PANTHERA SOLUTIONS

AUGMENTED INTELLIGENCE IN INVESTMENT MANAGEMENT

Integrating Human Intelligence, Artificial Intelligence, and Sustainability in Investment Decision Designs

White Paper / September 2024

TABLE OF CONTENTS

ABSTRACT

Since its inception, the global financial system has evolved to manage increasing complexity with greater efficiency whilst its fundamental role as a global facilitator of Pareto-efficient resource allocation has remained intact. So successful has finance been in allocating resources that it has become a primary driver in the creation of negative externalities - particularly environmental degradation - which pose a significant risk to future economic and social development. It is clear that humanity must adapt and reintegrate into Earth's homeostasis to successfully navigate the coming era of Planetary Time. Financial markets are the most effective intervention tool available for managing this reintegration. But how can they do this?

Seamlessly integrating Augmented Intelligence into investment decision-making is a prerequisite for financial markets to fulfill their essential role in reintegration. The current fragmented approach in both academia and practice inadequately addresses this need. This article describes the objectives, guiding implementation questions, and contextual reasoning for integrating Augmented Intelligence into investment management.

THE PURPOSE OF FINANCIAL MARKETS

Financial markets are complex adaptive systems (Lo, 2004). Their essential purpose consists of facilitating an efficient allocation of resources among their participants (Mishkin, 2018; Ross & Westerfield, 2016; Fabozzi & Modigliani, 2009). This purpose has not changed since Luca Pacioli introduced double-entry bookkeeping in 1494, the first stock exchange was launched in Amsterdam in 1602, or the interpretation of efficient allocations became standardized and scalable through Harry Markowitz et al. in 1952.

What has changed throughout financial market history is the degree of complexity participants have had to master to achieve an efficient allocation. This degree of complexity is determined by the **scope of the system and the dynamics within it**.

Humanity has extended the scope of factors to be considered for an efficient allocation decision over time. Financialization, globalization, and digitization have been dominant drivers in this extension of scope. Today, market participants can allocate their resources across a global capital stock of USD 795.7 trillion (Vacchino, Periasamy, & Schuller, 2024), which is unprecedented in human history.

To master the increased dynamics within the system–resulting from the widened scope–market participants have had to adapt their interactions, evolving from traditional belief systems about markets to the application of assessment techniques that are more insightful in understanding market complexity. This shift has led to a focus on which behaviors best contribute to integrating different sources of evidence into decisions at the point of allocation. Reasoning has morphed from deductive to inductive (Schuller, Mousavi, & Gadzinski, 2018), leading to an ever more accurate assessment of the dynamics within the financial system.

Complex systems produce **emergent phenomena**, that is, properties that can only be studied at a higher level. The intricate, non-linear interactions between the components of complex systems give rise to new, often unexpected properties or behaviors that cannot be explained simply by examining the system's individual parts. Emergence is thus a natural consequence of complexity, where the whole becomes more than the sum of its parts.

MASTERING PLANETARY TIME AS OBJECTIVE

A primary emergent property in the history of financial markets is the dominance of humankind over nature, which came to the fore following the Scientific Revolution in the late 15th century. This dominance has led to an unprecedented density of breakthroughs by humankind, equipping itself with ever more refined and scalable tools to master complexity.

Humanism is linked to the flourishing of science and the arts during the Renaissance of the 15th and 16th centuries, when the cultivation of human potential took center stage, breaking free from the restrictive mindset of the Middle Ages and reviving the reasoned sensibility of Greco-Roman antiquity. Even today, the humanist perspective shapes the open societies of the modern West, influencing their material progress, cultural achievements, and individual freedoms (Gardels, 2023).

The **Age of Enlightenment** built upon this scientific revolution, adding a philosophical notion to social ideas centered on the value of knowledge gained through rationalism and empiricism. Economic theories evolved alongside this Zeitgeist, enabling a continued series of basic innovations since the Industrial Revolution gained pace in the late 18th century (Smith 1759, 1776; Pareto, 1906). These basic innovations led to Kondratieff waves of economic value creation in the diffusion of innovation throughout our societies worldwide.

The dominance of humankind over nature has led to an **unprecedented creation of economic wealth**, coordinated in its resource allocation by financial markets. As one of many positive consequences, the share of the global population living in extreme poverty decreased from about 75% in 1820 to 10% in 2018 (Roser, 2021). The aggregate of negative externalities of this dominance was the human exploitation of natural environment, triggering **human-induced climate change** (IPCC, 2023).

As is common for complex adaptive systems, what started as a side effect–a negative externality–has turned into a dominant factor influencing the system. Currently, **the financial system is learning how to integrate factors beyond a human-centered worldview**. We have entered an era when time is no longer differentially distributed along human and non-human scales. That's what the Anthropocene shows us: "There's no longer a social history separate from natural history. That artificial separation is over. Human history and Earth history are now indivisible." (Mbembe, 2022).

Subsets of humankind, such as cultures or nation-states, must understand that, while looking back at a mostly separate past, they will experience a primarily common future. "The local narratives are being increasingly forced to coordinate the time horizons of their rooted history with the virtual synchronic horizon of the common world time." (Sloterdijk, 2018). This synchronous moment of temporal simultaneity could be called **planetary time** (Gardels, 2022).

There is resistance to change embedded in the incentive logic of the system itself. Human subsets are incentivized not to progress towards planetary time. For example, the sovereign nation-state, still the most potent legacy institution of human agency, exists to affirm historically-bound identities and accelerate 'endless' growth, especially in consumer democracies geared towards satisfying gratification here and now. Consequently, it is a platform that perpetuates the divergence of human and Earth history (Gardels, 2022).

Can we expect fast adaptation? As Carl Jung suggested more than a hundred years ago (Jung, 1912), our rapid evolution into the modern industrial age and beyond has not erased the archaic tendencies we evolved in over two million years as Homo erectus. These tendencies remain deeply embedded and dangerously inappropriate for the future we are fast approaching. Evolutionary biologist Richard Dawkins has pointed out that the human brain was not designed to comprehend slow, cumulative processes like ecological change (Dawkins, 1986). Our ancient instincts fail to recognize what lies ahead.

What can we do to change this?

PLANETARY TIME THROUGH AUGMENTED INTELLIGENCE

Human history and Earth history have become indivisible. While the Enlightenment focused on detaching human kind from nature, often exploiting it unsustainably, the current era is about **reintegrating humanity into the complex system that is our planet**. The problem is that the climate is changing faster than humans can cope. In the absence of our psychophysical constitution being able to adapt quickly enough to converge towards the necessary planetary time, can technology act as a bridge builder to close the gap? If so, what will become of human centrality as our species is knocked off its pedestal by machines more intelligent than we are and de-centered by the humbling realization that survival depends on reducing our outsized footprint on this fragile planet?

Are these even the relevant questions? Neuroscientist Antonio Damasio (Damasio, 2016) has observed that the intelligence of all organisms, from unconscious bacteria to the human body, aims for homeostasis–a state of balance with the environment that allows for survival and flourishing. If we consider the planet as a single organism that maintains homeostasis through the feedback loops of its complex ecosystem, the ability to sustain that balance has been compromised by the carbon emissions produced by human activity over the past century. To change course and survive, humanity's best hope lies in extending its instinct for survival, developed through evolution, to match the timescale and scope of the planetary system. This requires aligning our technological capabilities with nature, rather than opposing it.

In the context of homeostasis, amending humankind's explorative journey towards ontological truth with technologies in the realm of artificial forms of intelligence, those **technologies become an integral part of human evolution**. In the words of Benjamin Bratton (Bratton, 2021): "Human-machine intelligence becomes part of an expanded landscape of life, part of a living ecology, not a substitute for one. Put more specifically: The response to anthropogenic climate change will need to be equally anthropogenic."

The perceived dichotomy between Human and Artificial Intelligence (AI) converges into the emergent phenomenon of Augmented Intelligence, enabling the reintegration of our species into the homeostasis of planet Earth to master the coming era of planetary time.

AUGMENTED INTELLIGENCE THROUGH FINANCIAL SYSTEM DESIGN

For most of the Enlightenment, two subsystems of our societies have proven to be the dominant backbones and thus the most effective intervention pathways for societal change: **the political system and the financial system**.

The financialization, globalization, and digitization of our societies have changed the power balance between these two backbones. Despite humans becoming ever more interdependent globally, the sovereign nation-state has remained the most potent legacy institution of human agency in the political system, fragmented and relatively uncoordinated on a global scale.

With the last wave of globalization leading to an integrated world economy and global financial market, the financial system has become the dominant backbone. As such, the financial system's design to navigate capital flows is paramount to establishing an Augmented Intelligence that enables us to master the era of planetary time.

GUIDING QUESTION FOR FINANCIAL SYSTEM DESIGN

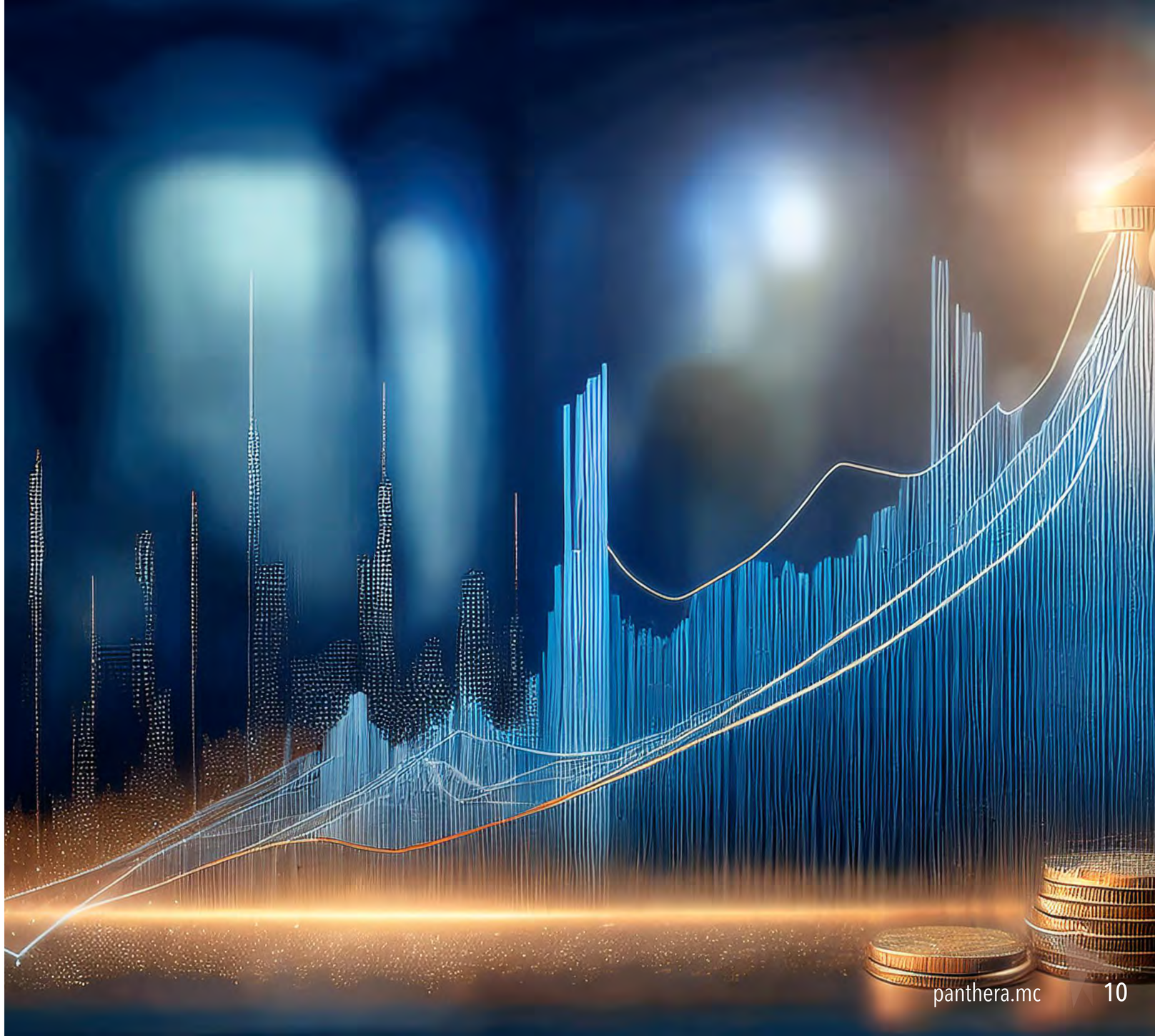
With the necessity for humankind to reintegrate into the homeostasis of planet Earth, the purpose of financial systems–namely facilitating an efficient allocation of resources among its participants–is set in a new context. This leads to the question of how to design a financial system in this context:

How can we design a financial system that integrates Artificial Intelligence with Human Intelligence to establish Augmented Intelligence and master the era of planetary time?

STATUS QUO
IN FINANCIAL SYSTEM DESIGN

Addressing this guiding question will require the seamless integration of Human Intelligence, AI, and sustainability considerations into the decision models underpinning investment. Academia, as well as industry practice, is treating these three elements in silos, and is too slowly breaking through those walls to integrate them into an holistic decision design.

What is the status quo for each silo?



HUMAN INTELLIGENCE IN INVESTMENT MANAGEMENT

In a transformative environment of ever-increasing complexity, adoption rates for new technologies continue to increase, often driven by "shiny object syndrome." In direct contrast to technologies, adoption rates for changed behaviors and decision models to master this complexity remain slow.

Over the past 40 years, behavioral finance has made numerous attempts to improve our behaviors in making evidence-based decision-making. Whilst we now know significantly more about the quantity of biases and how and why we tend to make investment decisions full of noise and bias, we have not done enough to help the various players in the global financial ecosystem bridge the knowing-doing gap, which is essential for accelerating the diffusion of innovation. Behavioral solutions to our cognitive biases have long been studied in academic literature (Zahera & Bansal, 2018). However, either professional investors tend to talk more about behavioral finance than make use of its insights, or debiasing cognitive biases only has a temporary effect (Gadzinski, Mousavi, & Schuller, 2022). Talking about behavioral change is easier than implementing it.

What has become more prominent academically is the focus on applied behavioral considerations, such as behavioral design configurations. The intent is not only to raise awareness of cognitive dissonances and their effects, but also to make it easier for decision-makers to improve such configurations with low cognitive effort. Awareness training has proven to be ineffective because it is too superficial in its impulse to facilitate behavioral change (Fleming, 2023). Alternatively, high-performance principles for designing an investment decision support system that produces evidence-based decisions are increasingly being explored (Schuller, 2021).

ARTIFICIAL INTELLIGENCE IN INVESTMENT MANAGEMENT

There is a long history of computational and machine contribution to investment management. For example, in the 1990s breakthroughs in the management and interpretation of data through quantitative finance techniques led to the development of algorithmic trading strategies.

With the public release of the first large language models (LLMs) about two years ago, awareness and applicability of AI have increased significantly. Initial generative AI (GenAI) applications are still a magnet of attention, despite funding for AI ventures being higher last year than it is this year so far. The capabilities of GenAI for the years to come have also become more visible. In complex environments, where creative and critical thinking are key success factors, GenAI can act as a personalized co-pilot, while not replacing the human decision-maker. Various public and in-house co-pilot applications have been developed since (here, here or here).

Awareness grew that the best way to benefit from AI is to strive for excellence in Human Intelligence. This insight is not new, while having grown critically in recent years (Schuller, 2017). Even AI thought leaders recommend not studying how to code but advancing associated cognitive skills to make the best use of these AI tools to enhance the quality of one's decision-making (e.g.,here, and here). This focus on **cognitive augmentation leading to Augmented Intelligence**, where AI can augment human cognitive abilities, assisting in problem-solving, decision-making, and memory recall Whilst Augmented Intelligence is currently being explored practically and academically, we are still at a very early stage of the journey.

Academically, initiatives are under way to evaluate what GenAI can contribute beyond accelerating the standardization and automation of managerial processes, which has been an ongoing trend since the 1950s. The scientific process takes time to add value. It has been less than two years since ChatGPT was launched, which, in academic terms, is only yesterday. Consequently, we are also at an early stage in reflecting on AI implications for managerial practice.

Thinking is more advanced in more deterministic managerial sciences, but thinking about how AI can add value in stimulating creativity, critical thinking, and decision-making are–quoting another professor at AOM 2024–"in the Stone Age." Research on these aspects suffers from the same constraints as LLMs themselves. LLMs are brute-force approaches to data and information management but lack an applicable theory of mind that would allow for personalization. There is still a long way to go for AI tools and related research.

In the investment management industry, the CFA Institute acts at the forefront of adding oversight and structure to the different unstructured attempts to integrate GenAI features into investment processes. A recent CFA employer survey (CFA, 2024) finds that 85% of respondents believe there is a need to set industry-wide standards and ethical guidelines for the use of AI/GenAI in investment roles. Almost half consider their organizations not well-prepared to adapt to potential regulatory changes regarding AI/GenAI in the investment sector. When asked about how the workforce feels about AI/GenAI, 60% say that the workforce seems anxious, and 48% say they seem resistant to AI/GenAI.

In another recent CFA study on GenAI implications (Pisaneschi, 2024), the Institute summarized recent findings on the adoption of alternative and unstructured data

sources in investment management, reflecting on fine-tuning language models for small and big data management. These features remain in the domain of standardizing and automating managerial processes.

Complementing that limited focus, entrepreneur Marc Andreesen highlighted AI's double-edged potential by stating, "AI can make everything we care about better." (Andreesen, 2023). This might be one of the outcomes but is not automatically the most likely one. Stanford University (Hamilton & Aaker, 2024) recently concluded that AI–if trained merely to accelerate productivity with our current agenda and values–will simply perpetuate social and environmental crises and widen the gaps in our society and between our society and the planet. They also outline how AI can help augment each human trait, a practice that could unleash more fulfilled and sustainable lives by integrating meaning and purpose into a dopamine-charged culture.

In short, today's AI agents, prompting cheat sheets, or chatbots are playful toys, not yet investment process-changing factors. More work needs to be done purposefully to integrate artificial forms of intelligence into human decision design to achieve Augmented Intelligence, shaping capital deployment towards **reintegrating humankind into the homeostasis of planet Earth with the goal of mastering the era of a planetary time**.

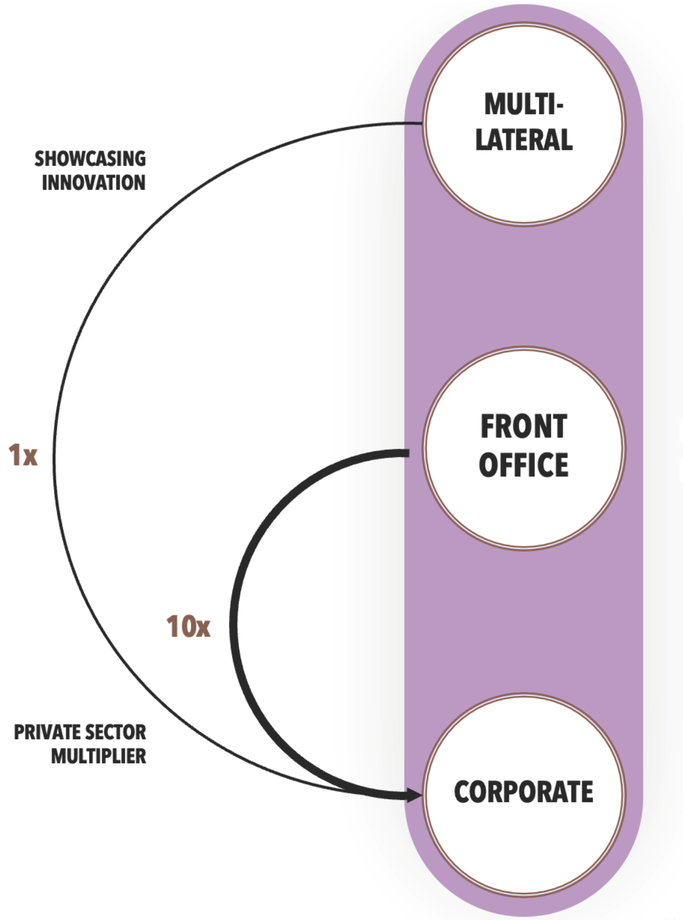
SUSTAINABILITY IN INVESTMENT MANAGEMENT

Sustainability considerations in the financial system are a possible gateway for Augmented Intelligence to create the impact needed in the real economy necessary to reintegrate humankind into the homeostasis with planet Earth. These considerations have a long, though not critically impactful, history in finance.

Only recently, Sustainable Development Goals (SDG)-related investing– as the most comprehensive iteration of sustainability considerations to date–has moved from a "nice to have" to a "must-have" practice of good management for investment managers and business leaders alike. The road to necessity has taken decades to build (Townsend, 2020). Starting with civil society activities about 50 years ago (Greenpeace founded in 1971, WWF founded in 1961, Club of Rome published "Limits to Growth" in 1972), which evolved into more institutionalized forms of national parties and policy agendas of supranational organizations, lobbying for awareness and increasingly demanding action. It was not until the 2000s that the investment management industry took notice in an institutionalized way (PRI, 2006), followed by the formal approval of SDGs in 2015 (UN, 2015). What policymakers and regulators have only recently accepted is their inability to be the primary driver to initiate, facilitate, and incentivize the direction of capital deployment towards making SDGs achievable. The actual redeployment of capital at scale must be done by market participants themselves, by creating value for stakeholders through an evidence-based assessment of the opportunity set in the risk/return profile. This translates into scale when front office specialists are incentivized to search for opportunities that generate more profits due to their sustainability.

SDG-related investing will fail if it is understood as merely another box-ticking exercise–a practice that boards, investment committees, and portfolio managers have sadly become accustomed to since the global financial crisis. This compliance-driven approach over the last 15 years has ended up being the responsibility of the middle and back offices, leading to higher reporting and administrative burdens but very limited success in capital redeployment towards SDGs by front office teams. The ineffective steering effect of environmental, social, and governance (ESG) ratings in capital allocation is well-researched (Berg, Heeb, & Kölbel, 2024). In short, the approach of policymakers and regulators to push front offices via their middle and back offices has failed.

Figure 1 > Alternative Approach by Multilateral Institutions



Policymakers and regulators are now looking at alternative ways to trigger a private sector multiplier in the front offices, establishing push-incentives that make it implicitly more difficult for front office decision-makers to delegate their responsibility to compliance teams, rating agencies, scoring models, ESG databases, or consultants. This is the bridge to be built by augmented intelligence. For instance, more effective, pull-based steering can be learned from behavioral sciences. Baskets of tested green nudges are available, describing small or large interventions that aim to influence behavior to make people act more sustainably (Green Nudges, 2024).

Academic research in the domain of SDG-related investing is currently of limited support because it is still in its infancy. The number of papers published in peer-reviewed journals has only increased significantly since 2019. From an academic perspective, that is a short period of time. Indicative of the early stage of academic contribution is the number and quality of journals dedicated to the topic. Until about ten years ago, research questions related to ESG/SDG/sustainability were included in well-established financial journals with a broader scope. Dedicated journals are young and not highly ranked. The Journal of Sustainable Finance & Investment (H-Index 16) has existed since 2011, the Journal of Sustainable Economy (H-Index 5) since 2017, and the Journal of Impact & ESG Investing released its first issue in 2020 (No H-Index).

Caveat: the portfolio management techniques used in these studies can be labeled as traditional. We see more-of-the-same factor-based portfolio construction techniques (Lioui, 2019) or prolonged assumptions of the Optimal Risky Portfolios (Blackrock, 2020) as valid starting points in strategic asset allocation.

It should not be surprising that an industry known for its slow adaptability (Stanford, 2015; Schuller, 2018) pursues well-established patterns in its portfolio construction methods, academics, and practitioners alike. The high market concentration of ESG data vendors and their converging approaches to measuring impact (Klein & Rajagopalan, 2020) align with the well-established industry culture of slow adaptability. This culture enables greenwashing to still be a widely applied practice (ESG Clarity, 2021; Amenc et al., 2021), a concern that the BIS had already warned about years ago (BIS, 2021).

TRANSITION PLANS AS OPPORTUNITY

Despite various failed attempts to redeploy capital towards SDGs since Paris 2015, recent developments align with the intent of push incentives as described earlier. Transition plans are on the rise. Their frameworks are defined (Transition Taskforce, 2024; Glasgow Financial Alliance for Net Zero, n.d.). They are now moving from a voluntary PR exercise to something regulators consider making mandatory (Panthera Solutions, 2024). Transition plans could act as a blueprint for capital market participants to align strategic goals, incentives, and actions when deploying capital towards integrating profit and impact motives, with an emphasis on profitability–making money to make a difference. For now, less than 1% of financial intermediaries have defined their transition plans. Even those that have will need to revise them because they were initially PR exercises written by marketing and compliance departments.

Creating transition plans will increasingly standardize in the coming years through digitizing and automating data collection and interpretation. Their success depends on the implementation of the transition plans. When taken seriously, such plans require a bank, institutional investor, or other entities to revise their investment business models to integrate profit and impact motives. Thus, **transformation management is required**.

THEORY OF CHANGE REQUIREMENT

In the context of transition planning, the adaptability of business models and investment processes will be a key success factor. Slow adaptability, which was the norm in professional investment management, will no longer be accepted by regulators or deemed acceptable for staying competitive against market forces. Innovative specialization in investment management will follow and is needed because any effort to repair planetary deformation through technology cannot be effective if it is solely focused on cutting downstream emissions or adapting to the consequences of rising temperatures (Gardels, 2021).

We are facing market phenomena that are increasingly complex to comprehend, while regulators are starting to expect a 'theory of change' from professional investment managers (Charatan & Kaur, 2024), showing how they intend to increase their adaptability and impact. This expectation is combined with transition planning and policymakers' awareness of the need to trigger private sector multipliers through market-based incentives.

THIRD GENERATION ASSET ALLOCATION

This article has built the case for seamlessly integrating Augmented Intelligence into investment decision designs as a basic prerequisite for financial markets to contribute to the sustainable reintegration of our species into the homeostasis of planet Earth. The previous chapter highlighted that the current state of investment management falls short of achieving the necessary seamless integration because it addresses its components in a fragmented manner, both academically and in practice.

Despite being siloed, these areas have made significant progress within their realms in managing the complexity of the financial system. This chapter will explore these advancements and discuss their implications for achieving seamless integration.

Since the beginning of modern portfolio construction techniques (Markowitz, 1951), the academic evolution can be categorized into three generations (Figure 2). The first two, single-period/single-factor models and multi-period/multi-factor models, share a set of assumptions based on the Homo oeconomicus concept of man (Schuller, 2015).

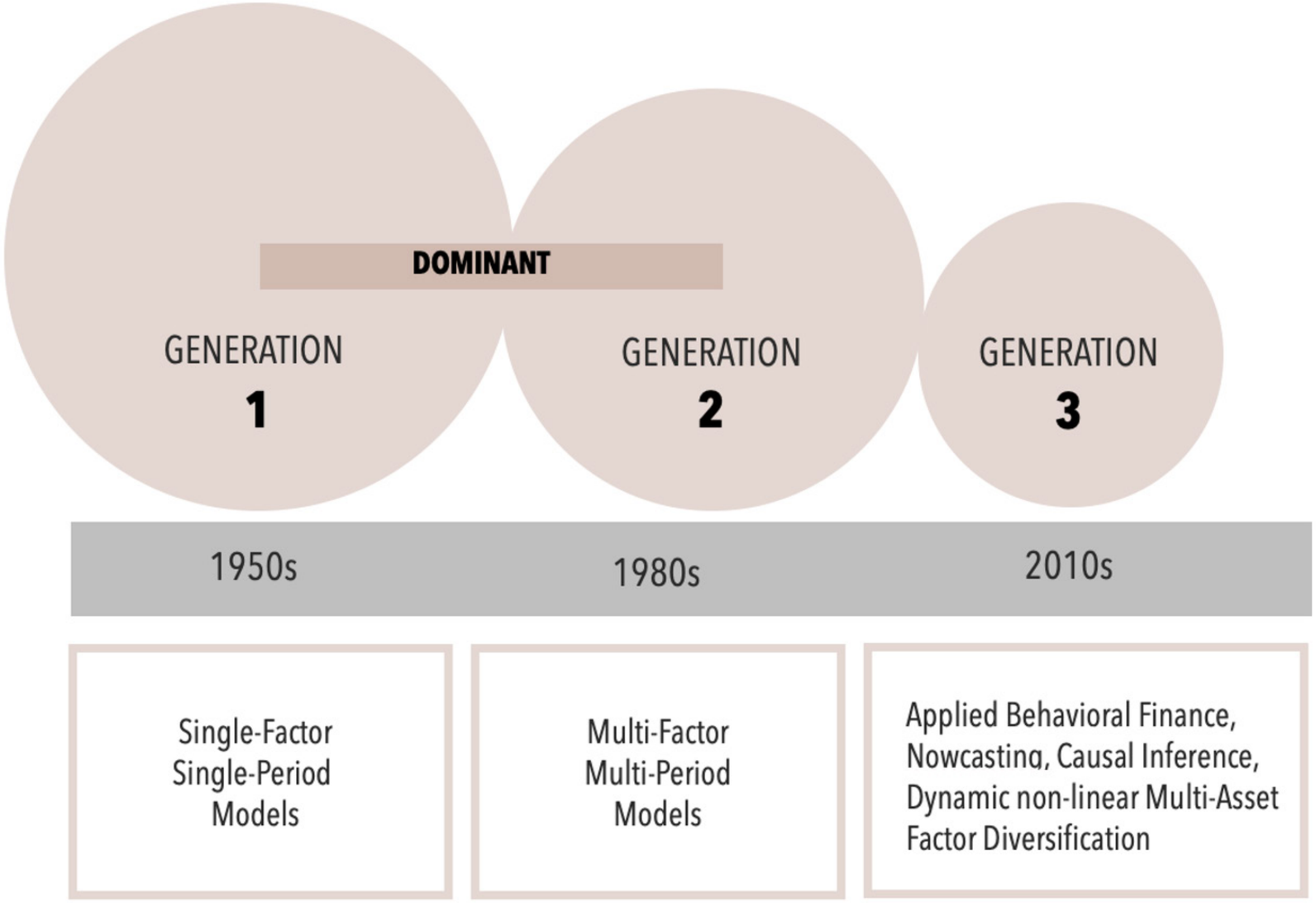


Figure 2 > Three Generations of Asset Allocation Techniques

Generation One: The basic concept of Capital Market Theory was developed in the 1950s and 1960s through the pioneering work of Henry Markowitz (1952), James Tobin (1958), Benoit Mandelbrot (1963), William Sharpe (1964), Paul Cootner (1964), and Eugene Fama (1965), among others. Their basic assumptions can be summarized as static optimization techniques for a static world, where portfolio construction was understood as an exercise in linear extrapolation of the past into the future.

Generation Two: Multi-factor, multi-period models, academically developed during the 1970s and 1980s, were used as quantitative optimization techniques for the second generation. These theories, such as the arbitrage pricing theory (Ross, 1976) and the three-factor model of Fama-French (1993), share basic assumptions with first-generation models while attempting to overcome their limitations through multiple regression analyses and other now-popular econometric methods. Their basic assumptions can be summarized as introducing forecasting into portfolio construction, expecting the accurate forecasting of future values to be discounted to present values.

Despite significant empirical and experimental evidence against the basic assumptions of the first two generations of models, and in support of the concept of biased human behavior of the third generation, the disunity of the scientific discourse persists to this day.

Third-generation asset allocation models represent an emancipation from the basic assumptions of the first two. The Homo oeconomicus no longer takes center stage or serves as the starting point for modeling. The third generation of models received its conceptual framework through Andrew Lo's (2004) combination of cognitive neuroscience and evolution theory, postulated as the adaptive market hypothesis (AMH).

Figure 3 summarizes the different streams that matured in academia over decades, having reached an applicable state since the global financial crisis, and laying the foundation for a new generation of asset allocation techniques that can **integrate different forms of AI**, both conceptually and practically.

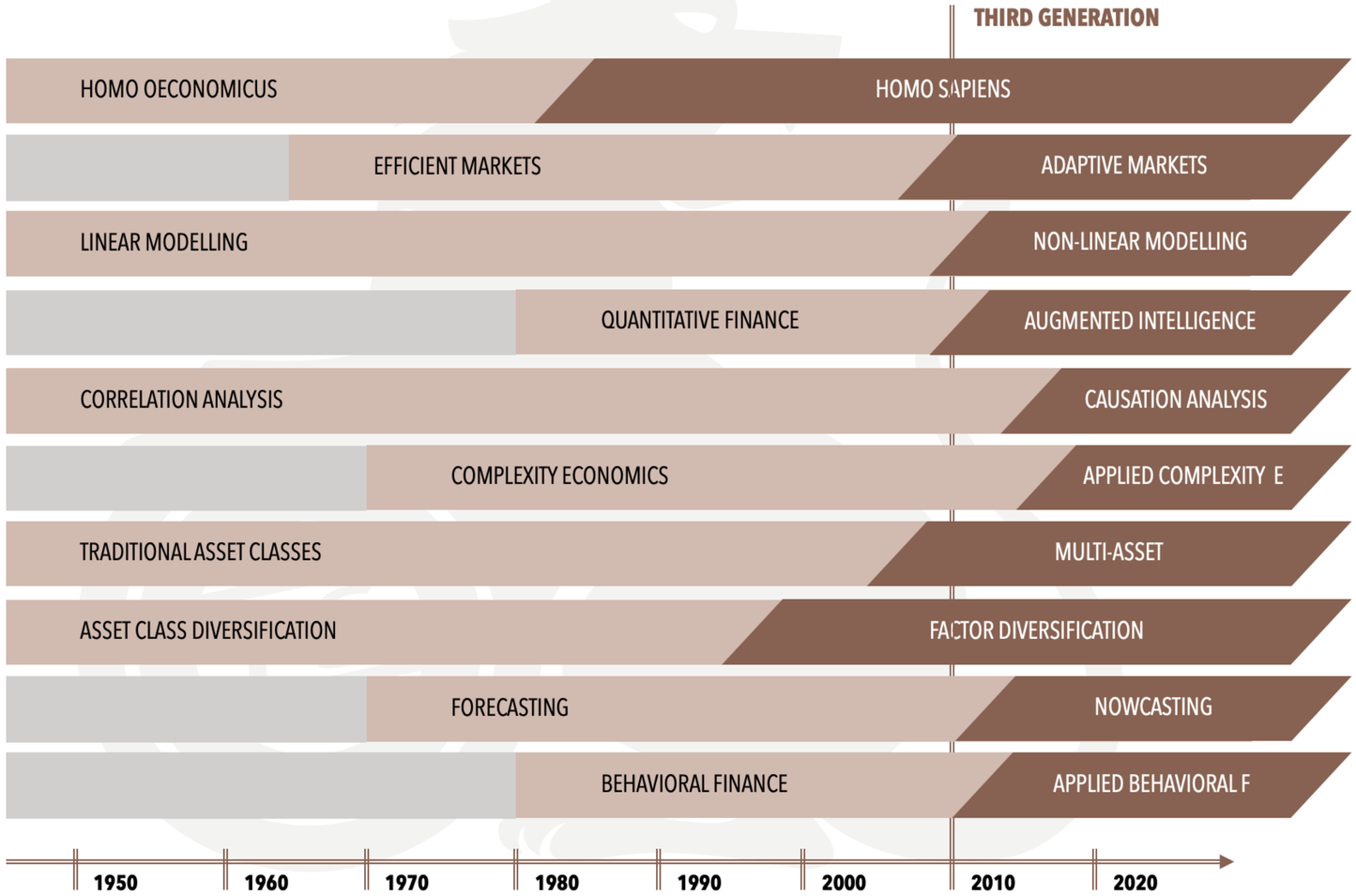


Figure 3 > Third Generation Tipping Point Reached

Third Generation Implications

The different streams have in common that they no longer assume linear extrapolation of the past into the future (1GEN) or forecasting future values and discounting them to present values (2GEN). Instead, they focus on assessing causal factors at present times, building their assessments not through deductive theorems, but via inductively generated evidence.

Example. Causality is a feature of life, as it is for capital markets. Causal discoveries help us make better sense of the world around us. By helping us understand relevant laws of nature, causality can give us prescriptive evidence for our analysis and guide us towards improved decisions. Indeed, causal knowledge and inferences based on it are critical for effective decision making in capital markets.

Nancy Cartwright even suggests that causal laws are required to distinguish between effective and ineffective investment strategies. Augmented intelligence helps turning complex and complicated causality assessment techniques into practical, easily applicable tools for investment decision makers. A comprehensive toolbox of those techniques has been established in recent years (Haberl, Schuller, 2021).

In short, this new generation allows for the creation of investment decision support systems that are adaptive, inductive, causal, and prospective in their quest for rational decisions. As such, they invert the traditional modeling approach of 'reality follows model' to 'model follows reality.'

CONCLUSION

The objective for stakeholders in the global financial system has become clear: How can we design a financial system that integrates AI with Human Intelligence to establish Augmented Intelligence and master the era of planetary time?

Meeting this objective requires a symbiotic relationship between humans, machines, and the impact their Augmented Intelligence creates with capital allocation decisions. Conceptual and practical silos will need to be broken down. The third generation of asset allocation techniques is young but already lays the foundation for what such a symbiotic relationship might look like.

The next step for our industry is to conceptualize investment decision support systems based on a framework of third-generation principles.

Onwards and upwards.

GLOSSARY

- **Augmented Intelligence**: The combination of human intelligence and AI designed to enhance human decision-making processes. In investment management, this involves integrating AI with human expertise to achieve more effective, evidence-based decisions, particularly in navigating complex and dynamic financial systems.

- **AMH**: A theory developed by Andrew Lo, proposing that market efficiency is not static but evolves over time as market participants adapt to changing environments. It integrates principles from evolutionary biology, cognitive neuroscience, and behavioral finance.

- **Behavioral Finance**: A field of study that examines how psychological factors and biases affect financial decision-making. It challenges the traditional assumption of rational behavior in markets by highlighting how emotions and cognitive errors can lead to suboptimal investment choices.

- **Cognitive Augmentation**: The enhancement of human cognitive abilities, such as problem-solving, decision-making, and memory recall, through the use of AI tools. In investment management, cognitive augmentation refers to using AI to support human analysts in making more informed decisions.

- **Complex System**: A system characterized by intricate interconnections among its components, where interactions give rise to emergent phenomena—new properties or behaviors that cannot be explained by examining individual parts in isolation. Examples include financial markets and ecosystems.

- **Deductive vs. Inductive Reasoning**: Deductive reasoning involves drawing specific conclusions from general principles or theories, often used in traditional financial modeling. Inductive reasoning, on the other hand, involves generating general principles based on specific observations or data, which is increasingly relevant in the context of big data and machine learning.

- **Emergent Phenomena**: New and unexpected properties or behaviors that arise in complex systems due to the non-linear interactions among their components. These phenomena cannot be predicted by studying individual parts in isolation and are a key characteristic of complex systems like financial markets.

- **ESG Criteria**: A set of standards for a company's operations used by socially conscious investors to screen potential investments. ESG criteria are a key component of sustainable investing, focusing on a company's impact on the environment, its relationships with employees, suppliers, and communities, and the quality of its governance.

- **Global Capital Stock**: The total value of financial and real assets held globally, representing the resources available for investment across various markets. This includes equities, bonds, real estate, and other financial instruments, which together form the global capital market.

- **Homeostasis**: A state of balance or equilibrium within a system. In this context, it refers to the balance between human activities and the Earth's natural systems, which is necessary for long-term sustainability.

- **Planetary Time**: A concept referring to the synchronization of human activities with the natural cycles and processes of the Earth, acknowledging that human history and Earth's history are now intertwined. It reflects the need for humans to reintegrate into Earth's homeostasis, particularly in the context of climate change and environmental sustainability.

- **SDGs**: A concept referring to the synchronization of human activities with the natural cycles and processes of the Earth, acknowledging that human history and Earth's history are now intertwined. It reflects the need for humans to reintegrate into Earth's homeostasis, particularly in the context of climate change and environmental sustainability.

- **Third Generation Asset Allocation**: An advanced approach to portfolio construction that moves beyond traditional static optimization and forecasting models. It incorporates adaptive, inductive, and causal methods to better handle the complexity and uncertainty of modern financial markets, particularly in integrating AI and sustainability considerations.

- **Transition Plans**: Strategic frameworks outlining how organizations, particularly financial institutions, plan to align their operations with long-term sustainability goals, such as achieving net-zero carbon emissions. Transition plans are increasingly becoming a requirement for demonstrating a commitment to sustainability.

BIBLIOGRAPHY

AlphaSense. (n.d.). AlphaSense. AlphaSense. Retrieved during August 2024 from https://www.alpha-sense.com/

Andreesen, M. (2023, June 6). Why AI will save the world. Retrieved during August 2024 from https://a16z.com/ai-will-save-the-world/

Amenc, N., Goltz, F., & Liu, V. (2021). Doing good or feeling good? Detecting greenwashing in climate investing. EDHEC Risk Institute.

Berg, F., Heeb, F., & Kölbel, J. F. (2024). The economic impact of ESG ratings. MIT Sloan School of Management. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4088545

Bratton, B. (2021). Planetary sapience. Noema Magazine. Retrieved during August 2024 from https://www.noemamag.com/planetary-sapience/

BIS. (2021). Sustainable finance: Trends, valuations and exposures. BIS Quarterly Review. Retrieved during August 2024 from https://www.bis.org/publ/qtrpdf/r_qt2109v.htm

BlackRock. (2020). Achieving a strategic asset allocation and generating long-term growth in a sustainable way. Case study for PRI. Retrieved from https://www.unpri.org/asset-owner-resources/achieving-a-strategic-asset-allocation-and-generating-long-term-growth-in-a-sustainable-way/6922.article

CFA Institute. (2024). AI disruption: Employer survey 2024 [PDF]. Retrieved during August 2024 from https://www.cfainstitute.org/-/media/documents/survey/AI-disruption-employer-survey-2024.pdf

Charatan, F., & Kaur, G. (2024, April 25). Theory of change for fund managers and impact investors. ThinkNPC. Retrieved during August 2024 from https://www.thinknpc.org/blog/theory-of-change-impact-investing-fca/

Damasio, A., & Damasio, H. (2016). Exploring the concept of homeostasis and considering its implications for economics. Journal of Economic Behaviour & Organization, 126, 125-129. Retrieved during August 2024 from https://doi.org/10.1016/j.jebo.2015.12.003

Dawkins, R. (1986). The blind watchmaker: Why the evidence of evolution reveals a universe without design. Norton & Company.

ESG Clarity. (2021). Net zero accounting tricks would land people in jail if tried. Retrieved during August 2024 from https://esgclarity.com/net-zero-accounting-tricks-would-land-people-in-jail-if-tried/?msdynttrid=HHIPqilJEUZICNwJFXd7qyhEh1Fw2d_0C4HGTizmfN0

Fabbro, R. (2024, August 9). JPMorgan Chase staff are getting a new AI assistant – powered by OpenAI. Quartz. Retrieved during August 2024 from https://qz.com/jpmorgan-chase-ai-assistant-openai-1851617640

Fabozzi, F. J., & Modigliani, F. (2009). Capital markets: Institutions and instruments. Prentice Hall.

Glasgow Financial Alliance for Net Zero. (n.d.). Financial Institution Net-zero Transition Plans. GFANZ. Retrieved September 3, 2024, from https://www.gfanzero.com/our-work/financial-institution-net-zero-transition-plans/

Global Financial Alliance for Net Zero. (n.d.). Financial institution net zero transition plans. Global Financial Alliance for Net Zero. Retrieved September 3, 2024, from https://www.gfanzero.com/our-work/financial-institution-net-zero-transition-plans/

Green Nudges. (2024). Promoting sustainable behaviors through nudges. Retrieved during August 2024 from https://www.green-nudges.com/

Gardels, N. (2023). Post-Anthropocene humanism: The world is returning to pluralism after American hegemony. Noema Magazine. Retrieved during August 2024 from https://www.noemamag.com/post-anthropocene-humanism/

Gardels, N. (2022). The politics of planetary time. Noema Magazine. Retrieved during August 2024 from https://www.noemamag.com/the-politics-of-planetary-time/

Gardels, N. (2021, February 25). Want not, waste not: To save the biosphere, curb upstream consumption – not just downstream emissions. Noema. https://www.noemamag.com/want-not-waste-not/

Intellectia. (n.d.). Intellectia AI. Intellectia. Retrieved during August 2024 from https://intellectia.ai/

Intergovernmental Panel on Climate Change (IPCC). (2023). Climate change 2023: Synthesis report. Contribution of working groups I, II and III to the sixth assessment report of the Intergovernmental Panel on Climate Change [A. Pirani, R. Zan, A. Cheng, D. C. Taylor, M. Hassan (Eds.)]. IPCC. Retrieved during August 2024 from https://www.ipcc.ch/report/ar6/syr/

Jung, C. G. (1912). The psychology of the unconscious. Moffat, Yard and Company.

Klein, C., & Rajagopalan, R. (2020). SDG Impact Measurement: A brief overview of providers, methodologies, data and output (Version 1.0). DVFA Commission Sustainable Investing. Retrieved during August 2024 from https://www.dvfa.de

Lioui, A. (2019). The decarbonisation factor: A new academic fiction? EDHEC Risk Institute. Retrieved during August 2024 from https://www.scientificbeta.com/media/files/2020/01/13/The_DeCarbonisation_Factor_A_New_Academic_Fiction.pdf

Lo, A. (2004). The adaptive markets hypothesis: Market efficiency from an evolutionary perspective. Journal of Portfolio Management, 30(5), 15-29.

Moore, M. (2024, March 21). Nvidia CEO says don't give up learning new skills – just maybe leave programming to AI. TechRadar Retrieved during August 2024 from. https://www.techradar.com/pro/nvidia-ceo-says-dont-give-up-learning-new-skills-just-maybe-leave-programming-to-ai

Masterson, V. (2023, May 1). Future of jobs 2023: These are the most in-demand skills now - and beyond. World Economic Forum. Retrieved during August 2024 from https://www.weforum.org/agenda/2023/05/future-of-jobs-2023-skills/

Mbembe, A. (2022). How to develop a planetary consciousness. Noema Magazine. Retrieved during August 2024 from https://www.noemamag.com/how-to-develop-a-planetary-consciousness/

BIBLIOGRAPHY

Mishkin, F. S. (2018). The economics of money, banking, and financial markets. Pearson Education.

Panthera Solutions. (2024, May 31). Transition Planning Kick-Off. LinkedIn. Retrieved during August 2024 from https://www.linkedin.com/feed/update/urn:li:activity:7202214056374505472/

Pisaneschi, B. (2024). Unstructured data and AI: Fine-tuning LLMs to enhance the investment process. CFA Institute. Retrieved during August 2024 from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://rpc.cfainstitute.org/-/media/documents/article/industry-research/unstructured-data-and-ai.pdf

Pareto, V. (1906). Manual of political economy. Oxford University Press. Retrieved during August 2024 from https://global.oup.com/academic/product/manual-of-political-economy-9780199607952

Roser, M. (2021). Extreme poverty: How far have we come, and how far do we still have to go? Retrieved during August 2024 from https://ourworldindata.org/extreme-poverty-in-brief

Ross, S. A., Westerfield, R. W., & Jaffe, J. (2016). Corporate finance. McGraw-Hill Education.

SoftBank Ventures Asia. (2023, June 12). OpenAI Sam Altman & Greg Brockman: Fireside chat in Seoul, Korea [Video]. YouTube. Retrieved during August 2024 from https://www.youtube.com/watch?v=_hpuPi7YZX8

Sloterdijk, P. (2018). The world is returning to pluralism after American hegemony, says German philosopher. Noema Magazine. Retrieved during August 2024 from https://www.noemamag.com/the-world-is-returning-to-pluralism-after-american-hegemony-says-german-philosopher/

Schuller, M. (2017). Survival strategy: A learning investment team. CFA Institute Enterprising Investor. Retrieved during August 202 from https://blogs.cfainstitute.org/investor/2017/03/30/survival-strategy-a-learning-investment-team/

Schuller, M., Mousavi, S., & Gadzinski, G. (2018). More rational investment decisions through heuristics management. Academy of Management Annual Summit, Chicago, IL. Conference paper.

Schuller, M., Mousavi, S., & Gadzinski, G. (2022). Long Lasting Cognitive Heuristics for Efficient Investment Decisions. Qualitative Research in Financial Markets, 14(4), 570-583.

Schuller, M. (2021). Principles of Net Zero Portfolio Management. Panthera Solutions.

Schuller, M. (2015). Man at the centre of the investment decision. Panthera Solutions. Retrieved during August 2024 from http://www.panthera.mc/de/psc-8-15-de-2/

Schuller M, Vacchino A, Periasamy N. (2024). Global Capital Stock Trends. Panthera Solutions.

Smith, A. (1759). The theory of moral sentiments. A. Millar.

Smith, A. (1776). An inquiry into the nature and causes of the wealth of nations: In two volumes. W. Strahan and T. Cadell.

van Gelderen, E. and Monk, A. (2015), Knowledge Management in Asset Management. Stanford University Press. Available at SSRN: https://ssrn.com/abstract=2642467 or http://dx.doi.org/10.2139/ssrn.2642467

Transition Taskforce. (2024). Guiding the transition to a sustainable economy. Retrieved during August 2024 from https://transitiontaskforce.net/

TEDx Talks. (2023, December 15). How AI is changing the world [Video]. YouTube. Retrieved during August 2024 from https://www.youtube.com/watch?v=_hpuPi7YZX8

Townsend, B. (2020). From SRI to ESG: The origins of socially responsible and sustainable investing. The Journal of Impact and ESG Investing, 1, 5-25.

UN (2015). Resolution of General Assembly. Retrieved during August 2024 from: https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

Walker, S. (2023). AI is Life. Noema Publication. Retrieved during August 2024 from https://www.noemamag.com/ai-is-life/

Zahera, S., & Bansal, R. (2018). Behavioural finance: A review of literature and its implications for investment decision-making. Asian Journal of Finance & Accounting, 10(1), 169-194.

BEST FINANCIAL SERVICE PROVIDER
Europe 2019

MOST INNOVATIVE BOUTIQUE ASSET ALLOCATION CONSULTANCY
Europe 2019

MOST INNOVATIVE TRAINING FOR INVESTMENT PROFESSIONALS
Europe 2020

MOST INNOVATIVE PROFESSIONAL FINANCE TRAINING
World 2022

BEST FINANCIAL SERVICE PROVIDER
Europe 2023

For more information contact
Christine Brown
cbrown@panthera.mc