Approaching the Singularity Behind the Veil of Incomputability: On Algorithmic Governance, the Economist-as-Expert, and the Piecemeal Circumnavigation of the Administrative State

ABIGAIL DEVEREAUX

Email: abigail.devereaux@gmail.com

> Compared with the totality of knowledge which is continually utilized in the evolution of a dynamic civilization, the difference between the knowledge that the wisest and that which the most ignorant individual can deliberately employ is comparatively insignificant. (Hayek, *The Constitution of Liberty*, p. 82).

1. INTRODUCTION

Roger Koppl's admonishment against design in his book *Expert Failure* is a product of the combinatorial richness of the world and the symmetry-breaking properties of time. Time breaks the symmetry of human experience so fundamentally that the concept of progress—what Robert Lucas said is so profound an idea it is hard to think of anything else[1]—is hidden behind it.

Invoking thinkers from Mandeville to Foucault, Koppl's book dances around what is theoretically out of the reach of the expert: the combinatorically rich and the epistemologically asymmetric. Koppl grants no special powers of vision to his experts. The theorists of system share the same limitations, the same myopia as the people about which they theorize. The future unfurls behind a veil of incomputability beyond which entrepreneurs of ideas and men of system can glimpse a small part, but never the entire vista.

Divested of their ivory tower, do we then conclude that experts play no special role in the progression about which they theorize? On the contrary. To understand the true role of the expert demands placing her first within her work, then tightly binding her eyes. Fumbling, entangled, the unidealized expert feebly and fallibly casts rules in the direction in which her expertise lies, no claim to systemic perspectives she does not possess. Doubly-bound, those upon which the unidealized expert seeks to impose her expertise become safer from the pitfalls Koppl assigns to her rule. Rule-making systems, freed from the reign of idealized experts, become less brittle to bias, ignorance, and small-groups influence, and more able to access the political idea of pluralistic democracy. Let's call the latter, the central thesis of Koppl's book, Koppl's Theorem.

Koppl attends his Theorem with a rich array of evidence and argument, including insights from computability theory and creative economics. It is into these areas I wish to more deeply delve, as they describe both in theory and example how modelers try but fail to wrest with the symmetry-breaking properties of time. I seek to extend Koppl's Theorem with a Corollary. Koppl is concerned about where experts tend to rule, the administrative state, and how a strong administrative state can negatively affect pluralistic democracy; he suggests that the piecemeal deconstruction of the administrative state may strengthen pluralistic democracy (Koppl 2018: 15-20). I believe Koppl commits an error of omission in his analysis, one which pits two sets of expert designers against each other: those who wish to increase the power and scope of the administrative state, and those who wish to carefully deconstruct its power to strengthen pluralistic democracy. By extending Koppl's computability argument to the level of algorithmic governance, and inching us all closer to the technological singularity using a framework of open-ended knowledge division, I sketch out a more realistic progression of the administrative state amidst combinatorially explosive economic growth (Koppl et al 2018).

The singularity is the name of a phenomenon coined by Vernor Vinge to mean the rapidly changing socioeconomic state that will accompany the demonstrated exponential increase in computing power known as Moore's Law[2]. Once in the singularity, the story goes, even relatively near-future economic and social states become impossible to predict. Technological cycles, where entire private and public sectors are replaced or made obsolete through technological progression, will get closer together as we approach the singularity. The uncertainty horizon, predictions about what the world will be like in any given context in *T* years but beyond which we cannot say, will get shorter and shorter. Some, like the futurist Ray Kurzweil (2005), say the technological singularity will coincide with the merging of human and artificial intelligence.

At bottom, the technological singularity is a theory of *computability,* namely, of the theoretical limits of physically realizable computers to decide decidable things. Let's shed for a moment the trappings of neoclassical theory and look at people as problem-solvers, in the traditional of Herbert Simon (1996). As we approach the technological singularity, intangible goods like mobile apps that rely mostly on quick calls to massive servers will get cheaper to produce. The intangible goods made cheaper to produce by next-generation technological innovation aren't likely to fit the neat categories of public and private defined by last generation's basket of available goods. What's more likely is that technological innovation in intangible goods will continue to piecemeal-circumnavigate administrative obstacles tailored more traditional products and services, thereby unlocking artificially locked-up value. We've already seen this with the sharing economy (Yaraghi & Ravi 2018), currency that enables extra-legal transactions and avoids state-based manipulation (Dunn 2018), and smart contracts that obviate the role of the state in protecting agreements, particularly in extra-legal markets (Hardy & Norgaard 2015).

> **The Piecemeal Circumnavigation Corollary**: The approach to the technological singularity shall be characterized by a piecemeal circumnavigation of the administrative state rather than the piecemeal deconstruction of the administrative state (as suggested on Koppl 2018: 16). Furthermore, untethering expertise from the administrative state shall unlock the value of extra-public social entrepreneurship.

Two parts are required to demonstrate the reasonableness of the Corollary. The first is to dig deeply into the nature of computability in a complex adaptive open-ended evolutionary social system characterized by individuals and institutions who exploit existing economic and social opportunities and create novel opportunities. Section 2 is our spelunking expedition into computability and the application of what we discover to expert theory. Section 3 deep-dives into the relationship between time, open-ended creative evolution in social systems, and expert theory. Section 4 presents evidence and argument that algorithmic governance harnesses the advantages of increasing computational power in a more agile way when it is allowed to emanate from polycentric (public-private) sources, instead of solely public sources. We also spend some words on the mechanics of piecemeal deconstruction versus piecemeal circumnavigation. In Section 5, we close with a short discussion on what radically subjectivist economists, as experts, should do in the run-up to the technological singularity.

As both Koppl and myself are economists, I am interested in the application of Koppl's Theorem to the economist-as-expert. Fredrich Hayek believed that one of the tasks of economics is to bound the designs of the men of system[3]. If an economist believes his is a science of allocations, he must know the cases for which his methods can reasonably say something about allocative states, but especially, the cases for which his methods *cannot* reasonably say something about allocative states. And similarly, for economists who believe themselves cycle-preventers, growth-promoters, or scientists of human action.

I hope to show in the course of this paper that Koppl's Theorem holds both for traditional kinds of expert rule, and for how expert rule evolves with rapid technological advancements, particularly in computing. I hope to show that the veil of practical incomputability places hard and fast limits on what experts can do even as we vastly extend the ability of people to understand and affect their world. There is no Holy Grail of Data Collection that will suddenly make the impossible possible, which may dash the hopes of some utopian economists (Lange 1972). No expert, no matter how powerful, can see behind the twin veils of time and incomputability.

2. THE COMPUTABILITY OF COMPLEX ADAPTIVE SYSTEMS

The meaningfulness of applying equilibrium theory to macroeconomic trends has long been in question. In Wicksell's *Geldzins and Güterpreise*, the author speculates that his model for stabilizing inflation "does not appear to me to be ripe for methods of precision" when the debate still raged as to in which direction economic processes react to causal factors (Wicksell 1898). Hayek warned of equilibrium's use in macroeconomics, saying that he believes the concept of equilibrium and pure analysis methods "have a clear meaning only when confined to the analysis of the action of a single person," and that economists are "introducing a new element of altogether different character when we apply it to the explanation of the interactions of a number of different individuals" (Hayek 1937: 35).

How and why people act the way they do, and what kind of social arrangements are possible, depend largely on how and what orders erupt spontaneously through time. Orders erupt on several levels, which we call *micro*, *meso*, and *macro*. The micro level consists of ontologically separable components like individuals, groups, and organizations. The macro level consists of trends on outcomes involving the separable components. The meso level is the intermediary layer whereby components entangle through time to produce macro trends such that the process and structure of entanglement are non-decomposable to some simple relationship between the micro components (Dopfer and Potts 2004).

It is notable that neoclassical economic theory has difficulty addressing the meso level, even though analysis at the meso level is as important to explaining and understanding the evolution of individual and social outcomes as the other levels (Dopfer 2007).

We can see the difference between models that traditionally ignore the meso layer and those that incorporate it by looking at the functional mappings between components at the micro level and trends at the macro level described by neoclassical economics. Consider a two-tier representative agent model:

$$\begin{array}{ccc} M(t) & \rightarrow^{h} & M(t+1) \\ \uparrow^{a} & & \uparrow^{c} \\ A_i(t) & \rightarrow^{f} & A_i(t+1) \end{array}$$

At the lower level, representative agent i is at some state $A_i(t)$ at time t. $M(t)$ is the aggregate of the states of all agents i using some kind of metric or statistical measure to represent the states of the agents so that they can be added together. $M(t + 1)$ is the aggregate at time $t + 1$. a, c, f, h are functions that map from either one state to the next, or from level to level.

It is tempting for economists to suppose some model $f(A_i(t)) = A_i(t + 1)$, and some model $c(A_i(t + 1)) = M(t + 1)$ such that changes at the micro level will realize desired changes at the macro level. If the economist believes they can apprehend the effects of both f and c—perhaps using statistical models on data to infer relationships, or by attempting to get at at the functional model forms directly using machine learning techniques—then their route to attaining desired effects at the macro level is $c(f(A_i(t))) = M(t + 1)$, where f is some behavioral intervention at the micro level and c is the change in agent behavior from which the new macroeconomic trend $M(t + 1)$ arises (traditionally, some sort of aggregation). Similarly, we see how $c(f(A_i(t))) = h(a(A_i(t))) = M(t + 1)$.

Note that the above model doesn't explicitly take into account an intermediate structure to economic interactions. There are no other variables, no other functional interactions between individual agents, or between agents and institutions like associations, firms, or political groups.

Let's see how explicitly including a meso level of socioeconomic structure complicates the coherence of neoclassical microfounded macro theory:

$$\begin{array}{ccc} M(t) & \rightarrow^{h} & M(t+1) \\ \uparrow^{j} & & \uparrow^{k} \\ B_i(t) & \rightarrow^{g} & B_i(t+1) \\ \uparrow^{b} & & \uparrow^{d} \\ A_i(t) & \rightarrow^{f} & A_i(t+1) \end{array}$$

Remember that the meso level is where interaction and entanglement occurs, and interest groups, creative organizations, and (endogenous) rules and norms emerge. We can no longer in general say that $c(f(A_i(t))) = h(a(A_i(t))) = M(t + 1)$, for we must first define agent-institution interactions b and d, institution evolution g, and institution-macrostate interactions j and k. We can only do away with the intermediate meso layer if we can reasonably argue that macrostates are reducible to their agent-components. This reducibility would then compress away the intermediate layer, in a sense encoding the intermediate layer in the functional relationships between agent behaviors and macrostates. Is it reasonable, however, to say that macrostates are generally reducible to agent behaviors? Let's recast the argument in terms of levels of complexity, and what we're really doing when we reduce away the meso layer.

Understanding the meso layer isn't just about how to round off statistical errors in linear relationships between micro components and macro trends. The meso layer is where virtually all the work of how people come together to form and reform social systems is done. Acknowledging that social systems are complex adaptive systems is about refocusing economic theory on the complicated, tangled, messy meso. It's about not zooming too far up from the micro level, but just far enough that we can start to see the emergence of structures. It's about an economic theory of clustering, context, cascades, and cycles. Not just in cost and choice.

The complex adaptive nature of social systems becomes even more clear when we think about two recent examples in which traditional prediction in the social sciences failed, and complexity-aware models were more successful at predicting or explaining observed behavior. The first is the cascade of events leading to the Arab Spring, which were unpredicted, and wrongly attributed to democratization except by complexity-aware models (Gard-Murray & Bar-Yam 2015; Parens & Bar-Yam 2017). The second is the herding and patterns of diffusion through banking networks that led to the bank failures that sparked the Great Recession, which were not predicted by widely used dynamic stochastic general equilibrium (DSGE) models, and were better explained by nonlinear, context-aware models (Haldane and May 2011; Helbing and Kirman 2013).

In complex adaptive systems, spontaneously ordered processes are generally *irreducible* to designed mechanisms. This is similar to Hayek's (1964) proposition that the classification of any phenomenon must be conducted by a theoretical apparatus of a higher degree of complexity than the phenomenon[4], and Stephen Wolfram's Principle of Computational Equivalence (2002). Beckage et al (2013) provide a compelling argument that social systems exist at the highest possible level of complexity, moreso than physical and even biological systems.

Generally, spontaneous ordering processes do not reduce to some set of instructions issued to individuals by an expert, policymaker, or some other agent. Instead, macrobehavior consists of overlapping sets of locally informed behavior which do not aggregate but rather interact in complicated ways to produce apparent patterns. Economists therefore need a concept of *systems*.

Systems thinking means looking at a system not just as the sum of its component parts, but as something more. Any social system with more than a few members is an example of a complex adaptive system that is irreducible to its component parts (Miller and Page: 2009). An economic theory based on a direct relationship between individual agents and macroeconomic trends suffers from a fundamental lack of ability to explain and predict the systemic properties of the macroeconomy as a whole; to explain and predict Great Recessions or Arab Springs.

Economists need a language of systemic behavior that is not simply reduced to a composition of individual behaviors. Given that economic decisions in any modern economy involve a combinatorically huge space of possibilities and opportunity costs, it is safe to say that however people make choices, it's likely to be more ecologically than individually rational (Gigerenzer et al 2000; Smith 2003). Economic agents do not choose "as if" they are utility maximizers, either, contra Friedman (1953). For if they did, the macroeconomy as a system would be reducible to its component parts. Even more concerning would be what is left unexplained by such a statement, namely, *what it is people are actually doing to make choices*. Business cycles, technological cycles, the economic effects of climate change, financial cascades, the hockey-stick growth trend—these are the bread-and-butter of economists, and these are the very kind of phenomena general equilibrium theory and "as if" equivalencies have difficulty with.

Design-by-expert also overlooks a concept so compelling that it drastically alters how we believe experts can change our world: undecidability. Economists choose how the transformation $f \circ c{:}A_t \rightarrow M_{t+1}$ realizes "better" outcomes for the agents that make up the system, which requires a measure of what it means for a macrostate to be "better." Call that measure W for "welfare." But there may be instances in which we can't decide if $W(M_{t+1}) \geq W(M_t)$, particularly in the presence of multiple equilibria or cycles[5]. In this case, there is no path $f \circ c{:}A_t \rightarrow M_{t+1}$ such that $W(M_{t+1}) \geq W(M_t)$ defined by this particular measure of welfare.

So, if economists want to build a model of some phenomenon, to reduce it from inscrutably complex reality to a simpler, scrutable form, we need reducibility. If we then wish to alter the state of the phenomenon in a way that positively affects the society within which the phenomenon is housed according to some measure, we need decidability. Computability is the next step: given such a model, can we in principle compute the algorithms $f \circ c$, W that satisfy the conditions laid out above? Furthermore, can we in *practice* compute these algorithms—are $f \circ c$, W constructive, in the sense that they can physically realize the outcomes we are able to prove they can in principle realize?

True physical realization is not a point to scoff at. Even when we in principle prove the existence of a Paretian welfare optimum, we have yet to prove they can exist in practice[6] (see in particular Lewis 1992; Velupillai 2007).

The federal government is one of the largest employers of economists. Whether or not policies created by the economists-as-experts can be practically realized is crucial to validity of policy results. The point of change through political institutions is not to simply muse if it is possible in principle to make the next generation of working-class urbanites better off, it is to create policies informed by experts meant to achieve actual results. Adding uncertainty in—changing unique precise equilibria to rational expectations equilibria—doesn't give one any more juice if the expert assumes, quite realistically, that agents in the model don't have access to perfect information about the entire economic system constituted by the model (Spear 1989).

Koppl (2018: 171-2) is generous with his treatment of computability theory. He introduces the standard notion of Turing computability wherein a computable function is a function that can be emulated by a Turing machine on a (possibly incredibly powerful) computer. Turing machines are simple computational systems that can be envisioned as a rotatable printer head printing along a potentially endless strip of paper, each line determined by the angle of the head and what was printed on the previous line. Universal Turing machines exist that can, in theory, emulate any possible computer program (Turing 1937; Shannon 1956).

Since we wish to talk about computability in this constructive, realizable sense—computability in practice as opposed to computability in principle—we will adopt David Wolpert's (2001) definition of computability: a program is computable if it can be compiled on a computer to complete a task in practice[7]. This means that computability in the Turing sense is not enough, we also require constructivity—the ability to physically realize the computation in question. Furthermore, a phenomenon is computable if a computer can emulate it and make predictions about future states of the phenomenon, i.e., if it can run a program emulating the phenomenon faster than the actual dynamic progression of the phenomenon (Wolpert 2001: 7-8).

Some of the main contributions to the application of computability theory to economics have been in the form of negative results, which imply positive results regarding mathematical methods in economics. Namely, the economist "doesn't attempt to analyze the impossible, or construct the infeasible, and so on" (Velupillai 2017). To say we lack a foundational theory of computable economics isn't to say that we cannot or should not advance the theory. A negative theory of experts, as Koppl's Theorem is—titling his book *Expert Failure* gives that away—advances the idea that a theory of experts needs to firmly embed expert advice, behavior, and influence in a framework that acknowledges all such advice must be implemented in a constructively computable way.

As economists, we must care about computability, because the frontiers of economics and public policy are algorithmic. The paramount concern of an economist-as-expert in an algorithmized world is the computability of their model. This is going to create a burgeoning field of people—social scientists, engineers, programmers, even physicists and mathematicians—whose jobs are to develop computationally solvable social models (Sipser 1997). The need for practical realization will drive complexification, and force developers to abandon incomputable, nonconstructive blackboard models where experts hovered above reality, never touching it.

3. TIME AND THE DIVISION OF KNOWLEDGE BEHIND THE VEIL OF INCOMPUTABILITY

"[T]o acting man the future is hidden. If man knew the future, he would not have to choose" (Mises 1998: 105). Choice is only choice under uncertainty. But what kind of uncertainty, and what do we mean by knowing the future?

Economics is mathematically founded, and as such we can readily answer this question: if our domain is the opportunity space S, and our range is the outcome space O, then choice is defined as a function $f : S \rightarrow O$. "Knowing" the future means there exists an inverse f^{-1} such that if $f(s) = o$, then $f^{-1}(o) = s$. So, choosing man can simply choose his desired outcome o and be able to intuit which s will attain that o. The same is true if we alter the outcome space slightly to be a distribution of expected outcomes. "Knowing" the expected future means there exists an inverse f^{-1} such that $E[f(s)] = o$, then $f^{-1}(o) = f^{-1}E[f(s)] = s$. f needs to be 1-1 for the inverse to be defined.

Epistemological considerations are essentially everything in economic theory, the difference between calculable risk and incalculable uncertainty, the difference between sheer ignorance and error, the difference between knowledge utilized by individuals but stored outside of individual and explicit speculative models meant to guide us from the inception of any goal to its conclusion. The epistemological embeddedness of social theory is central to Koppl's thesis on expert failure.

To help discuss the ways in which epistemological considerations cannot be compressed to given known distributions at the microeconomic level and exogenous randomness at the macroeconomic level, Koppl categorizes types of knowledge to illustrate what experts and individuals claim to know, and can know. Koppl defines SELECT knowledge as "Synecological, EvoLutionary, Exosomatic, Constitutive and Tacit" (Koppl 2018: 120). Synecological refers to knowledge held outside the individual, in groups of other people, or in some other kind of social institution; evolutionary refers to knowledge gained through time; exosomatic refers to knowledge held in objects like smartwatches; constitutive refers to to do something is conveyed in the doing; and tacit refers to knowledge that is inexpressible, yet relevant.

Contrast SELECT knowledge to speculative knowledge, the models scientists and experts form meant to explain the world. Speculative knowledge may be informed by elements of SELECT knowledge, and it may inform how individuals develop their knowledge in certain subjects, but it is the attempted abstraction of knowledge, not knowledge itself.

Synecological and evolutionary knowledge inextricably depend on the movement though time. Synecological knowledge is a kind of knowledge division, and thus enables the division of labor and specialization. Similarly, the cost of obtaining useful knowledge decreases when knowledge is stored in an easily accessible, distributed fashion, thus *adding something extra* to what we get from utilizing distributed knowledge.

People divide knowledge not just because they can't apprehend everything there is to apprehend at any given point of time, but because the sheer movement through time will tend to shrink their knowledge of the world relative to everything there is to apprehend at any given time. This holds even more true for people whose plans are more time-sensitive. When thinking about the work social knowledge division does, it's not enough to simply think of a collection of people taken together, we must also think about how those people are related to each other. By explicitly considering relationships between economic agents, say, by explicitly modeling economic behavior on a social network as in Devereaux and Yuan (2019), we are able to produce quite naturally the "extra stuff" of knowledge division.

This "extra stuff" of knowledge and labor division deserves its own section, as it hints at a concept of the production of novelty from two existing things, or at a creative economics as in Koppl et al (2015). As a way of conceptualizing this "extra stuff" and its importance to an economic theory that has a chance at explaining economic change and growth, let's consider the useful concept of *togetherness*.

Togetherness, as defined by Bob Coecke (2017), is the sense for which two abstract objects produce something novel when put together. $\otimes$ is a familiar symbol from its common use as a tensor product such that if V and W are two different vector spaces, $V \otimes W$ is a new vector space. $\otimes$ in Coecke's definition is more general, such that the symbol represents the "new stuff" we get from bringing two objects A and B together. Notably, in both definitions, the $\otimes$ product between two objects is not equal to the linear decomposition of those objects. In tensor products, we don't just, say, add two three-dimensional spaces and get a six-dimensional space. Instead, we consider all combinations of each dimension, and end up with 3 * 3 = 9 dimensions.

But that new dimensionality is given by a particular mathematical definition of how $V \otimes W$ combine to create new things. There are other ways that two objects can combine to create new things. we can even abstractly define one object as "stuff now" and the other as "movement through time," and express togetherness as a process by which new things are added to some phase space of all things. Koppl et al (2019) produce a "hockey stick" graph whose shape closely reproduces the global economic growth trend from AD 1 by simply explicating how the space of product combinations grows through the addition of new things, then substituting combinatorial growth for technological growth in traditional macroeconomic grow models.

One of the most fundamental ways of producing togetherness, most damning to the man of system, is sheer movement through time. To move through time means to move into the unknown, to gain something unexpected, to lose something ineffable. t progresses to $t + 1$ and, in the process, hatches something new, something that confounds the discovery of the hard-and-fast rules f that correspond with the complicated reality we experience. This is the essence of what we mean by creation, and by a creative universe. Only complex-enough systems—biological systems, ecological systems, man's imagination, man's imagination plus the imaginations of other men (Beckage et al 2013) —have symmetry-breaking properties.

The creative movement through time, such that creation is the addition and subtraction of the as-yet unknown of and outside man's imagination, is what the philosopher Henri Bergson referred to as *durée*.

Henri Bergson was a subjectivist French philosopher, whose philosophy Frank Knight labeled "irrationalistic" (Knight 1964 (1921): 209). As Knight understood it, Bergson's philosophy centered on "real change" in Knight's words, or what Bergson himself called durée. We can understand durée using a simple mathematical example. Consider a typical path function f that takes inputs and produces outputs. In economic theory, paths like f are constructed through a space of economic possibilities, with constraints like an assumed form of the utility function and budget constraints. This space of economic possibilities is known in complexity science as a "phase space," which is "the space of pertinent observables and parameters, within which the system unfolds" (Koppl et al 2015: 2). Path functions that transform continuously through time, often used by economists in growth theory texts to indicate policy functions, operate like so: $\pi(t) / E \rightarrow \pi(t+1) / E$. π is entirely defined over some economic phase space E (like the space of all possible consumption bundles and agents) for all possible values of t. Functions of this sort change through time, but they cannot be said to have *durée*. Durée is better described as the following transformation: $\pi_t (t) / E_t \rightarrow \pi_{t+1}(t+1) / E_{t+1}$ where $|E_{t+1}| > |E_t|$. The functional form π, the value of the form at t, and the phase space E are altered by time's arrow.

Not so "irrationalistic," just not expressible in static neoclassical economics where $\pi(t) / E \rightarrow \pi(t+1) / E$. The open-ended, creative framework can give us insight into theoretical formulations that don't have good representations in neoclassical economics. If we take Hayek at his word, that indeed the division of knowledge is the most central problem of economics (Hayek 1937, 1994), then we must wonder at how we economically experience the gains from the division of knowledge through time. For example, we can use Israel Kirzner's (1997) concepts of ex ante and ex post corrections as a kind of model of knowledge division in our framework. Represent π_t as the knowledge utilized by an economic agent to carry out some plan, and the mapping from ex ante knowledge to ex post corrections to knowledge as $\pi_t(t) \rightarrow \pi_{t+1}(t+1)$. The model an individual uses to make decisions recursively alters through time by means of learning—it "alters when it alteration finds." It is not just reactive to others, who form the field over which the function is defined, but to its own output. We can abstractly represent the generation of Kirznerian "surprise" by some transformation $E_t \rightarrow E_{t+1}$, where $|E_{t+1}| > |E_t|$. When we extend the Kirznerian metaphor for knowledge division from the individual to the system level, we get back our transformation from above: $\pi_t(t) / E_t \rightarrow \pi_{t+1}(t+1) / E_{t+1}$.

4. ALGORITHMIC GOVERNANCE BEHIND THE VEIL OF INCOMPUTABILITY

Algorithms may seem by definition practically computable and therefore suitable tools for conducting social theory. But algorithms are implemented with goals in mind, in particular, as proper means to attain some set of goals. Algorithmic governance is, simply, the increasing reliance by public officials on classifier-type algorithms in public-sector functions like the determination of taxes and benefits, regulatory oversight, and predictive policing (Perry et al 2013). Machine learning like deep learning algorithms and genetic algorithms are examples the kinds of classifier algorithms popular among social scientists.

As of February 2019, searching for "algorithmic governance" on Google Scholar turns up 661 results, 81% of which were published since 2015. The main issue in many critiques of algorithmic governance is reality creation, whereby a bias towards the status quo in algorithmic decision-making results in the realization of that status quo, even if, absent algorithmic decision-making, the status quo may not have persisted (Devins et al 2017; Boracas & Selbst 2016). Machine-learning algorithms used in many algorithmic decision-making procedures are only as accurate as their data, and data collected relevant to social systems tends to be heavily biased towards the status quo (Boracas & Selbst 2016). This results in strange results like the "Jared effect," where an algorithm built to rank CVs concluded that the strongest, most significant indicators of job performance were being named Jared and having played lacrosse in high school (Gershgorn 2018). A famous experiment by Amazon to algorithmically rank hires was scrapped when the algorithm scored an application lower based on the applicant being female (Dastin 2018).

Another issue with algorithmic pattern matching is the plethora of spurious correlations—ghostly patterns that appear to have correlative meaning in any data set, but are not, in fact, linked by some non-random underlying generating process. Calude and Longo (2017) warn against the substitution of correlative methods like classifier algorithms on Big Data for the scientific method. The authors use ergodic theory, Ramsey theory and algorithmic information theory to prove that prediction is generally contraindicated in large-enough data sets (ibid: 601-2), that large-enough data sets will always exhibit at least one highly regular pattern even if they are randomly generated (603-4), and that for an arbitrary correlation function and a large enough data set, we can always find a correlation between some subset of n elements (ibid: 606). Thus, Big Data comes with big challenges; the bigness of data is not a panacea to the problem of developing models of social systems complex enough to be reasonable representations of social phenomena.

Artificial intelligence is not just about pattern matching. The very problem with correlative frameworks, where $Y = aX + e$, is that they lack the asymmetric and often irreversible framework of causality (Pearl & Mackenzie 2018). Causal systems, where $X \rightarrow Y$, have a sense of time baked into them. Could causal inference be a way around the limitations on pattern-matching algorithms? But causal inference suffers from some of the same problems as correlative models when applied to complex adaptive social sciences, particularly the form suggested by Pearl & Mackenzie, that depend on the use of Bayesian belief networks. Cooper (1990) showed that this sort of probabilistic inference is NP-hard, a categorical membership that indicates practical incomputability in general.

From the meta-perspective of how science develops reasonable algebras of questions and answers to those questions, we find ourselves, as social scientists, in a kind of bind. As observed by Ioannidis (2012), "science is not necessarily self-correcting," by which he refers to traditional methods of science like hypothesis-testing. But algorithmic methods on Big Data suffer from their own kind of myopia. Certainly, for economic as a science, we can derive three lessons from our analysis so far: 1) our methods and models should be practically computable, 2) understanding knowledge division requires models where reasoning is asymmetric both within a phasal cross-section of time and evolutionarily, 3) algorithmic methods will not replace failing neoclassical methods and should not be used *on their own* as a magic wand to generate policy in the absence of reasonable backing theories.

However, we are certainly embarking upon an age of algorithms, in public governance and in private service provision. We have demonstrated that algorithmic decision-making is no public policy-making panacea. But we haven't yet discussed the nature of an *ecology* of algorithmic solutions to all kinds of problems, both public and private. The efficacy of a solution is, to paraphrase the physicist Richard Feynman, in whether it tests true or not. Which means that more efficacious solutions are possible in a system which regularly tests the outcomes of algorithms, and especially in one with some kind of endogenous mechanism to alter algorithmic solutions when they are in error.

We can categorize algorithmic solutions as kinds of intangible goods. There are many valuable intangible goods whose cost of production has been traditionally high, like standards of trustworthiness and currency dependability. So high that many justify public production of these intangible goods based on the assumption that whatever private solution might emerge will not service those who want them very well. There are also tangible goods like public transportation that interact strongly with intangible goods like connecting prospective riders with transportation systems that can accommodate them. It's the production of these sorts of intangible social goods in which we are especially interested, and where we derive the Corollary to Koppl's Theorem.

The approach to the technological singularity is characterized by an emergent ecology of algorithmic solutions. These solutions, as we've described above, are constrained by practical computability. They are also enabled by how epistemological togetherness is produced by time and creativity *when they are allowed to take advantage of epistemological togetherness*. The best solutions shall be the solutions that can best exploit the new opportunities that will rush forward in the ensuing combinatorial expansion of the economic phase space. This is when comparative institutional potentialities and drawbacks will come into their sharpest focus.

The institutional realities of public provision tend to exacerbate principal agent problems in innovation, to incentivize budget maximization rather than efficient and competitive use of funds, and to shift funds from research towards rent-seeking. As elaborated upon by Buchanan & Wagner (1999 (1977)), Buchanan & Tullock (1962), and as surveyed in Tollison (1982), there is a tendency in democracies towards redistribution from less to more politically powerful people and groups. Combining these insights with Koppl's Theorem and with the arguments of this paper, we should expect the political realm to be a much less agile innovator of intangible solutions to public goods problems. In addition, the state doesn't have any natural advantage in algorithmic solutions due to its relatively large scope and reach. We've already gone over how increasing the size of data sets comes with complications that do not necessarily improve the accuracy and predictive power of algorithms. So, when intangible solutions to public goods problems start to become feasible, it is reasonable to expect that social entrepreneurs who do not restrict themselves to purely public methods of provision will have an epistemologically competitive edge over purely public channels *given* the burgeoning abundance of new possibilities unlocked by the approach to the technological singularity.

As such, we expect there to be an inevitable piecemeal circumnavigation of traditionally public channels of social goods provision for social goods that are themselves intangible or are greatly enabled by intangible solutions. We are already seeing evidence of this piecemeal circumnavigation. There is the well-known example of how intangible solutions in computation enabled the emergence of the sharing economy by circumnavigating the regulatory burden placed on traditional forms of competition, often as a result of decades of rent-seeking. Despite efforts often initiated by traditional competitors to shut down sharing apps in various places, it's estimated that the sharing economy will unlock 335 billion dollars worth of value by 2025 (Yaraghi & Ravi 2017). Another major example is the development of cryptocurrencies, which could help people protect their investments and circumnavigate bad monetary policies like runaway inflation (Dunn 2018). The risks of engaging in extralegal market activity are being symmetrized through developments in smart contracts, which rely on alterations to a blockchain ledger to track and sometimes manage exchanges (Hardy & Norgaard 2016). Some are proposing smart contracts for legal businesses, too (Comm 2018). The omnipresence of smartphones is unlocking the ability for individuals to better surveil their own homes, protect against unwanted intruders using smart doorbells that automatically upload footage to an app shared by people in the neighborhood (Rubin 2018), monitor babysitters and pet sitters, and record traffic and police incidents using widespread and inexpensive dash cams. And we've only just begun to experience the innovative power of the "third wave" of internet-based technological innovation, characterized by omnipresent ambient technology, perpetual connectedness, and useful artificial intelligence (Ma 2011).

5. WHAT SHOULD ECONOMISTS AT THE EDGE OF THE SINGULARITY DO?

If the approach to the Singularity has the effect of further tipping the balance from fixity towards change, then economists will find ourselves taking Bergsonian durée and Kopplanian creative synecology more seriously out of sheer professional survival. Economic theory will either continue to make half-hearted attempts at dynamism through endogenous random walks or exogenous random shocks, succumb to the logical end-state of statistical inference and turn the whole business of theorizing over to AI, or it will begin to take seriously the idea of founding its theories in practically computable processes.

Economists as practitioners are often asked to advise or create policy, and as such, the economist-as-expert is embedded in the mechanics of the administrative state. If the economist-as-expert believes that pluralistic democracy has better outcomes than authoritarian democracy due to the pressures of competition, she should consider the advantages to pluralistic democracy when social entrepreneurs are untethered from the incentives to rent-seek, and administrators, from capture. Not only is the value that would have been tied up in rent-seeking and capture unlocked, but competitive pressure can stay higher when anti-competitive rules can't be purchased with the right amount of rent and clout.

It is my suspicion that ever-increasing change will continue to erode the efficacy of traditional political channels of pluralistic democracy relative to non-traditional, extra-political channels of pluralistic democracy, if we broaden the definition of democracy to mean something more like the ability of large-enough groups of people (in this case, consumers) to realize social outcomes. A sketch of a potential situation is as follows: What we may see replace traditional channels of pluralistic democracy is an increasing reliance on using artificial intelligence to incorporate change into policy, as political cycles and the reaction time of legislation become too long compared to the public's desired rate of change (which shall increase in concord with the socio-technological rate of change). Policy will become more algorithmic and will continue to detach itself from public comment and political consequences. Choosing good political representatives will matter less, and the opportunity cost of voting based on impulse and emotion rather than based on reasoned reflection will go down.

During a combinatorial explosion of goods that have the potential to solve traditionally public problems, pluralistic democracy under algorithmic governance by an administrative state becomes less effective *at an increasing rate*. The costs of circumnavigating administrative constraints, on the other hand, *goes down*. The costs of deconstructing or changing administrative constraints via the political process will, however, *go up* as the administrative state continues to insulate itself from political consequences by virtue of an increasing reliance on automated decision-making processes.

What does all this mean for the design of political institutions? The time component of the veil of incomputability creates an irreducible togetherness relation with the ontological objects of individual and social existence. In a sense, this veil of incomputability veils Rawls's veil of justice, defining his Original Position, the objective core of rights unilaterally agreed-upon by equal, contextless, timeless beings. If there is no ideal Person devoid from time, if we are created as we go through time, then we are, in a sense, made new as we encounter and interact with formerly unknowable things. This suggests a kind of irreducibility to the togetherness relation between the individual and time, one that confounds Rawls's thought experiment. The knowledge we gain through time informs our sense of justice, the rules we would agree upon with others in the Original Position. But we become different people as we add to our knowledge. Which knowledge time-slice is the "true" us, the person who can equitably vote on rights for herself and everyone else?

Perhaps cutting individuals from their social and historical fabric obscures more than it illuminates. If we follow the implications of Koppl's Theorem, we realize the expert exists at the same epistemological level as those who utilize her advice, and therefore the economist-as-expert is best utilized when she faces the constraints and pressures of a normal market. Furthermore, if we accept that as we approach the technological singularity the desire for structured expertise will not dissipate while the cost of accessing good quality expertise will go down, we must conclude that the seeker of expertise will tend to avoid expertise with normative frames and relevancies incompatible with her interests when seeking to solve both personal and social problems, which supports the Corollary. This does not mean that there will be consensus. On complex social issues that depend on relevancies, we would expect a complicated, interacting ecology of solutions to arise.

Historically, it has been difficult to sustain a stable interacting ecology of different solutions to social problems. My analysis suggests that economists might just get the chance to watch such a reality arise if we can curb our impulse to design and learn to love mucking about in the combinatorial chaos with everyone else.

NOTES

1. "I do not see how one can look at figures like these without seeing them representing possibilities. Is there some action a government of India could take that would lead the Indian economy to grow like Indonesia's or Egypt's? If so, what exactly? If not, what is it about the "nature of India" that makes it so? The consequences for human welfare involved in questions like these are simply staggering: once one starts to think about them, it is hard to think about anything else." (Lucas 1988)
2. Though there is some controversy over whether or not Moore's Law still applies or has begun to slow.
3. "The curious task of economics is to demonstrate to men how little they really know about what they imagine they can design. To the naive mind that can conceive of order only as the product of deliberate arrangement, it may seem absurd that in complex conditions order, and adaptation to the unknown, can be achieved more effectively by decentralizing decisions and that a division of authority will actually extend the possibility of overall order. Yet that decentralization actually leads to more information being taken into account." (Hayek 1988: 76)
4. Hayek proposed this in his Sensory Order, in particular reference to the human mind being fundamentally unable to comprehend its own innerworkings.
5. Famous examples of such cases exist in the form of Sonneschein-Mantel-Debreu, and in Arrow's Impossibility Theorem.
6. This is due mainly to the employment of the Law of the Brouwer Fixed Point theorem (Brainerd and Scarf 2005). in the proof of existence of unique welfare equilibria in the standard corpus of economic theory. While a subset of economists have attempted to prove that indeed one can have a Computable General Equilibrium theory, their proofs generally include a nonconstructive theorem, often the Bolzano-Weierstrauss theorem.
7. As noted in Bridges (2001), definitions of computability based on the system of classical logic, the normal system of logic that the vast majority of working mathematicians employ based on ZFC, the Zermelo-Fraenkl axioms plus the Axiom of Choice, do not discern between computable algorithms in principle (possibly nonconstructive) or in practice (provably constructive).

REFERENCES

Beckage, B., Kauffman, S., Gross, L. J., Zia, A., & Koliba, C. (2013). More complex complexity: Exploring the nature of computational irreducibility across physical, biological, and human social systems. In *Irreducibility and computational equivalence* (pp. 79-88). Springer, Berlin, Heidelberg.

Bergson, H. (1907). *L'Evolution Creatrice*.

Barocas, S., & Selbst, A. D. (2016). Big data's disparate impact. *Cal. L. Rev., 104*, 671.

Brainard, W. C., and Scarf, H. E. (2005). "How to compute equilibrium prices." In *1891. Am. J. Econ. Sociol.: Special Invited Issue: Celebrating Irving Fisher: The Legacy of a Great Economist, 64*(1), 57–83.

Bridges, D. S. (2012). *Computability: a mathematical sketchbook* (Vol. 146). Springer Science & Business Media.

Buchanan, J. M., & Tullock, G. (1962). *The calculus of consent: Logical foundations of constitutional democracy*. Ann Arbor Paperbacks.

Buchanan, J. M., and Wagner, R. E. (1999 (1977)). *Democracy in Deficit*. In Buchanan, J. M. *The Collected Works of James M. Buchanan*. Liberty Fund.

Coecke, B. (2017). From quantum foundations via natural language meaning to a theory of everything. In *The Incomputable* (pp. 63-80). Springer, Cham.

Comm, J. (May 16, 2018). "How Smart Contracts Could Change The Way You Do Business." *Forbes*. Accessed on Feb. 10, 2019: https://www.forbes.com/sites/forbescoachescouncil/2018/05/16/how-smart-contracts-could-change-the-way-you-do-business/#378743621288

Cooper, G. F. (1990). The computational complexity of probabilistic inference using Bayesian belief networks. *Artificial intelligence*, *42*(2-3), 393-405.

Dastin, J. (Oct. 9, 2018). "Amazon scraps secret AI recruiting tool that showed bias against women." *Reuters*. Accessed on Feb. 9, 2019: https://www.reuters.com/article/us-amazon-com-jobs-automation-insight/amazon-scraps-secret-ai-recruiting-tool-that-showed-bias-against-women-idUSKCN1MK08G

Devereaux, A. N., Yuan, X. (2019). Visualizing the Division of Knowledge: A Simulation of the Formation of Transactive Memory Systems. *SSRN,* working paper.

Devins, C., Felin, T., Kauffman, S., & Koppl, R. (2017). The law and Big Data. *Cornell JL & Pub. Pol'y*, *27*, 357.

Dopfer, K. (2007). The pillars of Schumpeter's economics: Micro, meso, macro. *2007). Elgar Companion to Neo-Schumpeterian Economics*, 65-77.

Dopfer, K., Foster, J., & Potts, J. (2004). Micro-meso-macro. *Journal of evolutionary economics*, *14*(3), 263-279.

Dunn, J. (May 16, 2018). "How the next economic crisis could make or break cryptocurrency." *Business Insider*. Accessed on Feb. 10, 2019. https://www.businessinsider.com/how-cryptocurrency-will-be-impacted-by-economic-crisis-2018-5

Friedman, M. (1953). "The Methodology of Positive Economics," in *Essays in positive economics*. University of Chicago press.

Gard-Murray, A. S., & Bar-Yam, Y. (2015). Complexity and the Limits of Revolution: What Will Happen to the Arab Spring?. In *Conflict and Complexity* (pp. 281-292). Springer, New York, NY.

Gershgorn, D. (Oct. 22, 2018). "Companies are on the hook if their hiring algorithms are biased." *Quartz*. Accessed on Feb. 9, 2019. https://qz.com/1427621/companies-are-on-the-hook-if-their-hiring-algorithms-are-biased/

Gigerenzer, G., Todd, P. M., & ABC Research Group. (2000). *Simple Heuristics that Make Us Smart*. Oxford University Press.

Haldane, A. G., & May, R. M. (2011). Systemic risk in banking ecosystems. *Nature*, 469(7330), 351.

Hardy, R. A., & Norgaard, J. R. (2016). Reputation in the Internet black market: an empirical and theoretical analysis of the Deep Web. *Journal of Institutional Economics*, *12*(3), 515-539.

Hayek, F. A. (1937). Economics and knowledge. *Economica*, *4*(13), 33-54.

__. 1964. *The theory of complex phenomena.* In M. Bunge (Ed.), The critical approach to science and philosophy: Essays in honor of K. R. Popper. New York: Free Press."

__. 1988. "The Fatal Conceit: The Errors of Socialism." In *The Collected Works of Friedrich August Hayek, Vol. I, ed. William W. Bartley III*. Routledge.

Helbing, D., & Kirman, A. (2013). Rethinking economics using complexity theory. *Real-world economics review,* issue, (64).

Kirzner, I. M. (1997). Entrepreneurial discovery and the competitive market process: An Austrian approach. *Journal of economic Literature*, *35*(1), 60-85.

Knight, F. H. (1921). Risk, uncertainty and profit. *New York: Hart, Schaffner and Marx*.

Koppl, R. (2018). *Expert failure*. Cambridge University Press.

Koppl, R., Kauffman, S., Felin, T., & Longo, G. (2015). Economics for a creative world. *Journal of Institutional Economics*, *11*(1), 1-31.

Koppl, R., Devereaux, A., Herriot, J., & Kauffman, S. (2018). A Simple Combinatorial Model of World Economic History. *arXiv preprint arXiv:1811.04502*.

Kurzweil, R. (2005). *The Singularity is Near: When Humans Transcend Biology*. London: Penguin Books.

Lange, O. (1972) "The Computer and the Market," in A. Nove and D. Nuti, eds. *Socialist Economics*. London: Penguin Books.

Lewis, A. A. (1992). Some aspects of effectively constructive mathematics that are relevant to the foundations of neoclassical mathematical economics and theory of games. *Mathematical Social Sciences*, *24*(2-3), 209-235.

Lucas Jr, R. E. (1988). On the mechanics of economic development. *Journal of monetary economics*, *22*(1), 3-42.

Ma, H. D. (2011). Internet of things: Objectives and scientific challenges. *Journal of Computer science and Technology*, *26*(6), 919-924.

Miller, J. H., & Page, S. E. (2009). *Complex adaptive systems: An introduction to computational models of social life* (Vol. 17). Princeton university press.

Mises, L. V. (1998). *Human action: A treatise on economics*. The Scholar's Edition. Auburn, Alabama: Ludwig von Mises Institute.

Parens, R., Bar-Yam, Y. (February 24, 2017). Six-year report on the Arab Spring. *New England Complex Systems Institute*.

Pearl, J., & Mackenzie, D. (2018). *The Book of Why: The New Science of Cause and Effect*. Basic Books.

Perry, W. L. (2013). *Predictive policing: The role of crime forecasting in law enforcement operations*. Rand Corporation.

Rubin, B. F. (Dec. 3, 2018). "How Ring's Neighbors app is making home security a social thing." *CNet.* Accessed on Feb. 10, 2019: https://www.cnet.com/news/how-rings-neighbors-app-is-making-home-security-a-social-thing/

Shannon, C. E. (1956). A universal Turing machine with two internal states. *Automata studies*, *34*, 157-165.

Sipser, M. (1997). *Introduction to the Theory of Computation*. Boston: PWS Publishing Company.

Smith, V. L. (2003). Constructivist and ecological rationality in economics. *American economic review*, *93*(3), 465-508.

Spear, S. E. (1989). Learning rational expectations under computability constraints. *Econometrica: Journal of the Econometric Society*, 889-910.

Tollison, R. D. (1982). Rent seeking: A survey. *Kyklos*, *35*(4), 575-602.

Turing, A. M. (1937). On computable numbers, with an application to the Entscheidungsproblem. *Proceedings of the London mathematical society*, *2*(1), 230-265.

Velupillai, K. V. (2007). The impossibility of an effective theory of policy in a complex economy. In *Complexity hints for economic policy* (pp. 273-290). Springer, Milano.

__. 2008. The Mathematization of Macroeconomics. A Recursive Revolution. *Economia politica*, *25*(2), 283-316.

__. 2017. Algorithmic Economics: Incomputability, Undecidability and Unsolvability in Economics. In *The Incomputable* (pp. 105-120). Springer, Cham.

Wagner, R. E. (2016). *Politics as a peculiar business.*

__. 2010. *Mind, society, and human action: time and knowledge in a theory of social-economy*. Routledge.

Wolpert, D. H. (2001). Computational capabilities of physical systems. *Physical Review E*, *65*(1), 016128.

Yaraghi, N., & Ravi, S. (2017). The current and future state of the sharing economy. *The Brookings Institute: India*.