Business Strategy & Development

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Business Strategy and Development

RESEARCH ARTICLE

Towards a Sustainable Bio-Based Future: A Governance Framework for Bioeconomy Initiatives

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Received: 5 February 2025 | **Revised:** 2 December 2025 | **Accepted:** 5 December 2025

Keywords: bioeconomy | governance | institutions | transaction cost

ABSTRACT

Despite new global efforts promoting a bio-based transition, the widespread adoption of bioeconomy initiatives remains limited. We argue that this slow progress is due to the neglect of the governance dimension in bioeconomy strategies. Our study aims to fill this gap by offering a conceptual framework focusing on the governance concept from New Institutional Economics and Transaction Cost Economics. Existing research on bioeconomy governance has so far ignored the transaction costs involved in coordinating the interests of various stakeholders. We argue that for bioeconomy strategies to succeed, their benefits must outweigh their costs, hence comparing various alternative solutions becomes a pivotal step in comprehensively understanding and evaluating these trade-offs. Here we propose a governance framework that equips actors with the necessary tools to systematically evaluate the merits of different options, whether comparing different bioeconomy initiatives or contrasting bioeconomy approaches against traditional practices.

1 | Introduction

A consensus has emerged that transitioning towards a bio-based economy is essential in shaping a more sustainable future (Stark et al. 2022). As bioeconomy is also one of the most politically complex domains confronting agri-food and rural resource sectors that encompasses a wide range of competing interests (Devaney et al. 2017), having an effective governance is a central concern. Existing research on bioeconomy governance, however, has largely concentrated on macro-level factors that constrain or dampen the implementation of bioeconomy strategies (Böcher et al. 2020; Dietz et al. 2018, 2023; Siegel et al. 2022). Far less attention has been devoted to governance costs and the coordination challenges faced by actors involved in such initiatives.

This study investigates coordination-related attributes that both constrain and enable the implementation of bioeconomy initiatives. Existing research suggests that bioeconomy transitions are often triggered by regulatory shifts or the emergence of new technologies (Bugge et al. 2019). The persistence and scaling of such initiatives, however, depend on the extent to which governance mechanisms can effectively coordinate a diverse pool of stakeholders and ensure a transparent distribution of incentives and responsibilities (Dieken et al. 2021). In this context, we shed light on (i) how governance costs can constrain the effective coordination of stakeholders and (ii) how adequate governance mechanisms can mitigate the impact of these costs in the establishment of bioeconomy initiatives.

Governance is a core concept across several social science disciplines, including international relations, political science, management, and economics. In this study, we draw specifically on the governance framework of New Institutional Economics (NIE), which, to the best of our knowledge, remains underexplored in the context of the bioeconomy. Governance costs are understood here as synonyms of transaction costs, that is, the costs of negotiating, supervising, and enforcing contractual relations (Williamson 1985, 1991b).

Governance problems in economic exchanges trace back to Coase's (1937) insight that firms arise because using markets entails high transaction costs. Williamson (1985) developed this logic and created the Transaction Cost Economics (TCE) theory, arguing that the efficiency of coordination depends on aligning transaction attributes, such as asset specificity, uncertainty, and frequency, with appropriate governance structures. When investments are highly specific, they generate quasi-rents that are vulnerable to opportunistic expropriation under incomplete contracts and weak institutional safeguards, thereby increasing the costs and risks of relying on the market (Klein et al. 1978). These contributions explain why firms often find it more (or less) efficient to "make" (integrate vertically) rather than "buy" (contract externally) in the presence of transaction costs. Building on this comparative governance perspective, Ménard (2004, 2022) conceptualizes that the real world actually happens in between, where hybrid governance structures as distinct organizational forms blend market and hierarchical mechanisms to manage coordination and safeguard specific investments. This perspective is still lacking in the bioeconomy literature, which tends to overlook coordination as an essential block of governance in highly specific bioeconomy investments.

Bioeconomy is commonly understood as the production, use, and conservation of renewable biological resources, such as crops, forests, fisheries, animals, microorganisms, genetic resources, supported by related knowledge, science, technology, and innovation to provide products, processes, and services across economic sectors in pursuit of a more sustainable economy. By definition, it is tightly coupled to the provision of ecosystem services and the management of shared, finite resources such as soil, water, and forests. If access to these common-pool resources is poorly coordinated, actors face strong incentives to overexploit them, risking a "tragedy of the commons" in which individually rational behavior ultimately erodes the resource base on which the bioeconomy depends (Hardin 1968). From this perspective, the transaction costs associated with monitoring and enforcement underscore the centrality of coordination in bioeconomy governance.

Our study employs a deductive narrative literature review that covers (i) articles that discuss bioeconomy governance strategies and (ii) contributions that scrutinize the coordination properties of governance. We first start by characterizing the TCE governance foundations according to Williamson (1985). We then extend the governance characterization by depicting each of the governance levels proposed by Williamson (2000). This study contributes to the literature by outlining the governance foundations and coordination mechanisms of bioeconomy initiatives, namely, sustainable business that integrates the principles of bio-based technology, resource, and ecology visions (Bugge et al. 2019). Strikingly, a Web of Science search conducted in November 2025 using the keywords "bioeconomy", "governance", and "transaction cost" identified only a single article explicitly linking these themes (Aza Mengoa et al. 2025), highlighting the limited engagement with TCE. Hence, this article develops an analytical framework intended to generate new insights into governance challenges in bioeconomy initiatives.

The remainder of this article is structured as follows. Section 2 presents the foundations of the TCE governance logic. Section 3 discusses the main perspectives on the concept of the bioeconomy. Section 4 introduces the analytical tools of TCE governance and illustrates their relevance with brief examples from bioeconomy initiatives. Finally, Section 5 presents concluding remarks, directions for future research, and implications for theory and practice.

2 | Governance Conceptualization

Governance in the bioeconomy is a multifaceted concept that spans a spectrum of perspectives. At the macro level, it encompasses interrelated elements such as social norms, formal rules, economic transactions, and resource endowments that must be aligned to steer the sustainable use of biological resources (Persson et al. 2025). This requires integrating social, economic, ecological, and regulatory dimensions so that bio-based activities are consistent with broader sustainability objectives (Dieken et al. 2021). At the micro level, governance entails the development of business models that operationalize bioeconomy principles by enhancing sustainability, reducing resource use, and extending product life cycles through the use of renewable biological resources and biotechnologies (Basile et al. 2023, 2025). Viewing bioeconomy initiatives as multi-actor configurations, in turn, underscores the need for a multi-level structure that can align rules, incentives, and technological standards to guide these actors toward sustainable development trajectories (Rennings et al. 2023; Waßenhoven et al. 2021).

One stream of literature that can strongly support such a view is the sustainability transition literature. Sustainability transitions are understood as long-term, multidimensional transformation processes through which established societal systems (e.g., energy, mobility, agri-food) shift towards more sustainable modes of production and consumption (Markard et al. 2012). These transformations extend well beyond technological change, encompassing interlinked shifts in institutions, cultural norms, business models and ecological interactions across multiple levels (Geels 2002). Transitions can typically unfold over several decades and engage a wide range of actors and domains, making them inherently complex and contested. Unfolding over several decades and involving a diverse set of actors and sectors, transitions are inherently complex (Kates and Parris 2003). A widely used approach distinguishes overlapping phases, ranging from early experimentation and small-scale niche initiatives, through the consolidation of protected niches and accelerated diffusion into mainstream markets—often marked by intense struggles with incumbent regimes—to the gradual displacement of the old regime by a new one that becomes embedded in infrastructures, practices, and norms, while also generating distributional and ecological effects (Geels et al. 2023). Although this perspective is highly promising for the bioeconomy field (Bosman and Rotmans 2016), the question of which governance arrangements are required to enable and steer transformations towards sustainability across multiple scales remains insufficiently resolved (Patterson et al. 2017).

While these perspectives are highly relevant for characterizing the multi-dimensional nature of the bioeconomy, they tend to remain at a macro or systemic level, overlooking that such transformations ultimately emerge from numerous micro-level

changes. They also largely neglect that most interactions in contemporary socio-ecological systems are structured as transactions between two (or more) parties. While existing debates emphasize costs from a more traditional view, they pay comparatively little attention to transaction costs and to how these costs can enable, redirect, or constrain behavior within bioeconomy strategies. This raises critical questions such as how substantial investments can be safeguarded, and how can actors identify the most appropriate governance arrangements for specific types of transactions? Given that bioeconomy strategies involve a wide range of interrelated transactions, a governance approach that can reveal patterns and generate clear, operational guidance on the design of coordination mechanisms would be particularly valuable.

TCE theory offers the analytical lens that current bioeconomy governance debate largely lacks. By shifting attention from price-based "choice" to the governance of transactions in their institutional context, TCE explains how different combinations of asset specificity, uncertainty, and frequency call for different coordination forms with distinct mixes of incentives, control, and safeguards (Coase 1937; Williamson 1985). For this theory, governance is understood as the set of mechanisms that infuse order, mitigate conflict, and realize mutual gains. Williamson's "discriminating alignment" hypothesis provides a simple but powerful logic: given particular transaction attributes, one can identify comparatively efficient governance structures. Applied to the bioeconomy and circular systems, this enables systematic comparison across different bio-based transactions, and guides the design of safeguards that address context-specific risks such as ecological uncertainty, spatially concentrated biomass, or dependence on local knowledge (Ouro-Salim and Guarnieri 2023). Aiming to provide a holistic, integrative approach, we follow the multi-layer governance perspective described by Williamson (2000). Specifically, we argue that the core of governance lies in the four interrelated levels of institutional attributes (see Figure 1).

Level one refers to informal institutions, which introduce the importance of integrating social structure within the economic actions of individuals. This level calls attention to the role of social relations and motivations that go beyond economic incentives and are dynamic and constantly reshaped through cultural interactions (Granovetter 1985). In this context, informal institutions such as conventions can evolve naturally without calculation, playing a pivotal role in driving human behavior in a world where transaction costs exist. As North (1990) underlines, these spontaneous norms embedded in society significantly influence economic actors operating under multiple property rights regimes, where gaps and contradictions may arise. Moreover, this approach provides additional insights into contexts where opportunities for opportunism can emerge when enforcement difficulties lead to imperfect enforcement of property rights rules.

Level 2 introduces the perspective on formal institutions. Institutional environments shape economic activities, including bureaucratic, legal, and political rules (Williamson 2000). These structured settings outline requirements for bioeconomy ventures and offer guidance to achieve desired goals. This connects to North's (1990) institutional analysis, which argues

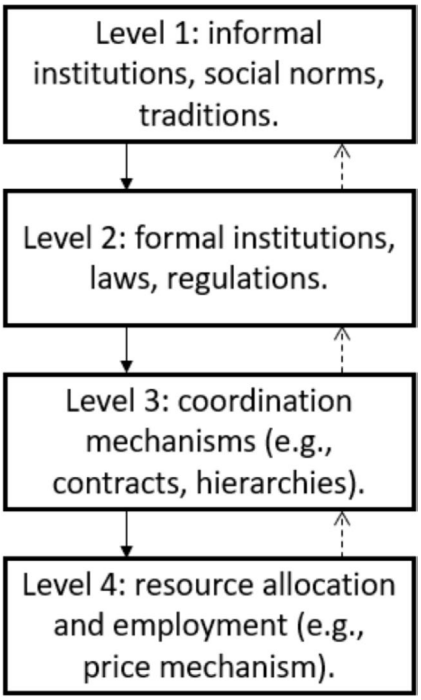

FIGURE 1 | Institutional levels. *Source:* Adapted from Williamson (2000).

that both formal institutions (like courts with codified norms and laws) and informal institutions (like societal norms and cultural values) play key roles in protecting property rights. Although bounded rationality, potential opportunistic behavior, and institutional inefficiencies imperfectly protect property rights (North 1990; Simon 1955), these factors are essential in outlining the definitive actions that authorities should take in instances of illegal activities.

Level three mainly refers to the work of Oliver Williamson on the adoption of coordination mechanisms to support the relationships among the multiplicity of agents involved in economic transactions. The adoption of governance mechanisms for transactions with the same attributes ensues from a search for efficiency in minimizing the governance costs, that is, the costs of negotiating, supervising, and enforcing contracts (Williamson 1985, 1991b). The primary foundation of this perspective is the 'discriminating alignment hypothesis', which sheds light on the transaction attributes and their governance arrangements (Williamson 1985). Three key transaction attributes are used to operationalize the discriminating alignment hypothesis: asset specificity, frequency, and uncertainty (Williamson 1985). These relationships are shaped by at least three contextual factors: (i) the incentives guiding the partners, (ii) the system for resolving disputes, and (iii) the contract laws framing the transaction (Tadelis and Williamson 2012). Transaction attributes and contextual factors interact to produce three main governance structures: markets, hybrids, and hierarchies, also known as vertical integration (Williamson 1985, 1991a, 1991b).

Finally, level four encompasses the logic of resource allocation. This level illustrates how resources, including human capital, are distributed to various activities. Neoclassical economic

models dominate this level. In this context, the firm is usually shown as a production function, and the market price mechanism is the main focus. The reasoning comes mainly from the traditional supply and demand perspective.

3 | Concept of Bioeconomy

The idea of the bioeconomy first appeared in the late 1960s, referring to an economic system recognizing the biological basis of nearly all economic activities. However, the term 'bioeconomy' now has a broader meaning (Birner 2018; Vivien et al. 2019).

From a policy perspective, several nations developed their own bioeconomy strategies during the 2010s. Earlier bioeconomy plans in the Northern Hemisphere focused on how biotechnology contributes to economic production and transforming renewable biological materials into value-added products. Some countries now utilize a more comprehensive definition, combining sustainable economic systems with biological processes and environmental factors. For instance, the European Commission conceptualizes the bioeconomy as an economic model in which renewable biological resources are produced and transformed into value-added products, including food, animal feed, goods derived from biological sources, and bioenergy (European Commission 2025). This definition encompasses a wide array of sectors, spanning traditional industries such as agriculture and segments of the chemical, biotechnological, and energy sectors. In contrast, the strategic approach to the bioeconomy in the United States is more specialized, focusing primarily on synthetic biology (USA 2012).

Recent scientific literature has delineated three 'bio' visions of the bioeconomy—biotechnological, bioresources, and bioecological (Bugge et al. 2019). The biotechnological vision focuses on the commercial application of biotechnology and economic growth under the assumption of positive environmental externalities from biotechnological progress. The vision of bioresources is centred on developing biologically based materials to replace fossil resources while significantly emphasizing sustainability. Finally, the bioecological vision prioritizes sustainability, ecological processes, and biodiversity conservation over economic growth. A key focus relates to circularity and self-sustaining production systems. Table 1 illustrates an overview of these three conceptualizations.

Bioeconomy, as a multifaceted concept, manifests through various definitions in the literature. Another emerging perspective views the bioeconomy as an approach that harnesses the potential of biological resources from terrestrial and aquatic environments through biotechnological advancements and knowledge-based innovations while also aiming to protect nature. This approach aims to develop and commercialize a broad spectrum of goods and services based on replacing fossil-based activities with those relying on living biomass (McCormick and Kautto 2013). Bioeconomy products can also vary significantly, from biomass-intensive, lower-value items like biofuels to higher-value, less biomass-dependent products such as bio-based chemicals or compounds (Mac Clay and Sellare 2025).

4 | Depicting Bioeconomy Governance

Figure 2 adapts the conceptual framework to the context of bioeconomy governance, briefly illustrating key aspects at each level of governance. A detailed discussion is provided below.

4.1 | Informal Institutions

Bioeconomy often encompasses natural resources that can be conceptualized within the framework of the widely known 'Tragedy of the Commons' (Hardin 1968). The term 'commons' refers to goods that community members provide to fulfil a

TABLE 1 | Bioeconomy visions.

	Bio-technology vision	Bio-resource vision	Bio-ecology vision
Objective	Economic growth and job creation	Economic growth and sustainability	Sustainability, biodiversity, conservation of ecosystems
Value creation	Application of biotechnology, commercialization of research and technology	Conversion and upgrading of bio-resources (process-oriented)	Development of integrated production systems and high-quality products with territorial identity
Innovation	R&D, patents, research councils and funders (science push, linear model)	Interdisciplinary optimization of land use, inclusion of degraded land in the production of biofuels, use and availability of bio-resources, waste management, engineering, science and market (interactive and networked production mode)	Identification of favorable organic agro-ecological practices, ethics, risk, transdisciplinary sustainability, ecological interactions, re-use and recycling of waste, land use, (circular and self-sustained production mode)

Source: Adapted from Bugge et al. (2019).

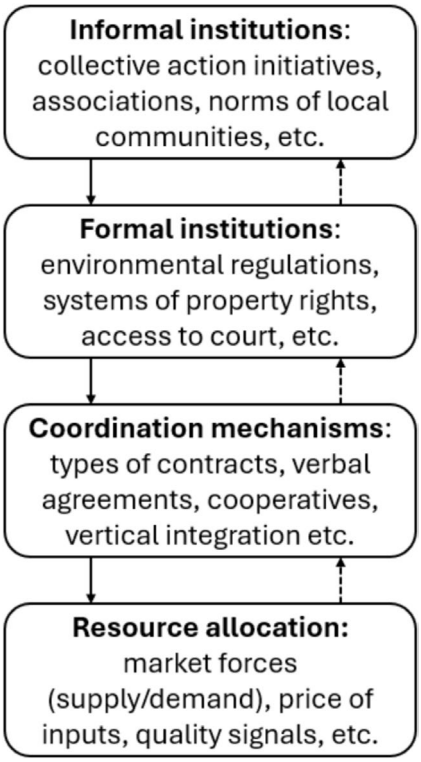

FIGURE 2 | Institutional levels and bioeconomy governance.

collective responsibility of caring for specific shared interests. These interests may encompass rights such as harvesting timber in forests or the communal utilization of pastures or fisheries. Hardin (1968) observed that exploiting natural resources can result in self-destructive tendencies and extinction due to excessive consumption and heightened pressure on these resources or the absence of adequate governance for attaining sustainability.

Indeed, the commons can be managed sustainably and economically, but only if governed by adequate institutional arrangements and designs. Such arrangements would emerge from negotiations among those interested in exploiting the 'commons', so these would vary according to each situation, including the 'regulation' of these goods and resources (Ostrom 1990). Thus, this governance system would be embedded in informal rules and based on collective action (Blomquist and deLeon 2011).

Ostrom (1990) provides insights into the necessary conditions within the definition of eight principles of the governance of common goods: (1) clearly delineated boundaries; (2) proportional correspondence between advantages and drawbacks; (3) arrangements for collective decision-making; (4) supervision; (5) graduated penalties; (6) mechanisms for resolving conflicts; (7) minimal recognition of rights to mobilize; (8) in the case of groups that are part of larger social systems, there must be appropriate coordination among relevant groups.

More specifically, Ostrom (2014) contends that governance efficiency can be enhanced through collective arrangements under certain circumstances, including: allowing the most affected participants to have a voice in proposing and deciding on rule changes; motivating participants to invest in the transaction costs of searching, debating, and learning about better options by offering significant stakes; aligning the interests of those with the most considerable stakes with increased productivity for the system; generating a range of rules across systems through diverse internal processes; operating within a social and economic context that promotes learning from others' successes and failures; establishing regular procedures for reviewing experiences, revising rules, and documenting changes; ensuring local autonomy in the political environment while also providing oversight against corruption, ensuring accountability, and facilitating conflict resolution; and experiencing biophysical disturbances with enough frequency for participants to develop coping mechanisms rather than being caught unprepared due to sporadic occurrences.

Numerous global initiatives have demonstrated the potential of community-based governance models in effectively managing the sustainable exploitation of natural resources (Berge and van Laerhoven 2011). However, implementing a purely communal resource management system faces obstacles in regions with high pressures for resource exploitation (Le Tourneau and Beaufort 2017). Introducing institutional changes and interactions with pre-existing local institutions can lead to expected and unexpected governance outcomes, potentially adding complexity to this process (Faggin and Behagel 2018). Such intricacies within bioeconomy initiatives call for this more multi-level governance perspective.

Experiences with non-timber forest products (NTFPs) underscore that local norms and informal institutions are not peripheral, but constitutive elements of a forest-based bioeconomy. NTFP initiatives are embedded in the customary rules, social organization, and traditional ecological knowledge of Indigenous and traditional communities whose livelihoods rely on extractivism (Chamberlain and Smith-Hall 2024). The literature shows that these arrangements tend to reinforce local culture and collective organization, and are associated with positive conservation outcomes, even when income gains are modest (Rosenfeld et al. 2024). Crucially, access, harvesting practices, benefit-sharing, and conflict resolution are often governed by community norms rather than formal law alone. Hence, the viability and legitimacy of NTFP value chains depend on whether external actors respect, and adapt to, these locally grounded governance systems.

Natura's operations in the Amazon illustrate how firms can engage productively with such informal institutions. By explicitly recognizing community rules, traditional knowledge, and local organizations as central to its sourcing strategy, Natura aligned its governance arrangements, contract design, benefit-sharing mechanisms, and monitoring practices, with the expectations and norms of supplier communities. This alignment was critical to securing reliable supply, maintaining trust, and avoiding social conflicts, while at the same time contributing to forest conservation by making "income with the forest standing" a credible alternative to deforestation-based land uses (McGahan and Pongeluppe 2023). More broadly, the case suggests that firms seeking to develop NTFP-based supply chains cannot rely on formal contracts and regulation alone: they must design their governance arrangements around the informal rules, social hierarchies, and collective decision-making processes that structure access to forest resources at the local level.

4.2 | Formal Institutions

Formal institutions have been studied mainly since Davis and North (1970). They have been assumed as sources of (under)development in terms of economic growth (Acemoglu and Johnson 2005; North 1990; Robinson and Acemoglu 2012) and social (dis)order (e.g., corruption, violence, etc.) (North et al. 2009). In bioeconomy strategies, institutions are essential in defining, protecting, and distributing property rights for a given bio-based economic activity. They influence the allocation and creation of incentives. Demsetz (1967) has argued that designing institutional arrangements is crucial to providing adequate incentives to encourage experimentation of new economic activities.

The assignment of property rights can dictate how much of the gains from the bioeconomy initiative are appropriated by whom. Property rights can influence the creation of bioeconomy initiatives as private actors assess the risk of expropriation by other stakeholders and the quality of formal institutions to resolve disputes and frame the contractual laws in the exchanges (Tadelis and Williamson 2012). In this case, formal rules can protect property rights and make investments more secure (Weingast 1995).

On one hand, robust property rights systems matter when an individual evaluates potential expected gains and losses of future business activity. A low risk of expropriation can reduce the cost of securing property, making starting a business more attractive. On the other hand, the possibility of expropriation should increase the risk of engaging in business activities if they have no mitigation or coping means and may serve as a disincentive to start a new bioeconomy initiative. Insecure property rights can influence investors, who may need to consider whether the business idea is viable and if their investment will be protected. Weaker protections for investors can increase their reluctance to invest in bio-based ventures. Private actors working in insecure property rights face uncertainty over their investment and may be less willing to risk their money (Acemoglu and Johnson 2005; Robinson and Acemoglu 2012).

It is crucial to recognize that in this context, the challenge is not merely a market problem but rather a fundamental issue concerning the protection of property rights. Although the State does not necessarily need to intervene in economic exchanges, it may provide a judiciary system that can be used when a private solution does not enable an optimally social solution when parties involved can freely negotiate (Coase 1960). In this case, while transaction costs are inherent to any economic exchange and can often be mitigated through efficient contracting and dispute resolution mechanisms, the costs to reach the judiciary and obtain the protection of property rights represent a subset of transaction costs that arise specifically when legal intervention is required (Tadelis and Williamson 2012).

Iogen Corporation, a Canadian biotechnology firm, can illustrate this (Altman et al. 2008). The firm developed a process to produce cellulosic ethanol from cereal straw and invested in a large, capital-intensive biorefinery tailored to this specific feedstock and region. The plant's viability depends on long-term contracts with nearby farmers, who in turn must adjust harvesting practices and invest in dedicated equipment and storage—assets that have little value outside the relationship with Iogen. This mutual dependence makes both sides vulnerable to hold-up and expropriation risks unless contracts are enforceable and property rights are secure. In this sense, Iogen's business model illustrates how robust formal institutions, clear contract law, reliable courts, and predictable regulatory frameworks are a precondition for large-scale bio-based investments that require significant, relationship-specific commitments by both firms and suppliers.

4.3 | Coordination Mechanisms

After fulfilling both informal and formal institutional conditions for bioeconomy strategies, the next step towards efficiency in governance involves analyzing the exchanges between actors within the bio-based setting from a coordination perspective. This perspective extends the basic logic of the discriminating alignment hypothesis to examine how interactions between actors unfold within a bio-based context. Williamson (1985, 1991b) conceptualizes the 'discriminating alignment hypothesis' by elucidating various coordination arrangements that can be employed to govern transactions between technologically separable stages of production. For instance, consider a scenario where a cooperative of nut collectors sells goods to a food processing firm. Both groups of actors in this relationship make specific investments and specializes in different activities. The coordination-centered governance perspective allows us to understand the factors influencing the choice of a specific coordination mechanism to govern such exchanges, such as vertical integration, contractual agreements, or market mechanisms/pricing (Williamson 1985). According to the discriminating alignment hypothesis, transactions with similar attributes should be governed by arrangements with similar characteristics. Hence, given the attributes of the transaction, one may observe a more economically efficient arrangement.

To apply the discriminating alignment hypothesis, it is essential to consider three transactional attributes—asset specificity, frequency, and uncertainty—as they play a crucial role in shaping the coordination mechanisms. Asset specificity refers to investments capable of generating value for a particular transaction, with potential risks of opportunistic appropriation of quasi-rent, that is, the surplus value between the current resource use and its second-best alternative (Klein et al. 1978). Transactions characterized by high asset specificity tend to generate greater quasi-rent. A natural solution to mitigate opportunistic behavior would involve implementing stricter contractual terms to safeguard the investments. For instance, terms guaranteeing long-term purchases could be established.

Beyond asset specificity, the frequency of transactions also plays a crucial role in determining the necessity for such governance mechanisms (Williamson 1993). Repetitive interactions can strengthen social bonds and facilitate the development of trust (Granovetter 1985), fostering relational governance. This form of governance supports cooperation through norms and reciprocal obligations that extend beyond initial contract clauses, thus reducing reliance on the legal system (Chiles and McMackin 1996). Given the significance of past and potential

frequency in long-term interactions, trust and contracts can complement each other to establish an effective governance arrangement (Poppo and Zenger 2002).

In addition to asset specificity and frequency, uncertainty can also play a role in this context. Uncertainty encompasses disruptions that elude anticipation, such as unforeseen shifts in political regimes or global disturbances such as the COVID-19 pandemic. While organizations may equip themselves for unforeseen incidents by establishing departments dedicated to crisis management, events characterized by genuine uncertainty cannot be fully understood until they occur (Dequech 2006). In contrast to risks that can be assessed in probabilities, uncertainty remains immeasurable (Williamson 1985). Entrepreneurs, for instance, may decide not to make specific investments if they face great uncertainty in securing their property rights (Bylund and McCaffrey 2017). To prevent such behavior and anticipate the unforeseen, coordination mechanisms may be implemented to ensure specific conditions when encountering these events.

The case of company The Body Shop illustrates the fragility of governance arrangements in bioeconomy initiatives. The company uses several natural inputs, such as Brazil nut oil, babassu oil, sesame oil, and shea butter, from community organizations in Latin America and Africa for the manufacture of its cosmetics. In 2024, however, The Body Shop went into administration in the United Kingdom less than 3 months after it was taken over by a private equity firm (The Guardian 2025). The consequences of this collapse have been felt along the supply chains, particularly overseas. Several suppliers reported being left with more than US$1 million worth of ingredients produced specifically for the company, often on the basis of long-term relationships without written contracts. One Peruvian cooperative held around US$500,000 of Brazil nut oil in inventory, a Brazilian cooperative had just shipped €300,000 of babassu oil, and a Nicaraguan sesame oil cooperative had roughly US$300,000 in stock, all at risk of never being paid (The Guardian 2024). It was later confirmed that unsecured creditors, including natural-ingredient suppliers, would receive only 16%–27% of the £219 million owed at the time of the retailer's collapse (The Guardian 2025). This episode shows that in bio-based sectors, even when inputs are ethically sourced and marketed as "sustainable", inadequate formal governance can turn specific investments in certified natural inputs into large financial losses. This highlights the need for more robust governance mechanisms to mitigate such risks for all stakeholders involved.

4.4 | Resource Allocation

Williamson (2000) posits resource allocation as the fourth level of analysis for governance. This aspect involves traditional market forces driven by supply and demand. Key considerations include price mechanisms, technological advancements, and consumer preferences. For example, formulating bioeconomy strategies depends on potential market demand for outputs. Assessing production costs, labor and capital, and consumer demand elasticity is also essential for bio-based decisions.

Imagine a hypothetical bio-based startup seeking to develop new cosmetics from an Amazonian plant. First, adopting an extractive approach, the firm must determine feasible input yields from the plant. Second, it must account for associated procurement costs like transportation and labor. Third, technological infrastructure must also be part of decision-making. Ex-ante, the company should anticipate the market potential for the cosmetics in terms of volume and pricing. The investment lacks viability if the acceptable price point does not offset production costs. Moreover, inadequate input volumes could impede the introduction of new products. Hence, traditional supply and demand conditions should also be part of a governance perspective for bioeconomy strategies.

5 | Conclusion

This study proposes a broad governance-based framework to facilitate the transition towards a bio-based economy. Drawing inspiration from Coase's seminal work (Coase 1960), we posit that this transition need not be driven solely by public initiatives, but rather should be evaluated based on the efficiency trade-offs between public and private solutions. Private or hybrid governance mechanisms can potentially be as effective as public coordination, provided that the value creation enabled by such mechanisms exceeds the associated governance costs. It is important to note that the Coase theorem, which is often misinterpreted, emphasizes the notion that we operate in a world characterized by positive transaction costs. Therefore, studies on bioeconomy should pay greater attention to the role of the design of organizational solutions that maximize the welfare of stakeholders with potentially divergent interests, while minimizing the governance costs required to coordinate these interests.

5.1 | Future Research Studies

The bioeconomy has mostly been examined in regulatory and technical terms. Yet the literature remains disproportionately oriented toward justifying the need for such transitions, with relatively little systematic discussion of their governance implications and challenges. This study contributes to debates on the bioeconomy by proposing a framework for governance analysis grounded in the organizational challenges of designing more sustainable, bio-based arrangements. This is especially important given that bioeconomy initiatives are often characterized by considerably higher governance costs than other private strategies based on traditional practices. Importantly, this does not imply the existence of a universal remedy. Rather, we hope that our framework will help reveal the main constraints on the adoption and diffusion of bioeconomy initiatives.

While our study is conceptual in nature and does not show empirical tests, the proposed framework may serve as a catalyst for the development of future empirical research that supports the transition towards a bio-based economy. The governance framework delineated herein, albeit not novel to the literature on new institutional economics, represents a relatively unexplored application within the bioeconomy context. This framework may illuminate pertinent governance forms to be designed to adequately address potential coordination challenges inherent in bioeconomy strategies. Despite not being the only solution, we have designed the framework to be applicable across diverse

contexts. Although the relative weights of the various levels governance perspective as highlighted in Section 4 may vary, each level retains (to some extent) relevance across all possible applications.

Future bioeconomy governance studies could benefit from interdisciplinary research that builds on concepts from political science, legal studies, and public administration. Future research should begin by selecting specific bioeconomy initiatives, mapping all relevant transactions along their value chains, and identifying where governance-related inefficiencies arise. Building on this, researchers can apply the analytical framework proposed in this article to assess whether these governance problems stem primarily from weaknesses in informal institutions, formal institutions, coordination structures, or conventional supply-and-demand dynamics. This sequential approach would allow for a systematic diagnosis of constraints and more targeted design of governance interventions. Qualitative approaches, such as in-depth interviews with policymakers and stakeholders, focus groups, document analysis, and ethnographic studies, could help to illuminate decision-making processes and social pressures.

Since our contribution here is largely conceptual, several avenues for future empirical work emerge. First, carefully designed case studies in specific investment contexts could be used to reconstruct how coordination decisions are structured and to examine whether actors choose governance arrangements following the presented theoretical expectations. Second, comparative case studies could help identify the coexistence of diverse architectures and explore how these configurations shape the adoption of bioeconomy strategies as well as their governance costs. Third, different forms of interdependence within bioeconomy initiatives could be systematically mapped and then explained. This would clarify how bridging coordination mechanisms contribute to the governance of activities and value distribution.

5.2 | Implications for Theory

The principles of the bioeconomy necessitate intricate coordination mechanisms that reconcile economic returns with the preservation of social and environmental values. Beyond the pure market logic of price mechanisms, the bioeconomy must account for the transaction costs associated with achieving these multidimensional objectives. Of course, the availability of bio-based resources is a necessary condition for bioeconomy initiatives to uptake (Maes and Van Passel 2019). However, even in regions endowed with readily available technology and abundant bio-resources that enable the production of high-value goods, bioeconomy initiatives may fail to emerge if governance costs are neglected.

This phenomenon can be attributed to the presence of opportunism and bounded rationality that characterize economic exchanges (Simon 1955; Williamson 1993). Value creation per se does not necessarily translate into fair value appropriation. Stakeholders who do not perceive their returns as fully satisfactory may refrain from engaging due to fear and/or uncertainty. Hence, the design of organizational arrangements that can effectively protect property rights and efficiently allocate decision rights is key. Traditional property rights theory posits that owning property rights grants the ability to capture the gains from using a given resource and/or transferring those usage rights (Libecap 1990). Put differently, clearly defined property rights allow people to develop expectations about the potential benefits they can derive from exploiting an asset (Demsetz 1967).

The transition towards a bio-based economy is contingent upon accounting for the intricate interdependencies among the various actors involved and effective governance. Comprehensively understanding the potential contribution of each stakeholder to the overall value creation process is equally crucial as the subsequent task of value distribution and appropriation. As Pfau et al. (2014) note, 'knowledge and insights from all related disciplines and stakeholders should be taken into account and translated into new research questions and policy interventions' and one should approach 'the bioeconomy systematically and in interdisciplinary or trans-disciplinary settings'. A comprehensive perspective is thus needed for the governance of bioeconomy initiatives.

The establishment of monitoring mechanisms to mitigate opportunistic behavior such as free riding is a crucial aspect of bioeconomy governance. It is also imperative to acknowledge the measurement challenges arising from the intricate interplay between economic, societal, and environmental objectives. Barzel and Allen (2023) highlight that while the State may assign and partially enforce legal property rights, the appropriation of a resource's value hinges on an individual's perception of their ability to deploy said resource. It is essential to recognize that although such rights can be guaranteed by the state or through private means (Williamson 2000), accurate measurement of value creation and value capture may not be straightforward. Governance costs encompass not only coordination but also measurement facets. Governance is expected to unfold in a manner that organizational solutions address both the costs associated with organizing and the benefits derived from minimizing value dissipation from measurement (Barzel 2005).

The successful transition towards a bio-based economic paradigm, whether implemented at a local or national level, necessitates a comprehensive delineation of the underlying governance mechanisms. While the reliance on informal institutional frameworks, legal systems, or tacit and contractual arrangements will be highly contextual in nature (Brinks 2019), the allocation of property rights and decision rights should always assume a pivotal role, as it constitutes a necessary precondition for the emergence of novel bioeconomy initiatives. Establishing robust arbitration mechanisms to resolve disputes, addressing measurement challenges, and clearly defining responsibilities are critical imperatives. Given the multifaceted nature of the bioeconomy, which encompasses a diverse array of stakeholders ranging from local communities to multinational enterprises engaged in the processing of bio-based inputs, the effective governance of all interests involved is the only way to incentivize and catalyze bioeconomy initiatives.

Here our conceptual study underscores the pivotal role of governance from both macro and micro perspectives, emphasizing that bioeconomy initiatives are often characterized by considerably higher governance costs compared to more traditional

non-bio-based arrangements. This is attributable to the collective nature of coordinating a multitude of stakeholders and their oftentimes highly divergent interests (Waßenhoven et al. 2021). The constraint in implementing bioeconomy strategies more broadly frequently hinges on the lack of a systematic understanding of the inherent governance costs involved (Banerjee et al. 2024). Human behavior is not solely motivated by economic logic, but a comprehensive understanding of all incentives and addressing all potential future challenges may unlock of new bio-based opportunities and enable a paradigm shift in the prevalence of more traditional systems.

The emergence of bioeconomy endeavors demands the implementation of an organizational framework that effectively balances the protection of investments and the facilitation of returns derived from new business opportunities. The collaborative nature intrinsic to bio-based initiatives amplifies risks, thereby prompting the creation of proper governance. Hence, for a transition towards bio-based practices to be warranted, the benefits must decisively offset the governance costs linked to resource exchange and the establishment of coordination mechanisms.

The bioeconomy literature has significant gaps of contributions from the social sciences (Sanz-Hernández et al. 2019), accompanied by a lack of studies specifically addressing the multidimensional facets of governance. Recent scientific work has predominantly adopted either a policy-oriented lens (Gould et al. 2023), scrutinized overarching, global trajectories for national strategies (Dietz et al. 2018, 2023), concentrated on stakeholder perceptions (Dieken et al. 2021), or the inherent politics and political processes (Böcher et al. 2020). Our study, in turn, brings into sharp focus the protagonism of governance, encompassing both a macro perspective on the institutional conditions of a given location and a micro-level view of the coordination mechanisms governing stakeholder interactions.

5.3 | Implications for Practice

Our framework can serve as a guiding compass for practitioners and policymakers as they examine a set of governance choices. More specifically, it can furnish a means through which governance failures and/or constraints can be mitigated. Anchored in the conceptual foundation of Williamson (1985, 2000), the framework presented in this study embraces a more relative/comparative perspective, wherein organizational solutions should be scrutinized in their different relative terms benefits and challenges in governing a given bioeconomy strategy. Little attention has been paid to how governance issues have impeded this bioeconomy-oriented transition. From a policy standpoint, this framework can accentuate the specific gaps that necessitate further actions, either in terms of crafting new rules (e.g., laws) or providing additional incentives to further influence the governance of bioeconomy strategies. We hope that our conceptual study equips stakeholders with the requisite tools to compare the governance costs and benefits of different organizational solutions.

Sustainable bio-based future hinges upon the clear identification of the myriad governance challenges that hinder bioeconomy strategies. Drawing upon the fundamental organizational features of economic transactions, we present a conceptual framework that dissects the governance elements that may arise in the design of a bioeconomy initiative. Aiming to bridge the knowledge gap surrounding the governance of bio-based transitions, we posit that all four levels of governance—informal institutions, formal institutions, coordination mechanisms, and resource allocation—are equally pertinent, albeit their relative importance may vary contingent upon the context in which the sustainable bio-based transition unfolds.

Acknowledgments

The author would like to thank the editor and three anonymous reviewers for their insightful comments and suggestions.

Funding

This study received financial support from Instituto Pensi - Fundação José Luiz Setúbal.

Conflicts of Interest

The author declares no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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