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Methodological and Ideological Options

C-frame thinking: Embedding behavioral economics into ecological economics

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ABSTRACT

This paper aims to explore opportunities for integrating Behavioral Economics (BE) into Ecological Economics (EE). By examining the frames of analysis for both disciplines, this study categorizes BE as operating at the individual level (*i-frame*), while EE addresses systemic aspects of society (*s-frame*) and extends its considerations to the biosphere (*n-frame*), advocating for collective action through bottom-up intermediate-level interventions (*c-frame*).

The study posits that EE can benefit from BE's rich insights into human behavior and decision-making, especially for *c-frame* action strategies. However, integrating these disciplines requires finding common ontological and epistemological ground to avoid eclecticism and methodological flaws. The integration is approached in two steps: first, adapting BE epistemology to the systems thinking approach of EE, and second, addressing the ontological gap in BE regarding the world surrounding the individual. This paper argues that embedding BE within EE's ontology points to the necessity of *c-frame* thinking for human decision-making.

A case study of the ex-GKN factory in Italy demonstrates the practical benefits of *c-frame* thinking in a complex decision process. An alliance of workers, researchers, and civil society movements collaboratively developed a future plan that considered the needs of all stakeholders, showcasing the effectiveness of collective action.

1. Introduction

In ancient Greece, mostly in Athens, participation in public life was considered vital for the well-functioning, if not for the survival, of the '*polis*' (i.e., the city-state). Political activity was also at the core of most philosophical thinking; the Greek philosopher Aristotle defined the human being as a '*zdōon politikón*', which means a 'political animal'. Plato wrote in his masterpiece *The Replublic* (1, 347c) that "[T]he greatest penalty is to be ruled under an evil person if one does not take initiative in politics". Two millennia later, public engagement and participatory processes are once again gaining prominence, even within economics, as societies grapple with challenges such as climate change, inequality, and energy transition. Historically, collective and collaborative actions have shaped human societies (Harari, 2015). However, recent decades have witnessed a pronounced emphasis on individual agency (Chater and Loewenstein, 2022), as articulated by a prominent proponent of neo-liberal ideology:

> "I think we have gone through a period when too many children and people have been given to understand 'I have a problem, it is the Government's job to cope with it!' or 'I have a problem, I will go and get a grant to cope with it!' 'I am homeless, the Government must house me!' and so they are casting their problems on society and who is society? *There is no such thing!* There are individual men and women and there are families and no government can do anything except through people and people look to themselves first". (emphasis added Thatcher, 1987)

The central argument asserts that societal issues cannot be collectively resolved, as the burden of responsibility falls solely on individuals' shoulders. This political notion has permeated economic methodology, with a predominant focus on individual economic agents as demonstrated by the endeavor to entirely ground macroeconomics in microeconomic analysis (Arestis and Ferreiro, 2014; De Grauwe and Ji, 2019; Martins, 2023).

However, in recent years, there has been a notable shift in mainstream economics towards acknowledging the limitations of the traditional depiction of *Homo oeconomicus* as rational and solely motivated by self-interest. This shift has led to increasing recognition

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of the importance of incorporating more realistic human behaviors into economic analysis. As a result, the field of Behavioral Economics (BE) has emerged and increased its presence at universities (Berg and Gigerenzer, 2010; Sugden, 2016), with notable figures such as Daniel Kahneman, Robert Shiller and Richard Thaler receiving Nobel prizes for their contributions in 2002, 2015 and 2017, respectively. Additionally, BE has also made significant inroads into policy-making, as shown by the increasing application of the "nudging" economics (Geiger, 2017). BE has its roots in transferring ideas and methods from psychology into economics. It draws mostly from experimental research to analyze human behavior and decision-making (Shefrin, 2015). While Behavioral Economics is still an emergent non-homogeneous field comprising different theories, most of these theories concentrate on the micro level and, hence, are based on methodological individualism.

This approach, rooted in a reductionist paradigm, seeks to break down social complexity into the characteristics of isolated agents. Recent literature in behavioral and cognitive sciences labels this level of analysis as the *i-frame*, which primarily focuses on individuals and their thoughts and behaviors within a specific context (Chater and Loewenstein, 2022; Camerer et al., 2003). In this framework, Behavioral Economics (BE) focuses on identifying potential biases — whether cognitive or emotional — that deviate from rational behavior. However, this approach tends to neglect the broader impact of the context in which individuals operate, as well as the feedback loops and autonomous dynamics of human interactions (Sugden, 2016).

By concentrating on the *i-frame*, BE may overlook how individual behaviors are influenced by and contribute to systemic structures (*s-frame*), which encompass aspects of society such as laws, public policies, and institutions. This limitation underscores the need for integrating BE insights with the more systemic and holistic perspectives offered by Ecological Economics (EE). Ecological Economics (EE) emerged as one of the most prominent heterodox approaches that align with and extend the *s-frame* approach, describing economic processes as embedded within society, which in turn is embedded within the biosphere.[1] This comprehensive perspective enables EE to address the complex interdependencies between economic activities, social structures, and ecological systems.

Furthermore, EE emphasizes the benefit of interdisciplinary research, as explicitly stated by the founders of the journal "Ecological Economics", issued by the International Society for Ecological Economics (Dube, 2021). The inception of EE is rooted in the idea of applying the law of entropy from physics to the social sciences, demonstrating its interdisciplinary nature (Røpke, 2005). However, EE scholars have cautioned against confusing this interdisciplinary approach with eclecticism (Spash, 2012, 2013; Puller and Smith, 2017). Eclecticism involves adopting selected parts of different disciplines or streams of thought without accepting their underlying paradigms, leading to the combination of elements from conflicting paradigms without resolving their inherent contradictions (Britannica, 2017). Rejecting eclecticism means that a theory and method can only be integrated with EE when common ontological and epistemological ground can be found. Fundamental differences at these levels can lead to incompatibility with EE thinking. Therefore, EE researchers must be cautious when incorporating elements from other economic schools of thought (Spash, 2012, 2013; Puller and Smith, 2017). Nonetheless, integrating EE with other economic approaches has proven feasible and rewarding, leading to new inspirations in some instances. Notable examples include the successful integration with institutional economics and evolutionary economics, which have provided valuable insights and expanded the scope of EE (Safarzynska, 2017; Vatn, 2020).

Given the presumptions of Behavioral Economics (BE) and Ecological Economics (EE) and their different frames of analysis, is there room to integrate the two approaches fruitfully? To answer this question, this paper begins by introducing the fundamentals of BE and EE in relation to their respective levels of analysis. Firstly, the study seeks to understand if EE researchers can benefit from BE insights without falling into eclecticism from an epistemological standpoint. Secondly, it aims to explore common ground for integrating the two theories by addressing a gap in BE ontology: BE has not developed an explicit shared theory about the world surrounding the individual (Ramos et al., 2021). Therefore, this paper analyzes the consequences for human decision-making processes when embedding the individual, as characterized by BE theory, into a world as characterized by EE ontology.

Applying both an analytical and normative standpoint, this paper argues for the integration of multiple frames with a focus on the *c-frame* (for collective actions), resulting from embedding BE into EE. Finally, a case study of the GKN factory in Italy demonstrates the practical application of collective action and its benefits from an EE and BE perspective, followed by conclusions and future directions.

2. The foundations of EE and BE

2.1. Ecological Economics: on the s- and n-frames

EE aligns with the *s-frame* approach as it describes any economic process as embedded within society. Yet, the discipline goes even beyond the *s-frame* by conceptualizing society as embedded within the natural system understood as the Earth ecosystems (*n-frame*)[2] and advocates for bottom-up intermediate-level interventions for radical changes. [The latter can be summarized as collective action, or *c-frame] (Bowles and Carlin, 2020)*. This perspective contrasts with neoclassical economics, which treats the economy as a separate abstract system (i.e., as a mathematical object), devoid of its societal and environmental context. EE acknowledges that any economic activity is primarily a physical process that transforms energy and matter from a low to a high entropy state. The concept of social metabolism is often employed to illustrate that the economy behaves like an organism, i.e., like a dissipative structure that absorbs and emits flows within its natural environment (Giampietro and Pimentel, 1991). Hence, EE recognizes that human life relies on finite natural resources, which are subject to irreversible qualitative changes due to extensive exploitation. This exploitation alters the biosphere's capacity to absorb waste products, highlighting the interconnectedness between economic activities and environmental sustainability (Røpke, 2005).

This description is firmly grounded in physical laws, particularly thermodynamics, and closely linked to the theory of *complex systems*. The ontology of complexity entails various epistemological, political and ethical implications that challenge the *i-frame* and the neoclassical economic foundation. Firstly, this modern branch of physics has been developed to explore the emergent properties that arise at higher hierarchical levels as a result of interactions among more elementary units within a given system (Giampietro and Mayumi, 2018). For example, one cannot 'deduce' the flow of traffic just by looking at the characteristics of a single 'representative' car, nor can traffic be solved by adjusting any mechanical problem of the car. By the same token, economic phenomena cannot be adequately explained by focusing solely on individual consumer or firm behavior (i.e., the *i-frame*). Following the EE approach, the biosphere, society, and economy are viewed as co-evolving nested hierarchical systems that are inherently

[1] The biosphere, in turn, can be analyzed with what we named the *n-frame*, as described by Fig. 1.

[2] The NASA defines the Ecosystems as '*[a] community of living organisms in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system. These biotic and abiotic components are regarded as linked together through nutrient cycles and energy flows. As ecosystems are defined by the network of interactions among organisms, and between organisms and their environment, they can be of any size but usually encompass specific, limited spaces (although some scientists say that the entire planet is an ecosystem).*' See https://www.biologyonline.com/dictionary/ecosystem.

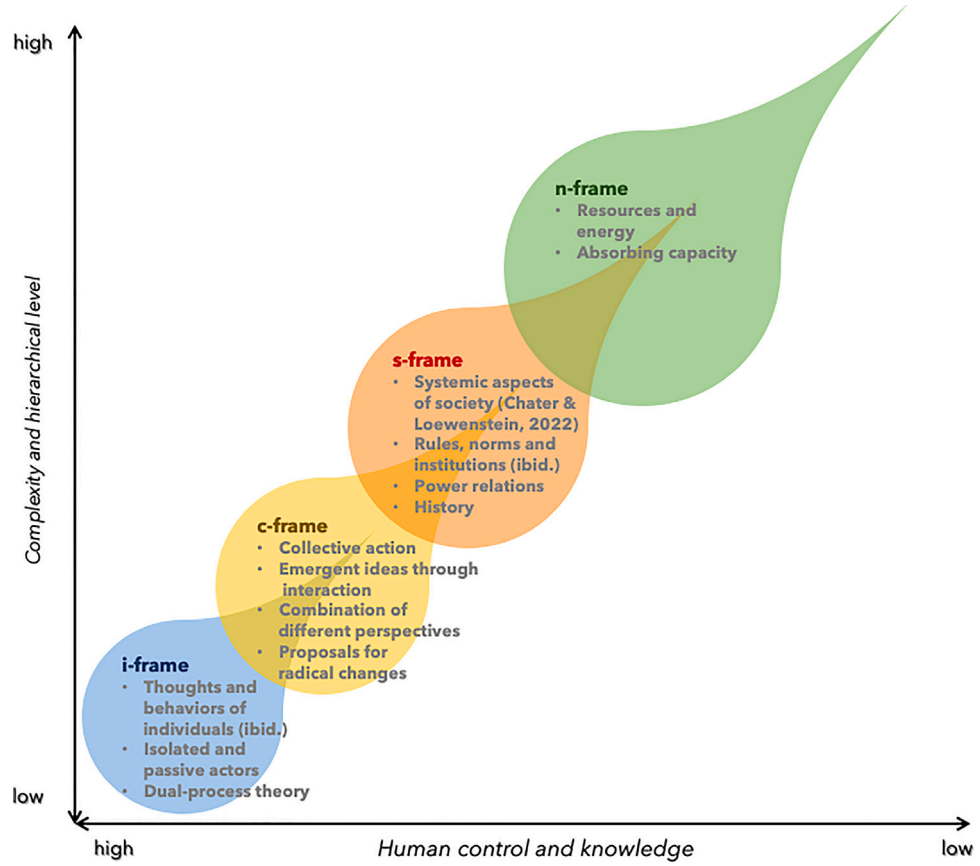

Fig. 1. Nested hierarchical frames. The four main frames identified in the study are ordered along the dimensions of complexity and human control and knowledge. Each level (or frame) is connected with the other ones following a hierarchy that goes from the *i-frame* to the *n-frame*. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

interconnected and cannot be fully separated (Giampietro and Mayumi, 2020).

Secondly, the prevalence of numerous interactions and feedback effects within complex systems can lead to the emergence of sudden and large-scale effects from minor changes, provided a critical threshold is surpassed. For example, unexpected ecosystemic effects due to global warming can arise from a seemingly small increase in average global temperature. A mounting body of evidence shows that considering the higher-order structure of complex systems helps to understand and predict collective behavior and system dynamics (Battiston et al., 2020). Moreover, complex systems evolve over time, leading to the emergence of individual and collective features that enhance adaptability. The evolution of behavioral strategies in higher-order population structures, which include pairwise and multi-way interactions, may explain the emergence and stability of honesty (Kumar et al., 2021) and cooperation (Sheng et al., 2024a) as successful moral strategies. However, evolution will follow unpredictable paths as an exhaustive identification of all knowledge gaps is impossible, which leads to the existence of 'unknown unknowns' (Chandler, 2014). In this context, the concept of risk loses its validity as it cannot be possible to recover any reasonable distribution of events nor know what kind of events may occur. Under these circumstances, how can the *i-frame* provide hints and who is entitled to 'imagine' an alternative future?

Thirdly, EE contrasts marginalistic and economic reductionism as it requires knowledge from different disciplines to face and manage multifaceted environmental crises. Also, given that each system exhibits path dependency, EE requires a reevaluation of historical trajectories and institutional contexts within the social sciences (i.e., the *s-frame*). Fourthly, the positivist epistemology of having a set of observable assumptions from which objective facts can be derived does not apply. Social complex systems are also characterized by non-equivalent irreducible descriptions of different domains, which calls for subjective choices and value attribution of the researcher or person generating knowledge (Giampietro and Mayumi, 2000). This preliminary character means that knowledge can always be reconsidered through the communication and collaboration between the scientific community and civil society (Preiser and Cilliers, 2010; Woermann and Cilliers, 2016; Funtowicz and Ravetz, 2018).

Hence, the EE ontology admits the coexistence of a plurality of moral vision and valuation systems, without necessarily following utilitarian ethics. For instance in the context of environmental conservation, the 'anthropocentric' approach can be considered, promoting the maintenance of the biophysical system to ensure the fulfillment of human needs, but also the 'ecocentric' position can be valid, recognizing an intrinsic value to nature beyond its utility for humans (Røpke, 2005). Furthermore, the livelihood of future generations is taken into account, which calls for a long-term preservation of the natural environment (Schultz, 2001; Røpke, 2005; Becker, 2006).

2.2. Behavioral Economics and the i-frame

Research in BE has started from critiques to the background of neoclassical economics (Albert et al., 2012), looking into psychology for alternative assumptions. First, BE has replaced the assumption of self-regarding preferences, which is typical of *Homo oeconomicus*, with the assumption of other-regarding preferences. While according to the former, an individual only cares about one's own income and consumption, according to the latter preferences are extended to others' income and consumption. Other-regarding preferences, sometimes called social preferences, allow accommodating many common dispositions towards others, such as altruism, envy, inequity aversion, and concerns for status (Bowles and Polania-Reyes, 2012).

Second, BE has criticized the assumption of full rationality, which is another distinguishing feature of *Homo oeconomicus* (Gowdy, 2010). Quite paradoxically, economics — the discipline which studies allocation problems generated by the scarcity of resources–has neglected that human cognitive resources used in decisions are scarce as well. As a consequence, full rationality has been replaced by some form of bounded rationality or procedural rationality, which are compatible with persistent mistakes (Rubinstein, 1998).

Third, standard economics has always been looking for an explanation of behavior that is goal-oriented: any action is the intentional choice aimed at achieving an individual's objective, as described by preferences. Undoubtedly, part of human behavior can be described as intentional. But not all of it. Our daily experience shows how some behaviors are not forward-looking but backwards-looking. These behaviors can be better understood as a response to a stimulus. Dual-process theories have become prominent in BE as they are capable of accounting for the dual nature-intentional and stimulus-response-of human behaviors.

Dual-process theory posits that human decisions are taken under two possible modes of cognition, often labeled System 1 (S1) and System 2 (S2), or intuition and deliberation (see Kahneman, 2013, for a comprehensive overview), which exhibit different degrees of rationality (Evans, 2008). Accordingly, humans profoundly depart from rationality when using S1. This way of thinking has the strong advantage of requiring lower effort, as it runs automatically and even unconsciously. It takes fast decisions, which is possible due to a reliance on intuition, routines, and heuristics (Capraro, 2024; Evans, 2008). However, this can lead to falling into biases or using the default option without evaluating all relevant aspects in a given situation (Evans, 2008). Hence, decisions coming out of an S1 thinking process are likely to not always reflect an individual's best interest (Thaler and Sunstein, 2021).

S2 differs from S1 in many ways, but still, it represents a departure from full rationality. Typically, it runs on a conscious level and therefore requires higher effort. As a result of its higher resource consumption, it is slower and has a very limited capacity. S2 applies logic and language to make decisions, relying on explicit cost–benefit analysis. It can evaluate different options against each other while relying on memory and human intelligence. When analyzing a situation, an abstraction is possible that enables a transfer to other situations (Evans, 2008; Kahneman, 2013). Yet, S2 is not perfect and it can make mistakes, despite the calculation efforts by the individual. While the bulk of the dual-process theory is widely accepted among psychologists, some aspects are still under discussion, such as how the two systems interact with each other (Capraro, 2024). Also, there is a debate whether S1 and S2 are really qualitatively different ways of cognition, or rather two poles of the same cognitive process, carried out to different degrees (De Neys, 2021).

As already outlined, a very significant difference between S1 and S2 is their motivational orientation. Although there are exceptions to this pattern, S2 typically takes decisions based on the expected outcomes, and S1 is based on the values and rules associated with the action of interest itself. Therefore, decisions taken with S2 are more closely aligned with the philosophical tradition of consequentialism, to which also the theory of utilitarianism belongs, while decisions stemming from S1 are more likely reconcilable with deontological philosophic reasoning (Capraro, 2024). Part of the literature on dual-process theory has already acknowledged the brain as a complex system composed of various autonomous subsystems. The Tripartite Model of Mind expands upon dual-process theories by introducing a third component, the reflective level, which oversees the algorithmic level and the autonomous mind, providing higher-order cognitive control and enabling the override of automatic responses when necessary (Stanovich, 2012). This tripartite structure aims to offer a more nuanced understanding of human cognition by highlighting the interplay between automatic processes, deliberate reasoning, and reflective oversight.

A few methodological observations follow here below, including the relationship between BE and Experimental Economics (ExE). ExE utilizes experiments under controlled conditions, typically in a laboratory setting, to get a clearer picture of relationships and causality of the phenomena under study (Kahneman and Smith, 2002; Davis and Holt, 2021). Given the many degrees of freedom due to its relaxed assumptions, BE is in particular need of discipline provided by experimental data, which allows for restricting possible preferences and behavioral rules. At the same time, ExE requires a theory to carry out hypotheses testing in the application of the scientific method. BE stands out as a prominent source of theoretical predictions to be tested experimentally but, remarkably, other theoretical approaches are compatible with ExE, for instance focusing on institutions and interactions of people rather than single individuals. In this context, ExE is applicable beyond the *i-frame* (Smith, 2000).

There is a lot of evidence in ExE, which adds to common sense, pointing out that individuals do care about others (Bowles and Gintis, 2013). Many laboratory tests have shown that, under some circumstances, individuals altruistically choose to improve the situation for others and often strive for fairness (Güth et al., 1982; Camerer, 2003). Remarkably from a methodological perspective, other-regarding behaviors are often compatible with consequentialism by simply introducing other-regarding preferences and assuming that individual choices are based on cost–benefit analysis at the group level. They are formally depicted by altering the preference function to integrate the notion of altruism and cooperation (Cooper and Kagel, 2016). Similarly, preferences for environmental behavior can enter the function to represent the value attributed to nature (Heinz and Koessler, 2021). In some cases, altruistic behavior cannot be explained based on outcomes since humans can deliberately favor moral preferences linked to deontological reasoning. Still, the behavior can be captured by an utility function that features aspects like social appropriateness or personal norms in order to integrate morality (Capraro et al., 2024). Hence, even when extending the phenomenon of interest beyond the individual level, BE continues building its analysis at the *i-frame*. However, as this section showed, the disciplines have created a rich body of insights into human behavior and decision-making.

However, ExE requires stringent control, where single aspects are manipulated while keeping the rest constant to maintain the ceteris paribus assumption. Moreover, both BE and ExE assume that individuals are 'passive' responders to a given context, thus excluding transformative bottom-up initiatives. This limitation is particularly relevant in a complex ontology where society, economy, and environment co-evolve. Although BE and ExE open the door for altruistic and environmental motivations for human behavior, from a theoretical and experimental standpoint, they lack a theory of change that starts from the *i-frame* to aggregate into the *s-frame*. Conversely, EE lacks attention for the relationship between *s-frame* changes and *i-frame* behaviors. In the following sections, we explore the potential combination of these disciplines to address their respective gaps.

3. Pathways towards the integration of Behavioral Economics into Ecological Economics

3.1. Exploring common epistemological ground for Ecological Economics and Behavioral Economics

Recapturing the previous two sections in terms of their frame of analysis, BE is focused on the *i-frame*. In contrast, EE primarily operates within the *s-frame* but also extends into the *n-frame* and advocates for *c-frame* actions.

The relationship between the different frames is illustrated in Fig. 1, which depicts a nested hierarchical order among the various levels. It begins with the individual *i-frame* (blue drop) as the lowest level of analysis, followed by the collective *c-frame* (yellow drop), the *s-frame* (orange drop) representing the social system, and finally, the *n-frame*

(green drop), which captures the natural environment. Additionally, human control over the frame and the available knowledge to capture it decrease as one moves from the *i-frame* to the *n-frame*. This refers to the possibility that a small group can exert full control over a set of functions. For instance, a village can relatively easily coordinate to create a small energy community. In contrast, the path towards energy transition at the state level must contend with a wide variety of factors, such as the global distribution of raw materials, geopolitical tensions, international agreements, government stability, and increased bureaucracy. While there may be counterexamples, we conceive this as a general condition. Control and knowledge are closely linked, with the latter typically decreasing as we move further from the technosphere (Cadillo-Benalcazar et al., 2020). The graphic also illustrates that the frames overlap, with higher-level frames encompassing lower-level ones and extending the picture by adding elements of a different type.

Notice that each bubble in Fig. 1 does not simply include the bubble at the lower level, as exemplified in traditional depictions of the Ecological Economics ontology (Daly and Farley, 2011, figure 3.2, pag.51), where concentric circles from economics to nature resemble a matryoshka doll. While the hierarchical system idea can be represented this way, such simplified representations neglect the interaction and co-evolution across different scales. Complex systems are characterized by dialectical penumbras, or permeable system boundaries (Georgescu-Roegen, 1970), where each category (frame) interpenetrates with the others, making it impossible to define precise boundaries. This highlights "the unavoidable arbitrariness entailed by the truncation problem", referring to the fact that several non-equivalent descriptions are unavoidable when describing a system operating simultaneously on multiple scales (Giampietro and Mayumi, 2008).

Against the background of a potential combination of EE and BE, the *c-frame* is particularly interesting. As an advocate for the *c-frame*, Bowles and Carlin (2020) argued that knowledge about how our actions can collectively make a difference in tackling environmental and societal problems can be a powerful motivator for supporting initiatives to promote radical changes. Psychological research indicates that humans can advance towards a sustainable society by establishing conducive conditions that encourage environmentally responsible collective action. These conditions involve overcoming cognitive limitations, establishing new situational incentives, fulfilling inherent needs, and fostering communities dedicated to social change (Amel et al., 2017). Moreover, Schill et al. (2019a) argue that a critical research challenge is to understand how contexts are generated, maintained and dissolved over time, and how individual behavior shapes and is shaped by context. Therefore, EE could enhance its approach by integrating insights from individual behavior and cognitive sciences. By doing so, it could better understand how collective actions emerge and persist over time, effectively managing conflicts and reconciling contrasting interests within collective endeavors. Thereby, it is important to note that the *c-frame* is positioned between the *i-frame* and the *s-frame* and thus mediating between individual action and systemic changes in society. Thus, at the *c-frame* level, activities are not analyzed in terms of interests of the individuals participating in collective actions but rather by looking at the collective actors as entities, which can develop their own dynamics. Moreover, how individual interests relate to *s-frame* issues often strongly depends on the *c-frame* actors present in the individuals' environment (Andretta, 2020).

In this context, there seems to be a fundamental difference in the underlying epistemology of both disciplines, since BE is based on methodological individualism. Historically, neuroscience and psychology have provided insights at the individual level to inform various policy measures. In the last decades, the focus has moved towards using *i-frame* insights to create *s-frame* policies (Camerer et al., 2003). The *i-frame* often emphasizes the freedom to choose under the assumption that societal issues can be attributed to individual biases (Dold, 2023). Hence, by identifying and addressing individual limitations (such as excessive self-interest, present bias, and confirmation bias), there is a belief that systemic problems (e.g., inequality, climate change, plastic production, energy transition) will be automatically resolved. This focus on individual interventions is also politically appealing because it can shift the burden of change to the single citizen, as it presumes that the summations of small changes will result in big differences and will be cheaper than traditional public policies. Importantly, interventions based on the *i-frame* do not alter the fundamental "rules of the game" but rather make incremental adjustments to assist fallible individuals in navigating the existing framework more effectively.

Since this *i-frame* approach is rejected by EE, on the first glimpse it seems that BE and EE are incompatible from an epistemological viewpoint. The critique on *i-frame* interventions from a higher-level perspective is summarized by Chater and Loewenstein (2022). They argued that the empirical evidence suggests that the actual impact of *i-frame* interventions is small or null (Deaton, 2020; DellaVigna and Linos, 2022). Second, even if working they would provide "tips to help individuals survive in a hostile world" (Chater and Loewenstein, 2022, pag. 2). Third, they shift responsibility away from corporations to make systemic changes. An oversimplified conception of individuals as passive actors–averse to mental effort and reliant on 'automatic' responses–is likely to lead to unrealistic expectations regarding what *i-frame* solutions can achieve (Newell et al., 2023). Consequently, an over-reliance on *i-frame* interventions may inadvertently reinforce the status quo by diverting attention from necessary systemic reforms. As Chater and Loewenstein (2022) argue, history demonstrates that addressing individual frailty requires systemic change rather than enhancing the individual. This underscores the importance of considering power dynamics and social conflicts (Connolly et al., 2024).

Still, room for integration of BE into EE is created when adding an increased understanding of complexity to BE. This implies acknowledging that the deduction of universal patterns of human behavior is not feasible when understanding humans as embedded into their social and natural environment (Schill et al., 2019b). Instead, interaction can lead to dynamic mechanisms and transformation. Furthermore, real-life decision making occurs within a context that can create emergent properties from the interaction, which can only be observed at a higher frame than the *i-frame*. Hence, a version of BE epistemology that is compatible with EE needs to acknowledge the relevance of higher hierarchical levels, most notably the *c-frame*, but also the *s-frame* and *n-frame*. Methodological approaches that allow an embedding of these perspectives have to be created. While first steps into this direction are being taken, for example by integrating group-level interactions into numerical simulations (Kumar et al., 2021; Sheng et al., 2024b), there is still a need to find more diverse approaches to Behavioral Economics research.

3.2. C-frame thinking as a consequence of embedding the Behavioral Economics individual into an Ecological Economics ontology

As a second step to the analysis of the potential integration of BE into EE, this section looks at the ontological gap around the individual as characterized in BE. Thereby, it explores the consequences for decision-making when embedding this individual into a surrounding shaped by the EE ontology. BE encompasses the dual-process theory, and recognizes the limits of S1 when making important decisions. However, S2 also seems inadequate to evaluate decisions within a surrounding characterized by the EE ontology because a clear representation of a decision problem is often unfeasible for at least two reasons: First, under complexity, there is often uncertainty and ambiguity instead of objectively valid facts. Second, the available information is unlikely to be complete (Preiser and Cilliers, 2010). Even if full information about a situation seems available, the possibility of 'unknown unknowns' cannot be ruled out (Chandler, 2014). This leads to the question of which alternative strategies can be employed for decision-making within an environment characterized by the assumptions of EE,

most importantly complexity. The answer to this question hints at the necessity to apply *c-frame* thinking.

To begin with, a helpful ingredient to facilitate decision-making within an EE ontology is the concept of ecological rationality, which was inspired by the ideas of Simon (1979). It is the outcome of humans adapting their decision-making strategies to their environment in an adaptive process (Mata et al., 2012). In the development of ecological rationality, strategies are tested through trial and error, and the most successful strategies are kept. Thus, the development of ecological rationality resembles a cultural evolution process. While this process can happen at an individual level, it can also be driven by group competition and evolve in a practice of social learning through interaction with others at the *c-frame*, potentially even spanning over many generations (Goldstein and Gigerenzer, 2002; Smith, 2003). Ecological rationality thus represents the embedded, interconnected, and emergent character of society and the ecological sphere, like it is assumed in EE ontology. Also in the social and cognitive sciences, an approach similar to ecological rationality is now gaining momentum to address complex problems like climate change mitigation: While ecological rationality relies on unformalized trial and error, intervention tournaments try out different strategies to reach a set goal for the same population within a formalized setting (Vlasceanu, 2024; Hameiri and Moore-Berg, 2022). Gigerenzer (2021) explains that the advantage of ecological rationality compared to S2 is that it can make favorable decisions despite the preliminary and incomplete character of knowledge. However, the process through which ecological rationality evolves means that it only leads to favorable decisions in the environment in which it has developed, while taken out of context, it loses its applicability. To some degree, this can be avoided, since one individual can hold ecological rationality derived from several environments, and is likely to be in the position to – even unconsciously – recognize cues that point to the relevant ecological rationality. Still, in a complex system with dynamically evolving properties, completely new environments with an unprecedented pattern of change are likely to be encountered (Mata et al., 2012). Hence, it must be considered that ecological rationality might become obsolete or even obstructive to favorable decision-making within a dynamically changing environment.

Therefore, Schill et al. (2019b) furthermore pointed to the relevance of continuity when considering context-adapted *c-frame* decision strategies like ecological rationality. Accordingly, these strategies require a dynamic approach in order to be helpful within complexity, since they need to adjust to the context of the ever-changing complex system itself. Similarly (Chandler, 2014), by focusing on the 'unknown unknowns' which are present under complexity, highlights the importance of a constant reconsideration of the situation as well as opening the door for alternative radical changes yet unexplored. While human interaction automatically facilitates an ongoing recalibration of behavioral strategies, these are often not translated into explicit policies or can lead to 'maladapted behavior (Amel et al., 2017). Hence, when applying context-adapted *c-frame* decision strategies, an emphasis should be set on the procedural character, in which joint knowledge and meaning are revised over time, creating context-adapted strategies that co-evolve with the complex system and thereby re-claim validity beyond one single snapshot in time.

Furthermore, several authors suggested different versions of participatory multi-stakeholder approaches for decision-making in settings equal or similar to an EE ontology (Lyon, 2018; Armitage et al., 2009; Eelderink et al., 2020). This approach is a direct example of collective action at the *c-frame* and means that, on the one hand, a variety of groups should be included in a discussion, including civil society, scientists, the private sector, and interest associations. The integration and contrasting of multiple perspectives is more feasible when engaging several stakeholders since an individual is always bound to the lens of her subjective perception (Lyon, 2018). Furthermore, multiple perspectives support the consideration of alternative ways of acting, which is key to navigate the dynamic and uncertain surrounding under complexity (Preiser and Cilliers, 2010). On the other hand, the goal is to trigger a fruitful engagement, through which new ideas and an understanding of other opinions can be developed. A participatory multi-stakeholder approach stands in contrast to merely expert or elite-driven decision-making, which bases its legitimacy on the claimed knowledge advantage. Since an EE ontology recognizes that knowledge transports values, an opportunity should be given to further stakeholders to bring their values and perceived truths to the table. The values underlying the discussed knowledge can become more explicit through engagement with other positions. Furthermore, through interaction, participatory multi-stakeholder approaches can turn into an emergent process itself, where the ideas arising through interaction are beyond the sum of individual ideas.

Finally, it is important to underline that the emergence and stability of successful *c-frame* initiatives, which apply the theoretical concepts outlined above in practice, depend on the context and may assume different forms. Examples include the self-organization of local communities (Ostrom, 1990), the pro-environmental initiative of poor people (Martinez-Alier, 2003), and protests driven by leftist political parties and trade unions to rise up against austerity measures during economic crisis (Andretta, 2020).

In the following section, we discuss an ongoing real-case *c-frame* initiative for bottom-up radical transformation that aligns with some of the concepts outlined in this paper. For the reasons explained so far, we have not focused on either BE or ExE due to the challenge of conducting *ceteris paribus* analysis within an evolving context, as well as the limitations of finding general rules through an inductivist approach in complex systems. Therefore, we describe the evolution of the ex-GKN factory through the different levels, from *i-* to *n-frame*.

4. Case study: The former GKN factory in Florence

The presented case study looks at the former GKN factory in Florence, Italy. In the context of this paper, the case of the GKN factory is a real-life 'experiment', which practically demonstrates the feasibility of implementing decision-making at the *c-frame*. The GKN factory, an automotive supplier that was part of the British GKN group, is located on the outskirts of Florence.

The factory was bought by the British investor Melrose in 2018, which had a business model based on buying companies, restructuring them, and thereafter selling them at a higher price. In 2021, Melrose wanted to sell the GKN factory to make profit from the deal, thereby relocating the production to other factories, although the factory in Florence had been economically sound up to this point (Allamprese et al., 2024). This led to the termination of more than 500 workers (Cini et al., 2022). The immediate response of the workers was to occupy the factory within one hour after the news had been communicated. It was orchestrated both through the official union 'Fiom-CGIL' as well as the GKN workers' autonomous organization 'Collettivo di Fabbrica', and facilitated by the high participation of the workers in these bodies since years (Cini et al., 2022; Cini, 2023; Gabbriellini et al., 2024). Especially the 'Collettivo di Fabbrica' has consolidated its standing within the factory through inclusive decision making and the circulation of knowledge about production processes. Thus, at the point of the attempted termination, the workers had been able to gather experience in engaging in the company's development as well as to intensify their interpersonal relationships over an extended period of time already (Gabbriellini et al., 2024).

The workers' movement had a first moment of success in their protest when the Florentine Labor Court declared the layoffs as void, based on the grounds that the union had not been consulted before the decision (Allamprese and Orlandini, 2024). Thereafter, a new potential buyer of the factory committed himself to fulfill the steps necessary for a reactivation of the plant. Yet, there was a delay in complying with these steps (Gabbriellini et al., 2024). At the same time, the workers

waited in vain for the government to step in to protect their employment and to avoid a relocation of the factory. Moreover, the draft of a law meant to protect the workers, which had been suggested to the parliament, was ultimately rejected (Allamprese and Orlandini, 2024). Hence, the protesters had to consider alternative options instead.

From the beginning of their struggle, the GKN workers were looking for allies. Hence, they organized several marches and strikes across the region's metallurgist industry, and joined forces with a range of actors from the region outside of the industry, including left-wing non-parliamentary political parties, the Italian Recreative and Cultural Association, and organizations associated with the church (Cini et al., 2022). In addition, the workers' partners – almost exclusively women – formed an association to support the uprising (Cini, 2023). Furthermore, the movement liaised with the climate justice movement under the slogan of 'End of the Month, End of the World, Same Struggle', and participated in joint protests with opponents of the attack of Russia on Ukraine (Andretta et al., 2023; Imperatore and Gabbriellini, 2023). Overall, the GKN workers' protest was the largest labor movement in the region in many years and even attracted attention at a national level (Cini et al., 2022). Remarkably, the protest managed to overcome the seemingly misaligned positions between members of the automotive industry and the environmental concerns of climate activists by emphasizing the need for socio-ecologically sustainable and local production (Andretta et al., 2023).

Considering this goal, together with a group of interdisciplinary researchers, the alliance for the support of the GKN workers drafted a long-term plan for the further development of the company, which was also published under the title "A plan for the future of the factory of Florence". It included a shift away from the automotive sector and towards alternative products with a more positive environmental impact. Furthermore, the plan represented the workers' perspective by emphasizing the goal of stable employment and income, and envisioned a strong voice for the workers, giving them the opportunity to co-determine the firm's decisions. The line of argument was based on the workers' rights at the workplace and their crucial role within the factory due to their knowledge about production processes.

The plan is supposed to be complemented by a new ownership model as well as the establishment of structures for a continued dialogue between the public, private, and academic sector (Cirillo et al., 2022; Imperatore and Gabbriellini, 2023). To actualize this vision, the cooperative 'ex-GKN For Future' issued a first 'solidarity stake' of one million euros in shares, aimed at promoting bottom-up reindustrialization through a 'popular shareholding' campaign. This campaign targets citizens, associations, movements, workers, trade union delegates, and solidarity activists, who will become part of the cooperative's assembly, exercising social control over the reindustrialization process.[3] This 'popular shareholding' initiative is a unique measure that allows the citizens of Florence and its province to participate in the same assembly as international climate and social movements, renewable energy communities, and associations. Whether or not the envisioned long-term plan will be successful or not is still to be decided. While the new potential buyer still pushes against the plan, the 'Collettivo di Fabrica' its allies continue their protest and strive for collective ownership of the factory (Pasotti, 2023).

Finally, the broad challenges due to climate change and energy transition (*n-frame*) have been embraced by the ex-GKN workers. After several meetings with the Fridays for Future movement and other organizations, they decided to create the GKN For Future (GFF). This initiative inspired the conversion of the former GKN factory into a cooperative for producing cargo bikes and the production of new-generation solar panels in partnership with an innovative startup (Gabbriellini and Imperatore, 2023; Leonardi, 2023). Additionally, for the first time in the EU, the project features a waste recycling process within the factory itself (Pasotti, 2023). This effort aligns with climate strikes and the increasing convergence between climate and social justice movements, showcasing strategic alliances between industrial workers and climate-justice movements (Gabbriellini and Imperatore, 2023; Leonardi, 2023). Thus, rather than adopting a defensive posture — reluctance to bear the full cost of productive eco-transformations — the GFF signifies a potentially path-breaking strategy for eco-syndicalism in the 21st century (Pansera et al., 2024).

This collective action provides an example of the benefits of approaching decisions with *c-frame* thinking under the consideration of the complexity of the situation for several reasons: First, the integration of multiple perspectives, with the actors coming from inside the company, academia and civil society, allowed to create a long-term plan despite the uncertainty about the further developments. This was moreover driven by the cooperation at eye level between the researchers and the workers, showing the validity of knowledge and values brought forward by both parties. Thereby, the applicability of the market logic postulated by the investor was questioned, triggering a re-thinking of how reality was presented and applying a non-positivist approach towards stated facts. Instead, the embeddedness of the factory into the socio-economic system of the region and a broader ecological environment was acknowledged, thus accounting for the complexity of the situation. Furthermore, the integrated goal of continuing the dialogue between the factory and other societal stakeholders shows the iterative character of the plan and thus its capability to dynamically adapt to new developments (Cirillo et al., 2022; Imperatore and Gabbriellini, 2023).

The collaborative and interactive process within the *c-frame* context led workers to develop a new approach to setting up and leading the new factory, characterized by emergent novelty through combination. This approach, conceived by the workers themselves rather than an external research team, cannot be subject to traditional experimental methods. Analyzing a real case where *c-frame* activity was translated into practice instead of reproducing it in a laboratory has two major advantages: First, the situation impacts the lives of the people involved, whereas the low stakes in a laboratory set-up might distort the procedure. Second, one main purpose of collective action within an EE ontology is to navigate complexity, which is hard to mimic in its full scope in a laboratory. Especially the connection between the individual and higher frames are hard to capture under isolated conditions.

From a BE perspective, the GKN case study exemplifies how individual biases and social influences can shape collective action in an economic context. Behavioral insights, such as the impact of fairness perceptions, group identity, and social norms, were crucial in mobilizing the factory workers and their allies. Furthermore, the long process of trust building and participatory engagement in decision making within the workers' organizations, i.e. the 'Collettivo di Fabbrica', which took place before the closure of the factory, is an important factor to understand how individual motivations and actions were translated into collective resources that supported the process of civil engagement and protest (Gabbriellini et al., 2024; Putnam, 1996). These insights help explain the robust communal response against the investor's short-term profit motive and support a more sustainable, long-term vision for the factory. By integrating BE with EE, a deeper understanding of how personal values and group dynamics interact with ecological goals is gained, enhancing the ability to design and implement solutions that align economic activity with broader societal and environmental objectives. This integration is vital for supporting the c-frame, as it enables a holistic approach to complex challenges, considering both human behavior and ecological impacts.

The developments around the GKN factory represent a unique case with several novel elements. It encompasses all levels of the framework, from the individual (*i-frame*) need for a salary to survive, to the collective (*c-frame*) action to regenerate the factory, and the societal (*s-frame*) protests urging state intervention to regulate the situation and support

[3] For further details see https://insorgiamo.org/100x10-000/.

the project startup. Finally, it involves the natural (*n-frame*) conversion of an automotive fabric into a producer of renewable energy.

In such real-life experimental settings, BE can provide opportunities for EE researchers by helping in understanding complex *c-frame* processes. BE can provide insights on the evolving behavior and decision-making, showing how the *c-frame* processes enter into existence, how they can be extended and which behavioral and decision-making challenges they need to overcome. Also, BE can play an important role in creating a holistic perspective on the different levels of the framework involved. While EE is rich in tools for understanding the *s-frame* and *n-frame*, BE provides a range of approaches and theories for analyzing the developments at the *i-frame*. Importantly, the application of these theories needs to consider the interaction of the *i-frame* with the upper levels, which might require a selection and modification of compatible approaches.

5. Conclusion

This paper has shown that an integration of BE into EE can be both fruitful and feasible if the epistemological and ontological disparities are resolved. When making a transfer from BE–as well as any other theory–EE researchers must be careful not to carry implicit ontological or epistemological elements from incompatible theories into EE. EE operates at the *s-frame* and *n-frame* while advocating for collective action at the *c-frame*. Yet, it can benefit from BE insights into how human behavior and decision-making are determined. However, on an epistemological level, this requires BE to consider higher hierarchical frames in order to accommodate that human decision-making is determined in interaction with its environment and, thus, cannot be captured in universal and stable patterns. On an ontological level, the paper has shown the consequences of embedding the BE individual into an EE ontology. While the validity of the two classic BE decision modes of S1 and S2 is limited within an EE ontology, decision-making should be shifted to *c-frame* thinking. In a world characterized by complexity, uncertain facts, and the embeddedness of humans into society and nature, *c-frame* processes allow to tap into a variety of perspectives and value systems. Furthermore, an iterative character of *c-frame* processes facilitates staying flexible when facing unforeseen developments. Thus, *c-frame* thinking provides guidance that facilitates active decision-making despite an unclear problem statement and the unpredictability of outcomes.

This is particularly valuable in complex real-world scenarios, like the case of the former GKN factory. Here, *c-frame* thinking was activated in a participatory process that challenged the narrative of the business owners and considered the perspectives of a variety of stakeholders, including broader social and environmental implications. Integrating multiple perspectives helps to remain aware of different options and allows to create emergent ideas through interaction. Thereby, opinions developed outside of expert and elite circles are valid and can transport a plurality of values. Also, in line with ecological rationality and social preferences, the opinions of lay people can be the result of an elaborate evolutionary process and thus reveal important insights.

Finally, considering further research avenues, the concepts and strategies captured under *c-frame* thinking are gaining momentum. On the one hand, this is due to the multifaceted challenges of modern society, which are increasingly cross-sectoral and operate at different spatial levels, from the local to the global scale. Moreover, multiple crises are erupting at the same time and compete for attention. To account for different needs and hopes related to these developments, an integration of multiple perspectives and heterodox approaches as opposed to top-down decision making are crucial. On the other hand, affluent and stable democracies provide unprecedented support for the implementation of *c-frame* practices. As a result of rights granted to citizens as well as the availability of resources facilitating knowledge sharing and communication, a large share of the population is able to engage in shaping societal and governance processes. Therefore, further research on how to best facilitate and promote *c-frame* activities is crucial to cope with the challenges faced by society.

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Leonardo Boncinelli: Writing – original draft, Methodology, Conceptualization. **Luzie Dallinger:** Writing – original draft, Methodology, Conceptualization. **Tiziano Distefano:** Writing – original draft, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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