Institutions and Cultural Capacity: A Systems Perspective

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Abstract

Societies rely on a mixture of markets, hierarchies, and democratic institutions to allocate resources, make decisions, and establish order. The success of any one institution depends on its design features, the nature of the task, and the cultural capacities of the society within which the institution is embedded. In this paper, rather than consider cultural capacity as exogenous, we model institutions and cultural capacities as interdependent. Different institutions build different types of cultural capacities. Cultural-institutional equilibria exist when cultural capacities are consistent with institutional choices, and institutional choices are optimal given tasks and culture. We highlight five results. First, positive feedback between cultural capacities and institutional performance produces multiple equilibria, implying that cultural capacities and ensemble compositions will vary by place. Second, cultural-institutional equilibria will generically not be efficient because of a disconnect between the production and utilization of cultural capacity. Third, we derive a *paradox of cultural capacity-building*: an institutional type that builds too much generic cultural capacity can collapse because it makes other types of institutions more effective. Fourth, we show that complementary feedback with another institution can prevent collapse. Finally, we show that complementary feedback between other institutional types can reproduce a collapse of the generic cultural capacity-producing institution.

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Societies rely on a mixture of institutional forms such as markets, hierarchies, and democratic decision rules to allocate resources, make decisions, and establish order. The success of any one institution depends on its design features, the nature of the task and the cultural capacities of the society within which the institution is embedded. In this paper, we analyze a society's selection of institutional form and the society's institutional-cultural capacity from a systems perspective. We model cultural capacities and the choice of institutional form as interdependent: societies select institutional forms that fit well with their cultural capacity, and their institutions in turn influence the evolution of their cultural capacity.

With that model, we show five implications of how changes in the nature and magnitude of cultural capacity building influence the institutional composition. First, we show that if cultural capacity-building is largely institution-specific, i.e., if markets build capacity for markets to perform well, then multiple outcomes can exist. Some societies may be market-dominated with risk-loving people. Others may be dominated by hierarchies with people who follow rules. Given evidence that maintaining a balance between adherence to rules and a willingness to challenge those rules is necessary for long-term economic success (Acemoglu and Robinson 2019), the potential for extremes is worrying.

Second, we show that, in general, cultural-institutional equilibria will not be efficient. Efficiency fails to hold because institutional types are selected based on their ability to leverage cultural capacity and not on the cultural capacity they build. Put simply, cultural capacity-building is a positive externality. A society might allocate housing hierarchically because is more efficient but had the society chosen a market, they might have produced more trust in institutions and stronger property rights that would have made other institutions perform better. Or, democracies and community-based institutions might both produce other-regarding behavior which would improve the performance of all types of institutions (Bowles 2018), but that positive externality is not a dimension of a social choice of institution.

Third, we show that if one institutional type builds generalized cultural capacity, such as trust, then increases in the rate at which it produces trust can result in the collapse of that type. For example, if democracies build generalized trust that other institutions utilize, democracies could collapse. We call this the *paradox of cultural capacity-building.*

Fourth, we show that the presence of another institutional type that produces complementary cultural capacities could prevent collapse. We construct an example in which self-organized communities build capacities that democracies utilize. This prevents democracies from collapsing.

Finally, we show complementary cultural spillovers produced by other types of institutions, say between markets and algorithms could lead to demise of democracies even with the complementary

effect of community organizations.

Our third and fourth findings imply that the demise of an institutional type, such as recent trends away from democratic (Flores and Nooruddin 2016, Levitsky and Ziblatt 2018) and hiearchical institutons (Davis 2017) could be the result of changes to culture capacities created by other instituitons, such as markets and algorithms. A change in technology could, for example, make markets and algorithms more effective. Societies then rely more on markets and algorithms and, as a result, build cultural capacities that support those types of institutions. Ironically, if democracies build generic cultural capacities like trust, that positive spillover can amplify the positive interdependence of markets and a market based culture.

Our findings all rest on the interdependence of institutional choices and cultural capacities. An extensive literature demonstrates that culture influences institutional performance and, therefore, institutional choices. (Alesina and Guilano 2015). Multiple historical analyses, most notably Putnam's (1993) study of social capital in Italy, reveal how similar institutions can perform differently based on context. Markets and hierarchies do not necessarily work. Markets require strong property rights, belief in a currency or other means of non-bartered trade, and accountability mechanisms, generally state-reliant, to make long-distance, impersonal trade possible (Milgrom, North, and Weingast 1990, Lipset 1959, Lipton and Sachs 1990). Hierarchies require high levels of trust within authority based networks (Banerjee et al 2013).[1] Given that culture varies by place, so too do institutional choices. Europe may choose bureaucratically enforced environmental policies, while the United States relies on market-based systems (Morag-Levine 2009).

The concept of culture has no generally accepted definition. In fact, it suffers from too many definitions. Culture includes artifacts, values, toolkits, beliefs, religion, rituals, knowledge, behaviors, norms, and networks. Here, we focus our analysis on those aspects of cultural that most contribute to institutional performance, and employ the term *cultural capacity* to capture them. Cultural capacity includes human capital and technological capacity (Hidalgo and Hausmann 2009), social capital (Putnam 1993), behavioral repertoires (Dolan and Galizzi 2015, Henrich et al 2001, 2004), toolkits (Swidler 1986), belief systems (Ingelhart 1997), network structures (Jackson, Rogers, and Zenou 2017), bounds on human cognitive capacity (Simon 1997), logics of appropriateness (March and Olsen 2004), strategies in games

[1] A significant empirical literature documents that culture influences institutional outcomes (Guiso, Sapienza and Zingales 2006). Gorodnichenko and Roland (2021) find individualism influences institutional performance but weaker effects of institutions on individualism. Disentangling the joint effects can be difficult at the country level (Michalopoulos and Papaioannou 2014).

(Bednar and Page 2018), and the distribution of knowledge (Hayek 1945, Chwe 2003, Easterly and Easterly 2006).

Of course, cultural effects do not deny that the success of a market, democracy, or hierarchy also depends on their design and context (Arrow 1974, Ostrom 2009). Markets will typically be better at allocating private goods than democracies or hierarchies (Sah and Stiglitz 1988). Often, though, no one institution will be necessarily best. Consider the integration of refugees. A society could just allow markets to function, it could rely on the government to build a bureaucratic mechanism, or it could even rely on an algorithm to assign people to communities (Ahani et al 2021). The success of each of these institutions will in part depend on cultural capacity. A community-based institution relying on informal norms may perform well in a high trust society with sharing behaviors and a highly connected social network. It may perform less well in a low trust society with predominantly self-interested behaviors and a status based social network (Bicchieri 2006). A market-based solution would likely require high levels of generalized trust, norms of reciprocity and strong social networks as well as specialized knowledge in order to succeed.

Our systems approach also assumes that institutions build cultural capacities. North (2005) makes a similar claim when he describes how the "institutional matrix" creates incentives and an informational context that steers the allocation of skills and knowledge. Many other scholars describe how cultural attributes, including levels of trust, individualism, and cooperation, depend on the mix of institutions (Tabelini 2008, Aghion et al 2010). Markets, for example, can build acceptance of rule of law, property rights, and contractual commitments. These are all components of cultural capacity.

This paper belongs to a theoretical literature exploring the interplay between institutions and culture. Other papers emphasize how interdependence produces multiple equilibria through path dependence (Grief and Laitin 2004, Crouch and Farrell 2004), and how institutions change beliefs and behaviors (Bednar and Page 2007). These papers show how one society might evolve high levels of trust and low levels of regulation, while another might fail to build trust and then have to rely on regulation (Bisin and Verdier 2021). These models, for the most part, consider the interdependence between institutional choices and a specific cultural trait such as cooperation or trust. Here, we take a more abstract systems approach and consider multiple types of interdependencies (Meadows 2009). This approach reveals the aforementioned tension between the production and utilization cultural capacity: a society prefers institutions that produce cultural capacity, but it only benefits from that capacity if it selects institutions that utilize it. The approach also allows us to explore the implications of different

types of interdependencies.

The first models we construct consider only markets, hierarchies, and democracies. Later, we add community-based institutions and algorithms, such as those used to allocated organs (Ergin, Sonmez, and Unver 2017).[2] Algorithms can often resemble other types of institutions. We consider an institution to be algorithmic if it gathers data and information and then makes an allocation decision without further human involvement. This definition includes matching processes for medical students and the use of drones to identify potholes in city streets and assign work crews to fill them.[3] For all of our institutions, we present them as stylized forms, and for each, only in a highly stylized manner, with qualities assumed to offer intuition about the model's potential.

In each domain, we assume that the society selects the highest performing institution. This is consistent with models from mechanism design which takes the cultural context as fixed (Maskin 2008, Myerson 2008).[4] Institutional types are chosen in sequence. Given that institutions produce cultural capacity, ensembles of institutions chosen based on allocative efficiency will not be optimal (Page 2012). To choose an efficient ensemble would require consideration of the cultural interdependencies when choosing institutional types.

1 The Interdependence of Institutions and Cultural Capacity

In this section, we describe three types of interdependencies between cultural capacity and institutions: *positively reinforcing interdependencies*, *negative spillovers*, and *generic capacity building*. We later build computational models for each, but for now, our purpose is to provide some examples of what cultural capacity is, how it can affect institutional performance, and how institutions can, in turn, build those capacities.

Recall that we take an encompassing view of cultural capacity. We take it to include those parts of culture that influence institutional performance. Thus, it includes but is not limited to behaviors, beliefs, values, toolkits, networks, logics of appropriateness, as well as the distribution of information. If they affect institutional performance, they also affect institutional choices.

[2] By a self-organized community, we mean a group that manages a resource or makes allocations or decisions collectively without a formal hierarchical structure. Our taxonomy differs from Jung and Lake (2011) who consider markets, hierarchies and networks.

[3] Alternatively, one could assume algorithms make each type of institution more effective but in different ways (Malone 2018). Such an assumption would require different assumptions than ours but might well produce qualitatively similar results on the effect of algorithms on democracy and self-organized communities.

[4] We do not consider the inclusion of informational and computational costs(Hurwicz and Reiter 2006) or the robustness of the outcomes implemented (Borgers 2018).

Positively Reinforcing Interdependencies

Positively reinforcing interdependencies exist when specific types of cultural capacity benefit a single institutional form and that institutional form, in turn, builds those types of cultural institutional capacity. This type of feedback have been the focus of papers on institutional path dependence (Pierson 2004). Positively reinforcing feedback are also implicit in Kranton (1996), which shows how reciprocal exchange creates an incentive to form networks with likely trading partners. Those networks become a type of cultural capacity that makes reciprocal exchange more efficient, leading to more reciprocal exchange. In the model, markets also have positively reinforcing culture capacity. Markets rely on people meeting at sites where commodities are traded impersonally. As more people participate in markets, market transactions become more efficient.

Positive reinforcement can also arise through beliefs (Grief and Laitin 2004) or in behaviors (Bednar and Page 2018). Figure 1 shows how markets, hierarchies, and democracies could all produce positively-reinforcing feedback with specific behaviors. At the top of the figure are three behavioral cultural traits. The first, *risk taking*, correlates with cultural measures of individualism in cross cultural studies of the insurance and banking industries (Gaganiss et al 2019, Mourouzidou-Damtsa, et al 2019). The second, *rule following*, refers to the propensity to adhere to informal laws as well as informal norms. The tendency to follow rules and punish violators a component of *tightness-looseness* measures of culture (Gelfand et al 2011).[5] The third behavioral cultural trait, *collaborating* corresponds to the ability to the ability to work effectively across differences.

The black arrows with the plus (+) signs denote that increases in each of those behavioral traits improve the performance of the corresponding institutional types. Rule following behaviors, for example, make hierarchies perform better. Here, we assume that they have no effect on markets or democracies. Similarly, the ability to collaborate and the willingness to take risk improve the performances of democratic and market institutions respectively.

This figure represents one of many possible examples of positive reinforcement as evident from descriptive accounts of feedback (Pierson 1994). We note that one can even adapt models of behavioral attention (Gabaix 2019) to produce self-reinforcement on institutional types. If we assume that people have limited attention to spread across institutions, and if institutions of the same type oblige that attention be allocated to similar stimuli, this too will produce self-reinforcement of institutional types

[5] Variation on tightness-looseness proved crucial for the success of COVID policies. A pre-registered global analysis using controls found that all else equal the loosest countries had five times the number of cases of COVID and nearly nine times the number of deaths (Gelfand, Jackson, Pan et al 2021).

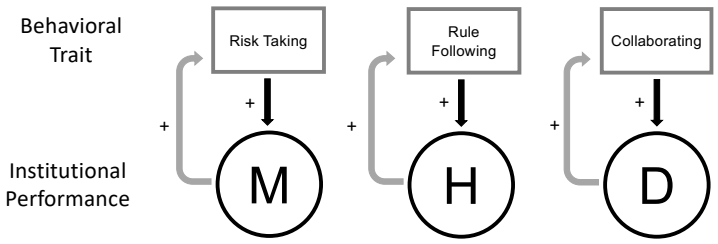

Figure 1: Positively Reinforcing Cultural Institutional Interdependence

(Jung and Lake 2011). Markets, for example, create incentives for people to allocate their attention to information relative to the markets in which they operate. A fruit grower follows weather reports and fuel prices but pays less attention to social issues and political issues. If few people pay attention to those issues, democratic institutions may not perform effectively.[6]

Cultural Capacity Spillovers

We next consider cultural capacity spillovers. A positive spillover arises when one institutional type builds cultural capacity that another institutional type can utilize. In some cases, two institutions may each build cultural capacity for one another. For example, democracies and self-organized communities might both build general knowledge and other-regarding information acquisition strategies. We refer to these as *complementary spillovers*.

Spillovers can also be negative. When this occurs, an institution builds a cultural capacity that hinders some other institutional type or types. Figure 2 shows one such example. The figure includes two positively reinforcing interdependencies between markets and cultural behaviors. Markets build risk-taking behavior and self-interested behavior. In turn, both of these behaviors improve the performance of markets. Implicit in the diagram is an assumption that risk taking behavior does not impact other institutions, but that self-interested behavior does. It reduces the efficacy of democracies which benefit

[6]Relatedly, countries that rely primarily on market institutions may promote individualism and produce generalized, as opposed to reciprocal trust (Alesina and Giuliano 2015).

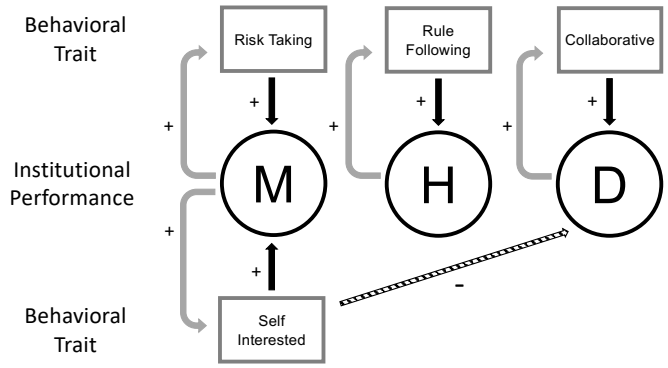

Figure 2: Negative Spillovers from Markets through Self-Interested Behavior

from people exhibiting other regarding behaviors.

To make the negative spillover even more explicit, one might draw a similar diagram linked to Hofstede's (1980) cultural dimensions and replace self interested with individualism and replace collaborative with collectivism. Hofstede considers these traits as in opposition. A person can be individualist or collectivist. If markets make people more individualist, they necessarily make people less collectivist.[7]

Generic Capacity Building

Last, we consider the possibility that institutions could build *generic* civic capacity. Here, we have in mind something like trust in institutions generally as shown in Figure 3. In the diagram shown, democracy builds trust which then improves the performance of all three institutional types. This could happen through the production of common knowledge of beliefs in the institutions—you know that I know that you trust the law (Chwe 2003)—a foundation of the rule of law. Trust could also be built through other-regarding preference creation (Bowles 1998). People who care about one another may be more likely to trust one another. If trust in the law leads to trust in contracts, property rights, and trust that other people will keep promises, then markets and hierarchies would also benefit from the trust built by democracies.

In the diagram, only democracies build generic trust. Markets and hierarchies do not. We are not

[7]Again—these assumptions are intended to be suggestive only.

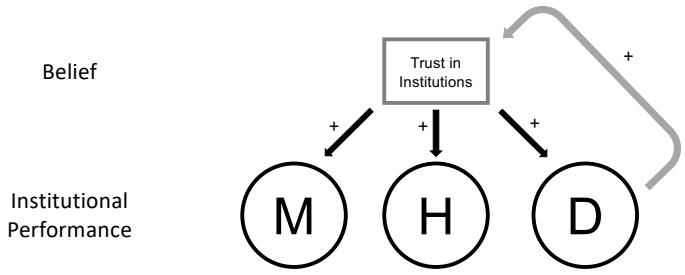

Figure 3: An Example of Generic Cultural Capacity Building

making an empirical claim that this is the case. In fact, one of our early mathematical results will assume that all three types of institutions build generic cultural capacity. For example, markets build dyadic trust relationships through exchange of goods and services. Those relationships may well be robust across institutional types. Trust in a market setting would extend to trust in nonmarket settings.[8]

To be clear, we do not intend for these three types of interdependencies to be exhaustive. Cultural capacity has many components. These diagrams show just a few, and they oversimplify institutions. Markets, hierarchies, and democracies can all take many forms. But any empirical treatment would have to consider the interdependence of cultural capacity with the particular features of institutions. Ostrom (1990) elaborates design principles for institutions that manage common pool resources.[9] Some of these—notably monitoring and dispute resolution—require significant levels of trust and common knowledge.

2 A Systems Framework

We now describe a framework that models systemic interdependence of cultural features, institutional performance, and selection of future institutional forms. We assume that societies rely on *ensem-*

[8]Evidence supports that claim. Bridging ties across ethnic groups created in markets may reduce ethnic conflict (Varshney 2002).

[9]Ostrom's eight design principles are (1) Clear group boundaries. (2) Match rules to local needs and conditions. (3) Allow modification of rules by the community. (4) Acceptance by external authorities. (5) Monitoring. (6) Graduated sanctions. (7) Dispute resolution. (8)Nested levels of governing.

bles of institutions to allocate resources, establish rights and social order, and make other decisions, that the performance of those institutions depends on levels of *cultural capacity*, and that institutional types build types of cultural capacity. As described in the previous sections, markets may produce relatively self-interested behavior, specialized information, and networks based on resources and information, while democracies may produce other-focused behaviors, generalized information, and networks based on shared interests.

These assumptions imply that institutional choices depend on cultural capacity and cultural capacity depends on institutional choices. A system will be in equilibrium when the culture capacities produced by an ensemble support the institutional choices that comprise the ensemble.

It can be helpful to think of cultural capacity and institutions as operating within a discrete time dynamical system as follows: Imagine that in each period, a new allocative or decision domain arises. A society must choose an institution for that domain. The institutional choice will alter cultural capacity. Those changes in cultural capacity will change the performance of existing institutions and possibly lead to revisiting past institutional choices.

We represent ensembles, E, as probability distributions over a set of N institutional types. These types can represent broad categories such as markets, hierarchies, and democracies, or they can can be more granular and represent matching markets, two-sided auction markets, participatory democracy, or matrix-structured organizations.

An **institutional ensemble**, *$\vec{e} \in E$, is a probability distribution defined over a set of N institutional types.*

We represent cultural capacity as a K dimensional vector. This formalism captures attributes that map into numerical values like trust or even aggregate variables (Inglehart 1997). It could even capture features of networks through statistics such as average degree and clustering coefficients. The formalism may be less adequate for representing toolkits (Swidler 1986) and cognitive conceptions of culture (Dimaggio 1987).

Cultural capacity, *$\vec{c} \in C$ is a k-dimensional weakly positive real valued vector.*

We define the effect of ensembles on cultural capacity levels with a cultural production function.

A **cultural production function**, *$G : E \rightarrow C$ maps institutional ensembles into cultural capacity*

levels.

Institutional choices depend on cultural capacity levels as well as the *context.* Some contexts may be well suited to one type of institution and others suited to other types. Markets perform well at allocating consumer products but are less effective for determining the guilt or innocence of alleged criminals. Hierarchies effectively manage complex production process but do a poor job of choosing vacation destinations for a population.

A **context**, $\theta \in [0,1]^N$, where θ_i denotes the **contextual fit** of institution, i in that context. Contextual fits are drawn from a distribution $\mathcal{F}(\vec{\theta})$.

We can then write expected institutional performance as a function of cultural capacity and context.

An **institutional performance function:** $V : C \times \Theta \rightarrow \Pi$*, where* $\Pi = [0,\infty)^N$ *gives the* performance*,* $(\pi_1, \pi_2, \ldots \pi_N)$*, of each institutional type given cultural capacity levels and contextual payoffs.*

To complete the model, we must specify how institutions are chosen. Populations select institutions based on their performance output.

An **institutional choice rule** $\Gamma : \Pi \rightarrow E$ *chooses a distribution across institutional types as a function of their performance.*

In what follows, we assume that this rule chooses the type with the highest realized type. This may overstate the performance of the mechanisms used to select institutions in the real world. Alternatively, we might assume that types are chosen with probabilities that increase with their relative performances (McFadden 1974).

Given this construction, an equilibrium consists of cultural capacity levels together with an ensemble such that two conditions hold. First, the cultural capacity levels are those produced by the ensemble, and, and second, the ensemble's composition is what would result from the institutional choice rule applied to the cultural capacity levels.

Given a cultural production function, G, an institutional performance function, V, a distribution over contextual fit, $\mathcal{F}$, and an institutional choice function Γ*, a* **cultural-institutional (CI) equilibrium** $(\vec{e^*}, \vec{c^*})$ *satisfies the following conditions:*

(i) $\vec{c^*} = G(\vec{e^*})$

(ii) $e_i^* = \text{Prob}[\Gamma(V(\vec{c^*}, \vec{\theta}) = i \mid \mathcal{F}]$ for $i \in \{1, 2, \ldots N\}$

For convenience, we denote a CI equilibrium by the institutional ensemble, $\vec{e}$, rather than the ensemble, cultural capacity pair.

3 Market, Hierarchy, Democracy Models

We begin with a class of models of three institutional types: *markets, hierarchies,* and *democracies* (Jung and Lake 2011). We denote an ensemble, (c, m, d), by its proportions of markets (m), hierarchies (h), and democracies (d) and cultural capacity with respect to institutional types, (c_m, c_h, c_d), where c_m corresponds to the cultural capacity relevant to markets.

To build intuition, we first assume that the performance of an institution of type i can be written as the product of the relevant cultural capacity and contextual fit, θ_i, which we assume to be drawn from a uniform distribution over the unit interval. Thus, $V_(\vec{c}, \vec{\theta}) = c_i\theta_i$, where θ_i is drawn independently from an i.i.d. uniform distribution on $[0, 1]$.[10] Recall that in each context, the institutional type with the highest realized value is chosen.

Given that this model is symmetric, we can assume that cultural capacity for democracies is highest and for markets is lowest ($c_m \leq c_h \leq c_d$). Our first claim characterizes the likelihood of choosing each institutional type as a function of cultural capacity.

Claim 1 *Assuming a uniform distribution over contextual fit and cultural capacity* (c_m, c_h, c_d)*, with* $c_m \leq c_h \leq c_d$*, the probabilities of choosing institutional types are as follows:*

$$(m, h, d) = \left(\frac{2c_m^2}{6c_h c_d}, \frac{3c_h^2 - c_m^2}{6c_d c_h}, \frac{6c_d c_h - 3c_h^2 - c_m^2}{6c_d c_h} \right)$$

This claim has three straightforward implication. First, if all three types of institutions have identical cultural capacity, then each type will be chosen with equal probability. Second, if there were no cultural capacity for an institutional type, then that type would never be chosen. Third, the expected performance of institutions can be written as follows:

Corollary 1 *Given an ensemble* (m, h, d) *that produces cultural capacity* (c_m, c_h, c_d)*, with* $c_m \leq c_h \leq c_d$*, the expected performance of institutions equals:*

[10] Were we to assume a truncated normal distribution, our results would not change qualitatively.

$$\frac{9c_m^3 \; + \; (8c_h - 8c_m + 12)(c_h^2 - c_m^2)}{12c_h c_d} \; + \frac{(c_d^2 - c_h^2)}{2c_d}$$

Notice, consistent with intuition, that increases in the cultural capacity for an institutional type both increases the likelihood that that type of institution is selected, and it increases that institution's overall performance.

3.1 Generic Cultural Capacity

Our next model assumes that markets, hierarchies, and democracies all build generic cultural capacity. We can think of this as trust in institutions or in the rule of law. We further assume that trust is the only component of cultural capacity, and we denote it by c_g.

Institutional performance for each institutional type is given by a *utilization parameter*, λ_i, times c_g. Thus, $(c_m, c_h, c_d) = (\lambda_m, c_g, \lambda_h c_g, \lambda_d c_g)$. Institutions with higher values of λ better leverage trust. Note that that the institutional performance function can be written as follows:

$$V(c, \vec{\theta}) = (\lambda_m \theta_m c_g, \lambda_h \theta_h c_g, \lambda_d \theta_d c_g)$$

where $\lambda_i \in [0, 1]$ for $i \in \{m, h, d\}$.

We also assume that institutional type i produces generic cultural capacity at rate given by a *production parameter* γ_i. Total cultural capacity equals the sum of that produced by the three institutions:$c_g = \gamma_m m^* + \gamma_h h^* + \gamma_d d^*$.

Notice that in a CI equilibrium, the prevalence of each institutional type will depend on the utilization parameters but not on the production parameters. We state this formally in the next claim.

Claim 2 *Assuming one-dimensional generic cultural capacity with production and utilization parameters $\vec{\gamma}$ and $\vec{\lambda}$, with $\lambda_m \leq \lambda_h \leq \lambda_d$ A CI equilibrium can be written as follows:*

$$(m^*, h^*, d^*) = \left(\frac{2\lambda_m^2}{6\lambda_h \lambda_d}, \; \frac{3\lambda_h^2 - \lambda_m^2}{6\lambda_h \lambda_d}, 1 - \frac{3\lambda_h^2 + \lambda_m^2}{6\lambda_d \lambda_h} \right) \qquad c_g^* = \gamma_m m^* + \gamma_h h^* + \gamma_d d^*$$

This result, though clear within the model, merits emphasis. Institutions are chosen based on how well they perform which is determined by how effectively they *utilize* cultural capacity. Choices do not take into account how much cultural capacity an institution *produces*.

The **production-utilization trade-off***: Choosing institutions involves a trade-off between selecting those that best utilize cultural capacity and those that are more effective at producing it.*

The *production-utilization trade-off* implies that if in each context the highest performing type of institution is chosen, then we should not expect equilibrium ensembles to be efficient. We prove this formally later.

Cultural capacity production does matter for expected performance, as shown in the next claim.

Corollary 2 *Assuming one-dimensional cultural capacity with production and utilization parameters* $\vec{\gamma}$ *and* $\vec{\lambda}$*, the expected performance of a CI equilibrium* $(m*, h^*, d^*, c^*)$ *equals:*

$$(\gamma_m m^* + \gamma_h h^* + \gamma_d d^*) \left(\frac{9\lambda_m^3 \ + \ (8\lambda_h - 8\lambda_m + 12)(\lambda_h^2 - \lambda_m^2)}{12\lambda_h \lambda_d} \ + \frac{(\lambda_d^2 - \lambda_h^2)}{2\lambda_d} \right)$$

Recall that in each context, society chooses the institutional type that maximizes performance. An implication of Claim 2 is that a CI equilibrium ensemble does not depend on the production parameters. It follows that the equilibrium will only maximize expected performance in rare cases.

Corollary 3 *Assuming one-dimensional cultural capacity with production and utilization parameters* $\vec{\gamma}$ *and* $\vec{\lambda}$*, the institutional type that produces the highest performance need not maximize the performance of the ensemble.*

An example suffices to prove the corollary. Suppose that markets produce cultural capacity but that hierarchies do not, $\gamma_m = 1$ and $\gamma_d = 0$, and that in a context a hierarchy produces higher performance than either a market or a democracy but that the performance of the market is arbitrarily close to that of the hierarchy. Choosing a market improves the performance of every other institution by an amount equal to γ times the production parameter of that institution. Thus, if the performance difference between markets and hierarchies is sufficiently small, the market would be the better choice.

3.2 General Self-Reinforcing Interdependence

We now return to the case of self-reinforcing interdependence described earlier. The assumption here is that each institutional type builds cultural capacity that makes its type, and only its type, more effective. A special case of this was shown in Figure 1 in which markets promoted risk-taking, hierarchies promoted rule following and democracies promoted collaborating.

We distinguish among three types of ensembles: *homogeneous ensembles* in which all institutions are of the same type; *equal representation ensembles* in which all three types of institutions are equally likely and *type predominant ensembles*, where one institution is more prevalent than the other two, and those two exist in equal proportions.

Initially, we assume that all institutional types build cultural capacity according to the same function. We can then state a result characterizing conditions for equal representation and homogeneous ensembles to be stable ECI equilibria. If increases in an institutional type do not produce much cultural capacity for that institution, that is if $G'()$ is small, then the equal representation ensemble will be an equilibrium. If, on the other hand, $G'()$ remains large even when all institutions are of one type, then only the homogenous ensembles will be stable.

Claim 3 *Assume that each institutional type builds cultural capacity only for its own type according to the same function* $(G(m), G(h), G(d))$ *where* G *is weakly concave, differentiable, nonzero and* $G(0) = 0$*, then the following hold:*

(i) the equal representation ensemble is a stable CI equilibrium if and only if

$$G'\left(\frac{1}{3}\right) < G\left(\frac{1}{3}\right)$$

.

(ii) homogeneous ensembles are stable CI equilibria if and only if

$$2G(1) > G'(0)$$

So that we can derive explicit comparative statics results, we restrict attention to specific family of convex cultural production functions: $G(m, h, d) = (m^\beta, h^\beta, d^\beta)$ where $0 \leq \beta \leq 1$ for which proportional cultural capacity building, $(\beta = 1)$, is a special case. The parameter β is key to what follows. At $\beta = 0$, institutional performance does not depend on the ensemble's composition, so only the equal representation ensemble will be a CI equilibrium. For small values of β, a small amount of cultural capacity for any institutional type will be sufficient for the institution to perform at near full efficacy. For example, if $\beta = 0.05$, then if only ten percent of institutions were markets, markets would still perform at 90% percent of their full efficiency. However if $\beta = 1$, and only ten percent of institutions were markets, the markets would only perform at 10% percent of their full efficiency. We will therefore

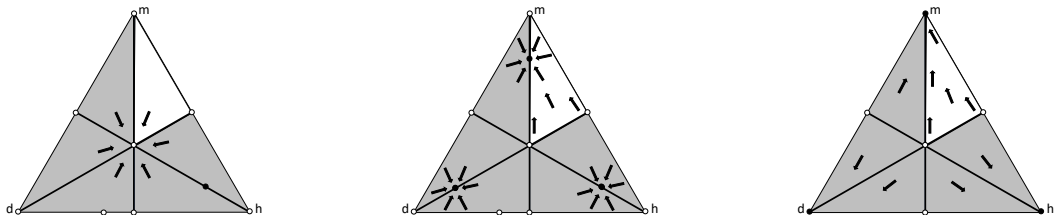

Figure 4: Dynamics for Low, Moderate, and High Sensitivity to Cultural Capacity

refer to β as the *sensitivity* to cultural capacity. When β is high, institutions are sensitive to reductions in cultural capacity.

Claim 4 characterizes CI equilibria as a function of the parameter β. When institutions are insensitive to cultural capacity levels, all institutions have equal representation. When sensitivity exceeds a threshold, $\beta > \frac{1}{3}$, the equal representation ensemble is no longer a stable equilibrium and three equilibria emerge, each with a single dominant institution. In the limit, as the cultural production function for each institutional type equals the proportion of institutions of that type, the only equilibrium consist all institutions of the same type.[11]

Claim 4 *If* $G(m,h,d) = (m^\beta, h^\beta, d^\beta)$*, the following hold:*

(i) If $\beta < \frac{1}{3}$*, the* equal representation ensemble *is the unique stable CI equilibrium.*

(ii) if $\beta \in (\frac{1}{3}, 1)$*, the CI equilibria ensembles include* institution predominant ensembles*:* $\{(x,x,y),(x,y,x),(y,x,x)\}$ *where* $y > x$*, satisfies* $3y^\beta \cdot (1-y)^{1-\beta} = 2^{1-\beta}$

(iii) if $\beta = 1$*, the* homogeneous ensembles*:* $\{(1,0,0),(0,1,0),(0,0,1)\}$ *are the only stable CI equilibria.*

Note that as β increases, that is as institutions become more sensitive to cultural capacity levels, the proportion of the dominant institution increases.[12]

Figure 4 shows the dynamics and equilibria for three levels of sensitivity (β). Imagine that the initial distribution of an institution exists in the white region. If sensitivity to cultural capacity is low, as shown in the left-most diagram, the equilibrium does not depend on the initial distribution. If we

[11] In dynamical systems theory, this is known as a *pitchfork bifurcation*. A graph of the equilibria as a function of β consists of a single line up to the threshold, and then it splits into multiple prongs resembling a pitchfork.

[12] The proportion converges to one as β approaches one, so the system has no discontinuity.

think of institutional choices accumulating over time as contexts are added, this would mean no path dependence.

In the middle and right diagrams, the path of institutional choices would matter. Early in the process of constructing an ensemble, each institutional choice has a large effect on the composition. If, as shown, markets were to perform well in initial contexts (the white region), the ensemble will be predominantly or entirely markets. These two cases on the right therefore exhibit *early path dependence* (Page 2006) and eventually *lock-in* to an equilibrium (David 1985).

In the previous model with generic cultural capacity-building, equilibria were inefficient because the production and utilization of cultural capacity need not align. Here, each institutional type builds the desired type of cultural capacity. If democracies predominate, then choosing democracies builds the cultural capacity that improve their performance. This would seem to produce efficient ensembles. However, as shown in the next claim, while all of the CI equilibria are stable, only the homogeneous and equal representation ensembles maximize expected performance.

Corollary 4 *If* $G(m, h, d) = (m^{\beta}, h^{\beta}, d^{\beta})$*, the only stable CI equilibria that maximize expected performance are the homogeneous ensembles and the equal representation ensembles.*

In the proof, we show that the institution predominant CI have too much institutional diversity. Performance would be even higher if more of the dominant institutional type were chosen. This occurs because each new dominant institutional type creates cultural capacity used in all of the other contexts that rely on that institutional type.[13]

We next analyze a situation in which one type of institution produces cultural capacity at a higher rate than the others. This could occur if advances in information technology enable people operating within markets to construct larger, more efficient networks. We suppose that cultural capacity for markets increases by a multiple, $\Delta > 0$. The equilibrium proportion of markets in the market dominant ensemble increases by a function of this multiplier because of an amplifying loop. Markets are more efficient, making them more prevalent, which in turn makes them more efficient. However, as stated

[13] To see why this is the case, note that a homogeneous ensemble's single institutional type has a cultural capacity level of one, implying that the ensemble has an expected realized payoff of one-half. For moderate sensitivity, equilibria ensembles produce relatively low levels of cultural capacity for the non-dominant institutions. For the case of $\beta = \frac{1}{2}$, the democracy dominant ensemble equals $(\frac{1}{6}, \frac{1}{6}, \frac{2}{3})$, producing cultural capacity levels of approximately 0.4 for markets and hierarchies and of approximately 0.8 for democracies. If given a new context, the contextual fit of democracy exceeds one-half, a democracy will be chosen, and the expected performance will equal 0.6. Conditional on the contextual fit of democracy being less than one-half, each institution is equally likely to be chosen, so the expected performance equals 0.3. This situation can be treated as if all three types have cultural capacity of 0.4. The best of three draws of contextual fit has an expected value of $\frac{3}{4}$. The average of 0.3 and 0.6 is less than one-half.

in the claim, contrary to what might be thought, the extent of the increase decreases in the level of sensitivity to cultural capacity, β.

Claim 5 *Let* $G(m, h, d) = ((1 + \Delta)m^{\beta}, h^{\beta}, d^{\beta})$*, the proportion of markets in the market dominant equilibrium,* m_{Δ} *satisfies the following equation:*

$$\frac{2^{1-\beta}}{3(1+\Delta)^{\beta}} = 3(1 - m_{\Delta})^{1-\beta} m_{\Delta}^{\beta}$$

implying that m_{Δ} *increases in the cultural capacity multiplier,* Δ*, and that the magnitude of the increase decreases in* β*.*

The decreasing marginal effects on the proportion of markets as a function of sensitivity requires some unpacking. The amount of the decrease correlates inversely with the increase in the effect of the multiplier. Thus, increasing the multiplier has more of an effect when sensitivity increases. However, the right hand side of the equation becomes more concave as sensitivity increases. This means that as sensitivity increases so does the proportion of markets. Markets have fewer contexts in which to expand. These two effects dominate. Therefore, higher levels of sensitivity produce smaller increases in the equilibrium proportion of markets holding the size of the cultural capacity multiplier fixed.

This can be seen Figure 5. The horizontal access represents the proportion of markets. The origin of the graphs corresponds to the diverse ensemble. The dashed line corresponds to the value of the left hand side of the equation in the baseline case ($\Delta = 0$). The grey line shows the value of the left hand side given a cultural capacity multiplier for markets ($\Delta > 0$). The addition of the cultural capacity multiplier produces a downward shift because the left hand side equals a constant times the inverse of the multiplier effect. Note that the relative effect size increases in the level of sensitivity.

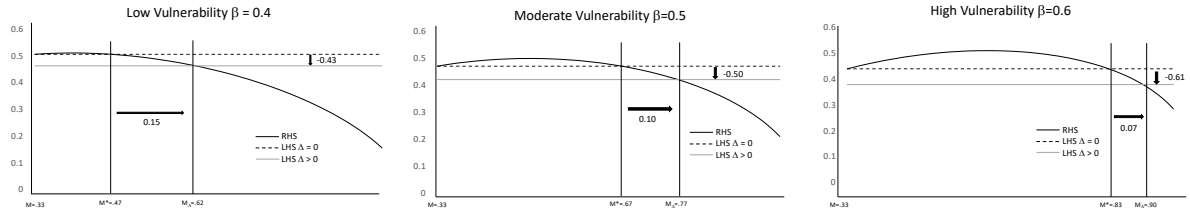

Figure 5: A Market Multiplier has Larger Effect for Low Sensitivity Cultural Capacity

The solid black curve corresponds to the right hand side of the equation. As sensitivity increases,

the curve becomes more concave as a function of the proportion of markets. This occurs because the marginal benefit of adding more markets from the diverse ensemble increases. And, as already shown, the equilibrium proportion of markets (in the market dominant equilibrium) increases in sensitivity. As evident from the figure, for higher levels of sensitivity, the term on the right hand side has a steeper slope, implying that a decrease in the proportion of markets produces a larger decrease in value. The change in slope is sufficiently large that, on net as shown by the horizontal arrows, the change in the proportion of markets in equilibrium *decreases* rather than increases as institutions become more sensitive to cultural capacity.

3.3 Self-Reinforcing Cultural Capacity with a Democratic Spillover

We now extend the previous model to include an assumption that democracies build a one-dimensional cultural capacity, in the form of trust in contracts that markets and hierarchies can utilize but that democracies cannot, as shown in Figure 6.

We assume linear production and utilization of trust in contracts. Borrowing our earlier notation, we assume that democracy builds this type of cultural capacity at rate $\gamma_d \in [0, 1]$. To make the closed form solutions more interpretable, we assume proportional positively reinforcing cultural capacity, i.e. $\beta = 1$.

For low levels γ_d, the democracy predominant CI equilibrium exists. However, once the production parameter, γ_d, exceeds a critical threshold, the democracy predominant equilibrium collapses, as shown in Figure 7. Above the critical threshold, the only equilibria consist of entirely hierarchies or entirely markets. This is an extreme form of the production-utilization tradeoff.[14]

Claim 6 *(Paradox of Cultural Capacity Building) If* $G(m, h, d) = (m+\gamma_d d, h+\gamma_d d, d)$*, where* $\gamma_d \in (0, 1]$*, then there is a critical value* $\bar{\gamma_d} = (2 - \sqrt{3})$*, such that if* $\gamma_d < \bar{\gamma_d}$*, there exists a democracy predominant equilibrium. If* $\gamma_d > \bar{\gamma_d}$*, the only stable equilibria are homogenous ensembles consisting of markets or hierarchies. At* $\bar{\gamma_d}$*, the proportion of democracies equals* $\frac{\sqrt{3}}{2}$*, which implies a collapse of the the democracy predominant equilibrium.*

Though the paradox of cultural capacity building calls to mind the democratic backsliding literature (Flores and Nooruddin 2016, Levitsky and Ziblatt 2018), the logics differ in two ways. First, the

[14] The logic underlying this collapse differs from that of democratic backsliding (Flores and Nooruddin 2016, Levitsky and Ziblatt 2018). Democratic institutions become less prevalent not because they are less efficient. In fact, they become more efficient, but relatively less effective when compared with other institutions.

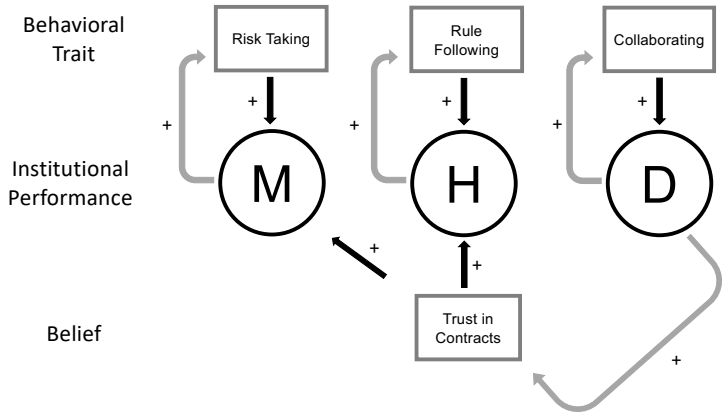

Figure 6: Positively Reinforcing and Democratic Cultural Capacity Building

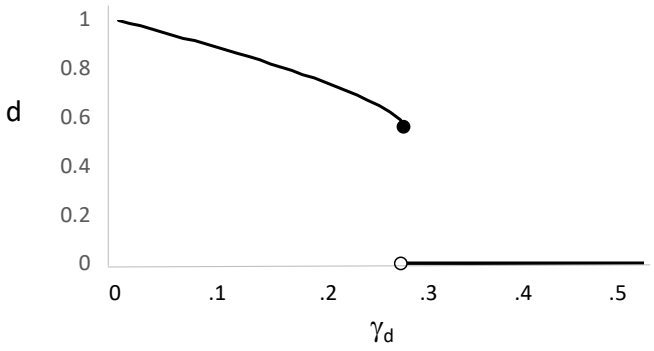

Figure 7: Collapse: Democratic Collapse From Positive Cultural Capacity Spillover

logic of the paradox applies to any institutional type that builds significant cultural capacity for other types. We make no special claim that it might only apply to democracies. Second, the paradox of cultural capacity building arises because (by our assumptions) democracy builds capacity for the other institutional types. Democratic institutions become less represented because other institutions become relatively more effective In democratic backsliding, democracies become less effective in an absolute sense.

4 Market, Hierarchy, Democracy, Community, and Algorithm Models

Assuming only three types of institutions limits the complexity of systems we can consider, so we now extend our framework to include two other types of institutions: *self-organized communities* and *algorithms*. We will use these models to show two implications of complementary cultural capacity building. On the one hand, complementarities between democracies and self-organized communities can prevent the collapse of democracies. On the other hand, complementarities between markets and algorithms could lead to the demise of democratic institutions.

In the two models that follow, we denote an ensemble as a probability distribution over five types of institutions, (m, h, d, s, a), and assume self-reinforcing cultural capacity building for each institutional type.

Complementarities Between Democracies and Self-Organized Communities

Our first model adds complementary capacity building between democracies and self-organized communities and directional cultural capacity building from democracies to markets. These assumptions are consistent with democracies and self-organized communities building other-regarding preferences and democracies building trust in contracts.

We write the cultural production function as follows: $G(m, h, d, s, a) = (m + \lambda d, h, d + \lambda s, s + \lambda d, a)$. We assume a single parameter λ so that the complementary and directional cultural capacity building have similar magnitude.

This construction does not imply that the proportion of democracies and self-organized communities are equal in equilibrium. There exists an equilibrium in which democracies predominate and equal

proportions of self-organized communities and markets. Such an equilibrium arises because self-organized communities and markets both utilize cultural capacity generated by markets. As λ, the magnitude of cultural capacity building increases, the proportions of markets and self-organized communities increase and the proportion of democracies decreases. However, in this case, collapse does not occurs. The complementary between democracies and self-organized communities produces a smooth decrease in the proportion of markets as shown in the next claim.

Claim 7 *$G(m, h, d, s, a) = (m + \lambda d, h, d + \lambda s, s + \lambda d, a)$, there exists a CI equilibrium of the form*

$$(m, 0, d, s, 0) = \left(\frac{3\lambda}{6 - 3\lambda}, 0, \frac{6 - 9\lambda}{6 - 3\lambda}, \frac{3\lambda}{6 - 3\lambda}, 0\right)$$

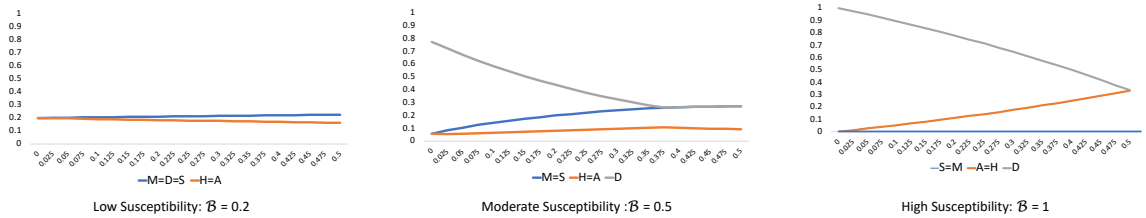

Figure 8: Complementary Cultural Capacity Building with a Positive Democratic Spillover

The graph on the right of Figure 8 plots the democracy and self-organized community predominant equilibrium as a function of λ for proportional self-reinforcing cultural capacity building. As is clear from the graphs, the presence of self-organized communities prevents the collapse but not the demise of democracies.

Adding Complementarities Between Markets and Algorithms

We now emend the previous model in two ways. First, we add in complementary cultural capacity building between markets and algorithms. Second, we include moderate positive cultural capacity building spillover from democracies to hierarchies.

We motivate the first assumption because algorithms and markets both promote self interest over other regarding preferences. The second assumption would hold if democracies build generalized trust or a belief in the rule of law.

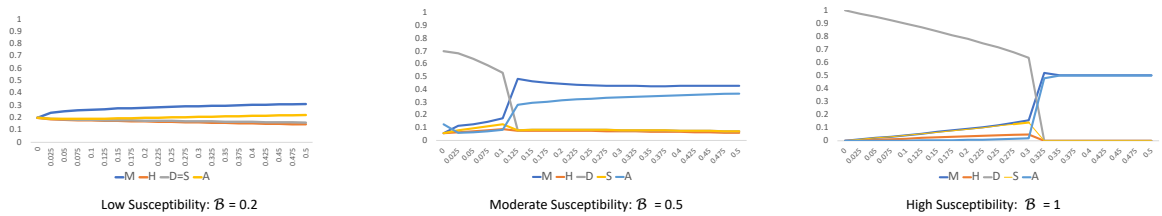

Figure 9: Market-Algorithm Complementarities and Democracy Directional Effect on Markets

$$G(m,h,d,s,a) = (m^{\beta} + \lambda(d+a), h^{\beta} + \frac{1}{2}\lambda d, d^{\beta} + \lambda s, s^{\beta} + \lambda d, a^{\beta} + \lambda m)$$

As this model is more complicated, we do not derive formal results and instead only show numerical results. These can be seen in Figure 9 for low, moderate, and high sensitivity to self-reinforcing civic capacity. Here, we find that the directional complementarity between markets and algorithms produces a dramatic decrease in the proportion of democracies and self-organized communities unless institutions are not sensitive to cultural capacity. For the case of proportional self-reinforcing capacity, this occurs at $\gamma = 0.3$. Below that level of complementary and directional cultural capacity building, the democracy predominant CI equilibrium ensemble consists of over 60% democracies. At $\gamma = 0.325$, almost no democracies exist in equilibrium. What happens is that the complementarity between markets and algorithms bootstraps the directional effect from democracies to markets.

5 Discussion

In this paper, we have constructed a framework to explore the interdependence between institutional ensembles and cultural capacity. In our framework, cultural capacity consists of a mixture of institutionally relevant aspects of culture including beliefs, networks, behavioral repertoires, norms and preferences.

Our analysis builds on a theoretical literature that emphasizes positive feedback for institutional types that operate through cultural capacity. We can thus expect market dominated societies comprised of self-interested actors along with societies that rely on communities that encourage collectivist behaviors. Positive feedback generally implies both sensitivity to initial conditions and path dependence. Early institutional choices or cultural features lead some societies to one equilibrium and other societies to another.

Our framework allows us to consider other types of interdependencies, including generic cultural capacity building, and to derive broader implications. First, we find that equilibria will not generally be efficient because there is no reason to expect that the utilization and production of cultural capacities will align.

We also derive a counterintuitive result, the *paradox of cultural capacity building*, in which positive spillovers plus self-reinforcing capacity building can produce the collapse of the institutional type that produces the positive spillovers. The collapse that occurs in the model would likely unfold more slowly in the real world because institutional switches occur at a relatively slow time scale. Nevertheless, the fact that the system produces a phase transition is still important, because it describes how an increase in trust-building by democracies could, in the long run, stop the spread of democratic institutions. More troubling, the average performance of institutions would fall.

We also construct models that expand beyond the traditional set of markets, hierarchies, democracies and include self-organized communities and algorithms. This allows us to study the effects of complementary spillovers between pairs of institutions. We found that complementarities between communities and democracies built upon other-regarding behaviors and beliefs could prevent democratic collapse, but that complementarities between markets and algorithms based upon individualist behaviors and specialized knowledge acquisition could lead to democracy's demise.

We make no empirical claims based on these models. These models are meant to introduce a systems perspective into the study of institutions. That said, we believe that this approach can be helpful in making sense of data by providing alternative hypotheses. Data that show a reduction in democratic institutions or a decline in democracy-specific cultural capacity could be the result of systems effects. The rise of other institutional types, possibly algorithms, that better leverage trust could be the proximate cause. What appears to be democratic decline might instead be a rising tide of all institutional forms in which democracies perform relatively worse.

A systems perspective produces other implications that we do not explore here. For example, marginal improvements in existing institutions to improve allocative efficiency without an awareness of the effects of those modifications on cultural capacity may not be beneficial in the long run. What looks good at the margin may be bad for the system.

That insight may be particularly germane considering that advances in technology lower transactions costs in favor of market based and algorithmic institutions (Davis 2017). If those institutions do not build the types of cultural capacity that enable democratic and community based institutions to thrive, then

technological advances could, in part, undermine democracies and collectives. Algorithms and markets would come to predominate not because they are inherently more efficient but because they encourage self-interested behaviors along specialized knowledge. If so, the past need not be predictive. Claims that government hierarchies outperformed the private sector at developing innovative technologies rest on no cultural effects shifting that calculus (Mazzucato 2021). Markets might now be more efficient at large projects, such as rocket building and space exploration, but this does not imply that government-run bureaucracies lack the potential to be more effective than the private sector were we to build the cultural capacity.[15]

Last, institutions are not castles built in the air but cathedrals resting on civic foundations. Institutions rely upon and produce cultural capacity, and we must consider that as an output. The United Nations Sustainable Development Goals include over two-hundred indices. Many of these overlap with what we call cultural capacity. Levels of education, gender equality, and access to work all influence how well institutions perform. To the extent that institutional choices include these goals, they may achieve a win-win by both advancing goals and building the cultural capacity that enables institutions designed for other goals to perform better. Choosing or designing institutions without considering cultural capacity spillovers runs the risk of building Escher staircases in which a sequence of apparently upward steps produce an ever downward sloping path (Harstad and Selten 2016).

[15] Though we describe the framework as applying to countries or regions, it applies as well to large organizations which also include a variety of institutional types. A university may decide on tenure democratically, assign offices within a hierarchy, and allocate the use of conference facilities through a market. A for-profit business might let the market determine wages, make promotion decisions within a hierarchy, and rely on informal norms among employees for making personal vacation decisions.

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7 Proofs

Proof of Claim 1: All realized values lie in the interval $[0, c_d]$. A market can be selected only if both democracies and hierarchies have realized values in the interval $[0, c_m]$. These occur with probabilities c_m/c_h and c_m/c_d respectively. Conditional on those holding, each institution is chosen with equal probability. Therefore, the probability of selecting a market equals $\frac{1}{3}$ times the product of c_m/c_h and c_m/c_d. This also equals the probability of choosing a hierarchy or democracy in the interval $[0, c_m]$. A hierarchy with value in the interval $(c_m, c_h]$ can be chosen provided the realized value of the democracy is not in the interval $[c_h, c_d]$. If the democracy has a realized value in the interval $[0, c_m]$, the hierarchy is chosen for sure. If the democracy has a realized value in the interval $(c_m, c_h]$, the hierarchy is chosen with probability one-half. Straightforward calculations give the result.

Proof of Corollary 1: All institutional types yield realized values in the interval $[0, c_m]$. We can partition this interval into three intervals $[0, c_d]$, $[c_d, c_h]$, and $[c_h, c_m]$. If the realized value lies in the first of these intervals, then all three institutions must have produced realized values in this interval. This occurs with probability $\frac{c_d^2}{c_h c_m}$. The proof is as follows. Democracies always produce realized values in this interval. Hierarchies and markets do with probabilities $\frac{c_d}{c_h}$ and $\frac{c_d}{c_m}$ respectively. Given the assumption of a uniform distribution on potential outcome values, it follows that the expected value of the best of the three realized values in this interval will equal $\frac{3c_d}{4}$. Therefore, the contribution to expected realized value from the first interval equals

$$\frac{3c_d^3}{4c_h c_m}$$

The realized value comes from the interval $[c_d, c_h]$ if both the market and the hierarchy produces realized values in this interval or if one produces a realized value in this interval and the other produces a realized value in the interval $[0, c_d]$. The first of these events has probability $\frac{(c_h - c_d)^2}{c_h c_m}$ and produces an expected payoff of $\frac{2(c_d + c_h)}{3}$. The probability that the market produces a realized value in the first interval and the hierarchy produces a realized value in the second interval equals $\frac{c_d}{c_m} \cdot \frac{(c_h - c_d)}{c_h}$. If this event occurs, only one draw from the second interval occurs, so the expected value of that draw equals $\frac{(c_d + c_h)}{2}$. Using the same argument, the probability that the hierarchy produces a value in the first interval and the market produces a realized value in the second interval equals $\frac{(c_h - c_d)}{c_m} \cdot \frac{c_d}{c_h}$. This also has expected value $\frac{(c_d + c_h)}{2}$. Therefore, the contribution to expected realized value from the second interval equals

$$\frac{(c_h - c_d)^2}{c_h c_m}\frac{2(c_d + c_h)}{3} + \frac{(c_h - c_d)}{c_m}\frac{c_d}{c_h}\frac{(c_d + c_h)}{2} + \frac{(c_h - c_d)}{c_m}\frac{c_d}{c_h}\frac{(c_d + c_h)}{2}$$

Which simplifies to

$$\frac{2(c_h - c_d)(c_h^2 - c_d^2)}{3c_h c_m} + \frac{(c_h^2 - c_d^2)}{c_m c_h}$$

Finally, if the realized value comes from the interval $[c_h, c_m]$, then it must come from a market. This occurs with probability $\frac{(c_m - c_h)}{c_m}$ and has an expected realized value of $\frac{c_h + c_m}{2}$ implying a contribution to expected realized value equal to the following:

$$\frac{(c_m^2 - c_h^2)}{2c_m}$$

Summing the contributions from the three intervals gives the following expression:

$$\frac{9c_d^3 + (8c_h - 8c_d + 12)(c_h^2 - c_d^2) + 6c_h(c_m^2 - c_h^2)}{12c_h c_m}$$

Proof of Claim 2: The cultural capacity for institutions of type i equals λ_i times the level of capacity c_g. The result follows from Claim 1.

Proof of Corollary 3:. The performance of institutional type i equals c_g times the product of θ_i and λ_i. Therefore, we can factor out c_g. The result follows from corollary 1.

Proof of Claim 3:

Proof of part (i): To prove stability for the equal representation ensemble, we first consider the case in which a single type of institution has increased in proportion . Without loss of generality, assume that democracies has increased to $\left(\frac{1}{3} + 2\epsilon\right)$, which implies that the proportion of markets and hierarchies have each reduced to $\left(\frac{1}{3} - \epsilon\right)$. From claim 1, the proportion of markets equals

$$m = \frac{G(\frac{1}{3} - \epsilon)^2}{3G(\frac{1}{3} - \epsilon)G(\frac{1}{3} + 2\epsilon)}$$

This simplifies to

$$m = \frac{G(\frac{1}{3} - \epsilon)}{3G(\frac{1}{3} + 2\epsilon)}$$

Using Taylor series expansion, it suffices to show:

$$\frac{G(\frac{1}{3}) - \epsilon G'(\frac{1}{3})}{3G(\frac{1}{3}) + 6\epsilon G'(\frac{1}{3})} > \left(\frac{1}{3} - \epsilon\right)$$

Multiplying through and ignoring higher order terms gives:

$$G(\frac{1}{3}) - \epsilon G'(\frac{1}{3}) > G(\frac{1}{3}) + 2\epsilon G'(\frac{1}{3}) - 3\epsilon G(\frac{1}{3})$$

Cancelling and rearranging terms gives $G(\frac{1}{3}) > G'(\frac{1}{3})$. Alternatively, suppose that the proportion of markets decreases by 2ϵ and the proportion of democracies and hierarchies increases by ϵ. It then suffices to show

$$\frac{G^2(\frac{1}{3} - 2\epsilon)}{3G^2(\frac{1}{3} + \epsilon)} > (1 - 2\epsilon)$$

Using Taylor series expansion, it suffices to show:

$$\frac{G^2(\frac{1}{3}) - 4\epsilon G(\frac{1}{3})G'(\frac{1}{3})}{3G^2(\frac{1}{3}) + 6\epsilon G(\frac{1}{3})G'(\frac{1}{3})} > \left(\frac{1}{3} - 2\epsilon\right)$$

This simplifies to:

$$\frac{G(\frac{1}{3}) - 4\epsilon G'(\frac{1}{3})}{3G(\frac{1}{3}) + 6\epsilon G'(\frac{1}{3})} > \left(\frac{1}{3} - 2\epsilon\right)$$

Multiplying through and ignoring higher order terms gives:

$$G(\frac{1}{3}) - 4\epsilon G'(\frac{1}{3}) > G(\frac{1}{3}) + 2\epsilon G'(\frac{1}{3}) - 6\epsilon G(\frac{1}{3})$$

Cancelling and rearranging terms also gives $G(\frac{1}{3}) > G'(\frac{1}{3})$.

Proof of part (ii): To prove stability for the homogeneous ensemble, we assume a perturbation from the ensemble consisting of entirely markets, $(0, 0, 1)$, to the ensemble with a proportion ϵ of hierarchies $(0, \epsilon, 1 - \epsilon)$. To prove stability, it suffices to show the proportion of hierarchies decreases:

$$\frac{G(\epsilon)}{2G(1 - \epsilon)} < \epsilon$$

Using Taylor series expansion and the fact that $\hat{G}(0) = 0$, it suffices to show:

$$\frac{\epsilon G'(0)}{G(1)+2\epsilon G'(1)} < \epsilon$$

Rearranging terms and ignoring higher order terms yields $G'(0) < 2G(1)$.

Proof of Claim 4:

(i) The equal representation ensemble is an equilibria by claim 1. From claim 3, let $G(i) = i^{\beta}$.. The necessary and sufficient condition can then be written as $\beta(\frac{1}{3})^{\beta-1} < (\frac{1}{3})^{\beta}$. Multiplying both sides by $(\frac{1}{3})^{1-\beta}$ gives $\beta < \frac{1}{3}$.

(ii) To derive the general form of the institution predominant equilibrium ensembles, we consider the democracy predominant ensemble (m_d, h_d, d_d), where $m_d = h_d < d_d$. It follows that

$$(m_d, h_d, d_d) = \left(\frac{m_d^{\beta}}{3d_d^{\beta}}, \frac{h_d^{\beta}}{3d_d^{\beta}}, 1 - \frac{m_d^{\beta}}{3d_d^{\beta}} - \frac{h_d^{\beta}}{3d_d^{\beta}},\right)$$

Solving for m_d gives $m_d^{1-\beta} = \frac{1}{3d_d^{\beta}}$, which implies

$$m_d^{\beta} = \left(\frac{1}{3}\right)^{\frac{\beta}{1-\beta}} \left(\frac{1}{d_d}\right)^{\frac{\beta^2}{1-\beta}}$$

Substituting this into the expression for d_d gives

$$d_d = 1 - \frac{2}{3}\left(\frac{1}{3}\right)^{\frac{\beta}{1-\beta}} \left(\frac{1}{d_d}\right)^{\frac{\beta^2}{1-\beta}} \left(\frac{1}{d_d}\right)^{\beta}$$

rearranging terms gives

$$\frac{2}{3}\left(\frac{1}{3}\right)^{\frac{\beta}{1-\beta}} = (1-d_d)d_d^{\frac{\beta}{1-\beta}}$$

raising both sides to the power $(1-\beta)$ gives

$$2^{1-\beta} = 3(1-d_d)^{1-\beta}d_d^{\beta}$$

Recall that $\beta \in (\frac{1}{3}, 1)$. The left and right side are equal at $\dot{d} = \frac{1}{3}$. The right hand side increases in d but reaches a maximum at $d_d = \beta$, where it takes the value $3\beta^{\beta}(1-\beta)^{(1-\beta)}$. If $\beta < 1$, then the left hand side exceeds one. Given the right hand side converges to zero, there will be an equilibrium $d_d \in (\frac{1}{3}, 1)$.

Proof of Corollary 4: We first derive first order necessary conditions for the democracy dominant ensemble (m_d, h_d, d_d) to maximize expected payoff. From corollary 1, we can write the expected performance in the general case as follows:

$$\frac{9c_m^3 \ + \ (8c_h - 8c_d + 12)(c_h^2 - c_m^2)}{12c_h c_d} \ + \frac{(c_d^2 - c_h^2)}{2c_d}$$

Given that $c_m = c_h$, the expected realized value equals $\frac{c_m^2}{4c_d} \ + \frac{c_d}{2}$. We ca thus write the expected performance as

$$\frac{m_d^{2\beta}}{4d_d^{\beta}} + \frac{d_d^{\beta}}{2}$$

Setting $m_d = \frac{(1-d_d)}{2}$ gives the following expression:

$$\frac{(1-d_d)^{2\beta}}{2^{(2+2\beta)}d_d^{\beta}} + \frac{d_d^{\beta}}{2}$$

If suffices to maximize the following expression:

$$\frac{(1-d_d)^{2\beta}}{d_d^{\beta}} + 2^{(2\beta+1)}d_d^{\beta}$$

Taking the partial derivative with respect to d_d gives the first order necessary condition:

$$\frac{-2d_d^{\beta}\beta(1-d_d)^{2\beta-1} + \beta d_d^{\beta-1}(1-d_d)^{2\beta}}{d_d^{2\beta}} + 2^{(2\beta+1)}\beta d_d^{\beta-1} = 0$$

Dividing by β and simplifying gives:

$$\frac{-2d_d(1-d_d)^{2\beta-1} + (1-d_d)^{2\beta}}{d_d^{\beta+1}} + 2^{(2\beta+1)}d_d^{\beta-1} = 0$$

Which reduces to the following::

$$\left(\frac{2d_d}{1-d_d}\right)^{2\beta-1} - \frac{(1+d_d)}{4d_d} = 0$$

Given that $d_d > \frac{1}{3}$, the term inside the first parenthesis strictly exceeds one and the term inside the second parentheses is strictly less than one. Therefore, if $\beta \geq \frac{1}{2}$, the right hand side is strictly greater than zero, which implies that performance increases in d. This implies that the homogeneous ensemble

maximizes expected payoff.

For $\beta < \frac{1}{2}$, we first multiply both terms in the first order necessary condition by $4d_d$ to obtain:

$$2^{2\beta+1} d_d^{2\beta} \left(\frac{1}{1-d_d}\right)^{2\beta-1} - (1+d_d) = 0$$

Recall that d_d satisfies the following expression:

$$d_d^{\beta} = \frac{1}{3}\left(\frac{2}{1-d_d}\right)^{1-\beta}$$

Which implies that

$$d_d^{2\beta} = \frac{1}{9}\left(\frac{2}{1-d_d}\right)^{2-2\beta}$$

Substituting this back into the first order necessary condition gives the following:

$$\frac{8}{9}\left(\frac{1}{1-d_d}\right) - (1+d_d) = 0$$

This implies $\frac{8}{9} = (1-d_d^2)$ and that $d_d = \frac{1}{3}$, which proves that no interior institutional dominant equilibrium can be payoff maximizing. Last, we consider the equal representation ensemble $(m, h, d,) = (\frac{1}{3}, \frac{1}{3}, \frac{1}{3})$. equilibrium ensemble must be the equal representation ensemble. We have just shown that this satisfies the first order necessary condition. However, to prove that this is a maximum, second order sufficient condition must hold:

$$2^{2\beta+1}(2\beta) d^{2\beta-1}\left(\frac{1}{1-d}\right)^{2\beta-1} - 2^{4\beta} d^{2\beta}\left(\frac{1}{1-d}\right)^{2\beta-1} - 1 < 0$$

Rearranging terms gives:

$$2^{2\beta+1}\left(\frac{d}{1-d}\right)^{2\beta-1}\left[2\beta + \frac{(2\beta+1)d}{1-d}\right] - 1 < 0$$

Evaluating at $d = \frac{1}{3}$ gives $(3\beta - \frac{1}{2}) < \frac{1}{4}$, which is equivalent to $\beta < \frac{1}{4}$ which completes the proof.

Proof of Claim 5: Denote the market dominant equilibrium ensemble by $(m_\Delta, h_\Delta, d_\Delta)$, with $m_\Delta > \frac{1}{3}$. It follows that

$$(m_\Delta, h_\Delta, d_\Delta) \;=\; \left(1 - \frac{2}{3}\frac{d_\Delta^\beta}{[(1+\Delta)m_\Delta]^\beta}, \frac{d_\Delta^\beta}{3[(1+\Delta)m_\Delta]^\beta}, \frac{d_\Delta^\beta}{3[(1+\Delta)m_\Delta]^\beta}\right)$$

Solving for d_Δ gives:

$$d_\Delta^{1-\beta} = \frac{1}{[3(1+\Delta)m_\Delta]^\beta}$$

Which implies

$$d_\Delta^\beta = \left(\frac{1}{3}\right)^{\frac{\beta}{1-\beta}} \left(\frac{1}{(1+\Delta)m_\Delta}\right)^{\frac{\beta^2}{1-\beta}}$$

Substituting this into the expression for m_Δ gives

$$m_\Delta = 1 - \frac{2}{3}\left(\frac{1}{3}\right)^{\frac{\beta}{1-\beta}} \left(\frac{1}{(1+\Delta)m_\Delta}\right)^{\frac{\beta^2}{1-\beta}} \left(\frac{1}{(1+\Delta)m_\Delta}\right)^{\beta}$$

rearranging terms gives

$$\frac{2}{3}\left(\frac{1}{3}\right)^{\frac{\beta}{1-\beta}} \;=\; (1-m_\Delta)\left((1+\Delta)m_\Delta\right)^{\frac{\beta}{1-\beta}}$$

raising both sides to the power $(1-\beta)$and rearranging terms gives the equilibrium equation:

$$\frac{2^{1-\beta}}{3(1+\Delta)^\beta} \;=\; 3(1-m_\Delta)^{1-\beta} m_\Delta^\beta$$

Implicit differentiation shows that m_Δ increases in Δ and that the rate of increase decreases in β.

Proof of Claim 6:. We first derive the threshold on γ_d for there to exist an equilibrium of the form $(\frac{1-d^*}{2}, \frac{1-d^*}{2}, d^*)$ with $d^* > \frac{1}{3}$. At such an equilibrium, the following equations must hold:

$$m^* \;=\; h^* = \frac{1}{3}\frac{\frac{1-d^*}{2} + \gamma_d d^*}{d^*} \qquad d^* \;=\; 1 \;-\; \frac{2}{3}\frac{\frac{1-d^*}{2} + \gamma_d d^*}{d^*}$$

Setting $m^* = \frac{1-d^*}{2}$ and multiplying both sides of the first equation by $6d^*$ gives $3(d^* - d^{*2}) = 1 - d^* + 2\gamma_d d^*$ which can be rewritten as $0 = 3d^{*2} - (4 - 2\gamma_d)d^* + 1$. This equation has real roots if and only if $4\gamma_d^2 - 16\gamma_d + 4 \geq 0$, which implies that $\gamma_d \leq (2 - \sqrt{3})$. The equilibrium proportion of democracies equals $d^* = \frac{4 - 2\gamma_d - 2\sqrt{\gamma_d^2 - 4\gamma_d + 1}}{6}$. At the threshold value for γ_d, the proportion of democracies equals $\frac{\sqrt{3}}{2}$, implying a discontinuous shift in the equilibrium set.

To prove that there cannot exist an equilibrium of the form $(\frac{1-d^*}{2}, \frac{1-d^*}{2}, d^*)$ with $d^* < \frac{1}{3}$, note that at such an equilibrium, the following equations must hold:

$$d^* = \frac{1}{3}\frac{d^*}{m^* + \gamma_d d^*} \qquad m^* = h^* = \frac{1}{2} - \frac{1}{6}\frac{d^*}{m^* + \gamma_d d^*}$$

The first equation can be rewritten as $(3m^* + 3\gamma_d d^*) = 1$, which if $m > \frac{1}{3}$ implies $d^* = 0$. It follows from the proof of corollary 3, that the equilibrium $(\frac{1}{2}, \frac{1}{2}, 0)$ is unstable. Finally, any equilibrium of the form (m^*, h^*, d^*) with $m^* > h^* \geq d^*$ must satisfy

$$d^* = \frac{1}{3}\frac{d^*}{m^* + \gamma_d d^*} \qquad h^* = \frac{1}{2}\frac{h^* + \gamma_d d^*}{m^* + \gamma_d d^*} - \frac{1}{6}\frac{d^*}{m^* + \gamma_d d^*} \qquad m^* = 1 - d^* - h^*$$

which from above has $d^* = 0$. It follows that $h^* = \frac{h^*}{2m^*}$, which given $h^* < m^*$, implies a unique solution at $(1, 0, 0)$.

Proof of Claim 7: We consider an equilibrium of the form $(m, 0, d, s, 0)$ with $m = s < d$. This implies that $c_m = m + \lambda(1 - 2m)$ and $c_d = 1 - 2m + \lambda m$. In equilibrium:

$$m = \frac{1}{3}\frac{m + \lambda(1 - 2m)}{1 - 2m + \lambda m}$$

Rearranging terms gives $(6 - 3\lambda)m^2 - 2(\lambda + 1)m + \lambda = 0$. This has real roots $\frac{3\lambda}{6-3\lambda}$ and $\frac{2}{3}$. Only the first root is feasible. It follows that the equilibrium has the form $(\frac{3\lambda}{6-3\lambda}, 0, \frac{6-9\lambda}{6-3\lambda}, \frac{3\lambda}{6-3\lambda}, 0)$