

# Neuro-legal nudging and sustainable economics: a behavioural approach to sustainability law

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## A. Introduction

Modern sustainability law operates under the fundamental economic principle that market actors are rational, driven by legal incentives and the rules that govern (and regulate) economic and social relations. Traditional environmental regulation, such as carbon taxes, emissions trading and mandatory corporate sustainability reporting, are built on the assumption that people and organisations will rationally weigh up costs and benefits of their actions when they take decisions that impact the environment.<sup>1</sup> Yet, this model of the rational actor is increasingly found wanting in the face of growing evidence from behavioural economics and neuroscience of the degree to which human decision-making is significantly ‘bounded’ by

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1 Richard H. Thaler/Cass R. Sunstein, *Nudge: Improving Decisions About Health, Wealth, and Happiness* (2008), p. 45.

cognitive biases, heuristic processing and neurological processes that run counter to narrow rational calculation.<sup>2</sup>

In sustainability contexts, the lack of correspondence between legal expectations and actual human behaviour causes considerable problems for the effectiveness of environmental policies. Notwithstanding decades of regulatory evolution, as well as increasingly sophisticated legal systems, levels of compliance remain unsatisfactory, economic inefficiency persists, and public resistance to sustainability measures continues to undermine policy objectives.<sup>3</sup> This gap is indicative of the fact that the traditional legal understanding, at least in theory, leaves very little space for the psychological and neurological facts about how the human decision-making process works and eventually shapes human behaviour in terms of individual and organisational compliance with sustainability regulations in our society.

Recent developments in cognitive neuroscience have started to shed light on the intricate neural machinery that underlies environmental decision-making, showing that sustainable decisions are mediated by the recruitment of a constellation of brain networks including the amygdala (responsible for fear and risk processing), the prefrontal cortex (site of rational planning and executive control), and the ventral striatum (involved in reward processing and motivational drive).<sup>4</sup> These findings imply that good sustainability law cannot just serve to increase the material incentives or costs of harmful or beneficial behaviour but must engage the real cognitive structure of human reason-making, as opposed to abstract rational choice assumptions.

In addition, research in behavioural economics has shown that cognitive biases, such as present bias, loss aversion, and social proof, have a significant impact on environmental decisions.<sup>5</sup> For example, people tend to underestimate the positive effects of long-term environmental benefits in comparison to short-term costs, a phenomenon known as temporal discounting that significantly reduces the effectiveness of policy approaches aimed at encouraging sustainable behaviour. Additionally, environmental

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2 Daniel Kahneman, *Thinking, Fast and Slow* (2011), p. 267.

3 Ameya Patil et al., 'Behavioral Economics and Environmental Sustainability—The Complicated Nexus', in Pardeep Singh/Shikha Daga/Kiran Yadav (eds.), *Nudging Green: Behavioral Economics and Environmental Sustainability* (2024), p. 123.

4 Letizia Richelli/Maria Arioli/Nicola Canessa, 'Neurosustainability: A Scoping Review on the Neuro-Cognitive Bases of Sustainable Decision-Making' (2025), 15(7) *Brain Sci.*, p. 678.

5 Thaler/Sunstein (2008), p. 78.

loss-frame messages have been demonstrated to be more effective in promoting motivation than equivalent gain-frame messages; thus, how regulatory information is conveyed psychologically can have a significant impact on the extent of compliance.<sup>6</sup>

This article presents a theoretical framework that systematically integrates findings from brain research, economic theory, and legal theory to enhance the effectiveness of sustainability law. The core contention is that we can help design better legal and regulatory architectures by strategically embedding 'neuro-legal nudging' strategies—regulatory design standards shaped by the cognitive and neuropsychological dimensions of human thinking about the environment. Instead of trying to subvert or bypass these psychological realities, the approach advances the idea of using them to promote sustainability.

This work has three research aims. First, to construct a comprehensive theoretical framework consolidating neuroscience, behavioural economics, and legal analysis in the context of sustainability regulation. This interdisciplinary synthesis aims to contribute to a deeper understanding of how legal compliance is achieved in the context of individual and organisational decision-making. Second, to propose an applied three-tier legal model that operationalises neurobiological and behavioural findings into specific regulatory design principles. This model considers cognitive bias attenuation, social norm incorporation and default optimisation as orthogonal strategies to improve compliance with the law. Third, to provide empirical research and policy innovation with a groundwork by stating transparent hypotheses about how neuro-legal approaches could enhance sustainability.

The implications of this study are not only theoretical but also far-reaching in the policy formulation and implementation. By delivering evidence-based approaches to improving compliance with the law through behavioural optimisation to policymakers, this framework has the potential to strengthen the impact of existing sustainability policies, while also reducing the social and economic costs of enforcement. Furthermore, the interdisciplinary methodology developed in this paper makes a contribution to the fledgling field of neurolaw by demonstrating how neuroscientific insights can inform regulatory design in complex policy fields.

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6 Eric Johnson/Daniel Goldstein, 'Do Defaults Save Lives?' (2003), 302 *Science*, p. 1338.

## *B. Literature review and theoretical background*

### I. Behavioural economics and environmental law

The convergence of behavioural economics and environmental law has become an area of significant scholarly inquiry, raising fundamental questions about what drives individuals and organisations to respond to sustainability regulations. Conventional economic theories of environmental policy-making assume that decision makers will always rationally balance costs against benefits in their decisions about whether to comply or not comply with environmental regulations.<sup>7</sup> Yet research in behavioural economics reveals that the rational choice framework does not adequately account for the psychological forces that influence environmental decision making.

Thaler and Sunstein's classic work on nudge theory proposes a framework for developing an environmentally effective yet freedom-preserving way of influencing environmental behaviour.<sup>8</sup> Their study reveals that seemingly minor changes to the presentation of options can sustainably alter decision outcomes, a finding with profound implications for the design of sustainability regulations. Several studies have shown that messages framed in terms of what can potentially be lost as a consequence of an activity (loss-framed messages) are more effective in inducing pro-environmental behaviour than their gain-framed counterparts.<sup>9</sup>

Another behavioural economics insight directly relevant to sustainability law is the phenomenon of temporal discounting. This 'temporal discounting' of future benefits, or equivalently, the tendency to focus on present rather than future costs, has been shown conclusively in many experimental settings, where it constitutes a strong bias and is problematic for policies involving environmental challenges, particularly when there is a divergence between immediate costs and long-term benefits.<sup>10</sup> This bias also serves to explain the resistance generated around carbon taxing schemes, even when they are in the potential best interest of the country in the long run, both in terms of economy and environment.

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7 Gary Becker, 'Crime and Punishment: An Economic Approach' (1968), 76(2) JPE, p. 169.

8 Thaler/Sunstein (2008), p. 6.

9 Amos Tversky/Daniel Kahneman, 'The Framing of Decisions and the Psychology of Choice' (1981), 211 Science, p. 453.

10 Shane Frederick/George Loewenstein/Ted O'Donoghue, 'Time Discounting and Time Preference: A Critical Review' (2002), 40(2) JEL, p. 351.

Loss aversion, another well-documented cognitive bias, has significant consequences for how we frame environmental rules. Prospect theory, developed by Kahneman and Tversky, reveals that people perceive losses as equivalent to gains about twice as intensely, suggesting that environmental policies framed in terms of avoiding losses may be more effective than those focused on potential benefits.<sup>11</sup> Social proof and conformity effects are another mechanism through which behavioural insights can increase the effectiveness of environmental law, with evidence demonstrating that people are significantly influenced by information on what others are doing.<sup>12</sup>

## II. Neuroscience of environmental decision-making

The new field of environmental neuroscience is just beginning to shed light on the brain systems involved in pro-environmental action, with potential implications for creating more effective policies for sustainability. Functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) studies have shown that environmental decision-making involves complex interactions between multiple brain networks, including regions associated with emotional processing, cognitive control, and social cognition.<sup>13</sup>

Recently, Richelli, Arioli, and Canessa summarised the role of the neurocognitive substrates underlying sustainable decision-making. However, the crucial brain circuits that contribute to pro-environmental behaviour remained an open question.<sup>14</sup> Their observed results further indicate that sustainable decision-making activates brain structures associated with mentalising and moral cognition, which may partly reflect the implication of these areas in integrating the personal and contextual dimensions of environmental choices. Furthermore, their findings suggest that sustainable choices are processed by brain regions related to attentional monitoring and affective motivation, as well as by circuits commonly engaged in value generation for decision making in general.

The temporoparietal junction (TPJ) has been identified as a key brain area in the study of environmental decision-making. Previous research indicates

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11 Daniel Kahneman/Amos Tversky, 'Prospect Theory: An Analysis of Decision under Risk' (1979), 47 *Econometrica*, p. 263.

12 Robert Cialdini, *Influence: The Psychology of Persuasion* (2006), p. 116.

13 Richelli/Arioli/Canessa (2025), p. 680.

14 Richelli/Arioli/Canessa (2025), p. 678.

that pro-environmental and prosocial choice decisions share neural substrates, with the TPJ being centrally involved in both types of decision-making.<sup>15</sup> This convergence lends support to the idea that environmental decision-making might be intrinsically social, necessitating reflection about what effects one's actions have on other people and the future. Research on the prefrontal cortex has demonstrated its key role in prioritising long-term benefits over short-term advantages in the environment. In contrast, the amygdala's role reflects the emotional nature of choices related to sustainability.<sup>16</sup>

### III. Legal compliance and behavioural insights

The influence of behavioural insights on legal scholarship has led to significant developments in understanding how and why individuals obey the law. According to traditional deterrence theory, compliance is primarily determined by the anticipated costs and benefits of legal violations. However, behavioural research has demonstrated that a broader range of psychological constructs strongly influences compliance.<sup>17</sup>

Social norms are a critical aspect of legal compliance, with research demonstrating that individuals are more likely to comply with legal requirements when they believe that compliance is widespread and socially expected.<sup>18</sup> This has profound implications for sustainability law, where it implies that policies that render compliance visible (and hence socially salient) might be more effective than those, even if formally sanctioned, that do not. Another important factor in legal obedience is the notion of legitimacy—people are more likely to comply with the law when they consider it to be legitimate and fair.<sup>19</sup>

Neurolaw is a nascent field that has begun to examine how neuroscience can illuminate legal theory and practice. Preliminary developments in neuroimaging have had a profound impact on doctrine regarding criminal

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15 Mauricio Delgado, 'Reward-Related Responses in the Human Striatum' (2007), 1104(1) *Ann. N.Y. Acad. Sci.*, p. 70.

16 Kevin Ochsner/James Gross, 'The Cognitive Control of Emotion' (2005), 9(5) *Trends Cogn. Sci.*, p. 242.

17 Tom Tyler, *Why People Obey the Law* (2006), p. 45.

18 Tyler (2006), p. 67.

19 Tyler (2006), p. 103.

responsibility—above all, on notions of guilt and dangerousness.<sup>20</sup> These changes present crucial challenges to the fields of forensic psychology and forensic psychiatry concerning the reformulation of knowledge about mental disorders and their consequences in legal contexts.

### *C. The neuro-legal framework for sustainability*

#### I. Theoretical foundation

This neuro-legal sustainability framework is a methodologically innovative approach that integrates knowledge from neuroscience, behavioural economics, and legal scholarship to improve the effectiveness of environmental regulation. Compliance with the law is, in essence, a psychological process that operates within the cognitive and neural substrates of human decision-making. Rather than viewing these psychological facts as barriers to be overcome, the approach aims to integrate regulatory design with the way people and organisations process information and make decisions about the natural environment.

This framework is based on three fundamental principles. First, human cognition about the environment is systematically skewed by cognitive biases and neural processes that, a priori, are not consistent with rational choice theory. Second, we can understand and predict these psychological mechanisms through science and use this knowledge for evidence-based regulatory design. Third, legal systems can be ‘cognitively and neuronally’ optimised, if cognitive and neural processes are taken into account when legal rules are created and enforced.

The psychological and neural architecture of environmental decision-making integrates the activities of several interacting brain systems, which contribute different types of information and processing toward the choice.<sup>21</sup> Emotional processing centres (based around the amygdala and associated structures) compute the affective meaning of information from the environment and generate motivational responses that may either facilitate or subvert pro-environmental activity. The cognitive control systems, including regions of the prefrontal cortex (pFC), allow individuals to over-

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20 Eric García-López/Cristina Nombela/Eduardo Demetrio Crespo, ‘Editorial: Law and neuroscience: justice as a challenge for neurorights, neurolaw, and forensic psychology’ (2025), 16 *Front. Psychol.*, p. 1615234.

21 Richelli/Arioli/Canessa (2025), p. 681.

ride immediate impulses and choose long-term environmental benefits, even when doing so entails short-term costs. The social cognition network, for example, the TPJ and medial prefrontal cortex (mPFC), is involved in encoding culturally specific information about social norms, expectations, and the repercussions of local actions on others in the environment.

Knowledge of these neural mechanisms is crucial for effective regulation. Policies that tap into emotional processing systems through relatable content or vivid imagery may be more effective at motivating behaviour change than those based on abstract statistical information. On the other hand, to the extent that these systems have evolved to promote efforts at decision-making, less taxing policies aimed at lowering demands on the cognitive control system through simplified choice architectures or default options may more effectively facilitate alternative decision-making approaches rather than interfering with these natural processes.

## II. Framework Components

The neuro-legal infrastructure consists of three interacting model components which address aspects of the psychology of environmental decision-making: cognitive bias correction, social norm incorporation and default enhancement. Each module addresses specific psychological processes and helps regulate the overall system.

Cognitive bias mitigation involves the systematic identification and correction of cognitive biases that interfere with accurate environmental decision-making. Present bias is especially central as a target for intervention because the tendency to put a lower value on future benefits creates systematic barriers to policies with long-term environmental payoffs. Regulations that address present-bias environmental decision-making include providing immediate information on consequences to increase the saliency of long-term outcomes, framing the costs and benefits of environmental behaviour in daily (rather than yearly) terms, and offering immediate rewards for pro-environmental behaviour.

Another means of reducing cognitive bias is through the mediation of temporal framing effects. It has been shown that the exact cost or benefit for the environment can be perceived very differently depending on how it is presented in time. For example, £365 per year is probably way more

expensive than £1 per day, even though they are mathematically the same.<sup>22</sup> Such legal frameworks that utilise psychological pricing mechanisms systematically can increase the attractiveness perception of sustainable options without compromising economic efficiency.

Social norm integration is based on the recognition that environmental decision-making is essentially social—that what others are doing and what is expected or accepted by others is taken into account. The framework we introduce is aimed at utilising social norm information for regulatory creation by systems such as peer comparison forces, public disclosure needs, and reputational incentives that render environmental performance visible to interested constituents.

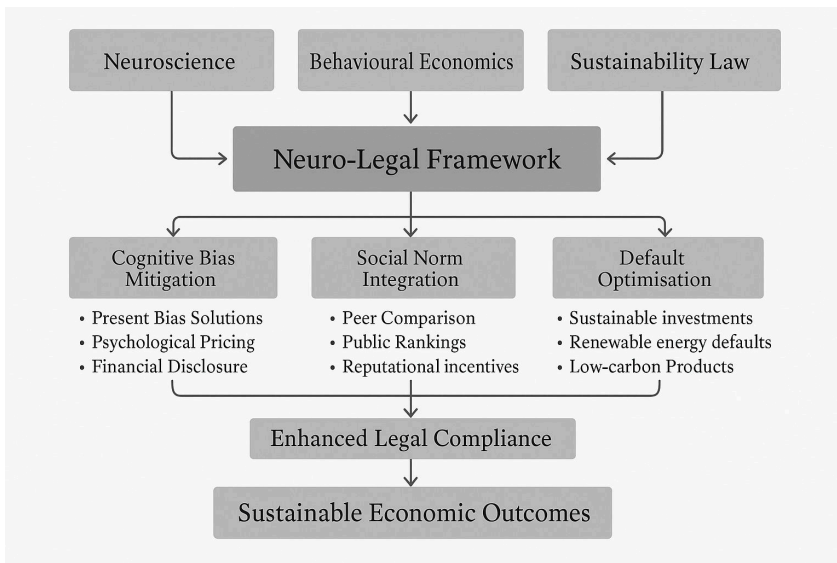


Figure 1: Theoretical model for neuro-law sustainability

Default optimisation is the final pillar of the model, dealing with the potent role of default settings in determining choice. The psychological literature has overwhelmingly shown that people have a strong bias towards defaulting and that even when changing a default is the best course of action, most people will

22 Thaler/Sunstein (2008), p. 89.

still stick with the default.<sup>23</sup> This default effect can be harnessed to encourage sustainable behaviours by designing choice architectures such that environmentally better options are taken as the default.

Figure 1 illustrates the intersection of neuroscience, behavioural economics, and sustainability law in a holistic framework to improve legal compliance by focusing on how to mitigate cognitive bias, integrate social norms, and optimise the default strategy.

#### *D. The three-tiered legal model*

For the proposed three-tiered legal model, the theoretical contributions of the extrajudicial neuro-legal framework are applied to specific regulatory design principles that can be effectively implemented within existing legal regimes. These tiers each target psychological mechanisms, making an independent contribution to the success of sustainability law through the use of coordinated and mutually reinforcing strategies to increase compliance and improve environmental performance.

##### I. Tier one: cognitive bias mitigation

The model's first tier involves the systematic detection and control of cognitive distortions that undermine ecological decision-making. This level acknowledges that traditional regulatory approaches are ineffective because they are not grounded in structures of rational decision-making that align with the psychology of how individuals (including firms) process environmental information and make decisions.

The most serious cognitive bottleneck in the development of effective environmental policy is present bias. 'This systematic bias in the overweighting of immediate costs vis-à-vis remote gains implies a natural resistance to environmental policies in which investments by a generation today translate into external benefits for a range of time in the future.'<sup>24</sup> The model deals with the present-bias key element in different ways. One such way is temporal reframing, which involves presenting environmental costs and benefits in terms of time to provide a sense of near-term future

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23 Johnson/Goldstein (2003), p. 1338.

24 Frederick/Loewenstein/O'Donoghue (2002), p. 351.

consequences that are psychologically relevant. For example, carbon tax policies can be presented in terms of daily rather than annual costs, making the financial impact feel more manageable whilst maintaining the same economic incentives.

Immediate feedback mechanisms are yet another way to reduce the effects of present bias. Many conventional environmental policies are based on a lengthy time lag between actions and outcomes, which weakens people's psychological link between their activities and results. The model includes provisions for honest or near-time feedback on environmental impacts, such as smart meter displays and feedback on immediate energy consumption costs, or corporate reporting systems that offer monthly updates rather than annual ones on environmental performance.

Psychological pricing tactics rely upon widely known framing effects to increase the saliency of the sustainable option. Studies have shown that the exact economic cost or benefit can be perceived in quite different ways, depending on how it is framed.<sup>25</sup> Environmental regulation can also be crafted to capitalise on these effects by being sensitive to how costs and benefits are framed. For example, a programme to encourage reusable shopping bags could be framed as either a discount for using reusable bags or a surcharge for using disposable bags. This demonstrates the power of loss-framed messaging over gain-framed approaches, consistent with loss aversion theory which suggests that people experience losses approximately twice as intensely as equivalent gains<sup>26</sup>. The requirement of financial disclosure is a mechanism in the legal regulation of the availability heuristic and other cognitive errors. The availability heuristic is a mental shortcut where people judge the probability of events based on how easily examples come to mind, leading to systematic overestimation of vivid, recent environmental incidents while underestimating gradual, less visible threats.<sup>27</sup> Other relevant biases include present bias, which causes individuals to systematically overweight immediate costs relative to future environmental benefits,<sup>28</sup> confirmation bias, where people selectively seek information that confirms pre-existing environmental beliefs while dismissing contradictory

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25 Tversky/Kahneman (1981), p. 453.

26 Kahneman/Tversky (1979), p. 263.

27 Amos Tversky/Daniel Kahneman, 'Availability: A heuristic for judging frequency and probability' (1973), 5(2) *Cogn. Psychol.*, p. 207.

28 Jiaying Zhao/Yu Luo, 'A framework to address cognitive biases of climate change' (2021), 109(22) *Neuron*, p. 3548.

evidence, and optimism bias, leading individuals to underestimate their personal vulnerability to environmental risks compared to others.<sup>29</sup> The model involves the compulsory reporting of long-term environmental costs and benefits in investment and corporate reports in a manner that is psychologically salient and accessible. For instance, a study demonstrated that environmental impact labels using simple A–F grading systems significantly reduced the environmental impact scores of food purchases across multiple indicators, suggesting that standardised Environmental Impact Scores similar to nutritional labels could enable investors and consumers to easily compare sustainability performance without requiring specialised expertise to interpret complex technical reports.<sup>30</sup>

## II. Tier two: social norm integration

The second tier of the model adopts the view that environmental decision-making is essentially social, considering others' actions, social expectations, and how decisions are likely to be perceived by those who matter. This level embeds information about social norms into policy design through tools that render environmental performance visible and that activate social influence processes to promote compliance.

Social comparison mechanisms are an integral part of internalising social norms. It has consistently been found in research that people will change their behaviours when they are informed that they score well or poorly on a comparative basis with similar other people.<sup>31</sup> Inclusion of peer comparison is added, along with compulsory reporting on peer comparison that leads to benchmarking systems, allowing organisations to compare themselves with the industry and ultimately providing public access to information where environmental risk is compared between entities, which again makes relative environmental risk visible to stakeholders.

Public disclosure mechanisms play various roles in the layer of social norm integration. These mechanisms 'make environmental performance

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29 John-Oliver Engler/David J. Abson/Henrik von Wehrden, 'Navigating cognition biases in the search of sustainability' (2019), 48(6) *Ambio*, p. 605.

30 Christina Potter et al., 'Effects of environmental impact labels on the sustainability of food purchases: Two randomised controlled trials in an experimental online supermarket' (2022), 17(11) *PLoS One*, p. e0272800.

31 Hunt Allcott, 'Social Norms and Energy Conservation' (2011), 95(9–10) *J. Public Econ.*, p. 1082.

more visible to stakeholders, thereby creating reputational incentives for better environmental performance'.<sup>32</sup> They also give the information needed for social comparison processes to operate efficiently and market mechanisms to reward better environmental performance.

Corporate sustainability ratings and indices are an example of the use of public disclosure mechanisms. The model encompasses a need for standardising the reporting of environmental performance for credible comparison among different organisations. The rankings can be designed to mobilise competitive dynamics and reputational concerns to drive environmental improvements beyond what formal regulations alone might accomplish.

Another manifestation of social norm integration is the use of consumer labelling schemes. As environmental performance information on products and services is disseminated, it enables consumers to articulate their environmental preferences through market choices, thereby generating competitive pressures to improve environmental performance.

### III. Tier three: default optimisation

The third layer of the model is the salience of default options within choice architecture. Evidence has shown that people are highly likely to opt for the default option, even when another choice would be better for them.<sup>33</sup> This default effect is one of the most robust results in behavioural economics and provides many possibilities to influence sustainable behaviour via the design of the choice architecture.

Default optimisation is a key application of automatic investment flow in environmental policy. The model includes features such as the automatic enrolment of pension funds and others into sustainable investment options, with an opt-out option allowing individuals to make a free choice, while utilising the default effect to achieve environmental aims. Research has shown that auto-enrolment can lead to a huge increase in take-up rates in retirement savings schemes, and the same is likely to be true of sustainable investment options.<sup>34</sup>

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32 Thomas P. Lyon/John W. Maxwell, 'Greenwash: Corporate environmental disclosure under threat of audit' (2011), 20(1) *JEMS*, p. 3.

33 Johnson/Goldstein (2003), p. 1338.

34 Brigitte Madrian/Dennis Shea, 'The Power of Suggestion: Inertia in 401(k) Participation and Savings Behavior' (2001), 116(4) *QJE*, p. 1149.

The structure of automatic investing systems necessarily needs to reconcile effectiveness with individual autonomy. Opt-out options enable individuals to make alternative investment choices, with the expectation that most will opt for the default distribution. Default options should be evidence-based on what most people would do if they had complete information and ample time to ponder which option they would choose.

Renewable energy defaults represent another application of default optimisation. The model incorporates automatic enrolment in renewable energy programmes for electricity supply, with opt-out provisions that allow individuals to choose conventional energy sources if they prefer. The default effect operates through a combination of psychological mechanisms that make the pre-selected option 'sticky' and resistant to change. Status quo bias leads individuals to maintain existing arrangements due to the cognitive effort required to evaluate alternatives, while loss aversion makes people reluctant to give up what they perceive as already obtained.<sup>35</sup> Additionally, the default option often serves as an implicit endorsement or recommendation from the choice architect, suggesting that this is the preferred or socially appropriate choice.<sup>36</sup> This approach leverages these psychological tendencies to increase renewable energy adoption whilst preserving consumer choice and avoiding the political resistance that might accompany mandatory renewable energy requirements. Field studies in Germany have demonstrated that green energy defaults can achieve adoption rates of approximately 80 % in both household and business sectors, with only 10 % of customers actively choosing to opt out when renewable energy is presented as the standard option.<sup>37</sup>

Banking and financial services can encourage the adoption of low-carbon financial products through default optimisation. The model incorporates financial institutions' obligations to provide low-carbon options as defaults across a range of financial products, from credit cards that automatically offset carbon emissions to bank accounts that redirect a proportion of consumer deposits into sustainable investment funds.

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35 Cass R. Sunstein/Lucia A. Reisch, 'Automatically green: Behavioral economics and environmental protection' (2014), 38 *Harv. Envtl. L. Rev.*, p. 127.

36 Ulf Liebe/Jennifer Gewinner/Andreas Diekmann, 'Large and persistent effects of green energy defaults in the household and business sectors' (2021), 5(5) *Nat. Hum. Behav.*, p. 576.

37 Micha Kaiser et al., 'The power of green defaults: The impact of regional variation of opt-out tariffs on green energy demand in Germany' (2020), 174 *Ecol. Econ.*, p. 106685.

### *E. Policy implications*

The utility of a neuro-legal paradigm is applicable in a variety of environmental policy settings, providing tangible approaches to maximise the impact of current policies by lowering the implementation costs and political opposition. The framework's focus on working with, rather than against, psychological instincts provides an opportunity to advance environmental objectives with tactics that feel organic and voluntary to those being regulated.

In the context of a carbon tax, the model suggests a couple of deviations from the classical model that could increase acceptance and adherence. Reframing carbon tax costs (from annual to daily) over time would lower the psychological costs of carbon taxes while maintaining their economic incentives. Inclusion of social comparison information, such as a household's carbon tax payments compared to neighbourhood averages, could potentially capitalise on social proof effects to increase compliance and decrease resistance.

Corporate environmental reporting is another area where the framework makes practical advances. Including peer comparison provisions within mandatory reporting standards may also increase the motivational potential of these regulations by making relative environmental performance more salient to the relevant audience. Such simplified yet psychologically motivated presentation formats may increase the likelihood that environmental information influences stakeholder decision-making.

Financial regulation has been identified as an area with particularly fertile ground for the application of default optimisation techniques. An automatic allocation of people's pensions into sustainable investment options and the right to opt out if you wanted would enable a sea change in investment—a flood of investment to environmentally beneficial projects—without in any way restricting personal choice. Analogous methods might be used for banking products, insurance contracts, and other financial services to support sound and sustainable economic behaviour by designing choice architecture.

### *F. Economic efficiency considerations*

The economic efficiency implications of the neuro-legal framework are typically favourable, as the framework attempts to realise environmental

goals by devising mechanisms that lower the costs rather than increase the costs of compliance and monitoring. By integrating regulatory design with underlying psychology, the framework may enhance compliance rates and reduce the need for costly monitoring and enforcement.

Default optimisation rules are especially appealing from an economic efficiency standpoint; they can induce significant changes in behaviour (toward the second-best optimal level) without the need to bear added costs by a regulator or its regulated entities. Compulsory investment of pension funds in sustainable investments would be almost cost-free administratively, potentially channelling billions of pounds into environmentally sound projects.

Cognitive bias mitigation tools are also economically efficient, as they help lower the information processing costs associated with environmental decision-making. By making environmental information accessible as a psychological resource, such approaches may improve the quality of environmental decisions and expedite the processing of complex environmental information by individuals and organisations.

Social norm integration mechanisms could improve economic efficiency by using the market to reward those with better environmental performance. Requirements for public disclosure of response activities and peer comparison-based systems drive competitive pressure for environmental upgrading through market incentives, rather than regulation.

### *G. Conclusion*

This article presents a new neuro-legal paradigm for sustainability law, critically drawing on intersecting lines from neuroscience, behavioural economics, and legal theory to improve environmental regulation. The three-tiered model, which outlines strategies to foster legal compliance through cognitive bias amelioration, social norm incorporation, and default upgrading, has implications for evidence-based policy innovation that align rather than contradict the psychological contours of human decision-making.

The theoretical implications of this article extend well beyond environmental law to encompass broader issues of psychology and legal efficacy. This study is the first to demonstrate how insights from neuroscience and behavioural sciences can be used to inform regulatory design, thereby contributing to the emerging field of neurolaw and providing a foundation

for future interdisciplinary collaboration among lawyers, neuroscientists, and behavioural economists.

The policy relevance of this framework is also significant, as it provides policymakers with evidence-based tools to improve their sustainability regulation outcomes and reduce implementation costs and political opposition. The focus on choice architecture and information design makes it possible to achieve environmental goals using methods that respect individual prerogatives, while capturing relevant psychological processes to induce sustainable behaviours.

The policy innovation possibilities of neuro-legal compositionality are broader than the range of neuro-legal interventions explicitly advanced in this paper; however, they involve a larger shift in how to think about and practice environmental law. This approach, by rooting regulatory design in the science of human psychology, holds the promise of considerably more effective, efficient, and politically durable environmental regulation.

Future advancements in this area will depend on ongoing interdisciplinary engagement among scholars, policymakers, and practitioners. The nature of environmental problems necessitates interdisciplinary approaches that transcend traditional disciplinary boundaries, as encountered in neuroscience, psychology, economics, law, and policy. Only by collaborating in this way can we harness the full potential of neuro-legal approaches to sustainability, which have become an increasingly urgent part of addressing climate change and environmental degradation through better laws.

The framework developed here represents a first step toward a psychologically informed sustainability law. Nevertheless, as empirical work confirms and qualifies these theoretical findings, and as regulators themselves have the chance to test-drive behaviourally informed regulation, the possibilities for achieving environmental policy goals through neuro-legal regimes will necessarily grow, with opportunities for more efficacious responses to the environmental problems that plague modern society.

