

Green Finance, Decarbonisation, And Industrial Performance: A Comparative Analytical Study of Sustainable Transition Pathways in Maritime Shipping and The Indian Cement Industry

Daniela Kovacs

School of Sustainable Business and Finance, Corvinus University of Budapest, Hungary

Amelia Hartwell

School of Business, Climate and Infrastructure Studies, University of Southampton, United Kingdom

Received: 08 February 2026; **Accepted:** 04 March 2026; **Published:** 01 April 2026

Abstract: This study examines the relationship between green finance, industrial performance, and decarbonisation strategy through a comparative analysis of two highly emissions-intensive yet structurally distinct sectors: maritime shipping and the Indian cement industry. The article is motivated by a central policy and managerial problem: while both sectors are indispensable to global trade, infrastructure development, and economic growth, both also face mounting pressure to reduce greenhouse gas emissions and improve long-term sustainability without undermining commercial viability. Existing scholarship on shipping has extensively discussed alternative fuels, energy efficiency, regulatory frameworks, and emerging green finance mechanisms, whereas studies on Indian cement have largely focused on profitability, operational performance, and firm-level financial comparison. However, the literature rarely brings these two sectors into the same analytical frame. This article addresses that gap by developing a comparative interpretive synthesis that connects industrial economics, sustainability transition theory, and financial innovation.

The study uses a qualitative, text-based methodology grounded in integrative review and comparative thematic analysis. The selected references are examined to identify recurring themes related to sectoral structure, emissions intensity, financial constraints, transition incentives, regulatory drivers, and strategic adaptation. The findings suggest that maritime shipping has advanced more visibly in developing a sustainability finance vocabulary, supported by international governance, voluntary frameworks, and lender-side innovation, even though implementation remains uneven and decarbonisation pathways remain technologically uncertain. By contrast, the Indian cement industry literature reflects stronger attention to profitability and operational performance than to structured green transition finance, indicating a relative gap between industrial necessity and financial modernization. The article argues that both sectors require a transition model that combines regulatory pressure, credible performance disclosure, investment discipline, and sector-specific technological realism. It also finds that sustainable transformation is not only a technical or environmental challenge, but a financial and institutional coordination challenge.

The study concludes that green transition success depends on aligning capital allocation with measurable decarbonisation outcomes while preserving industrial resilience. It further proposes that insights from sustainable ship finance may offer a useful conceptual template for future green financing approaches in heavy manufacturing sectors such as cement, particularly in emerging economies.

Keywords: Green finance, maritime shipping, Indian cement industry, decarbonisation, sustainable transition,

industrial performance, climate policy.

Introduction: The twenty-first century industrial economy is being redefined by a tension that has become impossible to ignore. On one side stands the long-established logic of production expansion, global trade integration, cost efficiency, and capital accumulation. On the other stands the accelerating imperative of environmental sustainability, especially the need to decarbonise sectors that are foundational to development but deeply embedded in fossil-fuel-intensive systems. Among such sectors, maritime shipping and cement production occupy a particularly important place. Shipping is indispensable to the circulation of global commerce, and cement is indispensable to the material basis of urbanisation, infrastructure, and construction. Both sectors are therefore simultaneously essential and problematic: essential because modern economies cannot function without them, and problematic because their current technological and financial configurations complicate efforts to align them with climate objectives (Balcombe et al., 2019; Bach & Hansen, 2023; Adlakha, 2021).

Maritime shipping carries the overwhelming share of world trade by volume and serves as the circulatory system of the global economy. Yet its dependence on carbon-intensive fuels and the operational longevity of vessels make rapid transformation difficult. The Fourth IMO Greenhouse Gas Study highlighted shipping's substantial contribution to global emissions and emphasized that, without meaningful intervention, those emissions could remain inconsistent with broader climate targets (IMO, 2020). Subsequent policy discussion has increasingly stressed that incremental energy efficiency will not be sufficient unless accompanied by deeper structural changes in fuel choice, vessel design, financing frameworks, and governance approaches (IMO, 2022; Romano & Yang, 2021). At the same time, the shipping sector is unusually international in character. Its assets move across jurisdictions, its regulatory structure depends heavily on multilateral coordination, and its financing arrangements often involve cross-border banking, leasing, and private capital. These characteristics make shipping a revealing case for examining how financial innovation intersects with environmental transition.

The cement industry presents a different but equally significant challenge. Cement is one of the most widely used industrial products in the world and a core input in development. In emerging economies, including India, cement demand is strongly linked to population growth, public works, housing, and industrial expansion. Studies of Indian cement companies have

traditionally focused on profitability, productivity, comparative performance, and sectoral growth prospects (Dr. P. Krishna Kumar, 2013; Balakrishna, 2015; S, 2017; Adlakha, 2021; Yadav, 2027). These studies show that cement is economically important and strategically resilient, but they also suggest that performance pressures, capital requirements, and market competition shape firm decision-making in powerful ways. What is less developed in this body of work is a systematic treatment of how decarbonisation finance might reshape the sector. Cement production is energy intensive and carbon intensive not only because of fuel consumption but also because of process emissions tied to clinker production. For this reason, the industry occupies a central place in debates on industrial decarbonisation. Yet the literature provided here indicates a relative imbalance: operational and financial performance have received notable attention, while the institutional design of green transition finance for cement remains less articulated than in shipping.

This contrast creates an important intellectual opportunity. The shipping literature has evolved toward a complex discussion of sustainability, green corridors, alternative fuels, disclosure frameworks, and lender responsibility (ABS, 2022; Bhat & Mitchell, 2021; Poseidon Principles, 2023; Pangalos, 2023). The cement literature, by comparison, offers insight into firm-level performance, financial analysis, and industry growth in India, but less explicit engagement with transition finance architecture. Bringing these two literatures together allows for a broader inquiry into how carbon-intensive sectors manage the intersection of profitability, policy pressure, and sustainability transformation. Such a comparison is not intended to erase sectoral differences. Shipping and cement differ sharply in supply chain structure, regulatory reach, and technological pathways. But precisely because they differ, comparing them may help identify what is sector-specific and what is generic in the political economy of green transition.

The broader theoretical significance of this inquiry lies in the relationship between finance and sustainability. Financial innovation has increasingly been framed as an enabling mechanism for sustainable economic transformation. Alonso and Marqués (2019) argue that financial innovation can support a sustainable economy when capital is directed toward long-term environmental goals rather than short-term extraction. In shipping, this logic has taken concrete institutional form through new lending principles, sustainability-linked instruments, and emerging expectations that

financiers should assess climate alignment in their portfolios (Rebelo, 2020; Bhat & Mitchell, 2021; Poseidon Principles, 2023). Yet there is an unresolved question about whether finance is genuinely driving decarbonisation or merely adapting rhetorically to environmental expectations while preserving traditional risk-return priorities. Schinas and Bergmann (2021) show that greening the global fleet has real short-term costs, which means financial markets cannot be expected to act as neutral or purely benevolent agents of transformation. Instead, they respond to incentives, regulations, risk perceptions, and competitive pressures. That insight is equally relevant for heavy manufacturing sectors such as cement.

A second theoretical issue concerns the difference between technical feasibility and transition feasibility. Much of the decarbonisation literature asks whether cleaner technologies exist or can be developed. But the more demanding question is whether these technologies can be financed, deployed, governed, and scaled under real-world industrial conditions. Balcombe et al. (2019) survey multiple options for decarbonising shipping and demonstrate that several pathways are technically imaginable, yet each comes with trade-offs involving cost, infrastructure, safety, and policy coordination. Similarly, Romano and Yang (2021) show that shipping decarbonisation is not blocked by a simple lack of alternatives, but by the difficulty of aligning technology, economics, and institutional action. The same principle applies to cement. Even where lower-carbon pathways are known conceptually, investment barriers, competitive pressures, legacy assets, and uncertain demand conditions can slow adoption. Therefore, the central question is not merely what should be done environmentally, but how decarbonisation can become financially and institutionally actionable.

A third conceptual dimension is the role of governance. Shipping is shaped by the International Maritime Organization, by classification societies, by private governance arrangements such as the Poseidon Principles, and by the decisions of banks, charterers, shipowners, and insurers (IMO, 2022; Poseidon Principles, 2023; ABS, 2022). This layered governance structure generates a rich field for examining how public and private norms interact. Bach and Hansen (2023) argue that the IMO is not yet on track for adequate decarbonisation, highlighting the limits of existing regulatory ambition. Lloyd's List (2023) further notes that future success depends on adopting a well-to-wake perspective rather than focusing narrowly on operational emissions. These debates reveal how governance standards can shape the meaning of

sustainability itself. In contrast, the Indian cement literature in the provided references is more grounded in company performance and industrial progress than in transnational environmental governance. This difference matters because it suggests that sustainability transition may advance faster in sectors where governance language has matured, even if implementation remains incomplete.

The present article is therefore guided by the following problem statement: how can green finance and industrial performance be understood together in carbon-intensive sectors, and what does a comparison between maritime shipping and the Indian cement industry reveal about the opportunities and constraints of sustainable transition? This problem has practical as well as scholarly importance. Policymakers need to know whether sectoral decarbonisation can be accelerated by better financial instruments. Lenders and investors need to understand how environmental commitments can be linked credibly to industrial realities. Managers in emissions-intensive sectors need frameworks that do not reduce sustainability to abstract compliance rhetoric. Scholars, meanwhile, need comparative models that move beyond sectoral silos and examine how different industries experience the same climate imperative through different institutional pathways.

The literature gap addressed by this study is thus threefold. First, there is a comparative gap: the provided references do not themselves integrate shipping and cement into a shared analytical conversation. Second, there is a finance gap: while shipping scholarship increasingly discusses green finance explicitly, the cement studies cited here emphasize financial performance without an equally developed green finance lens. Third, there is a transition gap: existing work tends to focus either on technological/policy decarbonisation or on corporate financial performance, but less often on the institutional bridge between them. This article seeks to build that bridge conceptually.

The core argument advanced here is that sustainable transition in carbon-intensive sectors depends not simply on technological possibility or regulatory declaration, but on the creation of a credible alignment between environmental goals, financial incentives, and sector-specific performance logics. Shipping has moved further in formalizing that alignment, although not yet in fully solving it. The Indian cement industry, as reflected in the selected literature, illustrates the continuing dominance of conventional performance assessment and the need for more explicit integration of sustainability finance. The comparative lesson is that decarbonisation succeeds when finance becomes not

an afterthought but a structured mechanism of industrial transformation.

To develop this argument, the article proceeds through a qualitative comparative synthesis. The methodology explains how the references were interpreted and coded. The results then identify thematic findings regarding sectoral structure, emissions challenges, financial innovation, regulatory pressure, and performance imperatives. The discussion explores the implications of these findings, evaluates limitations, and reflects on future research directions. The conclusion synthesizes the comparative insights and argues for a more integrated model of green industrial finance.

METHODOLOGY

This article adopts a qualitative, text-based research design grounded in integrative literature review and comparative thematic analysis. The chosen method is appropriate because the objective is not to generate new statistical evidence or test a causal model through numerical datasets, but to build an interpretive, publication-ready synthesis from the references provided. The references themselves span multiple document types, including journal articles, institutional reports, a master's thesis, sectoral commentary, and industry disclosures. They also cover two distinct but strategically comparable sectors: maritime shipping and the Indian cement industry. Because of this diversity, a purely quantitative meta-analysis would neither be feasible nor suitable. Instead, the study uses a structured interpretive approach to identify converging themes, conceptual tensions, and comparative insights.

The methodology begins from the premise that literature is not merely a collection of individual studies but a field of discourse. Each reference contributes not only data or isolated conclusions, but also a way of framing the underlying problem. Some references are diagnostic, identifying the scale and urgency of emissions challenges in shipping (IMO, 2020; Faber & Lee, 2020; ICCT, 2024). Others are strategic, discussing options for decarbonisation through fuels, technologies, and policy mechanisms (Balcombe et al., 2019; Romano & Yang, 2021; ABS, 2022). Still others are financial or institutional, focusing on green lending, alternative financing, sustainability-linked capital, and market restructuring (Alonso & Marqués, 2019; Ioannidis, 2021; Bhat & Mitchell, 2021; Pangalos, 2023; Poseidon Principles, 2023). In the cement literature, the framing is more strongly tied to firm performance, industry progress, profitability, and comparative financial analysis (Dr. P. Krishna Kumar, 2013; Balakrishna, 2015; S, 2017; Adlakha, 2021; Yadav,

2027). The methodology therefore treats the literature not as uniform evidence, but as a set of analytical voices whose emphases reveal what each sector has prioritized and what it has neglected.

The first step of the analysis involved categorizing the references into thematic clusters. The maritime shipping references were grouped into five broad clusters. The first cluster addressed emissions scale, climate urgency, and regulatory context. This cluster included the IMO reports, the IEA data, ICCT sectoral overview, and the UNEP-linked discussion by Faber and Lee (2020). The second cluster addressed technological and operational decarbonisation pathways, including alternative fuels, energy efficiency, and system-wide transition strategies (Balcombe et al., 2019; Romano & Yang, 2021; ABS, 2022; Lloyd's List, 2023; Piccolo, 2023). The third cluster addressed finance and financial innovation, including sustainable lending, alternative shipping finance, green guarantees, and universal frameworks for green shipping finance (Alonso & Marqués, 2019; Bank, 2016; Ioannidis, 2021; Rebelo, 2020; Bhat & Mitchell, 2021; Pangalos, 2023). The fourth cluster addressed cost, market structure, and transition tension, including the short-term cost of greening and the complex adaptive nature of shipping markets (Caschili & Meda, 2012; Schinas & Bergmann, 2021). The fifth cluster addressed market uncertainty and sectoral financial shifts, including COVID-19 disruptions and lender retrenchment (Shipping Law News, 2020; Papachristou, 2023).

The cement references were grouped into three main clusters. The first cluster examined sectoral growth, historical progress, and structural importance in India (Dr. P. Krishna Kumar, 2013; Balakrishna, 2015). The second cluster focused on firm-level financial performance, comparative profitability, and operational evaluation (S, 2017; Adlakha, 2021; Yadav, 2027). The third cluster was interpretively linked to sustainability transition not because the individual studies explicitly foreground green finance, but because cement's emissions intensity makes it impossible to discuss its long-term viability without considering the pressures of decarbonisation. In other words, the methodology reads the financial performance literature not in isolation, but as a baseline against which the absence of explicit sustainability finance discussion becomes analytically meaningful.

The second step involved comparative coding. Each reference was read in relation to five analytical questions. First, how does the source conceptualize the sector's core challenge? Second, what role does finance play in responding to that challenge? Third, how are environmental pressures framed: as

regulatory obligations, market opportunities, reputational issues, or existential risks? Fourth, what temporal logic governs the analysis: short-term profitability, medium-term competitiveness, or long-term transition? Fifth, what institutional mechanisms are presented as necessary for change? These questions made it possible to compare unlike sectors at the level of underlying governance and performance logic rather than only at the level of specific technologies.

The comparative nature of the study required careful attention to asymmetry. Shipping and cement cannot be compared as though they were identical. Shipping is a service sector tied to asset mobility, freight demand, fuel choice, international regulation, and chartering relationships. Cement is a manufacturing sector tied to raw materials, plant operations, domestic and regional demand, and industrial production structures. Therefore, the methodology does not compare them on a single metric such as emissions intensity or profitability ratio. Instead, it compares them on a broader conceptual terrain: how carbon-intensive sectors understand and finance transition. This helps avoid false equivalence while still enabling meaningful synthesis.

The interpretive framework also draws on three conceptual ideas that structure the analysis, though not as formal theories tested in a deductive way. The first is sustainability transition as a coordination problem. This view sees decarbonisation as dependent on the alignment of technology, policy, market incentives, and organizational behavior. The second is financial intermediation as a governance mechanism. This means that lenders, investors, and financial frameworks do not merely respond to industrial change; they can shape its pace and direction by altering access to capital, defining acceptable risk, and rewarding certain performance metrics. The third is sectoral path dependence. Both shipping and cement rely on long-lived assets and historically entrenched operating models. This means that transition is constrained by sunk costs, institutional habits, and uncertainty about alternative pathways.

Within this interpretive structure, the results are not treated as statistically generalizable in the conventional sense. Rather, they are analytically generalizable: they offer conceptual insights that may illuminate other carbon-intensive sectors as well. The goal is to produce a coherent and rigorous argument from the literature, not to claim that the selected references exhaust all possible knowledge on the topic. This distinction is important because the article is intentionally bounded by the source list provided. The analysis remains faithful to those sources and does not introduce

external literature beyond them.

A further methodological strength of this design lies in its ability to capture silence as well as presence. In comparative work, what a literature does not discuss can be as revealing as what it does. The extensive attention to green finance mechanisms in shipping and the relative absence of equivalent discussion in the cement studies is not treated here as a deficiency of scholarship alone, but as evidence of uneven transition discourse across sectors. This asymmetry becomes part of the findings. It suggests that some industries have developed a more explicit vocabulary for linking capital and climate, while others remain more firmly located within traditional performance analysis. Such differences matter because discourse influences institutional action. A sector that can name and standardize sustainable finance tools may be better positioned to attract targeted transition capital than one that cannot.

The methodology also acknowledges the heterogeneity of source types. Institutional reports such as those of the IMO, IEA, ICCT, and ABS provide broad sectoral framing and policy-relevant synthesis. Journal articles supply analytical depth and scholarly positioning. Industry commentaries and annual disclosures reflect market sentiment and practical implementation challenges. A master's thesis and financial journalism contribute contextual evidence on alternative finance and lender behavior. Rather than ranking these sources hierarchically in a narrow way, the study evaluates them according to their contribution to thematic understanding. This approach is justified because the article addresses an applied, interdisciplinary problem that spans policy, finance, and industrial practice.

Finally, the methodological limitations are recognized from the outset. The analysis depends on the available reference set and therefore cannot claim comprehensive sectoral coverage. The cement literature provided is narrower than the shipping literature in both thematic scope and environmental framing. This creates an imbalance, though it is also part of what the article aims to interpret. The study is also qualitative and synthetic, which means it cannot establish measured causal effects between green finance and emissions reduction. It can, however, show how the literature conceptualizes those relationships and where sectoral thinking appears more or less developed. In that sense, the methodology is appropriate to the article's purpose: to generate a complete, original, and publication-ready conceptual research article from the selected references.

RESULTS

The analysis produced several major findings. These

findings do not emerge as numerical outputs but as structured thematic patterns across the literature. Together they show that maritime shipping and the Indian cement industry are both confronting sustainability pressures, but they are doing so through markedly different discursive, financial, and institutional frameworks. The comparison reveals that decarbonisation is shaped not only by emissions profiles or technological options, but also by how a sector organizes its understanding of finance, risk, and strategic adaptation.

The first major finding is that maritime shipping has developed a much more explicit and institutionally mature discourse of green transition than the Indian cement industry literature represented in the reference set. In the shipping literature, sustainability is central rather than peripheral. The sector is discussed in terms of climate alignment, fuel transformation, energy efficiency, global regulation, emissions accounting, and transition finance (IMO, 2020; Balcombe et al., 2019; Romano & Yang, 2021; ICCT, 2024). Even where there is disagreement about pace or sufficiency, the decarbonisation frame itself is firmly established. Bach and Hansen (2023) criticize the IMO's course as insufficient for effective decarbonisation, which indicates not the absence of a climate agenda but a contest over its adequacy. Similarly, Piccolo (2023) discusses persistent challenges in reducing GHG emissions from shipping, reinforcing that the sector's problem is now defined through environmental transition. This contrasts sharply with the cement literature cited here, where the dominant language concerns comparative performance, profitability, industry progress, and business prospects (Dr. P. Krishna Kumar, 2013; Balakrishna, 2015; S, 2017; Adlakha, 2021; Yadav, 2027). The environmental dimension is structurally relevant but not comparably foregrounded in the source set.

This difference matters because sectors act through the categories by which they understand themselves. A sector with a strong decarbonisation discourse is more likely to generate specialized instruments, performance benchmarks, and policy coalitions around sustainability. Shipping has done precisely this. References to green shipping corridors, sustainable ship loans, well-to-wake accounting, and annual climate disclosure all indicate a field in which sustainability has become institutionally legible (ABS, 2022; Bhat & Mitchell, 2021; Lloyd's List, 2023; Poseidon Principles, 2023). In the cement studies, performance remains legible primarily through financial and operational indicators. This does not imply that cement is environmentally unconcerned in practice, only that within the provided literature the

language of transition finance is less developed. The finding suggests a discursive imbalance with practical implications: sectors with weaker sustainability-finance vocabularies may struggle to mobilize capital for transition at the same speed as sectors where such vocabularies are already standardized.

The second major finding is that finance in maritime shipping is increasingly treated not simply as a source of capital, but as a lever of environmental governance. This is one of the most significant patterns in the literature. Alonso and Marqués (2019) present financial innovation as a possible contributor to sustainability at the macroeconomic level. In shipping, this general proposition becomes concrete. Rebelo (2020) argues for the development of a universal vernacular for green shipping, suggesting that the sector requires a shared language through which financiers, shipowners, regulators, and other stakeholders can coordinate sustainable investment. Bhat and Mitchell (2021) describe sustainable ship loans as an emerging practice, while the Poseidon Principles (2023) annual disclosure report shows how lenders are being drawn into portfolio-level climate alignment. The European Investment Bank's green shipping guarantee programme further illustrates the use of public financial institutions to de-risk sustainable maritime investment (Bank, 2016). Together, these sources demonstrate that shipping finance is no longer only about vessel acquisition and freight market cycles. It is becoming a domain where climate performance, reputational standards, and capital access increasingly intersect.

This development is reinforced by the literature on alternative shipping finance. Ioannidis (2021) explores private equity as an alternative source of financing, indicating that traditional banking is not the sole channel through which shipping assets are funded. Pangalos (2023) extends the discussion by connecting financial innovation directly to sustainable dry bulk shipping and alternative energy. Such sources show that the sector is searching for financing configurations capable of supporting both competitiveness and environmental transition. Importantly, however, the literature does not romanticize this process. It acknowledges constraints, market retreat, and uncertainty. Papachristou (2023) describes market questions raised by HSBC's retreat from Greece, and Shipping Law News (2020) highlights the disruptions introduced by COVID-19. These developments show that finance can enable transition, but it can also contract under stress. Green finance, therefore, is not a guaranteed solution; it is a contested and market-dependent mechanism.

The third major finding is that decarbonisation in

shipping remains technologically plural but institutionally unsettled. Balcombe et al. (2019) demonstrate that multiple fuels, technologies, and policy options exist for decarbonising international shipping. Romano and Yang (2021) similarly provide a state-of-the-art survey of the decarbonisation field from 2000 to 2020, showing that no single pathway has emerged as universally dominant. The ABS report on green shipping corridors emphasizes synergies, suggesting that spatially concentrated pilot efforts may help overcome coordination barriers (ABS, 2022). Meanwhile, Lloyd's List (2023) stresses the importance of a well-to-wake approach, signaling that the sector is moving beyond narrow operational efficiency toward a fuller accounting of lifecycle emissions. These studies indicate that the problem is not a total absence of technological imagination. Rather, the problem lies in uncertainty about which combinations of fuel, infrastructure, regulation, and finance can be scaled at acceptable cost and risk.

This finding is crucial because it explains why finance has become so central. When technology pathways are unsettled, capital providers must evaluate long-lived investments under conditions of unusually high uncertainty. A ship financed today may still be operating decades later. If fuel systems, carbon rules, or customer expectations change dramatically during that period, investment risk rises. This helps explain why frameworks such as the Poseidon Principles matter: they provide a language of climate alignment in an environment where technological certainty is limited. However, Schinas and Bergmann (2021) remind us that greening the global fleet imposes short-term costs. Therefore, even as finance is being mobilized for sustainability, the economic burden of transition remains substantial. Shipping's challenge is not merely to find greener technology, but to construct a credible intertemporal bargain between present cost and future viability.

The fourth major finding is that the shipping sector's transition challenge is intensified by its character as a complex adaptive system. Caschili and Meda (2012) describe the maritime container shipping industry as a complex adaptive system, a formulation that helps explain why policy or financial interventions may produce uneven and sometimes unintended outcomes. Complex adaptive systems are marked by interdependence, feedback loops, nonlinearity, and the co-evolution of actors. In shipping, freight markets, port systems, fuel suppliers, lenders, regulators, charterers, and shipowners all affect one another. This means that decarbonisation cannot be managed through isolated technological upgrades alone. If cleaner fuels are unavailable at scale, if ports are not

prepared, if lenders price risk inconsistently, or if freight markets reward short-term cost minimization, the system resists change. The relevance of this finding extends beyond shipping because heavy industrial sectors more broadly often exhibit forms of path dependence and systemic interdependence. The lesson is that transition strategies must be systemic rather than fragmentary.

The fifth major finding concerns the contrast between transition discourse and performance discourse. In the Indian cement literature, the core analytical emphasis is on performance evaluation. Dr. P. Krishna Kumar (2013) studies the progress of the Indian cement industry, highlighting sectoral development and industrial significance. Balakrishna (2015) analyzes problems and prospects, suggesting an industry shaped by both growth opportunity and operational difficulty. S (2017), Adlakha (2021), and Yadav (2027) focus on comparative financial performance and profitability. These studies collectively show that the cement industry has been examined through lenses of efficiency, financial health, strategic prospects, and corporate comparison. The results indicate that such analyses are valuable for understanding the industry's economic functioning, but they do not develop a parallel green finance architecture comparable to what is now visible in shipping.

The absence of explicit sustainability finance discussion in this reference set should not be misread as evidence that cement does not face decarbonisation pressure. Rather, it suggests that the literature provided still reflects an earlier or narrower stage of analytical development in which financial performance is treated largely within conventional industrial terms. This is itself a finding. It implies that some carbon-intensive sectors may remain locked in performance discourses that are insufficiently integrated with environmental transformation. If profitability is measured without systematic reference to transition cost, carbon exposure, or climate-aligned capital access, firms may appear financially robust while remaining strategically vulnerable in the longer term. The literature on Indian cement thus reveals not only what has been studied, but also what remains to be more fully conceptualized.

The sixth major finding is that profitability and sustainability should not be treated as inherently opposed, but the literature suggests that their alignment is institutionally contingent rather than automatic. In shipping, the language of sustainable finance attempts to reconcile environmental goals with commercial logic. Sustainable ship loans, climate disclosures, and green guarantees all presume that environmental performance can be linked to financial discipline (Bank, 2016; Bhat & Mitchell, 2021; Poseidon

Principles, 2023). Yet the literature also shows that this linkage requires standards, monitoring, and credible incentives. Without them, sustainability rhetoric may remain superficial. Schinas and Bergmann (2021) show that the costs of greening are real in the short term, which means environmental improvement does not automatically translate into immediate profitability. The same tension can be inferred for cement. A sector long evaluated through profitability metrics may not easily absorb decarbonisation investments unless finance, regulation, and market expectations are reconfigured to reward long-term resilience rather than only short-term returns.

The seventh major finding is that international governance plays a stronger catalytic role in shipping than is visible in the cement literature provided. Shipping's decarbonisation debate is embedded in global governance structures. The IMO defines key efficiency and emissions frameworks, even if those frameworks are criticized as insufficient (IMO, 2022; Bach & Hansen, 2023). The IEA, UNEP-linked analysis, ICCT, and international industry bodies all contribute to a transnational policy conversation (Faber & Lee, 2020; ICCT, 2024). This creates an ecosystem in which environmental performance is publicly discussed, benchmarked, and gradually codified. By contrast, the Indian cement studies are primarily sectoral and national in focus. They provide valuable insight into domestic industrial performance but less visible engagement with climate governance architecture. This difference suggests that internationalized sectors may experience stronger external pressure to develop sustainability metrics and finance frameworks, while domestically oriented sectors may rely more heavily on local policy and market incentives.

An eighth finding emerges from the relationship between crisis and transition. Shipping finance was visibly affected by COVID-19, as shown by Shipping Law News (2020). Market retrenchment and lender repositioning, as discussed by Papachristou (2023), further reveal the fragility of capital availability. This suggests that green transition does not occur in a stable vacuum. It unfolds amid crises, credit shifts, and macroeconomic disruptions. In such conditions, sustainability commitments can be weakened, delayed, or selectively applied. Yet crisis can also accelerate change by exposing vulnerabilities in legacy models. If conventional financing becomes less reliable, sectors may become more open to innovative instruments. This dynamic may be relevant to cement as well, though the provided literature does not discuss it explicitly. Industries under pressure often reconsider capital structure, operational priorities, and strategic direction. Therefore, transition pathways are

historically contingent and responsive to external shocks.

The ninth major finding is that measurement itself is political and strategic. The movement toward well-to-wake accounting in shipping, emphasized by Lloyd's List (2023), shows that how emissions are measured affects which actors bear responsibility and which technologies appear credible. A narrower accounting framework may overstate the sustainability of certain options, while a broader one may reveal hidden upstream emissions. Similarly, annual climate disclosure in the Poseidon Principles framework institutionalizes portfolio-level measurement as a form of accountability (Poseidon Principles, 2023). These developments indicate that metrics are not neutral technical devices; they organize incentives and shape investment behavior. The relative absence of parallel metrics in the cement references implies a less developed linkage between financial evaluation and environmental disclosure, at least within the selected source set. This is an important result because transition depends not only on ambition but also on what is visible and countable within investment decision-making.

The final major finding is comparative and synthetic: maritime shipping appears further along in the institutionalization of green transition finance, while the Indian cement industry literature remains more strongly situated in conventional performance analysis. This does not mean that shipping is more sustainable in practice. Indeed, the shipping literature repeatedly underscores the insufficiency of current action, the uncertainty of fuel pathways, and the high cost of greening (Bach & Hansen, 2023; Schinas & Bergmann, 2021; Piccolo, 2023). But shipping has at least built a recognizable architecture of transition discourse involving regulation, disclosure, green lending, and financial experimentation. The cement literature, as represented here, reveals a sector still mainly described through profitability and industrial progress. The comparative implication is that institutionalized green finance discourse may be a precursor to more coordinated transition action, even where implementation remains incomplete.

DISCUSSION

The findings of this study invite a broader reflection on what sustainable industrial transition actually requires. One of the most important conclusions emerging from the comparison is that decarbonisation is not merely a technical challenge and not merely a regulatory challenge. It is a challenge of institutional alignment. Technology matters because sectors need feasible low-carbon pathways. Regulation matters because firms

rarely transform at the required scale without policy pressure. But finance occupies a bridging position between the two. It translates future-oriented environmental goals into present-day investment choices. When finance is not aligned with decarbonisation, sustainability remains aspirational. When finance begins to reward environmental performance, penalize carbon exposure, and standardize transition expectations, decarbonisation becomes more actionable.

The shipping literature illustrates this institutional bridge in a relatively advanced form. Sustainable ship loans, green guarantees, climate-aligned disclosures, and alternative financing models represent attempts to redesign capital allocation around environmental criteria (Bank, 2016; Bhat & Mitchell, 2021; Poseidon Principles, 2023; Pangalos, 2023). These developments do not solve the transition problem by themselves. Indeed, the literature is clear that maritime decarbonisation remains behind where climate logic would demand (Bach & Hansen, 2023; Piccolo, 2023). Yet what makes shipping analytically important is that the sector has begun to formalize sustainability in financial language. That matters because capital is one of the few mechanisms capable of affecting fleet renewal, fuel adoption, retrofitting, and technology experimentation at scale. Regulation without financing pathways can become symbolic. Technology without financing can remain marginal. The shipping case demonstrates that sectors need institutions that connect environmental ambition to capital discipline.

At the same time, the comparison reveals a paradox. Shipping has a stronger sustainability-finance architecture than the cement literature represented here, but it also remains trapped in high uncertainty. This suggests that the existence of green finance discourse is necessary but not sufficient. A sector may build impressive frameworks, annual disclosures, and voluntary principles while still struggling to decarbonise materially. One reason is that finance responds not only to environmental priorities but also to uncertainty, volatility, and expected return. When fuel pathways are unsettled, as Balcombe et al. (2019) and Romano and Yang (2021) make clear, investors and lenders face a difficult problem. They must back assets whose technological relevance may change, whose regulation may tighten, and whose operating economics are not stable. In such situations, financial innovation can soften risk but cannot eliminate it. This is why green finance should not be treated as a magic instrument. It is best understood as a governance technology for managing transition under uncertainty.

The Indian cement literature contributes a different but complementary lesson. By centering profitability,

comparative performance, and industry growth, it reminds us that sectors do not operate under abstract environmental ideals alone. Firms face immediate constraints: market competition, input cost pressures, capital commitments, and shareholder expectations. Studies by S (2017), Adlakha (2021), and Yadav (2027) show that financial performance remains a core metric of sectoral assessment. This focus is not inappropriate. In fact, transition strategies that ignore firm viability are unlikely to succeed. However, the comparative analysis suggests that a performance-only framework is increasingly inadequate for emissions-intensive industries. If financial analysis is disconnected from climate exposure, carbon cost, or transition readiness, it may misrepresent long-term risk. A profitable firm under current rules may become vulnerable under stricter environmental policy or shifting investor expectations. Therefore, the cement literature's emphasis on performance should not be discarded, but expanded. What is needed is not less financial analysis, but a different kind of financial analysis—one that incorporates decarbonisation as a determinant of future competitiveness.

This leads to a broader conceptual claim: sustainable transition requires the redefinition of performance itself. Traditionally, industrial performance has been measured through profitability, efficiency, market share, leverage, and growth. These indicators remain important, but for carbon-intensive sectors they no longer capture the full strategic reality. A firm that performs well today while remaining highly exposed to transition risk may not truly be performing well in a long-term sense. The shipping sector is beginning to institutionalize this redefinition through climate-aligned lending and disclosure. The cement literature provided here suggests that similar redefinition has not yet become central within the analyzed studies. If that is correct, then one of the key policy and research priorities should be to integrate environmental transition metrics into sectoral performance evaluation in heavy industry.

Another important point concerns the politics of timing. Industrial sectors often resist rapid decarbonisation not because they deny environmental pressure entirely, but because the temporal structure of costs and benefits is asymmetrical. The costs of transition are immediate, visible, and often concentrated. The benefits are longer-term, sometimes uncertain, and more diffusely distributed. Schinas and Bergmann (2021) explicitly identify the short-term cost of greening the global fleet. This insight is fundamental. It explains why voluntary action is often limited and why financial innovation becomes necessary. Sustainable finance mechanisms, in

principle, help bridge the time gap by reducing upfront burdens or linking cost to long-term environmental value. But they can only do so effectively if supported by stable standards and credible policy signals. Otherwise, actors may delay investment, hoping for regulatory leniency, technological clarity, or cheaper future options.

This temporal issue also sharpens the relevance of public institutions. The European Investment Bank's green shipping guarantee programme represents a case in which a public financial actor helps reduce transition risk (Bank, 2016). Such instruments matter because private markets alone may underinvest in decarbonisation when returns are uncertain or externalities are inadequately priced. The same logic may apply even more strongly to sectors such as cement, where transition technologies can require substantial capital and where competitive markets may punish firms that move unilaterally toward higher-cost production. Thus, the comparative analysis implies that green industrial transition likely depends on hybrid finance models involving both private discipline and public support. Pure market voluntarism is unlikely to be enough.

The discussion also highlights the importance of language and standardization. Rebelo (2020) calls for a universal vernacular for green shipping. This formulation is especially insightful because it recognizes that transition depends on more than money; it depends on shared meanings. Lenders, firms, regulators, and investors must be able to define what counts as green, what is being measured, which trajectories are credible, and how progress should be disclosed. Without this shared language, green finance risks fragmentation or superficial branding. The shipping sector has advanced this process through principles, reports, and policy-linked discourse. The apparent absence of similar vocabulary in the selected cement references points to a potential institutional weakness. Sectors that lack a common language of transition finance may find it harder to mobilize coordinated action because each actor interprets sustainability differently or treats it as secondary.

The comparison between shipping and cement also raises a question about scale and governance. Shipping is inherently international; its climate challenge is therefore visible in global governance forums. Cement, although globally significant, is often produced and consumed within national or regional markets, which can result in more fragmented policy pressure. This difference may partly explain why shipping has developed more visible transnational sustainability frameworks. However, it should not be assumed that domestic sectors are less important. On the contrary,

the national embedding of cement may make policy intervention even more decisive. Where international pressure is weaker or less direct, domestic institutions must carry greater responsibility for integrating environmental criteria into industrial policy and finance. The literature on Indian cement performance demonstrates that the sector is economically central. That centrality should be read as a reason for stronger sustainability-finance integration, not as a justification for postponing it.

The present analysis also suggests a caution against simplistic transfer of policy models from one sector to another. Shipping's green finance frameworks cannot be imported wholesale into cement. Sectoral characteristics differ too much. Vessel finance, freight charters, asset mobility, and global disclosure standards operate differently from plant-level manufacturing economics and domestic construction demand. Nevertheless, conceptual transfer is possible. The shipping sector offers a useful model of how to build a sustainability-finance conversation: define transition benchmarks, create disclosure norms, involve lenders in climate accountability, and link capital access to environmental trajectories. These are not shipping-specific ideas. They are institutional design principles that could, with adaptation, inform other carbon-intensive sectors. In that sense, the comparative analysis is productive not because it collapses sectoral differences, but because it identifies transferable forms of governance.

There are also significant limitations and counterarguments that must be acknowledged. One could argue that the difference observed between shipping and cement is partly an artifact of the reference set rather than a true difference in sectoral development. That is a valid concern. The shipping references provided are richer in environmental and financial content than the cement references. Therefore, the article cannot claim that no green finance discourse exists in cement beyond the selected studies. What it can claim is that within this reference set, such discourse is far more developed in shipping. This remains meaningful because the article is intentionally bounded by the sources supplied. Still, future research would benefit from incorporating a wider range of cement decarbonisation and sustainable finance studies to test whether the observed asymmetry persists.

A second limitation is that the analysis is interpretive rather than empirical in the narrow quantitative sense. It does not measure emissions reductions achieved by sustainable ship loans or compare returns on green versus conventional financing instruments. Nor does it quantify the decarbonisation cost curve of Indian

cement firms. Such tasks require dedicated datasets and different methods. The strength of the present study lies instead in conceptual integration. It maps how the literature frames the relationship between finance, performance, and transition. That makes it particularly useful for agenda-setting and theory-building, though less suited to causal estimation.

A third limitation concerns the uneven maturity of the policy environment. Some of the shipping references are closer to current regulatory debates and industry experimentation, while the cement studies emphasize financial comparison over a broader historical range. This creates a temporal and thematic imbalance. However, rather than invalidating the comparison, this imbalance reinforces one of the article's central insights: sectors evolve unevenly in their capacity to articulate and finance sustainability transitions. The task of comparative analysis is precisely to make such unevenness visible.

Future scope emerges clearly from these limitations. One important direction is sector-specific adaptation of green finance principles for heavy industry in emerging economies. Another is the development of integrated performance frameworks that combine profitability, resilience, and transition readiness. A third is comparative research across more sectors, including steel, aviation, and power generation, to determine whether shipping is unusually advanced in sustainability-finance institutionalization or merely one visible case of a broader trend. A fourth is closer study of public-private financing blends, particularly for hard-to-abate sectors where private capital alone may hesitate. Finally, there is scope for examining how disclosure frameworks shape actual investment behavior rather than only reputational positioning.

In interpretive terms, the deepest lesson of this study is that decarbonisation succeeds when it becomes embedded in the operational language of a sector. Shipping has not solved its climate challenge, but it has begun to institutionalize it in the domains of finance, disclosure, and governance. The Indian cement literature represented here shows that financial analysis remains robust, yet the sustainability-finance bridge is less explicit. Bridging that gap may be one of the most important next steps for industrial transition scholarship and policy.

CONCLUSION

This article set out to examine the relationship between green finance, industrial performance, and decarbonisation through a comparative analysis of maritime shipping and the Indian cement industry. Based strictly on the provided references, it has argued that the central issue is not simply whether carbon-

intensive sectors can become greener in technical terms, but whether their institutional and financial systems are capable of supporting that transition in a credible, scalable, and economically viable manner.

The study found that maritime shipping has developed a more explicit architecture of sustainable transition discourse. Emissions accounting, fuel alternatives, energy efficiency rules, green shipping corridors, lender disclosure standards, sustainable ship loans, and public guarantee mechanisms together indicate that shipping now frames decarbonisation as a central strategic problem (IMO, 2020; Balcombe et al., 2019; ABS, 2022; Poseidon Principles, 2023). Yet the literature also shows that this institutional progress has not eliminated uncertainty. Technology pathways remain contested, the short-term cost of greening remains significant, and regulatory ambition is still viewed by some scholars as inadequate (Bach & Hansen, 2023; Schinas & Bergmann, 2021; Piccolo, 2023). Shipping therefore represents a sector where finance has entered the transition conversation decisively, but where implementation remains incomplete.

By contrast, the Indian cement industry literature in the reference set is more strongly oriented toward traditional performance analysis. Studies of cement companies in India emphasize sectoral progress, problems and prospects, financial comparison, and profitability (Dr. P. Krishna Kumar, 2013; Balakrishna, 2015; S, 2017; Adlakha, 2021; Yadav, 2027). This body of work is valuable because it highlights the commercial and industrial realities that shape firm behavior. However, it leaves comparatively underdeveloped the question of how green finance and decarbonisation should be integrated into performance evaluation. The comparative lesson is not that cement is unimportant to sustainability, but that its transition-finance discourse appears less mature in the selected literature than that of shipping.

From this comparison, the article advances a broader conclusion: sustainable transformation in hard-to-abate sectors requires a redefinition of performance. Profitability, efficiency, and growth remain necessary metrics, but they are no longer sufficient on their own. In a carbon-constrained world, long-term industrial performance must also include transition readiness, capital alignment, environmental accountability, and exposure to future regulatory and market change. Finance becomes central in this context because it can either reinforce legacy carbon dependence or help accelerate strategic adaptation.

The article also concludes that green finance should be understood as a governance mechanism rather than merely a funding source. It shapes incentives, defines

risk, establishes reporting standards, and influences how sectors imagine their own future. Shipping offers a useful illustration of how such governance can evolve through public institutions, private principles, and cross-sector collaboration. While these mechanisms cannot be directly transplanted to the cement sector without adjustment, they provide important conceptual guidance. Emerging-economy heavy industry, including cement, may benefit from developing comparable frameworks that connect capital access to measurable transition pathways.

Ultimately, the sustainable future of both shipping and cement depends on institutional coordination. Technology alone will not deliver decarbonisation. Regulation alone will not guarantee investment. Finance alone will not overcome structural uncertainty. But when these elements are aligned, carbon-intensive sectors can begin to move from fragmented adaptation to purposeful transition. That is the central comparative insight of this study and the main implication for scholars, policymakers, and industry leaders working at the intersection of climate responsibility and industrial development.

REFERENCES

1. ABS. (2022). Green shipping corridors: Leveraging synergies. http://mission-innovation.net/wp-content/uploads/2022/10/ABS_Sustainability_Green-Shipping-Corridors_Leveraging-Synergies.pdf
2. Adlakha, M. M. (2021). A study on the performance of selected Indian cement companies. *International Journal of Advanced Research in Commerce, Management & Social Science*, 4(2), 123–126.
3. Alonso, A., & Marqués, J. M. (2019). Financial innovation for a sustainable economy. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3471742>
4. Bach, H., & Hansen, T. (2023). IMO off course for decarbonisation of shipping? Three challenges for stricter policy. *Marine Policy*, 147. <https://doi.org/10.1016/j.marpol.2022.105379>
5. Balakrishna, S. A. (2015). Problems and prospects of selected cement industry. *Academia and Industrial Research*, 4(4), 144–147.
6. Balcombe, P., Brierley, J., Lewis, C., Skatvedt, L., Speirs, J., Hawkes, A., & Staffell, I. (2019). How to decarbonise international shipping: Options for fuels, technologies and policies. *Energy Conversion and Management*, 182, 72–88. <https://doi.org/10.1016/j.enconman.2018.12.080>
7. Bank, E. I. (2016). Green shipping guarantee programme. European Investment Bank. <https://www.eib.org/en/projects/pipelines/all/20150334>
8. Bhat, S., & Mitchell, J. (2021). Sustainable ship loans set sail. *GreenBiz*. <https://www.greenbiz.com/article/sustainable-ship-loans-set-sail>
9. Caschili, S., & Meda, F. R. (2012). A review of the maritime container shipping industry as a complex adaptive system. *Interdisciplinary Description of Complex Systems*, 10(1), 1–15. <https://doi.org/10.7906/indecs.10.1.1>
10. Dr. P. Krishna Kumar, D. J. (2013). A study on the progress of Indian cement industry. *British Journal of Marketing Studies*, 1(1), 1–15.
11. Faber, J., & Lee, D. S. (2020). Bridging the gap: The role of international shipping and aviation. In *Emission Gap Report*. United Nations Environment Programme. <https://e-space.mmu.ac.uk/627068/>
12. ICCT. (2024). Maritime shipping. International Council on Clean Transportation. <https://theicct.org/sector/maritime-shipping/>
13. IMO. (2020). Fourth greenhouse gas study 2020. <https://www.imo.org/en/OurWork/Environment/Pages/Fourth-IMO-Greenhouse-Gas-Study-2020.aspx>
14. IMO. (2022). Improving the energy efficiency of ships. International Maritime Organization. <https://www.imo.org/en/OurWork/Environment/Pages/Improving-the-energy-efficiency-of-ships.aspx>
15. International Energy Agency. (2020). CO₂ emissions from international shipping (2010–2019) and projections for 2030. Retrieved July 5, 2024, from <https://www.iea.org/data-and-statistics/charts/co2-emissions-from-international-shipping-2010-2019-and-in-the-sustainable-development-scenario-2030>
16. Ioannidis, L. (2021). Alternative sources of shipping finance: Private equity funds (Master's thesis, International Hellenic University). <https://repository.ihu.edu.gr/xmlui/handle/11544/29897>
17. Lloyd's List. (2023). The success of IMO's new emission-reduction strategy hinges on a well-to-wake approach. <https://lloydslist.com/LL1145614/The-success-of-IMOs-new-emission-reduction-strategy-hinges-on-a-well-to-wake-approach>
18. Pangalos, G. (2023). Financing for a sustainable dry bulk shipping industry: Financial innovation and alternative energy. *Journal of Risk and Financial Management*, 16(2).

<https://doi.org/10.3390/jrfm16020101>

- 19.** Papachristou, H. (2023). HSBC's Greek retreat leaves market guessing on future path. TradeWinds.
<https://www.tradewindsnews.com/finance/hsbc-s-greek-retreat-leaves-market-guessing-on-future-path/2-1-1391174>
- 20.** Piccolo, V. (2023). GHG emissions from shipping: How to overcome persistent challenges. SSRN Electronic Journal.
<https://doi.org/10.2139/ssrn.4506467>
- 21.** Poseidon Principles. (2023). Annual disclosure report 2023. www.poseidonprinciples.org
- 22.** Rebelo, P. (2020). Green finance for a sustainable maritime transport system: Developing a universal vernacular for green shipping. Australian and New Zealand Maritime Law Journal, 34(1).
<https://openaccess.city.ac.uk/id/eprint/28815/>
- 23.** Romano, A., & Yang, Z. (2021). Decarbonisation of shipping: A state-of-the-art survey for 2000–2020. Ocean & Coastal Management, 214.
- 24.** S, S. (2017). A study on comparative financial performance of selected cement companies in India. Global Journal for Research Analysis, 6(4).
- 25.** Schinas, O., & Bergmann, N. (2021). The short-term cost of greening the global fleet. Sustainability, 13(16). <https://doi.org/10.3390/su13169439>
- 26.** Shipping Law News. (2020). Ship finance and COVID-19. Hellenic Shipping News Worldwide.
<https://www.hellenicshippingnews.com/ship-finance-and-covid-19/>
- 27.** Yadav, P. (2027). An analysis of Indian cement industry based on profitability performance. International Journal of Trade & Commerce, 6(2), 419–432.