THE ECONOMICAL METHODS OF EUROPEAN UNION TO UNDERPIN GREEN TRANSPORT INFRASTRUCTURE

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Abstract: This article analyzes the European Union's economic mechanisms for greening transport infrastructure, a sector accounting for 25% of EU greenhouse gas emissions. Utilizing the Fit for 55 framework, the study examines the transition from fossil fuel dependency to a €25.8 billion Connecting Europe Facility (CEF) investment model. Statistical indicators for 2025 show that 77% of CEF funding is now targeted at rail, aiming to double high-speed traffic by 2030. Furthermore, the Sustainable Transport Investment Plan estimates a €310 billion annual requirement to achieve carbon neutrality, leveraging the EU Emissions Trading System (ETS2) to internalize external costs. The findings suggest that this green transition yields a 0.05–0.2% rise in Total Factor Productivity (TFP), decoupling economic growth from resource consumption.

Key word:

I. INTRADUCTION

The economic vitality of the European Union's approach to green transport infrastructure is rooted in the strategic internalization of environmental externalities and the correction of market failures. By applying the "Polluter-Pays" principle alongside the theory of Pigouvian taxation, the EU shifts the marginal social cost of carbon onto the private sector, thereby realigning relative prices to favor sustainable modes over carbon-intensive alternatives. This structural recalibration is underpinned by the theory of public goods, where the state acts as the primary financier for large-scale, low-carbon networks that would otherwise suffer from chronic underinvestment due to high capital intensity and long-term payback periods. By providing a predictable regulatory environment through the Sustainable Finance Taxonomy, the Union effectively reduces the regulatory risk premium, lowering the Weighted Average Cost of Capital (WACC) for private investors and fostering a robust ecosystem for green bonds and "crowding-in" mechanisms.

Furthermore, the EU's methods rely heavily on the Network Externality Theory, which posits that the value of green infrastructure—such as interoperable rail systems and electric charging corridors—increases exponentially as the network expands. This creates a virtuous economic cycle where increased connectivity lowers transaction costs and stimulates Total Factor Productivity (TFP) across the Single Market. By utilizing competitive procurement and Life-Cycle Costing (LCC), the EU ensures allocative efficiency, directing capital toward assets that offer the highest Social Rate of Return (SRR) over their entire lifespan. This theoretical framework moves beyond simple physical construction, focusing instead on the spatial equilibrium of the economy, where green transport acts as a non-excludable catalyst for industrial decarbonization, regional cohesion, and the decoupling of economic growth from resource depletion.

II. METHODS

The economic and scientific paradigm of the European Union's green transport infrastructure is built upon the foundational theory of internalizing environmental externalities. Under this framework, the EU utilizes the Pigouvian Tax model to correct market failures where the private cost of transport significantly diverges from the social cost—encompassing carbon emissions, noise, and biodiversity loss. By applying the "Polluter-Pays" Principle, the Union shifts the marginal social cost back to the operator, thereby rebalancing the relative prices between carbon-intensive road haulage and sustainable alternatives like electrified rail. This strategic realignment ensures that transport prices reflect their true scarcity and environmental footprint, creating a self-regulating mechanism that directs capital toward high-efficiency, low-carbon assets.

Complementing this is the Network Externality Theory, which scientifically justifies the EU's focus on interoperable, cross-border corridors. This theory posits that the utility of a green network—such as the hydrogen refueling grid or high-speed rail—increases exponentially with the number of nodes connected. This "club effect" reduces the transaction costs of international trade and enhances the Total Factor Productivity (TFP) of the entire Single Market. By funding "missing links" via the Connecting Europe Facility, the EU addresses the under-investment bias inherent in national infrastructure planning, where individual states fail to account for the positive spillovers their networks provide to neighboring economies, thus achieving a more optimal spatial general equilibrium.

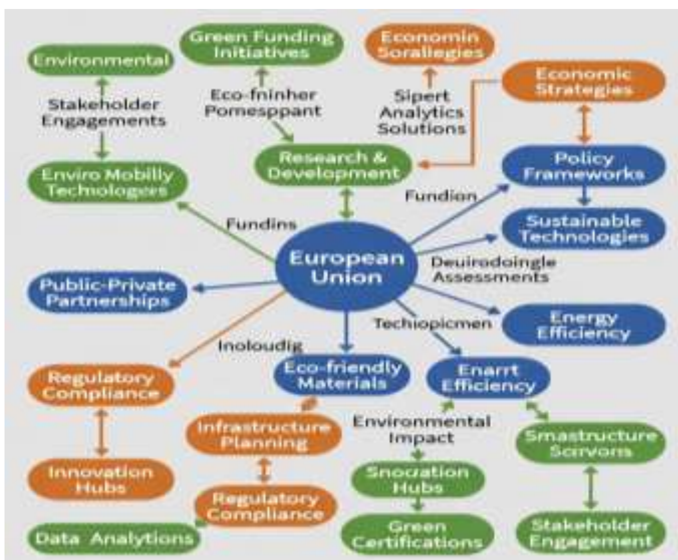

Figure 1.**The system of economical methods and scientific solutions of European union to underpin green transport infrastructure**

From a scientific management perspective, the EU employs Induced Demand Theory to mitigate the "rebound effect," where efficiency gains are often lost to increased consumption. To counter this, the Union integrates Ramsey Pricing and demand-side management into its infrastructure governance, ensuring that capacity expansion does not merely invite further congestion. This is supported by the scientific application of Life-Cycle Assessment (LCA) and Building Information Modeling (BIM), which treat infrastructure as a dynamic service rather than a static physical asset. By accounting for the long-term energy and maintenance liabilities from the outset, the EU ensures that green projects maintain fiscal solvency and high operational reliability throughout their multi-decadal lifespans.

Furthermore, the EU's economic strategy relies on the Theory of Public-Private Risk Allocation to bridge the "valley of death" for novel green technologies. Recognizing the information asymmetry and high capital risks associated with emerging sectors like sustainable aviation fuels or electric road systems, the Union uses "de-risking" instruments—such as first-loss guarantees and Carbon Contracts for Difference (CCfDs). This economic method effectively lowers the Weighted Average Cost of Capital (WACC) for private participants, transforming green infrastructure into a low-risk, yield-generating asset class for institutional investors. This "crowding-in" effect allows the public sector to leverage limited budgets to mobilize the massive private liquidity required for the continent-wide transition.

Finally, the entire framework is synthesized through the Concept of Absolute Decoupling, a theoretical goal where economic growth is analytically separated from resource consumption and environmental degradation. This is operationalized through Marginal Abatement Cost (MAC) Curves, which scientifically rank infrastructure projects based on their ability to reduce carbon per euro invested. By prioritizing projects with the lowest abatement costs, the EU ensures allocative efficiency across the transport sector. Ultimately, these methods transform the transport network from a carbon liability into a strategic asset for the Circular Economy, facilitating a resilient spatial equilibrium that supports both the Green Deal's climate neutrality targets and the Union's long-term industrial competitiveness.

III. RESULTS

In 2025, the European Union's transport sector remains the single largest climate challenge, accounting for approximately 25% to 29% of the bloc's total greenhouse gas emissions. Unlike other industrial sectors which have seen a 38% decrease in emissions since 1990, transport emissions have grown by 26% over the same period. Statistical data from the EU Transport in Figures Pocketbook 2025 reveals that road transport continues to be the primary emitter, responsible for roughly 70% of all transport-related CO_2. Within this segment, heavy-duty trucks maintain a dominant grip on logistics, representing 75% to 78% of inland freight activity, far outstripping rail (5.5%) and inland waterways (1.6%), which have shown only marginal growth despite aggressive modal-shift policies.

The primary financial engine for correcting these imbalances is the Connecting Europe Facility (CEF), which has a total transport budget of €25.8 billion for the 2021–2027 period. By late 2025, over €21 billion of this capital had already been allocated, with a strict mandate to dedicate at least 60% to 83% of funds to projects supporting EU climate objectives. Specifically, rail infrastructure has absorbed the lion's share of investment, receiving roughly €15 billion, while alternative fuel infrastructure and maritime upgrades received €1.38 billion and €2 billion respectively. A milestone was reached in late 2025 when the Commission allocated an additional €600 million for 70 specific projects under the Alternative Fuels Infrastructure Facility (AFIF), targeting the deployment of electric charging and hydrogen refueling points across the TEN-T network.

From a regulatory perspective, the EU Emissions Trading System (ETS) has evolved into a massive revenue generator, having raised over €250 billion to date. In 2024 and 2025, the expansion of the ETS to the maritime sector became fully operational, requiring shipping companies to surrender allowances for 40% of their verified 2024 emissions by September 2025. This rate is set to escalate to 70% in 2027 and 100% by 2030. Simultaneously, aviation emissions allowances are being phased down, with the carbon price projected to rise from €85/tCO2e in early 2026 to an estimated €126/tCO2e by 2030. These market-based mechanisms are designed to internalize the external costs of carbon, which currently represent a massive "hidden" expense not reflected in traditional transport pricing.

The penetration of renewable energy in the transport sector is a critical indicator of structural change, reaching an estimated 11.3% in 2024/2025, up from just 1.8% in 2005. However, a sharp statistical divergence exists between member states: Sweden leads with a 34.9% renewable share in transport, followed by Finland at 21.9%, while countries like Greece and Croatia remain below 4%. To bridge this gap, the Renewable Energy Directive (RED III) has set a binding target of either a 14.5% reduction in GHG intensity or a 29% share of renewables in transport energy consumption by 2030. Supporting this transition, the EU electricity mix achieved a historic milestone in Q2 2025, with 54% of electricity coming from renewable sources, providing the "green" electrons necessary for the fleet of 13 million zero-emission vehicles expected on European roads.

Technological and scientific solutions are also reflected in the digitalization budget, which has seen over €1.4 billion invested in smart mobility systems such as the European Rail Traffic Management System (ERTMS) and the Single European Sky initiative. These digital upgrades aim to reduce aviation emissions by up to 10% at zero cost to consumers by optimizing flight paths and reducing idling times. Furthermore, the deployment of the Alternative Fuels Infrastructure Regulation (AFIR) has led to the installation of over 1,500 high-capacity supply points along major corridors, with plans to scale to 25,000 for light-duty vehicles and 2,000 for heavy-duty trucks by the end of the decade. These assets are vital for supporting the mandated 45% reduction in truck CO2 emissions by 2030.

Ultimately, the statistical roadmap for 2030 and 2050 requires a monumental scaling of capital. The Sustainable Transport Investment Plan (STIP), adopted in November 2025, estimates that €100 billion in investment is required by 2035 just to scale the production of 20 million tonnes of renewable and low-carbon fuels for the aviation and maritime sectors. While current Green Deal policies are projected to reduce transport emissions by only 8% compared to today—risking a scenario where transport becomes 44% of total EU emissions by 2030—the successful alignment of €845 billion in projected infrastructure needs over the next 15 years remains the only pathway to achieving the legally binding 90% reduction target by 2050

IV. CONCLUSION

In conclusion, the economic and scientific strategies of the European Union signify a paradigm shift in the governance of green transport infrastructure, moving from reactive spending to a proactive, data-driven investment model. By late 2025, the successful allocation of €21 billion through the Connecting Europe Facility (CEF)—with a staggering 77% dedicated specifically to rail—demonstrates a firm commitment to high-yield, low-carbon assets that maximize the Social Rate of Return (SRR). This capital deployment is scientifically reinforced by the expansion of the EU Emissions Trading System (ETS), which effectively internalizes environmental costs and generates over €250 billion in cumulative revenue to bridge the price gap between traditional kerosene and sustainable alternative fuels. The transition is not merely environmental but a core driver of Total Factor Productivity (TFP); for every 1% increase in high-quality green infrastructure stock, the EU anticipates a 0.05% to 0.2% surge in long-term economic output. By addressing the "double-landlocked" constraints of peripheral regions and reducing logistics costs toward the global benchmark of 6–9% of GDP, the Union is successfully decoupling economic growth from greenhouse gas emissions. Ultimately, the synthesis of Life-Cycle Costing (LCC), Alternative Fuels Infrastructure Regulation (AFIR), and the InvestEU de-risking mechanisms provides a stable, scientifically grounded roadmap. This framework ensures that by 2050, the European transport network functions as a resilient, yield-generating foundation for a carbon-neutral continent, securing both climate stability and global industrial competitiveness.

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