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Abstract

Recent years have seen major political crises throughout the world, and foreign policy analysts nearly universally expect to see rising tensions within (and between) countries in the next 5–20 years. Being able to predict future crises and to assess the resilience of different countries to various shocks is of foremost importance in averting the potentially huge human costs of state collapse and civil war. The premise of this paper is that a transdisciplinary approach to forecasting social breakdown, recovery, and resilience is entirely feasible, as a result of recent breakthroughs in statistical analysis of large-scale historical data, the qualitative insights of historical and semiotic investigations, and agent-based models that translate between micro-dynamics of interacting individuals and the collective macro-level events emerging from these interactions. Our goal is to construct a series of *probabilistic scenarios of social breakdown and recovery*, based on historical crises and outcomes, which can aid the analysis of potential outcomes of future crises. We call this

approach—similar in spirit to ensemble forecasting in weather prediction—*multipath forecasting* (MPF). This paper aims to set out the methodological premises and basic stages envisaged to realize this goal within a transdisciplinary research collaboration: first, the statistical analysis of a massive database of past instances of crisis to determine how actual *outcomes* (the severity of disruption and violence, the speed of resolution) depend on *inputs* (economic, political, and cultural factors); second, the encoding of these analytical insights into probabilistic, empirically informed computational models of societal breakdown and recovery—the *MPF engine*; third, testing the MPF engine to "predict" the trajectories and outcomes of another set of past social upheavals, which were not used in building the model. This "historical retrodiction" is an innovation that will allow us to further refine the MPF technology. Ultimately our vision is to use MPF to help write what we call "a history of possible futures," in which the near- and medium-term paths of societies are probabilistically forecast.

Introduction

Can we model and forecast the dynamics of social breakdown and recovery, or society's resilience to internal and external shocks? The major research challenge in answering this question is that social breakdown results from multiple interacting factors: economic, political, cultural, and emotional. An approach that ignores any of these dimensions is bound to fail. Furthermore, these collective processes operate on multiple levels: from slow structural changes in economy and culture to faster-moving influences that affect the passions and actions of individuals.

We propose a new holistic approach to societal forecasting that builds upon recent breakthroughs in statistical analysis of large-scale historical data, the qualitative insights of historical and semiotic investigations, and agent-based computational models that translate between micro-dynamics of interacting individuals and the collective macro-level events that emerge from these interactions, such as social crisis and breakdown. Our goal is to construct a series of *probabilistic scenarios of social breakdown and recovery*. We call this approach—similar in spirit to ensemble forecasting used in numerical weather prediction—**multipath forecasting (MPF)**.

We can develop MPF, first, by statistically analyzing past instances of crisis to determine how actual *outcomes* (the severity of disruption and violence) depend on *input* factors (economic, political, and cultural). The second stage is to encode these analytical insights into a suite of probabilistic, empirically-informed mathematical and computational models of societal breakdown, recovery, and

resilience—the *MPF engine*. Third, we can use the MPF engine to "predict" another set of past societies' trajectories/outcomes, which were not used in building the model. This "historical retrodiction" will allow us to further refine the MPF technology. Ultimately, the vision of MPF is to help write what we call "a history of possible futures," in which the near- and medium-term paths of societies are forecast probabilistically by utilizing a massive set of relevant observable quantitative *inputs* (structural trends, environmental influences, and collective decisions).

The study of the processes that undermine social resilience has long suffered from the split between "the two cultures" (Snow 1959): humanities and science. However, we are now in a position to bridge this gap by measuring not just demographic and economic trends, but also public sentiments, such as moral outrage, resentment, fear, hope, and enthusiasm which flourish—implicitly or explicitly—in political visions, fill mainstream and social media, and fuel social protest. We will draw on recent literature pointing to the importance of levels of cooperation, trust, and feelings of (in)justice in explaining both social crisis and renewal (Witoszek 2013; Turchin 2016; Witoszek 2018; Witoszek and Midttun 2018). We can identify and study these narratives, images, and habits, which influence broad-based social cooperation, or conversely, foster partisan or polarizing agendas. In this sense, we propose a "holistic" approach to understanding and modeling the resilience/fragility of social systems, which investigates economic trends, power dynamics, cultural influences, and individual passions. Only a "disciplinary fusion" can lead to a better understanding of the linkage between micro-behaviors and emergent macro-effects.

In essence, MPF uses a combination of qualitative and quantitative data-analytic approaches, bridging "thick" historical and semiotic descriptions of past societies with "big" data techniques applying cutting-edge statistical and dynamic modeling procedures to large datasets of historical information, while explicitly linking micro-level behavior of individuals with macro-level dynamics of societies in distress (Thurner 2011). This will allow us to boost the understanding of the factors undermining or strengthening social stability, and how they (in combination) determine the likelihood of breakdown. The long-term longitudinal data will enable us to identify and empirically validate these factors, as well as their possibly relevant combinations (Turchin 2018).

The Challenge of Societal Prediction

Obviously, the track record of prophets and thinkers, from Nostradamus to Fukuyama, does not inspire confidence in the possibility of historical prediction. Forecasting social upheavals, outbreaks of political violence, and revolutions is particularly challenging (Cederman and Weidmann 2017). There are several reasons why historians, economists, and social scientists have so far been unable

to provide convincing, reliable *foresight* into global trajectories of social development, and especially in predicting internal conflict.

Revolutions are complex, emergent, collective processes driven by a combination of structural and transient forces alongside individual agency (Goldstone 2002). There is a large body of recent research focusing on transient forces and changes in individual behaviors that lead to mass protests and revolutions (Granovetter 1978; Kuran 1989; Macy 1991; Heckathorn 1993; Marwell and Oliver 1993; Oliver 1993; Lohmann 1994; 1995; Yin 1998; Centola 2013). This work on "micro-foundations" and research on the structural causes of revolutions (Skocpol 1979; Goldstone 1991; Turchin 2012) have developed largely independently of each other. Furthermore, most approaches studying the micro-foundations of collective behavior treat individuals as self-interested rational agents who choose the course of action yielding the greatest material benefit (Becker 1978; Elster 1999). Most predictive work, thus, overlooks how the internalized cultural norms and values of different groups within a society—known in sociology as *habitus* (Bourdieu and Nice 1977)—shape interactions between different groups in society, especially between elites and non-elites, and how a change or rupture of social norms governing the political discourse often precedes the outbreaks of violence that accompany societal breakdown.

There is a recent rich, but separate scholarly literature drawing attention to the importance of "irrational" motives: the "geopolitics of emotions," the "culture of fear," "cultures of resentment," and "schools of hate" (Moisi 2010; Nussbaum 2016; Mishra 2017; Davies 2018; Furedi 2018). Finally, while there is an abundance of approaches asking why and how societies slide into a revolution or civil war, the opposite dynamics—emergence from crisis and re-establishment of social order and communal cohesion—has been relatively neglected (Goldstone 2002: Chapter 5).

Further, since the classic work (Epstein 2002) there has been impressive computational progress in quantifying (Clauset et al. 2007) and modelling social unrest (Braha 2012). However, many agent models focus on reproducing stylized facts about social dynamics and not (yet) on systematic predictive understanding of the prerequisites for social unrest. So far agents have not yet been modeled with regard to realistic emotional/psychological features, nor have they been placed within a sufficiently realistic sociocultural context.

Previous work, thus, has been conducted largely by political theorists, policy analysts, sociologists, historians, and computational modelers who worked in isolation from each other with focused, domain-specific data sources. Separately, they all offer intriguing insights and have produced important discoveries, but ultimately each can provide only one piece of the puzzle. The critical next step, which has yet to be attempted in large-scale, systematic manner, is to fit these different disciplinary research strains together into a single, coherent, theoretical framework (Turchin et al. 2017). Indeed, any successful tool/framework for

estimating the risk of state breakdown needs to integrate the study of macro- and micro-levels of social unrest. Similarly, understanding and formulating informed responses to nascent crises should draw on an empirical knowledge of processes that enable societies to recover from crises. Such integration should include structural components, transient and emergent forces, and deeply entrenched cultural traditions, as well as the complex web of interrelationships and network interactions of individuals within social systems.

Building the MPF Engine

A central process that we aim to measure/quantify and model is the dynamics of social cooperation; that is, the level of cooperative social practices and values in a society opposed to the dominance of partisan, or polarizing agendas. Important contributors to this dynamic are changes in the perception of justice/equality and generalized trust (and its opposite, distrust). The study of cooperation/equality/trust dynamics crosscuts all the methodological approaches in MPF: (1) in the historical-semiotic exploration of specific case-studies; (2) in the historical database of social collapse and recovery; and (3) in computational agent-based models that will investigate factors that trigger changes in emotions and perceptions, e.g. from a phase of general trust toward a phase of trust evaporation, and vice versa. Here is a more detailed explanation of the three approaches.

In-depth Comparative Case-studies Investigating Emotive and Narrative/Mythic Drivers of Social Breakdown and Cohesion

The first objective is to forge our analytical framework by investigating the anatomy of collapse and recovery in a small subset of eight case-studies. This phase of the project will examine key factors highlighted by Structural-Demographic Theory (Goldstone 1991, Turchin 2003), among others, focusing on macro-level demographic and economic trends. But we are particularly interested in how these processes interact with *habitus*—cultural dispositions, values and practices that affect social cooperation, trust, and sense of justice. *Habitus* (Bourdieu and Nice 1977) is neither a sole result of free will, nor determined by structures, but is created by the interplay between the two. In the language of complexity science, it is an *emergent* property. The concept of *habitus* is similar to the special definition of *culture* used in the new discipline of Cultural Evolution (Brewer et al. 2017): socially transmitted information that influences human behavior. In addition to the role of economic factors provoking social disruption we will highlight often under-researched cultural accelerators of social unrest and renewal.

Witoszek's pioneering historical semiotics, which has yielded high-impact comparative studies of Ireland, Poland, Sweden, Norway and Germany, offers a good starting point and sheds new light on the role of cooperation in forging sustainable modernity in the Nordic countries (Witoszek et al. 1990; Witoszek and Trägårdh 2003; Witoszek 2018; Witoszek and Midttun 2018). Notably, Witoszek's

method allows for identifying a "cultural program" in a given society and thus prefiguring social responses to new challenges. Our primary focus is on European and North American societies (Germany, Austria, Italy, England, Poland, Ireland, Norway, and the US) and on two historical eras (mid-19th-century revolutions and civil wars and the turbulent 1910s–1930s). We shall define the elite-driven "vocabulary of crisis and renewal," i.e. rhetorical ploys, narratives, and behavioral patterns, which influence cooperation or sectarianism, trust or distrust, and thus fuel conflict or forge sustainable recovery. This approach will enable us to answer questions such as: why did the stresses of the 1920s and 1930s result in the rise of fascism in some countries (Germany and Italy most famously), but lead to very different outcomes in others (Norway and the USA)? Each case-study will comprise a century-long period with the focal episode of social turbulence—a revolutionary situation—at its mid-point. This long-term, historical approach will enable us to investigate how each society entered into crisis and then emerged from it, and how a sustainable "normality" returned (if it did). This will be, as far as we know, the first attempt to formally model *habitus* together with demographic and economic structures in a single theoretical framework. This theoretical advance, we believe, will be for predictive and retrodictive social science what the development of unified climate science was for comparable advances in weather forecasting.

A Massive Database of Social Collapse and Recovery

Building on the insights from the first phase, we propose to collect a massive amount of information on 200 past societies over the past five centuries that faced some societal crisis. In each case we will trace the long-term dynamics of both entry into a crisis and its consequences (recovery, upheaval, complete breakdown, see Figure 1). Data collection will focus on the key variables or parameters identified through the case-study analysis, including demographic, economic, institutional, and *habitus* data (entrenched cultural narratives, practices and values forging a cooperative or sectarian ethos). We will take a statistically sound sampling approach, encompassing both a global and long-term (longitudinal) view. To accomplish this phase, our team will leverage the considerable experience and methodology developed through work with *Seshat: Global History Databank* (Turchin et al. 2015), one of the most comprehensive history databases on a societal scale. Although the *Seshat* project addressed a different set of questions (how large-scale complex societies arose in human history), it pioneered the use of time-resolved (longitudinal) historical data for empirically testing social and historical hypotheses (Mullins et al. 2018; Turchin et al. 2018; Whitehouse et al. 2018). In MPF, we will use *Seshat* methodology to establish a novel type of historical database, of hitherto unknown scale and comprehensiveness, which will enable us to systematically test hypotheses explaining social resilience and breakdown.
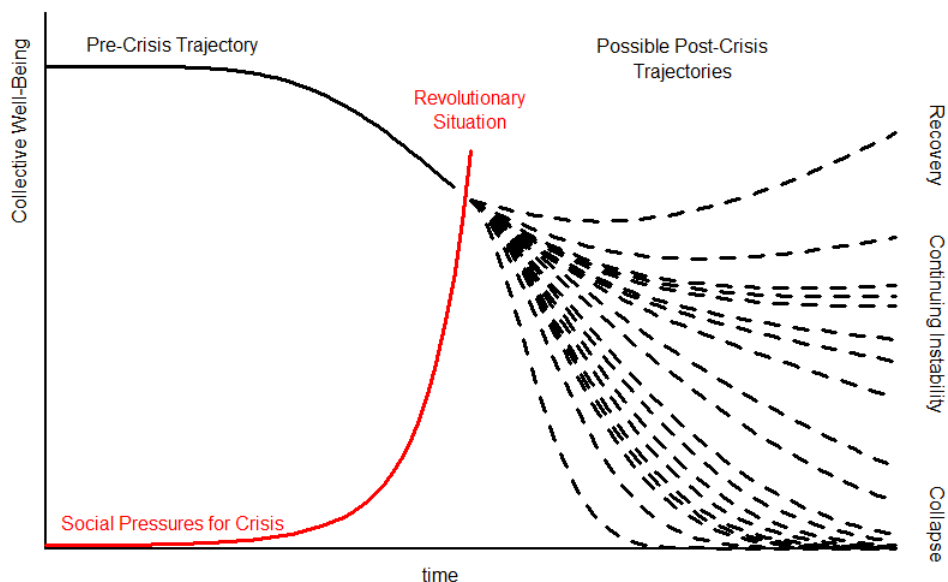
Figure 1. Idealized illustration of the entry into crisis and multipath trajectories following crisis, which range from the most negative (collapse) to most positive (rapid recovery). Black curves trace the dynamics of collective well-being, and the red curve indicates the rise of social pressures preceding crisis. A "revolutionary situation" arises when the state loses its resilience to internal and external shocks and becomes vulnerable to outbreaks of political violence. It is characterized by the proliferation of radical movements and extremist groups and a general climate of violence, but needs a trigger, or a set of triggers, to become an actual revolution, or civil war.

A Socio-computational Approach to Societal Collapse and Recovery

We will use insights about key processes and estimates of parameter values from the empirical approaches (phases 1 and 2) to construct computational agent-based models (ABMs) of individuals; as well as mathematical models of crisis and recovery dynamics operating on a more coarse-grained societal level. Taking advantage of the availability of computing power and progress in statistical and computational methods, it is now, for the first time, possible to build and analyze models of millions of interacting individuals. Pioneering work by Thurner and colleagues (Thurner 2011; Poledna et al. 2018) has demonstrated that these models can be used effectively to assess the complex dynamic interrelationships between individuals and their groups at all different scales. We have previously demonstrated in the context of the financial system that modeling at the individual scale (and taking individual interactions into account) is necessary to understand

system-wide collapse (Thurner and Fuchs 2015; Poledna and Thurner 2016). Using insights into the social mechanisms of crisis and recovery from the empirical analyses, we will construct a series of mathematical models that are able to describe the crisis dynamics and outcomes in the eight in-depth case-studies. We use a multilevel approach, combining micro- and macro-level models. The micro-models will take the form of agent-based simulations involving large numbers of interacting agents and their organizations/institutions. Macro-models operate on coarse-grained variables (averaged and aggregated quantities) that can be directly compared with the data. Typically, the macro-models will take the form of phenomenological non-linear differential equations that link the essential variables (Turchin 2005). The goal is to make the micro-models compatible with the macro-models. In other words, the aggregated results from the micro-model should predict the dynamics of the macro-variables. We will select an extra set of four cases outside Europe that will serve as an "out-of-sample" performance test of the MPF engine.
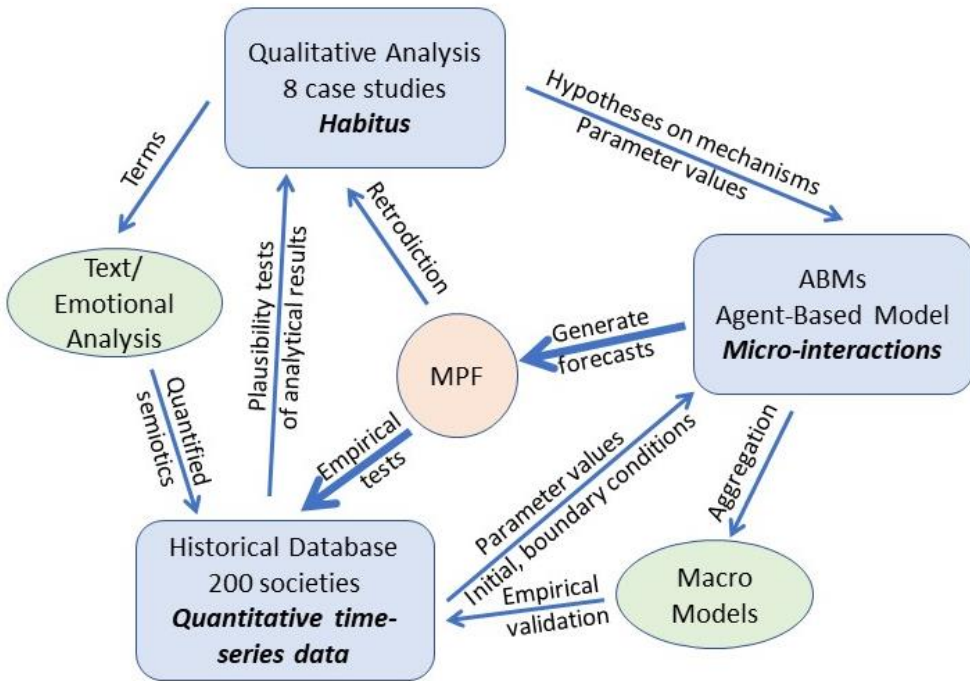
Figure 2. Synergistic interconnections between the various research strands in the MPF project.

Although we have divided the basic goals and approaches of this research initiative into three phases, this was done primarily for strategic convenience and clarity of presentation. As depicted in Figure 2, there is an intimate connection between the three main approaches (boxes), two cross-cutting approaches (ellipses), and the central research objective: multipath forecasting (MPF). The figure illustrates the thick web of feed-forward and feed-back loops between the different methodologies that integrates them into a seamless whole. The two linking approaches, Text/Emotional Analysis (automated analysis of large-scale textual data to quantify the expression of affect, emotional tone, optimism, etc) and Macro-Models (which aggregate micro-interactions into coarse-grained variables that can be compared to data), serve as explicit connectors between the three main ones.

The MPF engine will combine methodology from complexity science (agent-based models, coarse-grained aggregated dynamics, network science, big data analytics) with the insights from the human sciences (history, anthropology, cultural studies). Using an extended set of demographic, economic, political, and semiotic-historical data collected by our interdisciplinary team, we will quantify probabilistically the fragility of social systems and their vulnerability to potential triggers of social collapse. Iteratively working back and forth between models and empirical results, we will systematically develop the MPF engine by testing the assumptions and parameters in our models by "retrodicting" a set of historical cases in our database, using errors or failures to refine the models, and repeating until the predicted high-probability trajectories match the historical data.

The Innovation of MPF

All complex societies, including our own, experience recurrent (long-term) periods of declining sociopolitical resilience and stability, often resulting in systemic social breakdown (Turchin and Nefedov 2009). Previous research by Turchin and coworkers (Turchin 2003, 2013; Turchin et al. 2018) has identified a number of broad "macro-historical patterns" in human history, namely that specific combinations of factors tend to be present in the vast majority of known cases of societal breakdown and crisis. Witoszek (2003, 2018; Witoszek and Midttun 2018) has found that semiotic-emotional clusters are powerful triggers of social breakdown and recovery. Her research shows the potency of metaphors and cultures' founding narratives that have historically influenced levels of cooperation, trust, and perceived injustice. Drawing on her work, we shall ask how culturally significant and emotionally charged stories and practices have been used and abused by elites and politicians, and how they relate to national traditions. What is their power to polarize or unite the community? We shall also build on Witoszek's (2018) research on the catalyzing role of cultural outliers and innovators in the stabilization of chaos and stimulating social recovery. Thurner and collaborators have successfully built a data-driven model with millions of individuals interacting in a modern economic system. The model demonstrated

explicitly the impact of a financial shock on a society's economy (Klimek et al. 2015; Poledna et al. 2018). To move beyond previous work by our team, we need to synergistically combine these simulation methodologies with detailed knowledge of how interactions of people lead to societal patterns, and with longitudinal historical data on hundreds of cases of societal crisis and breakdown.

The novelty of our approach is both methodological and conceptual, and lies in the new way it couples qualitative and quantitative empirical information on past societies. It combines thick description of cultural norms and values that influence social crisis and resilience with big data analytics to detect their actual dynamics in a multitude of cultures. Further, it links micro-social behavior of individuals with collective macro-level societal dynamics. We explicitly incorporate into our mathematical and computational models the mechanisms drawn from sociological, anthropological, and semiotic research about cultural expectations, norms, and values, as well as under which conditions and how these aspects of *habitus* break down. Typically, predictive societal models incorporate only readily quantifiable information concerning financial activity, economic and institutional structures, demography, climate, and environmental or ecological trends (Goldstone et al. 2010; Cumming and Peterson 2017; Messner et al. 2018). However, such a limiting view fails to account for the role played by cultural values and perceptions of (in)justice and social cooperation, even if these traits may be more elusive to measure. Indeed, the often-unwritten expectations that characterize a society are challenged during shocks, and guide—if not constrain or even force—the possible responses of individuals (and factions) to a crisis. As these norms are challenged, the kinds of disruptive collective actions groups undertake escalate, often with increased levels of political violence. Encoding the *habitus* of different social groups into the MPF engine will be key to understanding the multifaceted mechanisms of social breakdown and allowing the emergence of macro-historical patterns from our fine-grained models. This enables our probabilistic multipath forecasting approach to explicitly track the trajectories of groups and coalitions within the society with respect to collective harmonization or collective antipathies in response to various shocks.

A second major innovation of our project is to combine theoretical approaches and massive empirical data sources pitched at multiple scales. Rather than relying on a single modeling approach, as much of previous work, we will develop a *multilevel modeling framework* encompassing two types of models: (1) fine-grained, micro-level (agent-based) models of individual behavior and decisions and (2) more coarse-grained, macro-level models that aggregate individual behaviors into broader economic, social, and cultural variables (incomes, social mobility rates, and moral sentiments held by different factions within the population). Rather than focusing on one or two main causes of social crisis and recovery, our approach emphasizes a systematic application of a comprehensive set of literally dozens of accessible factors and potential causes to determine the

probabilities of different paths the societies might take depending on initial and boundary conditions.

The Feasibility of the Approach

The prediction of possible future trajectories of sociopolitical instability is a very ambitious goal. It is therefore legitimate to ask whether such a goal is achievable, especially given that such predictability has eluded seers, social scientists, and even well-funded government agencies in the past. Karl Popper (1957) argued that a science of history is impossible and, under the influence of poststructuralism, historians have largely abandoned "grand theory" be it in the guise of Marxism, Social Darwinism, or Postmodernism (Darnton 1999).

However, such "grand" qualitative theory is not what we intend to do. Neither do we aim to predict detailed future paths of history, or unique events. Instead, we want to understand which factors (economic, social, cultural, emotional, psychological, group-dynamical), and which combinations of them, create environments where social breakdown is highly likely. Many of these factors change gradually and can be observed with the present availability of data. Data on many of the factors are also available for historical societies, so that the intended "retrodiction" with our computational models should be feasible. Thus, we emphasize the *foresight* in our conception of forecast, because the focus is on scenario exploration rather than on "hard" prediction. Our MPF is an entirely different beast from the data-poor and speculative qualitative and teleological historical narratives that Popper derided as "historicist." We have entered a new research era, characterized by previously unimaginable computational power, readily available or "obtainable" data, and, most importantly, novel conceptual and theoretical tools with which to study complex systems.

Agent-based simulations give us a tool for detailed understanding of why certain conditions (factor combinations) lead to disruptive events. Again, we are not interested in predicting when and how specific events occur, but in the (possibly abrupt) increase in their likelihood, given that certain combinations of factors are realized. We know from our previous work on financial and economic crisis and recovery (Thurner et al. 2012; Klimek et al. 2015) that ABMs play a crucial role in the detailed understanding of the collective mechanisms that emerge from individual behavior in certain environments. We have already demonstrated that we've mastered these modeling techniques on massive scales. The challenge now is to enrich economic agents with realistic emotional and psychological components, which is why the input from cultural historians and semioticians is crucial. This will enable our models to predict collective dynamics of violence outbreaks, from urban riots to popular insurrections. Thurner has used this fact in numerous previous ABMs of collective human behavior: opinion formation (Lambiotte et al. 2007; Klimek et al. 2008), financial investments (Thurner et al. 2012, 2013), organization of human groups (Szell et al. 2010; Fuchs et al. 2014,

2014; Klimek et al. 2015), emergence of cooperation (Thurner et al. 2012), voting behavior (Klimek et al. 2012), and rice farming in Bali (Lansing et al. 2017).

A century ago, the idea of reliable weather and climate forecasting seemed outlandish. Yet today it is a reality—with certain caveats well known to complexity scientists. Agent-based models, coupled with modern data approaches, are powerful tools for visualizing possible futures, and the probability of these futures. Through MPF we can investigate not only the paths illuminated by hard data but also the intended, as well as the unintended, consequences of human actions.

We think that achieving a level of multipath forecasting as envisioned here is analogous to the current predictive ability of earth sciences such as meteorology, climatology, and geology. Combining modern analytic tools with the mutually enriching conversation between the humanities and the natural sciences, the idea of building a forecasting engine for societal breakdown is too tempting to resist. We are convinced that as a result of our attempt to refine sociopolitical forecasting by drawing on deep history through MPF, this project will not only allow us to rethink the discipline of history but will show that it is indeed possible to link the humanities with complexity science to create something radically new: a way of understanding the patterns underlying the dynamics of social conflict and resilience whose recognition can make better sense of the past while informing policy decisions and political choices influencing the future.

Acknowkledgements

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