GREEN SUBSIDIES UNDER INFLATIONARY PRESSURES: INSIGHTS FROM INDIA'S ENERGY TRANSITION: A REVIEW

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Abstract

In the present chapter we have discussed the topic"Green Subsidies under Inflationary Pressures: Insights from India's Energy Transition." The chapter examines the relationship between rising inflation and the effectiveness of green subsidy policies in India, particularly in the context of renewable energy development and clean mobility initiatives. Green subsidies are widely used as policy instruments to promote sustainable technologies and accelerate the transition toward low-carbon energy systems. However, their effectiveness is not determined solely by technological readiness or political commitment; macroeconomic conditions such as inflation also play a crucial role in shaping their outcomes. The chapter explores how inflation influences the functioning of green subsidy programmes by increasing the cost of raw materials, labour, and financing, which in turn reduces the real value of subsidies and alters investment incentives. Using examples from India's renewable energy and clean mobility policies, the chapter illustrates how inflationary pressures can delay project implementation, reduce policy effectiveness, and create uneven benefits across regions and social groups. The discussion also places these challenges within the broader political economy of India's energy transition, highlighting the tensions between fiscal discipline, climate policy commitments, and social equity. Furthermore, the chapter discusses possible policy responses that can improve the effectiveness of green subsidy programmes during inflationary periods, such as subsidy redesign, institutional coordination, and risk-sharing mechanisms between the government and private sector. By reading this chapter, researchers and policy analysts will gain knowledge about the interaction between inflation and climate policy instruments, the challenges faced by green subsidy frameworks in emerging economies, and the policy strategies that can enhance the resilience of sustainable energy transitions.Overall, the chapter demonstrates that understanding macroeconomic constraints is essential for designing effective climate policies. India's experience provides valuable lessons for policymakers and researchers seeking to balance economic stability with environmental sustainability in inflation-prone economies.

Keywords

Green subsidies; Inflation; Energy transition; Political economy; Climate governance; India

1. Introduction

Green subsidies have emerged as a central policy instrument in India's transition toward a low-carbon and climate-resilient economy. By lowering upfront capital costs and reducing investment risk, these subsidies aim to accelerate the adoption of renewable energy, electric mobility, and other environmentally sustainable technologies. Such interventions are particularly important in emerging economies, where market imperfections, high capital intensity, and limited access to finance often hinder the diffusion of green technologies[1, 2]. However, the effectiveness of green subsidies is not independent of broader macroeconomic conditions. In recent years, rising inflation has posed a significant challenge to the real value, fiscal sustainability, and implementation outcomes of subsidy-driven green policies in India. Inflation influences green subsidy effectiveness through multiple channels. First, rising prices of critical inputs—such as solar modules, battery minerals, steel, cement, and skilled labor—increase the total cost of green technology projects, thereby reducing the real purchasing power of nominally fixed subsidies[3]. Second, inflationary pressures often trigger monetary tightening, leading to higher interest rates and increased financing costs. This disproportionately affects green technologies, which are typically capital-intensive and characterized by long payback periods [4]. Third, inflation constrains government budgets, making it more difficult to sustain or scale subsidy programs over time, especially in the presence of competing social and developmental expenditures.

Despite the rapid expansion of green subsidy programs globally, the interaction between inflation and subsidy effectiveness remains underexplored in the academic literature. Much of the existing research on green subsidies and energy transitions implicitly assumes stable macroeconomic environments or treats inflation as an exogenous background variable[5]. This assumption is particularly problematic for countries like India, where inflation volatility has been persistent and where ambitious climate targets rely heavily on public financial support. This chapter addresses this gap by examining how inflation affects the design, implementation, and outcomes of green subsidy programs in India. Focusing on major initiatives in renewable energy and electric mobility, the chapter assesses how inflation erodes real subsidy value, alters private investment incentives, and contributes to delays and cost overruns. The analysis highlights heterogeneity across states and technologies and identifies policy design features that enhance resilience to inflationary pressures. Overall, the chapter argues that inflation is not merely a macroeconomic backdrop but a critical determinant of green subsidy effectiveness in emerging economies.

2. Background — India's Green-Subsidy Architecture

India has developed one of the most extensive green subsidy frameworks among emerging economies, reflecting the central role of public policy in advancing the national energy transition. This framework comprises a combination of centrally sponsored schemes, state-level incentives, and public financial support mechanisms targeting renewable energy deployment, clean mobility, and energy efficiency[6]. These subsidies are designed to address market failures, reduce technology costs, and mobilize private investment while advancing energy access and energy security objectives.

Renewable Energy Subsidies

Renewable energy subsidies in India focus primarily on solar energy, which constitutes the backbone of the country's renewable capacity expansion strategy. Rooftop solar programs provide capital subsidies to residential, institutional, and social-sector consumers, thereby reducing upfront installation costs and encouraging decentralized generation. In parallel, utility-scale renewable energy projects benefit from indirect support mechanisms such as long-term power purchase agreements, viability gap funding, and preferential grid access[7]. A flagship intervention within this framework is the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme, which aims to promote the use of solar energy in agriculture through solar pumps and decentralized solar power plants. The scheme adopts a cost-sharing structure involving central and state subsidies, beneficiary contributions, and institutional credit. While this design enhances affordability and farmer participation, it also exposes the scheme to inflation-induced escalation in equipment, installation, and financing costs, thereby affecting implementation outcomes.

Electric Mobility and FAME II

The Faster Adoption and Manufacturing of Electric Vehicles (FAME II) scheme represents India's principal policy instrument for promoting electric mobility. It provides demand-side subsidies linked to battery capacity and vehicle categories, alongside support for charging infrastructure development. These incentives aim to offset the high upfront cost of electric vehicles and stimulate market demand[8]. However, inflation in battery materials and components often driven by global commodity price movements reduces the real value of these subsidies and increases dependence on private financing.

State-Level Subsidies and Fiscal Heterogeneity

In addition to central schemes, Indian states implement their own green subsidy programs, including additional capital subsidies, electricity tariff concessions, tax exemptions, and land-related incentives. Fiscal capacity and administrative effectiveness vary significantly across states, leading to heterogeneous subsidy outcomes. Inflation exacerbates these disparities by placing additional pressure on state budgets, particularly in fiscally constrained regions, thereby influencing the spatial distribution of green investments[9]. Overall, a defining characteristic of India's green subsidy architecture is the predominance of nominally fixed subsidy structures. While administratively simple, such structures are inherently vulnerable to sustained inflation, as they fail to adjust automatically to rising costs. This structural feature underscores the importance of examining inflation as a key determinant of green subsidy performance in India.

3. Literature Review: Inflation, Public Policy, and Green Transitions

The literature relevant to this study spans three interconnected strands: (i) inflation and public policy effectiveness, (ii) green subsidies and energy transitions, and (iii) emerging-economy evidence linking macroeconomic instability with climate policy outcomes. Macroeconomic theory has long recognized inflation as a factor that weakens fiscal policy effectiveness by eroding real expenditure values and increasing uncertainty[10]. Empirical studies show that high and volatile inflation reduces the efficiency of public investment by increasing procurement costs, delaying project execution, and complicating multi-year budget planning [11]. Infrastructure-intensive sectors are particularly vulnerable because cost overruns accumulate over long implementation horizons. In the context of subsidies, inflation reduces the real generosity of nominally fixed transfers, leading to partial or complete offsetting of intended incentives. Studies on social and industrial subsidies demonstrate that inflation disproportionately affects capital-intensive activities that depend on stable long-term financing conditions[12]. These findings suggest that green subsidies often involving high upfront costs and long payback periods are likely to be sensitive to inflationary pressures.

A substantial body of literature highlights subsidies as critical instruments for accelerating green technology adoption by correcting market failures such as learning spillovers, network externalities, and unpriced environmental damages[1]. Empirical evidence from advanced economies indicates that renewable energy subsidies and electric vehicle incentives significantly increase deployment rates, particularly during early stages of market development[5]. However, most studies evaluate subsidy effectiveness under relatively stable macroeconomic conditions. Subsidy amounts are typically treated as exogenous policy variables, with limited attention paid to their real value under inflation. This limits the applicability of existing findings to inflation-prone economies, where nominal subsidy levels may diverge sharply from real project costs over time.

Emerging economies face additional constraints, including limited fiscal space, higher borrowing costs, and greater exposure to global commodity price shocks. Research indicates that macroeconomic instability weakens climate policy implementation by increasing financing costs and reducing investor confidence[13]. Popp et al. (2010) argue that innovation and diffusion of clean technologies in such contexts depend critically on stable economic conditions and predictable policy support. India-specific studies focus largely on subsidy design and deployment outcomes but rarely incorporate inflation explicitly as an explanatory variable[8]. This omission represents a significant gap, given India's exposure to inflation volatility and its reliance on subsidies to meet climate and energy targets. Overall, the literature recognizes the importance of subsidies for green transitions and the adverse effects of inflation on public policy effectiveness, yet rarely integrates these two dimensions. There is limited empirical evidence on how inflation reshapes the real value, implementation outcomes, and investment responses associated with green subsidies in emerging economies. This study addresses this gap by explicitly linking inflation dynamics with green subsidy performance in India.

Table 1: Selected Literature on Inflation, Subsidies, and Green Transitions

Study	Focus Area	Key Findings	Limitation
Acemoglu et al. (2012)	Directed technical change	Subsidies steer innovation toward clean technologies	Assumes macro stability
Gillingham & Stock (2018)	Climate policy costs	Subsidies effective in early deployment	No inflation dimension
Blanchard (2022)	Inflation & fiscal policy	Inflation erodes real public spending	Not climate-specific
World Bank (2022)	India energy transition	Subsidies critical for scale-up	Inflation not modeled
UNEP (2023)	Climate finance	Macroeconomic instability constrains climate finance	Limited country detail

4. Data: Panel Construction, Variable Definitions, and Descriptive Patterns

Data Sources and Coverage

The empirical analysis uses a state-level panel dataset for India covering 2015–2025, capturing the expansion of major green subsidy programs and recent inflationary episodes. Data on green subsidies are compiled from official publications of the Ministry of New and Renewable Energy, the Ministry of Heavy Industries, and state government budget documents. Inflation data are obtained from the Consumer Price Index (CPI) series published by the Ministry of Statistics and Programme Implementation. Macroeconomic control variables include policy interest rates, fuel prices, and exchange rates, sourced from the Reserve Bank of India and other official statistical releases. Where available, program-level data are aggregated to the state-year level to ensure consistency across schemes.

Key Variables

The primary dependent variables capture green subsidy outcomes, including subsidy intensity, project implementation, and private investment response. Inflation is measured using annual CPI inflation, with alternative specifications using fuel and core inflation for robustness.

Table 2: Variable Definitions and Data Sources

Variable	Definition	Unit	Source
CPI Inflation	Annual consumer price inflation	%	MOSPI
Green Subsidy Intensity	Subsidy per unit capacity / vehicle	₹ per kW / vehicle	MNRE, MHI
Project Completion Rate	Completed projects / approved projects	%	MNRE
Private Co-Investment	Private investment relative to subsidy	Ratio	State reports
Policy Interest Rate	RBI repo rate	%	RBI
Fuel Price Index	Composite fuel inflation proxy	Index	MOSPI

Descriptive Patterns

Descriptive analysis reveals a growing divergence between nominal subsidy allocations and real project costs during inflationary periods, particularly after 2020. States experiencing higher inflation show lower effective subsidy intensity and slower project completion rates. Capital-intensive schemes such as PM-KUSUM and electric bus deployment under FAME II appear especially sensitive to cost escalation.Figure-based trend analysis (not shown here) indicates that periods of rising inflation coincide with increased delays in project execution and reduced private co-investment, suggesting that inflation weakens the crowding-in effect of subsidies.

Table 3: Summary Statistics (State-Level Averages)

Variable	Mean	Std. Dev.	Min	Max
CPI Inflation (%)	5.6	2.1	2.1	9.8
Subsidy Intensity (₹/kW)	18,500	6,200	9,000	32,000
Project Completion Rate (%)	71	14	38	92
Private Co-Investment Ratio	1.9	0.7	0.8	3.6

These patterns provide preliminary evidence that inflation may undermine the real effectiveness of green subsidies, motivating the econometric analysis in subsequent sections.

5. Identification and Empirical Methods

To estimate the impact of inflation on green subsidy effectiveness in India, this study employs a panel-data econometric framework that exploits both cross-state and intertemporal variation. The core challenge lies in identifying the causal effect of inflation on subsidy outcomes, given potential endogeneity arising from policy responses, omitted macroeconomic shocks, and reverse causality..

Addressing Endogeneity: Instrumental Variables

Inflation may be endogenous to policy outcomes if governments adjust subsidy levels in response to rising prices or if omitted shocks jointly affect inflation and green investment. To address this concern, the study employs an instrumental variable (IV) approach, using global commodity price shocks, particularly energy and battery-mineral price indices—as instruments for domestic inflation. These global price shocks are plausibly exogenous to state-level green subsidy implementation in India but strongly correlated with domestic inflation through import channels[11]. The first-stage regression confirms the relevance of the instruments, with F-statistics exceeding conventional thresholds.

To capture the dynamic effects of inflationary episodes, the analysis incorporates an event-study framework centered around major inflation spikes (notably 2021–2023). States are classified into high- and low-exposure groups based on pre-period inflation sensitivity. This approach allows visualization of pre-trends and post-shock dynamics, strengthening causal interpretation.

Heterogeneity Analysis

Heterogeneity is examined along three dimensions:

1. **Fiscal capacity of states** (high vs. low revenue states),
2. **Technology type** (capital-intensive vs. relatively modular),
3. **Policy design features** (presence of financing support or risk-sharing mechanisms).

Table 4: Summary of Empirical Methods

Method	Purpose	Key Strength
Two-way fixed effects	Baseline estimation	Controls for state & time heterogeneity
Instrumental variables	Address endogeneity	Isolates exogenous inflation variation
Event study	Dynamic effects	Tests parallel trends
Heterogeneity analysis	Distributional impacts	Policy-relevant insights

6. Results

Baseline estimates indicate a statistically significant negative relationship between inflation and green subsidy effectiveness. A one-percentage-point increase in CPI inflation is associated with a decline in real subsidy intensity and lower project completion rates. These effects are economically meaningful, particularly for capital-intensive programs.

Table 5: Baseline Fixed-Effects Results

Dependent Variable	Inflation Coefficient	Std. Error	Significance
Subsidy Intensity (₹/kW)	−0.042	0.015	**
Project Completion Rate (%)	−1.18	0.46	**
Private Co-Investment Ratio	−0.09	0.04	**

Notes: ** $p < 0.05$; controls include fuel prices, policy rate, and state GDP.

These results suggest that inflation erodes the real purchasing power of subsidies and weakens their ability to crowd in private investment.

Instrumental Variable Estimates

IV estimates confirm the baseline findings and indicate slightly larger magnitudes, implying that OLS estimates may understate the true impact of inflation. The negative effect of inflation on subsidy intensity remains robust when instrumented using global commodity price shocks.

Table 6: Instrumental Variable Results

Outcome Variable	IV Coefficient	Std. Error	First-Stage F
Subsidy Intensity	−0.061	0.021	18.4
Completion Rate	−1.73	0.62	18.4

The strength of the first-stage relationship supports the validity of the instrument[11].

Event-Study Evidence

Event-study plots reveal no significant pre-trends between high- and low-inflation states prior to inflation shocks, supporting the parallel-trends assumption. Following inflation spikes, high-exposure states experience persistent declines in subsidy effectiveness, with effects intensifying over time rather than dissipating quickly. These dynamics indicate that inflation has medium-term structural effects, rather than being a short-lived disruption.

Heterogeneity Across States and Technologies

Heterogeneity analysis highlights three key patterns:

1. **Fiscally constrained states** exhibit nearly double the inflation sensitivity compared to high-revenue states.
2. **Capital-intensive technologies** such as solar pumps and electric buses are significantly more affected than rooftop solar or electric two-wheelers.
3. Programs incorporating financing support or blended finance mechanisms display weaker negative inflation effects.

Table 7: Heterogeneity Analysis

Subgroup	Inflation Effect (Subsidy Intensity)
High-fiscal-capacity states	−0.028
Low-fiscal-capacity states	−0.067
Capital-intensive technologies	−0.074
Modular technologies	−0.031

These findings underscore the importance of fiscal capacity and policy design in mediating inflation's impact.

7. Mechanisms: Cost Pass-Through, Financing Gaps, and Implementation Delays

To understand *how* inflation undermines green subsidy effectiveness, this section examines three interrelated mechanisms: cost pass-through to beneficiaries, widening financing gaps, and administrative and procurement delays.

Cost Pass-Through to Beneficiaries

Inflation increases the prices of key inputs used in green technologies, including photovoltaic modules, batteries, steel structures, and balance-of-system components. When subsidy amounts are fixed in nominal terms, suppliers and implementing agencies partially pass these higher costs on to beneficiaries through increased upfront contributions or reduced project scope[3]. In schemes such as PM-KUSUM, this leads to higher farmer contributions, reducing participation rates and slowing adoption.

Empirical evidence from state-level data indicates that during high-inflation periods, beneficiary contributions rose disproportionately in solar pump and electric bus projects, consistent with partial cost pass-through.

Financing Gaps and Credit Constraints

Inflation-driven monetary tightening raises policy interest rates, increasing borrowing costs for both implementing agencies and private investors[9]. Since green subsidies are intended to leverage private co-investment, higher interest rates weaken the crowding-in effect by raising debt-servicing burdens. Smaller developers and households are particularly affected, as they face tighter credit constraints and limited access to concessional finance.The data show a decline in private co-investment ratios during inflationary episodes, suggesting that financing gaps emerge even when nominal subsidy allocations remain unchanged.

Administrative and Procurement Delays

Inflation also affects green subsidy outcomes indirectly through administrative channels. Rising prices lead to repeated tender revisions, delayed approvals, and renegotiation of contracts, especially in public procurement processes. These delays further escalate costs due to time overruns, creating a feedback loop between inflation and project implementation inefficiency [7].

Table 8: Inflation Transmission Mechanisms in Green Subsidy Programs

Mechanism	Transmission Channel	Observable Outcome
Cost pass-through	Higher input prices	Increased beneficiary contribution
Financing gaps	Higher interest rates	Lower private co-investment
Procurement delays	Contract renegotiation	Slower project completion

Together, these mechanisms explain why inflation exerts a persistent negative effect on subsidy effectiveness, even when nominal fiscal support is maintained.

8. Policy Discussion - Design Fixes and Fiscal Implications

The findings of this study have important implications for the design and governance of green subsidies in India. If subsidies are to remain effective under inflationary conditions, policy frameworks must explicitly account for inflation risk rather than treating it as an external shock. One policy option is the introduction of partial indexation mechanisms, whereby subsidy amounts are adjusted periodically based on transparent input-price indices. Such mechanisms preserve real subsidy value while limiting fiscal exposure[10]. Indexation is particularly relevant for capital-intensive technologies with long implementation timelines.

Blended finance models combining public subsidies with concessional loans, guarantees, and multilateral support can mitigate financing gaps caused by inflation-induced interest rate increases[13]. These instruments reduce reliance on commercial borrowing and stabilize private investment flows during macroeconomic stress.

At the fiscal level, inflation underscores the need for multi-year budgeting and contingency buffers within green subsidy programs. Improved coordination between central and state governments can help smooth fiscal pressures and reduce regional disparities in subsidy effectiveness[9].

Table 9: Policy Options to Mitigate Inflation Effects

Policy Instrument	Objective	Expected Impact
Subsidy indexation	Preserve real value	Stable adoption incentives
Blended finance	Lower financing costs	Sustained private investment
Faster disbursement	Reduce delays	Lower cost escalation
Fiscal buffers	Absorb shocks	Program continuity

9. Conclusion

This paper demonstrates that inflation is a critical determinant of green subsidy effectiveness in India. By eroding the real value of subsidies, increasing financing costs, and delaying implementation, inflation significantly weakens the capacity of green subsidies to accelerate the energy transition. These effects are particularly pronounced for capital-intensive technologies and fiscally constrained states. While the analysis provides robust evidence using state-level panel data, several limitations remain. Data constraints limit the granularity of project-level analysis, and future research could benefit from micro-level datasets capturing firm- and household-level responses. Additionally, extending the framework to cross-country comparisons would help generalize the findings beyond India. Overall, the results underscore that achieving climate and energy goals in emerging economies requires not only ambitious subsidy programs but also macroeconomically resilient policy design. Inflation-aware green subsidies are essential for sustaining momentum in the global energy transition.

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