of the economic landscape. They impact behavior and outcomes.

These provocative comparisons initially played a role in bolstering the field of complexity economics. Viewed from a broader perspective, they were one of many empirical and theoretical challenges to neoclassical economics. Those challenges have been successful. Present-day economics makes more realistic assumptions about the capacities of actors and the spaces in which they operate. Current mainstream economic models include heterogeneous, boundedly rational agents who learn. Economic models even include network effects, peer effects, and altruistic preferences.

The incorporation of the various assumptions of complexity science did not, however, result in a paradigmatic shift. Neoclassical economics has not become complexity economics. Instead, we argue that the economics profession has become more expansive in the types of assumptions it makes about how people act and how the world works.

On the whole, the evidence suggests that some economic phenomena can be explained quite well with the minimalistic version of neoclassical economics, while others require moving in the direction of complexity economics and taking seriously the many dimensions of human diversity (not just preferences, but perspectives, belief systems, and culture), bounded rationality, peer effects, and self-organization. Economists, while still searching for general theories of human behavior, now pick and choose models based on context. Actors in large firms and sophisticated financial investors who operate in high stakes, repeated settings may well optimize, or come close to it. Students deciding on whether to take out college loans decidedly do not.

To summarize, in our view economics has evolved in directions that show there is no fundamental incapability of adapting ideas from complexity theory. The irreducible core of economic theory involves reasoning about purposeful agents who make choices given preferences, monetary and time constraints, information, and beliefs, and whose choices interact via various socioeconomic structures ranging from markets to politics

to social networks. Assumptions about the determinants of choices and features of institutions are the loci in which complex-systems thinking may be introduced.

We therefore see little current value in attacking economics from a complexity perspective or in positioning complexity economics as somehow correct and neoclassical economics as wrong. These are two classes of models. Individually, each is useful and wrong. Collectively, they are more useful and less wrong (Page, 2018).

That said, moving in the direction of complexity economics differs from adopting the paradigm as a whole. One can construct equilibrium models of agents who learn strategies in a game played on a network. Or one can construct a dynamic general equilibrium growth model with heterogeneous agents. Though neither should be considered a model of a complex system, both move in that direction. And, as stated, our strong belief is that viewing inequality as resulting from multiple interacting complex systems operating within political structures offers powerful insights into the causes of and corrections for inequality.

A Taxonomy of Models

Models of inequality, especially those that have been brought to data, reflect the aforementioned blurring between neoclassical and complexity economics. To demonstrate that claim, we categorize models based on their core assumptions. Inequality models can be loosely partitioned into four types of explanations: *individual characteristics models*, *social interaction models*, *institutional and social structure models*, and *intergenerational models*. These category boundaries will vary in the extent to which they explicitly include complex processes. We first describe them and then discuss their implications when inequality dynamics are considered.

Individualistic Models

Individualistic models assume a population of agents who differ on a single attribute or combination of attributes. An agent's income is a function of that attribute. A simple example would be a model that

explains individual i 's income, y_i , as a function of some measure of ability a_i . That function could be linear, $y_i = \beta_0 + \beta_a a_i + \epsilon_i$, where β_a represents economic returns to ability, β_0 is baseline income for someone with no ability, and ϵ_i captures the many unobserved contributions to income. Of course, the function need not be linear. Income could exhibit increasing or decreasing returns to ability. The functional form will depend on how ability has been measured.

Income will also depend on the supply of labor and the technology (Goldin and Katz, 2008). Positing income as a function of something called ability also ignores the role of parental investment, individual effort, and beliefs about the returns to investments.

As should be obvious, these models can quickly become complicated as an individual chooses an effort level and their parent (most economic models assume parents that act as a single rational actor) makes investments in education based on their beliefs about the return to education and effort, and (in some models) on general equilibrium effects.

We note with a touch of irony that almost no social scientist would describe this class of models as complex. These are canonical neoclassical models. Such models assume that everyone optimizes given their attributes, resources, beliefs, and, most critically, the actions of everyone else.

As limited in scope as it seems, the model just discussed captures five possible causes of inequality: differences in ability, differences in returns to effort, differences in parental wealth, differences in parental preferences toward offsprings' future income, and differences in beliefs. Individual models take variation on these variables as features of the world. But these variations and their consequences also depend on large social and structural factors, to which we now turn.

Social Interaction Models

Individual characteristics and choices do not arise *de novo* but rather occur within social systems. Social influences can range from peer effects to neighborhood effects to network effects and racial and cultural effects. For example, an individual's returns to education depend on how much other individuals believe in the value of education. This in turn will influence their and others' investments in education. In our view,

this is a *systemic* effect.

In social interaction models such as this, an outcome of interest such as educational attainment depends not just on a person's own characteristics but on the actions and beliefs of their peers and their larger community. One important dimension involves identity. What constitutes an ideal behavior depends upon a person's peer group, their attitudes, and how those attitudes align with the school's culture (Steele, 2018; Akerlof and Kranton, 2000; Akerlof and Kranton, 2002).

Models in this category often assume local interactions, a feature of complexity models but not the canonical neoclassical models. In local interaction models, an individual's beliefs, actions, and returns can all depend on the people with whom they interact. An individual who belongs to a peer group who believe education offers few opportunities, who don't put forth effort in school, and who sanction the individual's attempts to succeed will have lower income than a person with similar characteristics placed in a more supportive neighborhood.

Once network structures are introduced (cf. Calvó-Armengol and Jackson, 2004), then the rates of diffusion of information will depend on social distance between individuals. It follows that the introduction of social influences creates correlations in outcomes between individuals and can produce theories of group-level inequalities. Further, interdependences between individuals mean that changes in one individual's characteristics will affect others as well. Collectively, social interactions produce a social multiplier, whereby initial inequalities are amplified by the interdependences between individuals.

Social influences not only produce inequalities, they can result in persistent inequalities (Page, 2011). One cause of persistence is that interdependences between individuals can lead to multiple self-consistent choices. If one's peer works hard, hard work is a best choice; if one's peers shirk, shirking becomes a best choice. The key formal condition for multiplicity is strong complementarities in individual choices, which means that the benefits of one person's choice increase when others make the same or similar choices.

A second reason is that social interactions create incentives for individuals to segregate themselves. Affluent parents have incentives to choose neighborhoods with other affluent parents, which can produce equilibrium configurations of income segregation.

In other cases, the rules by which public goods are produced can induce segregation. Local finance of education is an obvious example. Other examples derive from decisions on what a policymaker deems the optimal way to assign individuals and environments. Educational sorting rules ranging from ability grouping in classrooms to admissions rules that condition on grades and test scores can have multiplier effects that amplify individual ability differences. In fact, Markovits (2019) challenges meritocracy as a social goal because of the inequalities it can induce. These mechanisms, in turn, can be amplified by neighborhood effects. Beliefs in the value of education can depend on local information and on the ways that one's social environment shape aspirations. In a remarkable study, Hoxby and Avery (2013) show that there are thousands of adolescents with high test scores who, despite eligibility for scholarships, fail to apply to elite schools. Finally, there are basic differences in exposure to neighborhood ills, such as exposure to lead and exposure to violence, that can profoundly inhibit education. Manduca and Sampson (2019) document how, for the city of Chicago, Black and White children are deeply segregated in levels of exposures.

Considered collectively, social models provide multiple mechanisms that can explain poverty and affluence traps. A poor community finds itself stuck in a what dynamical systems theorists would call a large "basin of attraction." Imagine a ball sitting at the bottom of a bowl. Policies intended to improve health status and socioeconomic well-being push the ball up the side of the bowl, but only temporarily. The gravity within the system, in the form of the level effects and negative feedback loops, pulls the ball back down to the bottom. A large basin corresponds to a large bowl. Getting the ball out requires a large push.

In these models, social and individual sources of disadvantage are interdependent, not additive, a distinction that must be front of mind if we hope to reduce inequalities. In a complex system, single isolatable interventions generally do not produce large, persistent improvements. Reinforcing loops within the system pull it back to its status quo. Evidence from fifty years of randomized controlled trials testing policies to reduce crime reveals that few prove replicable and those that do have effects of small magnitude at best

(Stevenson, 2024).

By intergenerational persistence, we mean low levels of income across generations of the same family. Social and structural effects will influence every variable and coefficient in the production of skills. Educational sorting rules ranging from ability grouping in classrooms to admissions rules that condition on grades and test scores can have multiplier effects that amplify individual ability differences. Differences in parental incomes can produce these skill differences both via direct investments and via access to better schools.

When one integrates individual and social mechanisms, one can produce more elaborate models of inequality. These models can produce inequality as an emergent phenomenon. Levels of socioeconomic and racial segregation are emergent properties of (constrained) individual choices. The classic Schelling model of racial segregation shows how complete segregation can emerge in environments where individuals prefer some levels of integration but do not wish to be completely isolated from their in-group. It is unsurprising that complexity scientists developed variants of this framework to show how it can also produce segregation by income and segregation by race and income.

Political Institutions and Structural Causes

The first two classes of models demonstrate how individual attributes and social (systemic) interactions can produce and maintain inequality. They take the institutional structure as given. Within that structure, individual choices be amplified and reinforced by social forces to produce persistent inequality. That persistence is not intended. It is an emergent phenomenon.

This view must be complemented with considerations of how institutions support and reinforce inequalities. Racial inequality in America is an obvious context. Jim Crow laws are the most obvious example of postbellum structures inducing inequalities, but they are hardly unique. Rothstein (2017) delineates the long history of government policies, such as the exclusion of Black people from receiving Federal Housing Administration loans to public housing that promoted segregation; Aaronson et al. (2021) demonstrate how far just one of these policies—loan exclusion—can explain contemporary segregation patterns.

Beyond the explicit introduction of unjust inequalities via discrimination, there are powerful ways that democratic institutions potentially amplify inequalities. The simplest model of equilibrium voting patterns is the so-called median voting model, in which policies are implemented in accordance with the median preferences among voters, since alternatives to the policy would be defeated in a head-to-head election against them. This implies that changes in the income distribution will change redistributive policies such as taxes and transfers.

Roemer (2006) offers a clear demonstration on how democratic choices may not eliminate poverty when voters are self-interested. Further, differentials in political power associated with wealth can distort voting outcomes in ways that perpetuate inequalities (see Acemoglu et al., 2015, for a survey). All of these can lead to distributional instabilities.

Intergenerational Models

Intergenerational models build from the previous models by considering lineages. Rather than consider an individual i at a single moment in time, these models assume a lineage of individual i s and a sequence of generations indexed by t . Income for lineage i at time t , written as y_{it} , is a function of variables that include the income of the lineage at time $t - 1$. Intergenerational mobility is studied via lineage models. These models typically have a Markovian structure where t denotes generations. These models are capable of producing persistent inequalities.

Social and structural factors are a natural route to these. When neighborhood and school factors are combined, one can see how a system in which families choose neighborhoods subject to constraint generated by house or rental prices and the unmeasured costs of social acceptance or antipathy, combined with the sorting rules for education, can create deep distributional instabilities as parental inequalities induce inequalities in children that amplify initial inequalities. (Durlauf, 1996a; Durlauf, 1996b) demonstrates that, in theory, these social factors can produce a nonergodic system in which the descendants of the rich and poor never alter their relative positions in society.

Chetty et al. (2014) launched a research program demonstrating large spatial heterogeneity in intergener-

ational mobility, as predicted by such models. Here as well, the implicit interpretations very much align with a complex systems view of the economy, but the formal model does not. It estimates fixed racial differences in the slopes and intercepts of a linear dynamic model, implying a significant Black–White steady-state difference in average income rank. The approach here systematically controls for a number of factors in a linear fashion (including some that are endogenously related to parent and child income, such as parental wealth), finding the steady state difference is driven by males and segregation. However, Black–White inequality remains in 99% of census tracts. The only areas that reach parity are those with low levels of anti-Black bias among Whites, high Black father presence, and low poverty rates. Very few Black children grow up in such unique areas, hindering intergenerational mobility.

Our discussion of systems and intergenerational inequality speaks to an important empirical regularity that has been found, namely, that greater cross-sectional inequality is associated with greater intergenerational persistence of socioeconomic status across generations. The regularity, which has been dubbed the Great Gatsby Curve, was first identified at a global level by Corak (2013) . This finding has been replicated within countries as well. An analogous finding holds for intergenerational mobility: Greater inequality across parents reduces mobility. (Durlauf et al., 2022) survey theory and evidence for this relationship. Our vision of an evolving cross-sectional distribution in which family, social, and institutional systems create nonlinearities in individual level transmission provides the microfoundations. Fogli and Guerrieri (2019) show how these ideas can replicate important aspects of US inequality.

Intergenerational Models and Systemic Inequality

The intergenerational models add dynamics to the other three classes of models, allowing us to capture how systemic inequality emerges. Once these are embedded in contexts where individual and social interactions operate under distinct rules, one can think about inequality as the outcome of a system as opposed to being a consequence of individual differences.

Our reading of the evidence is that systemic inequality can be best understood as the translation of initial individual-level inequalities into equilibrium levels of inequality through contemporary and dynamic

interdependences. In our judgment, these differ from structural causes that can be traced to political institutions and collective choices and laws. That said, systemic and structural causes of inequality mutually reinforce each other.

To see how to operationalize this type of reasoning, consider one essential dimension of American inequality: discrimination. How would one model individual acts of discrimination by employers? First, one would specify the decision-making process of those committing the acts. It is standard to think of discrimination, individual actions, as driven by two factors: animus toward Black people and statistical discrimination, the formation of beliefs about Black people that lead to differential treatment from White people of equal ability. Individuals actions will, however, have social roots. Some factors are structural. Jim Crow laws structured individual employment outcomes. Alternatively, one can think of unequal educational opportunities for Black people and White people, which means that even if equally productive individuals are hired, the distribution of skills is the product of discrimination.

Beyond this, systemic factors need to be modeled. Animus is the outcome of social processes. Beliefs about the potential of Black job applicants will be conditioned on the information sets of potential employers. Hence, employers' lack of interactions with Black people can lead to an inability to discern skills due to cultural capital deficits. Alternatively, suppose that White employers possess adverse priors—prejudices—about Black applicants. How can information be transmitted to the employers so that they move away from these priors? Every failure to hire a Black applicant is a loss of information about the potential of Black applicants. Generally, when individuals segregate themselves due to adverse priors, they shut off the potential for these priors to evolve.

Social multipliers will emerge as individual acts of discrimination amplify equilibrium racial inequality. One reason is that information about job opportunities flows through networks (see Calvó-Armengol and Jackson, 2004, for a formalization). Hence every act of discrimination against one Black person can affect everyone in their network. Further, every act of discrimination means that information about Black people's potential is lost to all employers. It is possible for inequalities to become permanent when these feedback effects are strong enough so that prejudice-based priors are not overcome by adequate data. Further, dis-

crimination can damage incentives for educational attainment and hence prejudices are *ex post* confirmed, not because of intrinsic differences but because prejudices put into motion chains of decisions from which *ex post* confirmation emerges.

Complexity Theory and Policy Interventions

A complexity-theory perspective on inequality assumes that the compounded disadvantages are interdependent, not additive. This distinction should be front of mind as we consider how a complexity-theory lens would influence policy that aims to reduce inequalities. In an additive system, inequality is caused by a collection of mostly independent factors with a smattering of interactive terms. It follows that the most effective policy will identify the most important variables and enact policies that change their values. If math education has the largest return on investment in the estimated equation, then money should be allocated there.

The idea that we can gather data, fit models with lots of linear terms and a few interaction terms, and then allocate resources to key variables has guided a large share of government and philanthropic spending. This approach to evidence-based policymaking has had limited success. A complexity-theory approach would not expect isolated interventions to succeed in systems that contain mutually reinforcing or balancing feedbacks.

Nonetheless, scholars have often relied exclusively on reduced-form approaches when evaluating interventions rather than considering the effects of interventions through a complexity lens. This evaluative narrowness is surprising in the field of education, given that a large empirical and qualitative literature demonstrates that educational success and failure results from a system of political, social, economic, and psychological factors (Ladson-Billings and Tate, 2006; Lee, 2008).

A complexity lens may also help to unpack empirical puzzles, such as the mixed results on fadeout and persistence of educational interventions, and potentially identify features of complex systems, such as reinforcement processes that can be disrupted or exploited to produce persistent intervention effects. For example, the feedback between low self-concept, low effort, and low achievement might be disrupted

with growth mindset interventions or exploited with self-concept-improving self-affirmation interventions (McMillon, 2024a).

The causes of racial inequalities also include discrimination. This, too, can become systemic when the initial effects of an injustice become amplified through social multipliers, reinforcement processes, and complementarities (McMillon, 2024b). Racial wealth inequalities make Black Americans more vulnerable to macroeconomic shocks (De et al., 2021), in part because of consumption smoothing (Ganong et al., 2020).

Amplification mechanisms also occur within other systems. This is especially true for health. Biological mechanisms that make people with heart disease more susceptible to COVID-19 result in increased risk for Black Americans, who face preexisting differences in heart disease (Wadhera et al., 2021).

Health disparities, as well as educational disparities, can then spill over into the economic system. McMillon (McMillon, 2024b) refers to these as *intersectoral spillovers*. Often, a given inequality will have systemic effects both within and across systems. Disparate treatment in charging decisions within the criminal justice system spills over into disparities in sentencing outcomes (Rehavi and Starr, 2014). These differences create an intersectoral spillover into labor market outcomes (Agan and Starr, 2018).

A complex-systems perspective leads organically to three policy insights. First, we might seek to disrupt the mechanisms that amplify inequalities. This could mean reducing the impact of a feature within a system (e.g., levying a wealth tax to effect income transfers to disrupt poverty traps in economic systems) or demolishing a structure that reinforces systemic effects (e.g., abolishing private prisons).

Second, policies might attempt to exploit systems effects to amplify equality-focused interventions (e.g., a policy that enhances access to capital markets for minorities). In either case, we are leveraging the same systemic processes that produced systemic discrimination and inequality to eradicate them. That is, “using the mechanics of systemic discrimination against itself” (McMillon, 2024b).

Third, adopting a complex adaptive system of systems perspective and representing inequality as being produced by multiple, interdependent systems with reinforcing and amplifying loops implies the need to coordinate policies across systems. Multiple levers must be activated simultaneously at the community level if any are to have their full effect. Attempts to improve a local economy without also putting resources in

the health system and the educational system may not succeed because the failure of one system will prevent progress in others. Poorly educated people living in unsafe communities with little access to health services cannot take full advantage of economic opportunities.

The failure to think systemically may not only produce ineffective policies, but also lead to misleading inferences. A recent large-scale test of universal basic income that targeted individuals and not entire communities found only modest effects (Vivalt et al., 2024). This experiment, which had enormous cost, tells us little about what would happen if every member of a single community were given a basic income. Evidence from a second unconditional cash transfer program that found significant indirect spillover effects on ineligible individuals (Angelucci and De Giorgi, 2009) suggests the possibility that, had the entire community been given transfers, these spillovers might have become synergies.

List et al. (2019) find similar results in the context of early childhood education interventions, which are traditionally randomized at the individual level, within school districts. Students given additional resources have positive effects on untreated students, and thus the true overall effect would be underestimated were spillovers not taken into account. Under traditional assumptions in economic experiments, treated and control units do not influence one another. If they do, then treatment effect can be underestimated.

This observation also holds for other contexts in which social interactions matter, such as the spread of crime (McMillon et al., 2014) and wealth transfer networks under a reparations policy for slavery and Jim Crow. Within-community experiments of reparations policies may underestimate the extent of persistence compared with cross-community experiments due to social multipliers (McMillon, 2024b). A large-scale reparations policy would leverage the economic interdependence of recipients to enhance persistence.

To summarize, traditional economic models have provided deep insights into the causes of economic inequality. They demonstrate that inequality results from differences in individual attributes—often resulting from historical injustices, social interactions, and political institutions. Those differences are then often magnified in the labor market and within the criminal justice system.

Intertemporal models further explain why inequality persists and proves robust to interventions. Neither of these classes of models are antithetical to a complexity approach. To the contrary, both embed, at least

implicitly, ideas and concepts from complexity economics. And, when viewed through a complexity lens, we can distinguish between bottom-up systemic features and top-down structural features that produce and maintain inequality.

What economic models emphasize less explicitly is how economic inequalities are amplified and reinforced by other systems. Many economic models include social, educational, political, health, and psychological variables, but few include them as separate, interdependent systems.

We see the value of adopting a complex adaptive system approach as potentially significant. It should lead to better policies and to more informative policy experiments in three ways: first, by recognizing that effective policies must improve communities as well as give assistance to individuals; second, by connecting economic disparities to health, educational, and social disparities and encouraging coordination; and third, by generating more support for enacting policies to reduce inequality. When people view racial inequalities as due to systemic and structural effects and not individual shortcomings, they become more likely to advocate for reform (Rucker and Richeson, 2021).

We end, therefore, on an optimistic note. A greater emphasis on the complexity of inequality and how it results from systemic and structural causes across multiple, interdependent systems may not only result in deeper, more accurate understandings and better policies, it may also produce greater social support and political will to make the coordinated efforts and investments necessary to reduce inequality.

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