Towards a Sustainable and Non-Ergodic Theory of Economics

Paper presented at the 27th Forum for Macroeconomics and Macroeconomics Policies, "Inflation, Distributional Conflict and Just Transition," 19 - 21 October 2023, Berlin.

Graham Boyd
Founder and Chair of Evolutesix
London and Brussels
graham@evolutesix.com

Jack Reardon
Senior Lecturer at the University of Wisconsin-Eau Claire, Wisconsin (USA) and the University of Wisconsin Claire Eau Claire, Barron County, in Rice Lake, Wisconsin.
Founding Editor, *International Journal of Pluralism and Economics*, Education
reardonj@uwed.edu and jackreardon864@gmail.com

Colten Ziacik
Student, University of Wisconsin-Eau Claire (USA)
ziacikc2077@uwec.edu

Note: this is a preliminary draft!! Comments and suggestions are most welcome!

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt., Nicht Kursiv

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt.

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt., Schriftfarbe: Schwarz

Formatiert: Links, Einzug: Links: 0,63 cm, Keine Absatzkontrolle, Trennen, Hängende Interpunktion nicht zulassen, Leerraum zwischen asiatischem und westlichem Text nicht anpassen, Leerraum zwischen asiatischem Text und Zahlen nicht anpassen, Zeichenausrichtung: Grundlinie

hat formatiert: Schriftart: Nicht Fett

Formatiert: Links

hat formatiert: Schriftart: Nicht Fett

hat formatiert: Schriftart: Nicht Fett

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt., Schriftfarbe: Automatisch

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt., Schriftfarbe: Automatisch

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt., Schriftfarbe: Automatisch

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt., Schriftfarbe: Automatisch

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt., Schriftfarbe: Automatisch

hat formatiert: Schriftart: 12 Pt.

hat formatiert: Schriftart: 12 Pt., Kursiv

hat formatiert: Schriftart: 12 Pt.

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt.

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt.

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt.

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt.

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt.

hat formatiert: Schriftfarbe: Rot

hat formatiert: Schriftfarbe: Rot

Towards a Sustainable and Non-Ergodic Theory of Economics

1. *Introduction*

As the authors of the influential book, *Net Zero Business Models: Winning in the Global Net Zero Economy*, argue "the shift from a fossil fuel-based economy to a net zero emission one is the biggest transformation project in human history" (Montgomery and Van Clieaf 2023, p. 3). They estimate that this transition will require "$275 trillion of cumulative investments in physical assets alone by 2050" (Montgomery and Van Clieaf 2023, p. 3). This is roughly three times the current level of global GDP, and raises questions about how this investment will be financed and how investment decisions will be determined. It also raises questions about the role of the firm and the industry, and how each should be reconceptualized~~what type of changes will be necessary for each~~. And it also raises questions about how fit the discipline of economics is to the task, and whether it needs a partial or even complete makeover.

The current thinking in economics assumes gratuitously that ~~all~~ investment decisions are for ergodic systems, i.e., the time average and the expectation value of a variable are the same. However, just about all aspects of life, including nature itself, and of course our economy, are non-ergodic, meaning that the time average and the expectation value of a variable are not the same. Furthermore, a non-ergodic theory of investment recognizes the inherent nonlinearity and path-dependence of all living systems, including business itself, along with the critical role of unpredictables and unknowables.

Formatiert: Einzug: Erste Zeile: 1,27 cm

Thus, the current theory leads to a faulty understanding and specious decisions that are inconsistent with sustainability, making our goal of Net-Zero much more difficult to attain. To successfully achieve our "biggest transformation project" we need an accurate theory of investment, one that is based on non-ergodicity and thus mirrors nature itself. Only a non-ergodic theory of investment (housed within a non-ergodic theory of economics) can comport with the principles of sustainability. To construct and offer such a theory is the purpose of this paper. At this point, our paper is in the rudimentary and formative stages, and we would appreciate constructive feedback.

Section One will discuss the shortcomings of traditional economics, particular its ergodic assumptions. Section Two will (briefly) discuss the concept of non-ergodicity and how its ~~can~~ used ~~can to~~ help alleviate the effects of climate change and help us transition to Net-Zero. Section Three will sketch some thoughts on inflation and ergodicity.??? ~~why it matters. Section Three will discuss a non-ergodic theory of investment, and how it can help us transition to Net Zero.~~ Section Four will discuss the role of a new non-ergodic theory of investment within a modern macroeconomics that itself is (or needs to be) sustainable and how this will be a central cog in reducing inflation and transitioning to Net Zero. Section Five concludes.

2. What is Ergodicity?

We believe that a direct cause of our current myriad and interconnected problems from species depletion to climate change to inflation and inequality~~.~~ is our gratuitous assumption that all economic processes are ergodic, when in fact they are practically all non-ergodic. We also believe that in order to successfully transition to Net Zero we need to recognize and incorporate non-ergodicity into our models. Not only must the disciplines of economics and finance become non-ergodic, but the business firm (along with investors and entrepreneurs) must transmute their current modus operandi from one of ergodicity to non-ergodicity.

As neoclassical economics developed during the late 19th century, its founding fathers, well versed in science, ~~and tried to~~ emulated the thinking and modus operandi of contemporary science, fashioning a self-image as the queen of the social sciences. Thus, we find~~found~~ it surprising that as neoclassical economics matured in the late 19th/early 20th century it parried two of the most important contemporary scientific developments. One: quantum physics, which would have introduced uncertainty and unpredictability into economic model-making and would have made its practitioners much less arrogant, paving the way for active cooperation with the other social sciences. And two: ~~The second is~~ ergodicity, which if properly understand and incorporated, would have gone a long way reducing environmental destruction, as well as encouraging inclusivity and pluralism within the discipline. With one or both developments incorporated into the discipline of economics, our economies would look very different, as would capitalism itself.

But these 'what ifs' are just conjecture. Let's get down to business and explain ergodicity.

hat formatiert: Schriftart: Kursiv

hat formatiert: Schriftart: Kursiv

Formatiert: Abstand Nach: 0 Pt.

Formatiert: Einzug: Erste Zeile: 1,27 cm, Abstand Nach: 0 Pt.

Formatiert: Abstand Nach: 0 Pt.

Richard Feynman, the late Nobel Laureate in physics, once quipped ~~said~~ "if you understand quantum ~~physics you really don't understand it~~mechanics, then you don't understand quantum mechanics". To a lesser extent, some say the same about ergodicity. The Austrian physicist and philosopher Ludwig Boltzmann (1844-1906) coined the term from the Greek words 'ergon' work and 'hodos' path[1]. As we explain, in any process with randomness, there are two ways of figuring out what to expect in the limit where all randomness cancels. Either you let time go to infinity to see where we end, or average over ~~a set number~~the entire ensemble of systems at a fixed time. If the two answers are the same, the system is ergodic. But if the path one takes matters (as if often the case) the~~a~~n the two answers will diverge, which means that the process is non-ergodic.

In other words, for a system to be ergodic regarding the stochastic variable X, then,

$$1/N \quad x_i = 1/T \quad x(t)$$

for sufficiently large time T, and N states in the ensemble. If the expected value ~~at a specific point in time~~ is the same as the time average across time on a specific path at a large enough time T, then we say that the dynamics of this process are ergodic~~;~~ if not, then the dynamics are non-ergodic.

Here's a simple example. Say you a playing a dice game. Whenever you throw a one, two, three, four, or five, your wealth doubles, but if you throw a six, then you lose everything. If 1000 individuals do this once (i.e., at one point in time) 830 can expect to double their wealth. And given ~~on the basis of~~ these odds, one might decide to play the game. But if you do this 1000 times in succession, then sooner or later you are out. ~~and p~~Probably sooner. Game over.

Assuming an ergodic process we also mistakenly assume that the path of a stochastic ~~the~~ variable will trend towards the average~~; ,~~ we just need to keep going ~~for~~ long enough and the law of averages will correct. ~~Thus~~However, for non-ergodic processes this is not true, they always tend to a smaller expected outcome than the average.

A preponderant explanation for the divergence between the two is the existence of unpredictables. We have entered a new geological era—the Anthropocene. The transformations created by humanity over the past two centuries are now the driving force. These transformations

[1] In addition, Boltzman developed the statistical explanation for the second law of thermodynamics, and the concept of entropy. Thanks to Max Planck, the constant in the entropy equation is named the Boltzman constant.

Formatiert: Einzug: Erste Zeile: 1,27 cm, Abstand Nach: 0 Pt.

hat formatiert: Schriftart: (Standard) Times New Roman, Schriftfarbe: Benutzerdefinierte Farbe(RGB(32;33;34)), Tiefgestellt

Formatiert: Abstand Nach: 0 Pt.

Formatiert: Einzug: Erste Zeile: 1,27 cm

have only just begun and the future is laced with unpredictables, which, by the way, ~~-~~ can ~~either~~ be positive or negative; and either known, unknown, or unknowable.

To assume that all unpredictables can be assigned probabilistic weights is conceptually flawed and will lead to highly erroneous results, as if you are using a 19th century map to study a ~~of~~ 20th century problem. In addition, there is a significant degree of randomness associated with unpredictables. So rather than assuming unpredictables and randomness away under the false and misleading cover of ergodicity, or even worse that we can somehow control them, we must deal with them head on. It is ~~becoming g increasingly~~ clear that our economy is becoming increasingly filled with known, unknown, and unknowable unpredictable. ~~Enter~~The non-ergodicity of our economy is thus more relevant than ever before, and the errors caused~~s~~ by implicitly assuming ergodicity are more harmful than ever before.

In business (as in most stochastic processes of life), the path dependent, time-expected outcome matters because business is a sequence of one thing after another along a path. Economists typically average first across a range of unpredictables and then extrapolate this average across the time horizon. But as many of us learn, one unpredictable can change everything; and what's worse, the effects of unpredicatables are multiplicative rather than additive.

~~Most business plans are constructed based on the expected value, assuming that the stochastic variable in question (be it profits, revenue, capital) or being ignorant of the difference. If you are constructing a business plan assuming based on the erroneous assumption of ergodicity, then your business has a much higher probability of failure, than one assuming the correct process.~~ Assuming ergodicity when the stochastic process is non-ergodic is a reckless and profligate waste of resources.

6#W 0 # v

# #

s u r y lv lr qv

#

Formatiert: Einzug: Erste Zeile: 0,63 cm

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt., Kursiv

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt., Kursiv

Formatiert: Einzug: Links: 0 cm, Rechts: 0 cm, Abstand Nach: 0 Pt., Zeilenabstand: 1,5 Zeilen

$$\lim_{T\to\infty}\frac{1}{T}\int_0^T f(\omega(t))\mathrm{d}t=\int_\Omega f(\omega)P(\omega)\mathrm{d}\omega,$$

Formatiert: Rechts: 0 cm, Abstand Nach: 0 Pt., Zeilenabstand: 1,5 Zeilen

Formatiert: Einzug: Links: 0 cm, Erste Zeile: 1,27 cm, Rechts: 0 cm, Abstand Nach: 0 Pt., Zeilenabstand: 1,5 Zeilen

Formatiert: Rechts: 0 cm, Abstand Nach: 0 Pt., Zeilenabstand: 1,5 Zeilen

Formatiert: Einzug: Links: 0 cm, Erste Zeile: 0 cm, Rechts: 0 cm, Abstand Nach: 0 Pt., Zeilenabstand: 1,5 Zeilen

Formatiert: Einzug: Links: 0 cm, Erste Zeile: 0 cm, Zeilenabstand: 1,5 Zeilen

Formatiert: Abstand Nach: 0 Pt., Zeilenabstand: 1,5 Zeilen

Formatiert: Rechts: 0 cm, Abstand Nach: 0 Pt., Zeilenabstand: 1,5 Zeilen

Formatiert: Rechts: 0 cm, Zeilenabstand: 1,5 Zeilen

Formatiert: Einzug: Erste Zeile: 0,58 cm, Rechts: 0 cm, Abstand Nach: 0,25 Pt., Zeilenabstand: 1,5 Zeilen

i_t w

j_t w # # lv#

j_t w 1

$\langle j \rangle$# j j

j d W #

exugr qvr p hexughqvr p h #

$\langle j \rangle$#

$$\bar{g} = \langle g \rangle - \frac{\sigma^2}{2}$$,

$^5 2$

$^5 2$ # $\langle j \rangle$1

Lq#r wkhu# # r xuh{shf whg# / #z khq# r x#nhhs#j r lqj #r qj # | #

$\langle j \rangle$

# #

WI

$p\,d\{lp\,xp$

hqwluhwlhvhqwluhwlhv#

j_t w # j_t w # j_{m} w

1 #

5

#

i_m w lv/

D

¦ i_m w i_m w °¦ m w¦ w ,

$\langle j \rangle$,#

1

#

1

Formatiert: Rechts: 0 cm, Zeilenabstand: 1,5 Zeilen

Formatiert: Rechts: 0 cm, Zeilenabstand: 1,5 Zeilen

Formatiert: Rechts: 0 cm, Abstand Nach: 0 Pt., Zeilenabstand: 1,5 Zeilen

Formatiert: Einzug: Links: 0 cm, Rechts: 0 cm, Abstand Nach: 0 Pt.

Formatiert: Einzug: Links: 0 cm, Rechts: 0 cm, Abstand Nach: 0 Pt., Zeilenabstand: 1,5 Zeilen

Formatiert: Einzug: Links: 0 cm, Rechts: 0 cm, Zeilenabstand: 1,5 Zeilen

1 #

hqwvwhkhqwvhqwvwhv#

i^Q i_m+w i^Q+w Krz hyhu

fdslwdo# m#

D

¦ i_m+w i^Q+w °¦ m+w¦ w/ ,

Formatiert: Rechts: -0,25 cm, Abstand Nach: 6 Pt.

=

i^Q+w i^Q+w °¦ m+w¦ w1 ,

Formatiert: Einzug: Erste Zeile: 0 cm

Formatiert: Einzug: Links: 0,25 cm, Rechts: 0 cm, Abstand Nach: 0 Pt., Zeilenabstand: 1,5 Zeilen

i_m+ ¦ w i^Q+ ¦ w =

$$f^N(t+\Delta t) = \frac{1}{N}\sum_{j=1}^{N}\left(f^N(t) + f^N(t)\left(\mu\Delta t + \sigma\xi_j(t)\sqrt{\Delta t}\right)\right) \quad (1.7)$$

$$= f^N(t)\left(1 + \mu\Delta t + \frac{1}{N}\sum_{j=1}^{N}\sigma\xi_j(t)\sqrt{\Delta t}\right). \quad (1.8)$$

42Q # #

Formatiert: Einzug: Links: 0 cm, Rechts: 0 cm, Zeilenabstand: 1,5 Zeilen

°1

m+w

Formatiert: Rechts: 0 cm, Zeilenabstand: 1,5 Zeilen

Q+w p /

$$\xi^N(t) = \frac{1}{\sqrt{N}}\sum_{j=1}^{N}\xi_j(t)$$

,

D

Z klfk#p hdqv#wkdw#wkh#qhz #vwdqgdug#ghyldwlr q#ri#wkh#hfrvlvwhp #lv# #Q #

Formatiert: Zeilenabstand: 1,5 Zeilen

j =

$$\bar{g}^N = \mu - \frac{\sigma^2}{2N}$$

Wklv#lv#z k|#qdwxuh# #elr p dvv#lv#wkh# , #lv#r#dqvliudj ldh# #

fdslwdov / #

# #

Hqwhusuhqhxu# ## r # #

exvlqhvv#

p

#Vnhvfklqj # # huj rglflv#

We believe that inflation can be maintained consistently at a healthy level by correctly accounting for the non-ergodic dynamics of capital and building businesses appropriately. First, the impact of inflation is itself directly non-ergodic, and the higher the rate and the bigger its volatility, the bigger the divergence between the ergodic assumption and the non-ergodic outcomes. In particular, the non-ergodic time expected outcome is even smaller vs. the ensemble average the bigger the volatility in the inflation rate. That exacerbates all of the other volatilities in a company's growth rate. All of which push the actual growth rate even further down vs. the growth rate promised to investors based on ergodic capital dynamics. This gap between the promised and actual performance has to be closed; or the company will be shut down by investors shifting their money elsewhere, or through bankruptcy, leading to the profligate use of resources.

So ignoring the non-ergodic nature of capital leads to companies performing below par, for that specific company, forcing it to externalize costs to maintain profitability, excessive consumption of natural and human capitals, and multiple other inflation-driving activities. Then, central banks react to inflation rates with measures usually uninformed by non-ergodic capital dynamics, and as such may unwittingly exacerbate the problem.

All of these add up to one simple statement: inflation is a simple single measure of a bulk property of an economy as a whole, somewhat like temperature is a simple measure of the bulk property of a glass of water. Our current focusses on each individual company and optimizes that

Formatiert: Zeilenabstand: 1,5 Zeilen

Formatiert: Rechts: 0 cm, Zeilenabstand: 1,5 Zeilen

hat formatiert: Schriftart: (Standard) Times New Roman, Kursiv, Schriftfarbe: Schwarz, Ligaturen: Standard + Kontextbezogen

hat formatiert: Schriftart: Nicht Kursiv

hat formatiert: Schriftart: Kursiv

hat formatiert: Schriftart: Kursiv

entity in isolation from all other entities, leading to outcomes sub-optimal for the bulk, therefore sub-optimal for each company, according to the non-ergodic nature of the economy.
We can only manage the bulk properties of the economy as a whole, including inflation, if we have structures and interactions at all scales that enable optimization with full recognition of the non-ergodic dynamics of each of the six capitals, and especially financial.

~~3~~5 *How can the concept of ergodicity help in solving our problems and lead the way to Net Zero ~~Ergodicity~~ and Stable Inflation?*

For starters we must reconceptualize the firm away from today's ~~an~~ insular, ~~collaborative~~, hyper competitive entity toward a multi-capital, multi-stakeholder ~~commons~~collaborative-competitive entity, with an equitable distribution of governance and growth share~~s~~ across all capitals and all stakeholders, i.e., the Fair Shares Commons. Yes, ~~I know~~ this ~~that~~ is a mouthful but let's tackle a few key phrases. First, '~~first zoom in~~ all capitals'. If we define capital as "a store of anything that has value to a living entity or organization of people," (Boyd and Reardon 2020, p. 51~~ of Rebuild~~) then there are six all-told: natural, h~~H~~uman, social and relational, intellectual, manufactured, and financial. Each capital should have its own currency, i.e., "that which enables or represents something of value when it is put to work, i.e., flowing from where it is stored to where it is needed" (Boyd and Reardon 2020, p. 51) ~~:~~but modern economics over-emphasizes financial capital, while ascribing money (euros or dollars) as the currency for all capitals.

If we are to tackle inflation, and successfully transition to Net~~non~~-Z~~z~~ero, then all currencies, along with their corresponding currencies, ~~-~~must be utilized. Not having separate currencies means that an exchange loss is suffered (i.e., a transaction cost) when we use financial capital for all other capitals. The ~~And finally, the~~ company should multiply all its capitals, and not just limit itself to growing financial capital at the cost of the other ~~capital~~s. This requires a reinvention of monetary policy that moves away from a solo focus on just financial capital and includes the velocity of each capital, as well as the respective demand and supply. This of course requires a multi-capital accounting system, not like our current system built on financial assumptions and a way of thinking from an earlier age ~~.xx~~(Brown and Dillard 2019). ~~x~~

Formatiert: Einzug: Erste Zeile: 0 cm

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt., Kursiv

Formatiert: Nummerierte Liste + Ebene: 1 + Nummerierungsformatvorlage: 1, 2, 3, … + Beginnen bei: 5 + Ausrichtung: Links + Ausgerichtet an: 0,63 cm + Einzug bei: 1,27 cm

All capitals and all stakeholders touched by the company should have appropriate voting and wealth rights, since they all be affected, transformed, created or even destroyed by a company's activities" (Boyd and Reardon 2023, p. 51~~p. 50~~). And "a systemic cause of today's problems is our attempt to attribute value to all capitals using money as the only currency, rather than the currency intrinsic to each capital" (Ibid, p. 52).

~~The classical economists conceived of I~~inflation is ~~as~~ rooted in class conflict, which has been exacerbated by the corporation pitting different stakeholders against each other. Mistakenly,

neoclassical ~~Most~~ economics view money as ~~itself a~~ neutral ~~medium~~, much as classical physicists used to view the vacuum as neutral. However, once we look at the consequences of the non-ergodicity of financial capital dynamics in our economy it becomes perfectly clear that money is far from neutral. Because money is issued by layers of issuers, as a form interest bearing debt, and both the value of the unit, and the interest changing the value of the unit itself changes over time, economics must use the full non-ergodic equations. Brikhoff's equation is rarely (~~,~~probably never), satisfied.

The Fair Shares Commons firm is deliberately designed to mitigate this conflict. Instead of simple voting we need to use processes such as deep democracy, sociocratic voting, and/or Holacratic decision making. Effective bottom-up governance is key, which in turn, is based on the principles of stewardship which can effectively change the need structures and flows in any system of governance. (Boyd and Reardon 2023, p. 88-89).

In incorporating such a fundamental entity, it is important to use the company's articles of incorporation to state the firm's purpose(s), along with the resulting key external drivers which had resulted in the stated purpose[2], while recognizing that when the driver(s) change so should the purpose, and likely the company.

~~Of course, incorporation need not necessarily be limited to just one company, but can become part of a combination of cooperatives, limited companies, and trusts.~~ The key is to connect within an ecosystem[3] of companies and then scale up all the way to the global environment if possible. Granted, we are currently too myopically focused on the firm as a

---

[2] Doing so is the first and probably most import step in a firm creating value. See Madden 2020 pp. 24-30.
[3] An ecosystem is sometimes conflated with a system, but the two are distinctly different. In an ecosystem both its structure and flows are optimized. a biological community of interacting organisms and their physical environment

separate non-collaborating entityies, but with the quest for Netnon-Zzero and the once-in-a-lifetime weather events now routinely happening with alarminggreat frequency, we must now focus on the ecosystem and how it is constructed. BBy becoming part of a nested set of ecosystems, this help companies survive; so dDoing this will aid companies in assessing their global warming emissions, especially Scope 3 especially emissions.[4]: ~~"Collaborate, collaborate, collaborate. Our sample companies recognize that they cannot reduce their Scope 3 emissions[5] without engaging their entire value chain. These companies actively collaborate with governments, NGOs, and other companies" (p. 149)~~

Nature thrives because it pools all capitals at all scales, from within a single celled amoeba, through entire ecosystems like the African Savannah, to the entire planet. All of these are crosslinked, pools of pools~~. Pooling all capitals between similar companies clustered within an ecosystem will enable the company to become be flexible, adaptive, and even emergent~~. ~~Working together with similar companies within its ecosystem.~~ And,

> "Whether you are talking about the growth of algae on a pond, doubling every day, or rabbits, or wolves; each of them grows over some natural time period as a percentage of the starting value. In other words, the dynamics are multiplicative and dynamic… the dynamics of biomass capital growth mathematically ties individual success to having a group pooling resources, and so evolution acts at the group level, i.e., the level of the resource pool as a whole. The fittest individuals[6] are those that build the most effective resource pooling groups" (Boyd and Reardon 2023, p. 93).

Pooling all capitals between similar companies clustered within an ecosystem will enable each company to become flexible, adaptive, and emergent. As we transition to Net-Zero, we should look to nature for ideas, instead of assuming that our knowledge can subdue and even conqueringing

---

[4] These consist of indirect GHG emissions that occur both upstream and downstream in a company's value chain; see Montgomery and Van Clieaf (2023) pp. 26-42 for a good discussion of the full range of emissions from Scope 1 to Scope 4. The authors exhort: "Collaborate, collaborate, collaborate. Our sample companies recognize that they cannot reduce their Scope 3 without engaging their entire value chain. These companies actively collaborate with governments, NGOs, and other companies" (p. 149)

[5] ~~These consist of indirect GHG emissions that occur both upstream and downstream in a company's value chain; see Montgomery and Van Clieaf (2023) pp. 26-42 for a good discussion of the full range of emissions from Scope 1 to Scope 4.~~

[6] We've re-read Charles Darwin's *On the Origin of Species* (1859[2000]). Like most great thinkers, his ideas are often misconstrued, especially by those who have never bothered to read his work. The 'survival of the fittest' is, of course, a key concept, and while some equate 'fittest' to 'strongest,' Darwin means it as ~~it is actually used to~~ fitting best into the space in their environment. As Darwin writes, "I have called Natural Selection, or the Survival of the Fittest, the preservation of favorable individual differences and variations, and the destruction of those which are injurious [by nature] … It implies only the preservation of such variations as arise and are beneficial to the being *under its conditions of life*" (pp. 108-109; emphasis added).

hat formatiert: Schriftart: 10 Pt.

nature. Instead of clobbering nature let us learn from nature. After all, we are part of nature, and it is critical that we finally recognize that. Fighting nature is fighting ~~ourself~~ourselves, a fight that we lose when we win!

Most readers will vehemently object that resource pooling contravenes ~~goes against~~ everything capitalism stands for, bordering on socialism. Three comments. First, socialism means that the state mandates what and how each company produces. Resource pooling is not socialism. Second, we are only suggesting a small percentage of resource pooling across all capitals, say one percent. And finally,~~Second,~~ it is engrained in our thinking that ~~shouldn't~~ businesses should compete rather than collaborate.~~?~~ After all, d~~D~~oesn't competition reduce prices and increase innovation?~~.~~ ~~Just so that we are on the same page:~~ Here, ~~w~~we~~e~~ define collaboration as resource pooling between multiple entities across all capitals, and competition as resource accumulation within an entity across all capitals. Such a complementary pair exists in nature,

> "With a blend of cooperation and collaboration…where even predator and prey are structured by nature into both competing and collaborating in a way that leads to resource pooling…of course, collaboration within groups of animals and plants automatically comes out of the mathematics, rendering unnecessary any behavioral explanation…The right level of competition and collaboration emerges naturally in nature. Neither word is right; rather it is the context-dependent balance that nature harnesses" (Boyd and Reardon 2023, pp. 93-94)

We are not arguing that competition is now- passe, inconsistent with sustainability, ~~out the window; of course not,~~ but rather that competition and collaboration should be recognized as a complementary pair, i.e., two ostensibly different entities that have a deeper relationship. As ~~xxx~~ Montgomery and Van Clieaf write,

> "Industry leaders understand when companies in the industry need to collaborate and work together to achieve net zero and when they need to compete. They are adept at forming, participating in, leading, and leveraging strategic partnerships, public/private partnerships, joint ventures, knowledge networks and other collaborations" (~~Montgomery and Van Clieaf,~~ 2023 p. 202).

Competition underscores its ~~is really pointing at an~~ underlying principle: self-interested behavior. There is a difference between the optimum self-interested strategy in a non-ergodic world and in an ergodic world: the self-interested strategy in a non-ergodic world requires a degree of collaboration, in the form of capital pooling. You see this throughout nature, where

Formatiert: Einzug: Erste Zeile: 1,27 cm

Formatiert: Einzug: Links: 1,27 cm, Erste Zeile: 0 cm, Zeilenabstand: einfach

more closely related-/-interdependent living beings pool a greater percentage, ~~directly:~~directly, and a more distant pool less, often indirectly.

~~And third, we are only talking about often only a very small percentage of resource pooling across all capitals, say one to 15 percent.~~ We have done the mathematics to demonstrate that such a small percentage will decrease the ~~variance in firm profitability~~ risk of capital loss and simultaneously increase each firm's ~~survival~~probable growth rate by making it more adaptive, antifragile, and emergent (Reardon and Boyd 2023). This will cushion businesses in the ecosystem to move beyond planning based on a 'knowable knowns' strategy, to build for and adapt to unknowable unpredictables, which seem to be happening everywhere with greater frequency. Not to do so, is a recipe for continued business failure, worsening inflation, excessive and needless resource consumption, and continued environmental destruction.

While it is easy (relatively) to demonstrate the necessary and supporting mathematics on paper, it is quite arduous to actually implement a non-ergodic pooling system for all capitals across the economy, given our ideological hard-core objections and hard-wired opposition. Not to mention a legal and accounting system that doesn't recognize the efficacy of active cooperation, and actively restricts it within an arcane legal system. Yes, of course we need laws ~~(otherwise, we have anarchy)~~ but the laws themselves need to be adaptive and emergent.

Kommentiert [1]: Strictly not - anarchy follows strict laws too, but they are evidence-based, and voluntarily subscribed to, rather than imposed by a power.

6~~4~~ *Conclusion*

We believe that creating an ecosystem of companies which goes beyond the traditional firm[7] is necessary to transit to N~~n~~et~~on~~-Z~~z~~ero, which, in turn, will help ease inflationary pressures. Ideally, the intelligent investor and entrepreneur of the future will invest in (or start up) strongly connected ecosystems of companies, at all scales, sitting at the sweet spot between collaboration and competition, with just the right amount of resource pooling actress all capitals, at the right size, and with appropriately matched processes to create, grow, shrink, and shut down non-performing companies.

In addition, a ~~A~~ benefit of companies working within an ecosystem is the increased chance of conflict between individuals which can often lead away from one voice or one way of doing something and towards a plurality of frames of reference and of doing things. This in turn

Formatiert: Zeilenabstand: 1,5 Zeilen

[7] See Madden (2020) for a new theory of the firm focusing on what businesses actually do, especially pp. 3-32.

hat formatiert: Schriftart: (Standard) Times New Roman

hat formatiert: Schriftart: (Standard) Times New Roman

can lead to innovation and the ease of pivoting in the face of an unknowable unpredictable. But doing so requires transformational thinking at all levels so that we can readily embrace change, while holding contradictory viewpoints simultaneously while developing our capacity for systems thinking. A lot to ask, but we believe this is doable. It also requires individuals to develop and adaptive capacity which enables one to change one's beliefs instead of stubbornly holding on to them. In short, we need to rethink how we think[8], since we are looking at

> "a shift in the paradigm [which] is far more complex than developmental or transitional change [i.e., more or less what we have been doing since the Industrial Revolution]… Transformational change bears a quality of stepping into the unknown…The learning and discovery mechanism means that it is full of course corrections. …Successful transformation change comes from innovation, maximum stakeholder commitment and engagement and new ways of thinking and doing things. Transformational change demands breakthroughs in conventional wisdom" (Montgomery and Van Clieaf, 2023, p. 221).

Strongly connected ecosystems, i.e., resource pooling that are built to simultaneously deliver the complementary pair of both high and low variance in the growth rate, e. This makes strongly connected business ecosystems maximally antifragile, enabling maximally successful investing in high potential growth, innovative companies. Exactly the kind of companies needed today to solve our global climate, social, and environmental problems.

It is high time for both a new economics and a new discipline of finance that recognizes and harnesses the non-ergodic, path-dependent, multiplicative dynamics of all capitals.

Input – not sure where to put it.

What lies behind our hypothesis that inflation can be maintained consistently at a healthy level by correctly accounting for the non-ergodic dynamics of capital, and building businesses appropriately?

[8] For concrete lessons on how to do so see Boyd and Reardon 2020, especially pages 202-225.

Formatiert: Abstand Nach: 0 Pt.

Formatiert: Einzug: Erste Zeile: 1,27 cm, Abstand Nach: 0 Pt.

hat formatiert: Schriftart: (Standard) Times New Roman

hat formatiert: Schriftart: (Standard) Times New Roman

First, the impact of inflation is itself directly non-ergodic, and the higher the rate, and the bigger the volatility in the rate, the bigger the divergence between the ergodic assumption in today's econmies, and the non-ergodic outcomes. In particular, the non-ergodic time expected outcome is even smaller vs. the ensemble average the bigger the volatility in the inflation rate. That exacerbats all of the other volatilities in a companies growth rate. All of which push the actual growth rate even further down vs. the growth rate promised to invetors based on ergodic capital dynamics.

this gap between the primised performance and the actual perfomance has to be closed; or, the company will be shut down by investors shifting their money elsewhere, or through bankruptcy. All of which causeses losses in the economy.

Formatiert: Abstand Nach: 0 Pt.

So ignoring the non-erogdic nature of capital leads to companies performing below par, for that specific company, and n particular it leads to a drive twoards externalising costs to mainain profitabilty of the company, excessive consumption of natural and human capitals, and multiple other inflation driving activities.

Then, central banks react to inflation rates with measures usually uninformed by non-ergodic capital dynamics, and as such may unwittingly exacerbate the problem.

All of these add up to one simple statement: inflation is a simple single measure of a bulk property of an economy as a whole, somewhat like temperature is a simple measure of the bulk property of a glass of water. Our current neoclassical economics paradigm focusses on each individual company, and optimises that entity in isolation from all other etitities, leading to outcomes sub-optimal for the bulk. And actually therefore sub-optimal for each company, according to the nn-ergodic nature of the economy.

Formatiert: Einzug: Erste Zeile: 1,27 cm, Abstand Nach: 0 Pt.

We can only manage the bulk properties of the economy as a whole, including inflation, if we have structures and interactions at all scales that enable ptimisation with full recognistion of the non-ergodic dynamics of each of the six capitals, and especially financial.

References

Boyd, Graham and Jack Reardon (2023) *Rebuild the Economy, Leadership, and You: A Toolkit for Builders of a Better World,* Evolutesix, London.

Boyd, Graham and Jack Reardon (2023) *The Ergodic Investor and Entrepreneur*, Evolutesix, London.

Brown, Judy. and Jesse Dillard (2019) 'Accounting education, democracy and sustainability: taking divergent perspectives seriously', *International Journal of Pluralism and Economics Education*, Vol. 10, No. 1, pp.24–45.

Darwin, Charles, (1859[2000]) *On the Origin of Species,* The Modern Library, New York.

Madden, Bart (2020) *Value Creation Principles*, Wiley, New York.

Montgomery, John and Mark Van Clieaf (2023) *Net Zero Business Models: Winning in the Global Net Zero Economy,* Wiley, New York.

Peters, Ole and Alexander Adamou (2022) 'The Ergodicity Solution of the Cooperation Puzzle', *Philosophical Transactions of the Roual Society*, Volume 380.

Peters, Ole and M. Gell-Mann (2016) 'Evaluating Gambles using Dynamics,' Chaos: An *Interdisciplinary Journal of Nonlinear Science,* Vol. 26, No. 2

hat formatiert: Schriftart: Kursiv

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt.

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt., Kursiv

hat formatiert: Schriftart: (Standard) Times New Roman, 12 Pt.

hat formatiert: Schriftart: 12 Pt.

hat formatiert: Schriftart: Kursiv

hat formatiert: Schriftart: Kursiv