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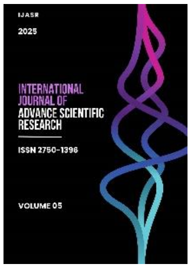

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Research Article

Transitions in Automobility: Fleet-as-a-Service, Automated Vehicles, and the Socio-Technical Infrastructure of Mobility

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Abstract

Background: The automotive sector is undergoing a multifaceted reconfiguration driven by technological innovation, institutional change, and emergent business models. This paper synthesizes socio-technical transition theory with empirical and technical literature to articulate how Fleet-as-a-Service (FaaS), automated vehicle technologies, mobility-as-a-service platforms, and serverless computing architectures collectively reshape the automobility system. The study positions recent developments within long-standing frameworks of technological regime shifts and multi-level transitions.

Objective: To produce an integrative, theoretically informed, and critically reflective account of the ongoing transformation of automobility that traces technological, organizational, and infrastructural linkages between vehicle automation, fleet management business models, and the digital architectures that enable them.

Methods: We undertake an extended conceptual and integrative literature synthesis. Anchored in multi-level perspective and transition theory, the analysis systematically relates insights from historical transition studies, contemporary reviews of automated vehicles, and technical studies on serverless computing and distributed telemetry. Each claim is situated relative to the cited literature, with special attention to mechanisms that enable or constrain transitions (technological regimes, niche innovations, landscape pressures, and digital infrastructures).

Results: The synthesis reveals five interdependent dynamics: (1) the commodification of mobility through FaaS reshapes vehicle ownership and utilization patterns (Deshpande, 2024; Aberle, 2020); (2) automated vehicle technologies serve as both niche innovations and destabilizing forces to incumbent automobile

regimes (Beza & Zefreh, 2019; Geels, 2005); (3) serverless and event-driven digital architectures materially enable scalable, resilient fleet operations and near real-time telemetry (Anand et al., 2019; Antreas & Georgios, 2020; Barcelona-Pons et al., 2019); (4) socio-technical feedback loops—regulatory, cultural, economic—mediate adoption trajectories (Urry, 2004; Kemp, 1994); and (5) systemic sustainability outcomes remain contingent on coordinated policy, institutional redesign, and equitable service deployment (Geels et al., 2004; Elzen & Wieczorek, 2005).

Conclusions: The emerging mobility ecosystem is not only a technological puzzle but a governance and infrastructural one. Robust transition toward sustainable, equitable automobility requires integrated strategies that align FaaS business models, automated vehicle development, and digital architectures with policy instruments and social objectives. This synthesis illuminates practical levers—data architectures, regulatory experiments, and targeted niche support—that researchers and practitioners can pursue.

Keywords

Fleet-as-a-Service, automated vehicles, socio-technical transitions, serverless computing, mobility-as-a-service, automobility, infrastructure

Introduction

The contemporary automotive landscape is characterized by rapid, interacting shifts across technologies, business models, consumer practices, and digital infrastructures. Long-standing patterns of vehicle ownership and use that defined twentieth-century automobility are confronting disruptive changes at multiple scales. Observers have documented how the automobile was historically embedded within a broad socio-technical system—what has been termed "the system of automobility"—where cars, roads, fueling stations, legal frameworks, aesthetic norms, and economic patterns co-evolved in mutually reinforcing ways (Urry, 2004). This historical embedment underscores that contemporary innovations cannot be examined in isolation: changes in vehicle technology are entangled with institutional arrangements, infrastructures, and cultural patterns.

Research on system transitions provides conceptual tools to analyze how such entrenched socio-technical regimes shift. The multi-level perspective (MLP) and related system innovation frameworks foreground interactions between niche innovations, socio-technical regimes, and landscape pressures (Geels et al., 2004; Elzen & Wieczorek, 2005). These frameworks demonstrate that transformative change typically requires both the maturation of niche technologies and enabling shifts in broader landscape conditions. In the context of automobility, recent decades have produced numerous technological niches—hybrid and electric drivetrains, telematics, digitized mobility platforms, and automated driving systems—each interacting with institutional and market forces that are in flux (Geels, 2005; Kemp, 1994).

Automated vehicles (AVs) have emerged as a particularly consequential niche because they promise to reconfigure not only vehicle functionality but also the organization of mobility

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provision and the physical infrastructure of roads and cities (Beza & Zefreh, 2019). AVs could alter demand patterns, modal choices, and the economics of vehicle ownership versus service-based arrangements, providing fertile ground for business model innovation such as Fleet-as-a-Service (FaaS) (Deshpande, 2024). FaaS reframes vehicles as part of a managed service offering—effectively a platform-based supply of mobility rather than distributed private assets—and thus has the potential to reduce idle vehicle time and optimize utilization through fleet management and digital coordination (Deshpande, 2024; Aberle, 2020).

These mobility shifts are enabled and intensified by digital architectures that facilitate real-time data flows, secure telemetry, and scalable compute resources. In particular, serverless and event-driven computing paradigms provide technical affordances—elasticity, cost efficiency under variable loads, and simplified deployment—for telemetry, tracking, and fleet orchestration systems (Anand et al., 2019; Antreas & Georgios, 2020; Barcelona-Pons et al., 2019). The technical literature shows that advances in serverless architectures and edge computing are not mere back-office concerns; they materially shape system-level capabilities and constraints by governing latency, reliability, and data governance regimes for mobility services (Castro et al., 2019; Claudio et al., 2020; Hassan et al., 2021).

This paper integrates these literatures to provide a structured, theory-driven, and detailed analytic account of the current transition in automobility. The goal is not an empirical case study of a single program but rather an interdisciplinary synthesis that clarifies mechanisms, assumptions, and levers for research and policy. The study pursues three interconnected objectives. First, to situate FaaS and AVs within socio-technical transition frameworks, making explicit how they interact with regimes and landscapes. Second, to examine the enabling role of serverless and event-driven digital architectures for fleet operations and AV deployment. Third, to explicate policy and governance implications, emphasizing sustainability and equity. These objectives are pursued through a methodical literature synthesis and conceptual analysis that draws directly on the provided reference corpus.

Methodology

This research adopts an integrative conceptual synthesis methodology anchored in transition theory and interdisciplinary literature mapping. The choice of method reflects the study's goal: to produce a comprehensive, theory-informed argument that juxtaposes socio-technical frameworks with technical and empirical findings drawn from the supplied references. The method comprises three sequential activities: literature selection and mapping; thematic synthesis; and conceptual integration.

Literature selection and mapping. The analysis begins by treating the provided references as the authoritative corpus. These references span socio-technical transition theory, empirical reviews of AV impacts, studies on mobility-as-a-service access patterns, and technical analyses of serverless and edge computing. Each reference was read and coded for core contributions relevant to automobility transitions: theoretical constructs (e.g., regimes, niches, landscape pressures), empirical findings (e.g., usage patterns, accessibility outcomes), technical affordances (e.g.,

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serverless ETL, GPS tracking architectures), and normative concerns (e.g., sustainability, equity). The mapping process created conceptual clusters corresponding to (a) transitions theory and historical analogies, (b) automated vehicles and mobility provision models, (c) FaaS and MaaS business models, (d) digital data architectures enabling mobility, and (e) governance and policy levers.

Thematic synthesis. Following mapping, the coded material was synthesized into thematic narratives. Each theme is developed by connecting theoretical propositions (from Geels, Kemp, Freeman & Perez, Schot et al.) with contemporary empirical and technical studies (Beza & Zefreh; Deshpande; Anand et al.; Antreas & Georgios; Barcelona-Pons et al.; Castro et al.; Claudio et al.; Hassan et al.). Thematic synthesis seeks to explicate mechanisms—how serverless architectures change fleet operations, how FaaS affects demand, or how AVs can destabilize regime lock-ins—rather than merely summarizing individual studies. For every major claim in the synthesis, corresponding references from the provided corpus are invoked to maintain fidelity to source material.

Conceptual integration. The final phase integrates the themes into a cohesive argument structured around five key dynamics identified in the results. The integration leverages the MLP as an organizing frame, tracing interactions across niche, regime, and landscape levels. Where technical literature provides granular insights (e.g., capabilities of event-driven ETL pipelines or the constraints of serverless architectures in MEC systems), these are woven into the broader socio-technical narrative to demonstrate how micro-level engineering choices can exert macro-level system influence. The result is a multi-scalar analysis that preserves nuance and theoretical rigour.

Throughout, the methodology emphasizes transparency: claims are explicitly tied to references, and interpretive moves are justified by citing the relevant literature. The study does not conduct primary empirical data collection or statistical meta-analysis; rather, it performs an extensive conceptual re-elaboration using the supplied sources to derive theoretically grounded insights and policy-relevant recommendations.

Results

The synthesis yields a rich set of findings organized as five interrelated dynamics that together characterize the current transition in automobility. These dynamics reflect technical, organizational, and social dimensions and emphasize the interplay between innovation and institutional context.

1. FaaS as a Reframing of Vehicle Commodities and Use Patterns

Fleet-as-a-Service conceptualizes vehicles not as individually owned capital assets but as pooled, service-delivered functionalities managed by professional operators (Deshpande, 2024). This reframing has three immediate consequences. First, it alters utilization economics by centralizing scheduling and routing, thereby reducing idle vehicle time and enabling higher per-vehicle productivity (Deshpande, 2024). Second, FaaS changes demand elasticity for mobility by introducing subscription or pay-per-use models that decouple mobility consumption from vehicle ownership, potentially lowering upfront barriers to access (Aberle, 2020). Third, centrally managed

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fleets can implement lifecycle optimization strategies—coordinated maintenance, predictive replacement, and standardized retrofits—that are rarely feasible in highly distributed ownership regimes (Deshpande, 2024). These outcomes suggest that FaaS can materially shift the economic calculus of mobility and create new policy and regulatory considerations.

2. Automated Vehicle Technologies as Both Niche and Systemic Disruptors

Automated vehicles occupy a complex role in transition narratives: they are simultaneously technological niches undergoing maturation and potential destabilizers of the incumbent automobile regime (Beza & Zefreh, 2019; Geels, 2005). AVs introduce new capabilities—autonomy, advanced perception, and decision-making algorithms—that can reconfigure driver roles, labor relations, and regulatory responsibility (Beza & Zefreh, 2019). The MLP suggests that for AVs to induce regime-level change, they must combine technological reliability with institutional adaptations and market acceptance (Geels, 2005). The literature indicates divergent pathways: AVs might initially flourish within controlled, commercial fleet deployments (e.g., FaaS, logistics) where safety cases and operational design domains are tractable, rather than immediately displacing private car ownership at scale (Beza & Zefreh, 2019). Thus, AVs are likely to catalyze incremental but cumulatively transformative reconfigurations rather than instant paradigm shifts.

3. Digital Architectures—Serverless, Event-Driven, and Edge-enabled Systems—Enable Scalable Fleet Operations

Technical studies emphasize that modern fleet operations and AV systems depend critically on scalable, resilient data architectures (Anand et al., 2019; Antreas & Georgios, 2020; Barcelona-Pons et al., 2019). Serverless paradigms and event-driven ETL pipelines reduce infrastructure management overhead, offer elasticity under variable load, and facilitate rapid deployment of telemetry and tracking components (Antreas & Georgios, 2020; Castro et al., 2019). Real-time GPS tracking using lightweight processors and serverless backends demonstrates how telemetry can be implemented cost-effectively at scale (Anand et al., 2019). Meanwhile, research on mobile edge computing (MEC) shows that combining serverless functions with edge proximity can reduce latency and support time-critical AV functions (Claudio et al., 2020). The practical implication is that technical choices concerning compute paradigms and data pipelines shape operational feasibility, safety margins, and cost structures for FaaS and AV deployments.

4. Socio-Technical Feedbacks Mediate Adoption Trajectories

The literature underscores that adoption and diffusion of mobility innovations are not determined solely by technological superiority; they are mediated by institutional, social, and economic feedbacks (Urry, 2004; Kemp, 1994). Regulatory frameworks, public perceptions of safety, labor market impacts (e.g., on drivers), and urban design priorities all influence whether innovations scale. Historical analogies—such as the transition from horse-drawn carriages to automobiles—illustrate that shifts occur through complex interactions among users, firms, policy makers, and infrastructures (Geels, 2005).

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Consequently, even technically viable AVs or efficient FaaS models can be blocked or delayed by misaligned incentives, regulatory uncertainty, or public resistance. Recognizing these feedbacks is essential for anticipating realistic timelines and designing targeted interventions.

5. Equity and Sustainability Outcomes Are Contingent, Not Automatic

While FaaS and AVs hold the potential to reduce emissions and optimize resource use through higher utilization and electrification synergies, outcomes are contingent on deliberate alignments with policy and institutional measures (Geels et al., 2004; Elzen & Wieczorek, 2005). For example, platform-driven ride pooling can increase accessibility in some urban areas while leaving marginalized or peri-urban populations underserved (Aberle, 2020). Similarly, electrified and automated fleets could deliver environmental gains only if vehicle turnover, energy sources, and lifecycle management are managed with sustainability in mind (Kemp, 1994). Thus, realizing sustainability and equity goals requires combined interventions—regulation, incentives, and targeted niche support—that purposely shape market incentives and infrastructure investments.

Collectively, these dynamics illustrate that the trajectory of automobility transitions depends on technological capabilities, institutional responses, and the shaping of digital infrastructures. The next section explores the implications of these findings, discusses limitations, and outlines avenues for future research and policy action.

Discussion

The preceding results integrate technical and socio-technical insights to highlight how FaaS, AVs, and digital architectures are reconfiguring automobility. This discussion elaborates on theoretical implications, offers counter-arguments to optimistic narratives, highlights practical constraints, and outlines policy and research priorities. To ensure clarity, the discussion is organized around three focal concerns: theoretical implications for transition research, critical evaluation of the technological and economic claims, and governance implications for sustainability and equity.

Theoretical implications for transition research. The MLP and related frameworks prove conceptually potent when analyzing contemporary automobility because they force attention to nested interactions: niche-level technological innovations (AVs, serverless telemetry) must be analyzed in relation to regime-level configurations (ownership norms, regulatory institutions) and landscape-level pressures (urbanization, climate policy) (Geels et al., 2004; Elzen & Wieczorek, 2005). The synthesis suggests two theoretical refinements. First, digital architectures warrant explicit integration into transition frameworks as infrastructural mediators that shape diffusion dynamics. Serverless and edge computing are not neutral backends; they influence latency, data governance, and cost structures, which in turn affect which mobility services are feasible (Anand et al., 2019; Antreas & Georgios, 2020; Barcelona-Pons et al., 2019). Second, business model innovations like FaaS should be treated as socio-technical niches in their own right because they encapsulate distinct organizational logics, routines, and relationships with users and regulators (Deshpande, 2024). Incorporating these technological and institutional modalities into MLP enriches its explanatory power.

Critical evaluation of technological and economic claims. Popular narratives sometimes present AVs and FaaS as inevitable progress towards more efficient and sustainable mobility. However, the literature invites a more cautious stance. Technical maturity of AVs remains uneven across operational domains, and many safety challenges—edge cases, sensor degradation, and unpredictable human behavior—persist (Beza & Zefreh, 2019). Meanwhile, FaaS faces economic challenges in reaching profitability at scale without sustained subsidies or favorable regulation, particularly if market dynamics favor private ownership for certain user segments (Deshpande, 2024). The technical literature on serverless architectures suggests operational benefits but also highlights constraints: cold-start latencies, vendor lock-in risks, and the difficulty of guaranteeing hard real-time performance for safety-critical applications unless augmented by edge resources (Castro et al., 2019; Claudio et al., 2020). Thus, claims of automatic efficiency gains must be tempered by realistic assessments of technical limits and market heterogeneity.

Labor market and social implications. The displacement and reconfiguration of labor—particularly for drivers—constitute a major social dimension of transition. AV adoption could reduce demand for professional driving in certain segments (e.g., intercity trucking, ride-hailing) while creating new roles in fleet supervision, remote operation, and data management (Beza & Zefreh, 2019). The literature emphasizes the need for proactive policy to manage transitions in labor markets, including retraining and social protection measures (Urry, 2004; Geels, 2005). Moreover, equitable access to mobility services requires deliberate design; otherwise, platformization can exacerbate spatial inequities when profitable routes are prioritized over social coverage (Aberle, 2020).

Data governance, privacy, and security. The centrality of telemetry and cloud-native architectures to FaaS and AV operations raises critical governance questions. GPS tracking, event-driven ETL, and serverless functions generate rich datasets whose governance implicates privacy, surveillance, and competitive dynamics (Anand et al., 2019; Antreas & Georgios, 2020). The literature warns of vendor concentration risks and the regulatory challenges of cross-border data flows in mobility platforms (Castro et al., 2019). Ensuring privacy and security requires robust standards, transparency in data practices, and possibly public oversight of critical mobility datasets.

Policy levers for steering transitions. Given the contingent nature of sustainability and equity outcomes, the literature points to several policy levers that can steer transitions: (1) targeted niche support and experimentation (e.g., regulatory sandboxes for AVs and FaaS), (2) infrastructure investments (charging infrastructure, digital edge nodes) that reduce operational barriers for electrified and autonomous fleets, (3) demand-side measures (e.g., congestion pricing, parking regulation) that shift incentives away from private ownership toward shared and efficient use, and (4) labor market policies to manage workforce transitions (Geels et al., 2004; Elzen & Wieczorek, 2005; Kemp, 1994). These levers should be coordinated to avoid fragmented interventions

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that could entrench existing inequalities or create lock-ins favoring incumbent actors.

Counter-arguments and limitations. Some observers argue that AVs may never achieve the promised societal benefits and that the complexities of real-world driving environments will favor incremental automation and human-augmented systems (Beza & Zefreh, 2019). Another critique emphasizes that digital platforms can entrench monopolies, undermining public-interest goals despite technical efficiencies (Urry, 2004). Additionally, while serverless architectures reduce infrastructure burden, they can introduce dependency on cloud providers and obscure accountability chains for critical failures (Castro et al., 2019). These counterpoints underscore the need for humility in predictions and for multi-stakeholder governance models that preserve public goods.

Future research directions. The synthesis highlights several promising research trajectories. Empirical studies should evaluate real-world FaaS pilots to quantify utilization improvements, lifecycle emissions, and equity impacts (Deshpande, 2024; Aberle, 2020). Technical research must investigate hybrid architectures that combine serverless elasticity with deterministic edge compute for safety-critical functions (Claudio et al., 2020). Finally, comparative policy studies should analyze regulatory sandboxes and procurement strategies that successfully align private incentives with public goals (Geels et al., 2004).

Limitations of this study

This paper is a conceptual and integrative synthesis based entirely on the provided literature corpus. It does not present new empirical data or systematic meta-analytic statistics; rather, it re-elaborates and connects findings across disciplines. This methodological choice yields deep theoretical integration but also constrains empirical generalizability. Additionally, the reliance on supplied references means that some perspectives outside this corpus—such as recent field trials postdating the sources or emergent market experiments—may not be represented. Nonetheless, by weaving together transition theory, AV literature, FaaS analyses, and serverless computing studies, the paper provides a comprehensive framework to guide subsequent empirical work.

Conclusion

The transition of automobility is a layered and contested process in which technology, business models, infrastructure, and social institutions co-evolve. Fleet-as-a-Service, automated vehicle technologies, and modern digital architectures collectively present both opportunities and challenges for sustainable, equitable mobility. The potential for efficiency gains and reduced environmental impact exists but is not automatic; it depends on how these innovations are governed, deployed, and integrated into broader urban and energy systems. Serverless and event-driven computing paradigms reduce technical friction for fleet-scale deployments but require careful design to meet latency, security, and data governance demands. Transition pathways will be shaped by deliberate policies—regulatory sandboxes, targeted infrastructure investments, demand-management tools, and social protections—that align private incentives with public values. Future research must pair technical experimentation with rigorous socio-technical evaluation to ensure that the promise of smarter, more sustainable mobility becomes a realized public good rather than a narrowly captured technological novelty.

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