On the Promotion of Industrial Diversification in the Deep Cooperation Zone Through Macao's Legislation on Fuel Vehicle Restrictions and Revision of Electric Vehicle Subsidy Standards

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Abstract

This paper comprehensively examines how Macao's legislative restrictions on fuel vehicles and revised electric vehicle subsidy standards facilitate industrial diversification in the Guangdong-Macao Deep Cooperation Zone. It analyzes how creating demand for new energy vehicles during the initial phase of free trade zone development stimulates manufacturing growth and raw material demand, attracts international traders for bulk commodity transactions, and enhances exchange prosperity and cross-border trade in the Greater Bay Area. The study outlines the strategic framework for industrial development in the Hengqin Deep Cooperation Zone, encompassing employment expansion, prioritized development of new energy vehicles and high-end manufacturing, while discussing the necessity of moderate industrial diversification and the relationship between financial services and the real economy. Specific strategies for leveraging Macao's advantages to develop new energy vehicle manufacturing, legislative recommendations for fuel vehicle restrictions, and optimization of subsidy standards are proposed, providing theoretical and practical insights for industrial development in the Guangdong-Macao cooperation zone.

Research Article

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1. Introduction

1.1 Challenges in Industrial Development Foundations

1.1.1 Weak "Four Emerging Industries" Base

The "Four Emerging Industries" in the Hengqin Deep Cooperation Zone—technology R&D, high-end manufacturing, traditional Chinese medicine, cultural tourism/exhibitions, and modern finance—lack robust foundations (Porter, 2001). For instance, Hengqin's semiconductor output ranks eighth nationally and second in the Greater Bay Area after Shenzhen. However, its strength lies in design rather than manufacturing. Semiconductor manufacturing generates wastewater and waste incompatible with Hengqin's green development goals, limiting competitiveness against Shenzhen. Meanwhile, Macao's economy remains overly reliant on gaming (38.3% of 2023 GDP), impeding endogenous momentum for industrial diversification and causing fragmented supply chains.

1.1.2 Low Industrial Synergy

Divergent development plans and immature industrial clusters between Hengqin and Macao hinder integrated growth. For example, Macao's traditional Chinese medicine and exhibition sectors contributed only 0.13% and 0.24% to GDP in 2021, respectively (Rodrik, 2004), while its finance sector lacks diversity and high-end manufacturing remains nascent. This fragmented landscape leads to resource misallocation, stifling diversification.

1.2 Urgent Need for Structural Economic Improvements

1.2.1 Monolithic Industrial Composition

Macao's economy is dominated by the tertiary sector (services), while the secondary sector accounts for a minimal share, and the primary sector is nearly negligible. Below is a detailed breakdown of Macao's 2023 industrial structure:

Primary sector (negligible): Encompassing fisheries, agriculture, and livestock, these industries contribute insignificantly to Macao's economy due to the region's limited land area and natural resources, which preclude large-scale agricultural or fisheries development.

Secondary sector (5.6%): Comprising industry, manufacturing, and construction, this sector accounted for 5.6% of Macao's total gross value added in 2023, a decline of 3.6 percentage points compared to 2022. Sub-sector contributions include construction (4.0%), utilities (water, electricity, and gas supply: 0.9%), and manufacturing (0.8%).

Tertiary sector (94.4%): As the cornerstone of Macao's economy, the service sector contributed 94.4% of total gross value added in 2023, rising by 3.6 percentage points from 2022. Key components include: Gaming (38.3%), Hospitality (5.9%),Food and beverage (2.1%), Wholesale and retail trade (8.1%), Non-gaming services, representing 61.7% of the tertiary sector, saw a 12.9-percentage-point increase from 2019.

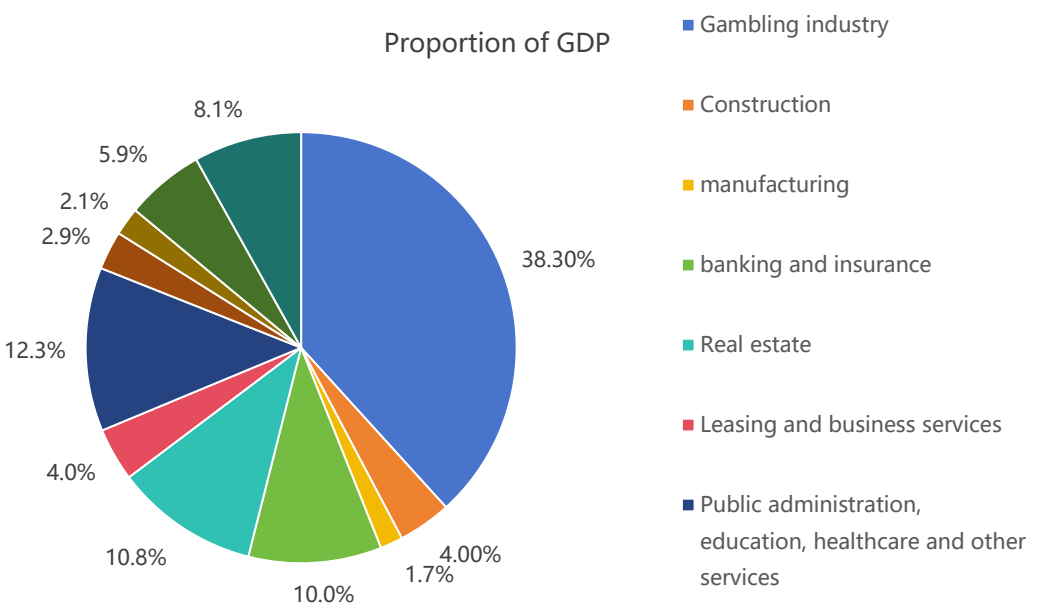

Figure 1 Composition of Macau's GDP

1.2.2. Structural Economic Fragility

Macao's economy has faced significant setbacks in recent years. According to data from the Statistics and Census Bureau of Macao, the COVID-19 pandemic caused a drastic reduction in inbound tourism in 2020, leading to a 78.4% year-on-year decline in total industry revenue to MOP63.94 billion (Macanese pataca, same below). Key impacts include:

(1) Gaming revenue: Plunged 79.4% to MOP60.32 billion

(2) Leasing income: Fell 29.1% to MOP38 million

(3) Interest income: Dropped 1.9% to MOP2.65 billion

Total industry expenditures decreased by 60.6% from 2019 to 46.42 billion. The collapse of gaming revenue drove an 83.3% contraction in procurements, commissions, and customer rebates—previously the largest expense category—to MOP9.43 billion, reducing its share from 47.9% (2019) to 20.3% (2020). Operational expenses fell 68.8% to 9.95 billion, with their proportion dropping from 27.1% to 21.4%. Notably, spending on complimentary guest services (hotel accommodations, dining, etc.) plummeted 74.5% to 4.64 billion. Labor costs decreased by 12.5% to 19.71 billion, yet their share surged from 19.1% (2019) to 42.5%. Conversely, interest expenses rose 23.2% to 3.88 billion, elevating non-operational expenditures by 6.5% to 7.33 billion. This structural overreliance on singular industries severely weakens economic resilience, posing risks to Macao's social stability.

1.3 Challenges in Spatial Resource Allocation

1.3.1 Severe Land Scarcity

With a mere 33 sq km of territory, Macao's urban development is constrained by acute land shortages, as over 30% of its land is already developed—exceeding the international warning threshold for development intensity. The Hengqin In-depth Cooperation Zone, offering 106 sq km of expansion potential, faces similar limitations: 45.31 sq km of developed land and 32.09 sq km of non-adjustable land account for 70.83% of its total area, leaving minimal remaining developable space and narrow margins for future planning adjustments (Keyu & Zhide, 2024). This scarcity hampers industrial expansion and upgrading due to insufficient land supply and prohibitive costs for new projects.

1.3.2 Inefficient Spatial Utilization

The Cooperation Zone's commercial office buildings and industrial parks report a 45.6% vacancy rate, reflecting a lack of occupancy by operating enterprises (Trade & Development, 2021). Such underutilization not only wastes resources but also undermines industrial clustering and regional competitiveness, creating barriers to attracting investments and businesses while diminishing the area's developmental appeal.

1.4 Demographic and Livelihood Infrastructure Challenges

1.4.1 Sluggish Population Growth

Hengqin's population growth has fallen far short of projections, stagnating both the scale and vitality of its consumer market while restricting labor availability and hindering industrial diversification. This sluggishness complicates efforts to develop labor-intensive industries and service sectors, skewing regional economic structures.

1.4.2 Inadequate Public Amenities

Gaps in education, healthcare, housing, and elderly care infrastructure persist, failing to meet demands posed by talent attraction and industrial diversification. For instance, healthcare and housing facilities remain insufficient relative to population growth and sectoral needs. These deficiencies weaken the region's ability to attract and retain skilled professionals, constraining innovation capacity and industrial competitiveness.

2. Moderate Industrial Diversification: Incremental Reform through Prioritized Development

2.1 Economic Foundations Shape Superstructures: The Imperative for Diversification

Material conditions underpin societal structures, and by extension, Macao's overdependence on gaming as its economic bedrock has rendered its growth vulnerable to systemic risks and constraints (Fan et al., 2025; Hausmann & Rodrik, 2003). Absent a transformative shift in this foundation, superficial measures—be they leadership changes or zonal expansions—will fail to catalyze substantive economic restructuring. True strategic value for the Hengqin In-depth Cooperation Zone hinges on elevating manufacturing output to parity with or surpassing the gaming sector, thereby securing sustainable regional development through moderate industrial diversification.

2.2 Strategy of Prioritized Development: Automotive Manufacturing as a Catalyst

Moderate diversification represents an incremental reform model centered on "building new pillars before dismantling old ones (Lee & Ki, 2017)." As President Xi Jinping emphasized, "Efforts must intensify to foster appropriately diversified economic growth by leveraging intrinsic strengths and resource endowments, refining industrial planning, and channeling targeted policy and capital support toward cultivating globally competitive sectors." Within China's industrial landscape, automotive manufacturing uniquely combines competitive advantage with high employment multipliers. Analysis by the National Information Center highlights a 1:7 employment ratio between the automotive sector (including components) and related industries—each new automotive job spurs seven additional positions across ancillary fields.

The automotive value chain encompasses over 100 interrelated sectors. A 2005 State Council Development Research Center study of input-output matrices across 62 industries revealed that every 1 yuan of added value in automotive manufacturing generates 2.64 yuan in upstream (steel, petrochemicals, rubber, glass, electronics) and downstream (finance, insurance, maintenance, tourism, leasing, hospitality) sectors. By 2014, China's automotive industry contributed over 5% to GDP through these multiplicative effects—a figure amplified by ongoing technological and industrial chain advancements.

Thus, reform strategies must first anchor themselves in automotive manufacturing's growth, particularly emerging sectors like new energy vehicles. By systematically elevating manufacturing's economic share, subsequent structural adjustments can then optimize other industries, achieving comprehensive industrial upgrading with minimized systemic risk (Liu, 2024b). This approach aligns with President Xi's vision to "deepen synergy and regulatory alignment between the Hengqin-Guangdong-Macao Cooperation Zone and Macao's economy, ensuring efficient cross-border flows of capital and talent (Yang & Lin, 2025). By scaling signature industry clusters and catalytic flagship projects, the Zone will fulfill its mandate of diversifying Macao's economy while enhancing residents' livelihoods."

3. Modern Financial Sector and the Real Economy: Servicing Productive Sectors as the Core Mandate

3.1 Asset-Light Dynamics and Regulatory Complexities in Finance

While the financial sector plays a pivotal role in economic advancement, its asset-light nature—epitomized by brokerages, microloan firms, and investment entities—introduces systemic vulnerabilities. During market upswings, such institutions generate rapid wealth accumulation, yet their revenue models remain prone to volatility, speculative excess, and high regulatory oversight costs. This fragility stems from their reliance on financial assets (e.g., digital currencies, equities) whose valuations fluctuate with market sentiment, compounded by the breakneck pace of financial innovation that outpaces regulatory frameworks.

3.2 The Stability Imperative: Heavy-Asset Enterprises as Economic Anchors

In contrast to their asset-light counterparts, heavy-asset industries like manufacturing exhibit enduring economic value once competitive edges are established. Anchored in tangible assets (machinery, facilities, infrastructure) with stable valuations and standardized operational protocols, these enterprises impose lower regulatory burdens while delivering sustained regional economic dividends. Thus, the financial sector must reorient its priorities to bolster the real economy—particularly manufacturing—as a cornerstone of stable, long-term growth.

3.3 Harnessing Modern Finance for Free Trade Zone Synergy and Momentum

3.3.1 Strategic Demand Creation: The New Energy Vehicle (NEV) Paradigm

In nascent development stages, free trade zones like Hengqin require deliberate demand-generation strategies to attract capital and catalyze industrial clusters. Amending traffic regulations to incentivize NEV adoption exemplifies such forward-thinking policy design (Mazzucato, 2016). NEV industry expansion stimulates demand across upstream sectors (iron ore, lithium, rubber) while positioning Hengqin's bonded zone as a hub for global commodity trading. This dual effect ensures stable material inputs for manufacturing while enhancing the zone's appeal to international traders.

3.3.2 Commodity Trading as a Multidimensional Economic Accelerant

Robust commodity trading within Hengqin's bonded zone achieves three cascading benefits (Liu & He, 2024).

(1) Supply Chain Security: Guarantees uninterrupted raw material flows for manufacturers.

(2) Financial Ecosystem Vitality: Elevates trading volumes, enhances regional financial market liquidity, and amplifies the zone's global financial footprint.

(3) Trade Optimization: Synergizes with the Greater Bay Area's import-export ecosystem, scaling trade volumes and refining structural efficiency.

Even amid fierce NEV market competition, Hengqin's early-stage resource clustering and institutionalized trading practices have fostered a resilient economic foundation. By prioritizing transaction volume—the lifeblood

of capital markets—the zone can innovate financial instruments while capitalizing on its regulatory agility. Comparatively, while Hong Kong's equity market is saturated with speculative "shell stocks," Macao's fledgling exchange, though limited in offerings, holds strategic appeal as a clean-slate platform primed for incremental, growth-oriented capital inflows—an arena where investor appetite for emerging opportunities eclipses stagnant incumbents.

4. Macao's Industrial Advantages and Strategic Opportunities in New Energy Vehicle (NEV) Manufacturing

4.1 Leveraging Existing Competitive Industries

Macao currently boasts four comparatively advantaged sectors that serve as economic stabilizers for GDP growth. Notably, its semiconductor industry has cultivated a robust talent pool and technological expertise—assets critical for jumpstarting automotive manufacturing within the Hengqin In-depth Cooperation Zone. This cross-sector synergy positions Macao to capitalize on advanced manufacturing ecosystems.

4.2 NEV Manufacturing: A Strategic Window of Opportunity

The Greater China region exhibits strikingly low NEV penetration rates, unveiling vast unmet demand:

(1) Hong Kong: 93,173 NEVs registered as of April 2024, constituting 10.3% of total vehicles (649,540).

(2) Macao: 11,786 electric vehicles (4.66% of 252,777 registered vehicles) as of November 2024.

(3) Taiwan (China): NEVs accounted for a mere 0.36% (28,560 units) of 7,832,573 registered automobiles through September 2024.

This market landscape presents Macao with unparalleled potential to establish a competitive NEV manufacturing base. Strategic pathways include:

(1) Cost-Efficient Market Entry: Acquiring insolvent Mainland NEV production licenses for bonded zone manufacturing, slashing capital expenditures through regulatory arbitrage.

(2) Differentiated Competition: Forging niche positioning against Greater Bay Area rivals by capitalizing on Macao's distinct tax regimes and semi-mandatory NEV adoption policies to achieve rapid scale economies.

(3) Geopolitical Advantage: Exploiting Taiwan's sub-1% NEV penetration through Macao's unique cross-strait economic identity—offering mainland brands unparalleled market access channels compared to direct Mainland-Taiwan engagements.

By strategically timing interventions during industrial consolidation phases and leveraging policy tools like preferential land leases, Macao can transform its bonded zones into NEV export hubs (Leung & Guo, 2023). This aligns with broader ambitions to upgrade manufacturing value chains while expanding the tax base—a dual imperative for sustainable post-gaming economic transition.

5. Legal Framework and Regulatory Dynamics: Mainland China's Green License Plate System

5.1 Policy Efficacy: Shanghai's Green Plate Initiative

Shanghai's implementation of the New Energy Vehicle Promotion and Management Regulations ("Green Plate Law") from February 1, 2018, has driven transformative market growth (Liu, 2024a). NEV registrations surged by 73,724 units in 2018—a 20.2% year-on-year increase—with acceleration post-2020 as policy incentives synergized with industrial upgrades. By 2023, NEV ownership reached 1.288 million units, reflecting a 437% cumulative growth rate since 2018 (35%+ CAGR) and achieving 59.2% market penetration—a global benchmark

in urban electrification (Zheng et al., 2022).

5.2 Regulatory Architecture: Key Provisions of Shanghai's Green Plate Framework

5.2.1 Dedicated License Quota System

Private consumers purchasing NEVs for non-commercial use—without prior NEV registrations in Shanghai—receive free specialty license quotas under the city's total passenger vehicle control mechanism. A one-plate-per-vehicle principle applies, with quotas automatically invalidated upon vehicle retirement, cross-regional transfers, or theft.

5.2.2 Commercial Fleet Prioritization

Public transport operators and commercial fleet buyers of battery-electric/hydrogen-fuel-cell vehicles receive expedited license approvals and regulatory guidance to accelerate electrified mobility adoption.

5.2.3 Manufacturer Compliance Obligations

NEV producers/distributors seeking policy benefits must:

(1) Technical Accountability: Maintain R&D/QA capabilities, ensure compliance with statutory obligations under China's Automotive Product Recall Regulations, Automotive Three-Guarantee Policy, and Vehicle Repair Technical Disclosure Rules.

(2) Real-Time Data Governance: Implement 24/7 telematics monitoring, interface with municipal data hubs, and guarantee full lifecycle traceability.

(3) Charging Infrastructure Mandates: Pre-assess buyer charging capabilities under Shanghai EV Charging Infrastructure Guidelines, commit to installing compliant charging facilities pre-delivery.

(4) Battery Circularity Protocols: Establish closed-loop recycling systems scaled to sales volume, implement battery coding/tracking systems, and coordinate with authorized recyclers. Importers must additionally obtain CIQ certification for critical components.

This tripartite regulatory architecture—balancing consumer incentives, fleet electrification priorities, and producer accountability—offers actionable insights for Macao's policy design. Strategic adaptations could integrate Hengqin In-Depth Cooperation Zone's supply chain advantages while tailoring compliance thresholds to local industry capacities, ensuring feasible yet ambitious NEV market transformation.

5.3 NEV Tax Exemption Eligibility: Key Technical Benchmarks

China's Ministry of Industry and Information Technology (MIIT) mandates stringent criteria for vehicles listed in the Catalog of New Energy Vehicles Eligible for Purchase Tax Exemption:

5.3.1 Performance Thresholds:

(1) Pure electric passenger vehicles: Minimum sustained speed of 100 km/h over 30 minutes.

(2) Pure electric range: ≥200 km (NEDC cycle).

(3) Battery energy density: ≥125 Wh/kg.

5.3.2 PHEV/EREV Requirements:

Equivalent all-electric range: ≥43 km under conditional driving modes for plug-in hybrids.This regulatory framework underscores a strategic focus on battery technology leapfrogging—prioritizing high-performance energy storage systems while phase-shifting subsidies away from incremental fuel efficiency upgrades of legacy ICE vehicles (Nykvist & Nilsson, 2015).

5.4 Shanghai's Traffic Restriction Framework

Shanghai currently exempts NEV green-plated vehicles from all congestion charges and peak-hour driving bans,

granting unrestricted urban access. Conventional vehicle restrictions—tailored to local air quality goals and traffic patterns—hold limited relevance for Macao given its distinct urban morphology and mobility demands. Policymaking priorities should instead concentrate on designing bespoke EV adoption incentives aligned with Macao's compact geography and cross-border logistics dynamics.

6. Critical Gaps in Macao's Green Plate Regulatory Framework

6.1 Systemic Flaws in NEV Tax Incentive Design

6.1.1 Misaligned Subsidy Eligibility

Market Distortion via Volumetric Policy: Macao's current displacement-based tax exemptions lack supply chain localization safeguards, permitting foreign OEMs (e.g., German/Japanese brands) to qualify subsidies despite using non-mainland battery suppliers. This perpetuates consumer dependence on ICE-adjacent technologies and fails to cultivate domestic EV adoption behavior.

Technological Backwardness: Hybrid EVs (HEVs)—ineligible for China's Green Plate Law due to subpar battery metrics (range <200 km, energy density <125Wh/kg)—receive disproportionate incentives in Macao. These transitional powertrains, with miniature batteries incapable of supporting autonomous driving or ecosystems (Howlett & Rayner, 2013), represent incremental ICE optimization rather than meaningful electrification.

6.1.2 Strategic Incoherence in Subsidy Architecture

Macao's displacement-centric framework, while nominally environmental, neglects industrial catalyzing effects achieved by Mainland China's battery-capacity-weighted subsidies. The latter propelled CATL, BYD, and others into global battery leadership—reducing oil dependency, circumventing legacy automaker patents, and enabling intelligent NEV ecosystems. Macao's policy inertia risks locking the region into outdated mobility paradigms.

6.2 Non-Existent Congestion Management Strategy

Macao's sole regulatory gesture—yellow plates for emission-compliant NEVs—constitutes passive symbolic governance (Lin et al., 2022). Unlike Shanghai's NEV exemption from peak-hour bans, Macao lacks proactive traffic-demand management tools to accelerate EV adoption. Urgent recalibration toward dynamic road pricing and zero-emission zones is needed to align with carbon neutrality targets.

7. Legal Reengineering: Mobility Policy Framework for Macao

7.1 Battery Passport Protocol & Tax Parity

Given the environmental externalities of battery production—misaligned with Hengqin's green industrial strategy—Macao-based automakers must prioritize sourcing, not manufacturing, energy storage systems (Jordan & Huitema, 2014).

Cross-Border Battery Sourcing Mandate: Enact a "Battery Passport" system requiring full supply chain transparency (manufacturer audits, material traceability, carbon footprint analytics) for all NEV batteries entering Macao. Alternatively, mandate exclusive procurement of Mainland China-manufactured cells.

Tech-Driven Tax Criteria: Align subsidy thresholds with China's Technical Requirements (≥200km pure range, ≥125Wh/kg energy density), de facto reserving incentives for vehicles integrating PRC battery ecosystems. This shields domestic NEV makers while permitting foreign JVs using Mainland cells to compete, fostering trade equilibrium through shared industrial dependencies.

7.2 Adaptive Traffic Restriction Regimes

7.2.1 Phased Mobility Governance:

Green Plate Exemptions: Adopt Shanghai's NEV exemption model but escalate restrictions on ICE vehicles via calendar-based plate bans (e.g., odd-even plate restrictions calibrated to alternating month-day cycles).

Zonal Differentiation: Impose strict limits in congested Macao Peninsula while exempting Coloane, Taipa, and Cotai—leveraging spatial inequities to incentivize EV adoption without crippling logistics in low-density areas (Sterner, 2007).

7.2.2 Penalty-Driven Industrial Funding:

Institutionalize progressive penalty frameworks for ICE violations, with fines channeled into NEV infrastructure trusts. This creates a self-reinforcing fiscal loop: penalizing carbon-intensive mobility while accelerating NEV market penetration through penalty-derived fiscal recycling (Monteiro et al., 2024).

8. Epilogue: Legal-Industrial Symbiosis in Regional Development

Macao's legislative recalibration—fusing vehicular emission controls with NEV subsidy precision—exemplifies law's catalytic role in orchestrating post-carbon industrial transitions. By embedding battery localization mandates and smart traffic algorithms into statutory frameworks, Macao transcends mere regulatory compliance, positioning itself as a norm entrepreneur within the Greater Bay Area's green tech corridor (Chen et al., 2022; Ju, 2025).

The Hengqin-Macao Synergy gains juridical heft through such reforms: tax levers and access restrictions coalesce into a legal scaffolding for industrial diversification (Lin et al., 2022; Zhao et al., 2024). This jurisprudence of sustainability—where environmental liability morphs into innovation stimulus—redefines law not as a static code but as adaptive infrastructure, capable of shepherding economies from fossil lock-in to electrified autonomy.

Crucially, Macao's experiment validates a tenet of developmental statism: legislative foresight, when aligned with industrial geostrategy, can transmute jurisdictional constraints (limited land, resource dependence) into comparative advantages. The city-state's emergent NEV ecosystem—buttressed by cross-border battery alliances and AI-optimized traffic regimes—offers a replicable blueprint for compact economies navigating the dual imperatives of decarbonization and technological sovereignty.

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