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Subsidies, costs, and local taxes: a theoretical note on circular economy investments

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Abstract

This paper develops a theoretical model to examine how investment subsidies for circular economy projects influence local taxation in decentralized governance systems. When environmental infrastructure is co-financed by higher-level governments but operated locally, fiscal effects depend on how investments modify cost structures. Using a principal–agent framework, I show that the relationship between subsidies and local taxes is non-monotonic: at low investment levels, subsidies reduce costs and taxes, but beyond the efficiency threshold, further investment raises operational complexity and fiscal pressure. A dynamic extension incorporating transition costs explains why local taxes may temporarily increase before efficiency gains materialize. The model offers a tractable framework to interpret the fiscal implications of circular economy policies within multi-level European governance, with specific relevance to current EU funding schemes.

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1 Introduction

The transition to a circular economy has become a central objective of contemporary environmental policy. By shifting away from linear modes of production and consumption, circular economy strategies seek to reduce waste, enhance resource efficiency, and promote long-term sustainability through closed material loops. The environmental case for circularity is well established; what remains less developed is the understanding of its fiscal and institutional implications, particularly at the local level. In practice, circular economy reforms are implemented through a wide array of local infrastructures—ranging from advanced waste sorting facilities and water reuse plants to decentralized renewable energy systems and repair networks. Each of these requires substantial up-front investment and ongoing operational coordination, both of which are mediated through public finance.

To overcome the financial barriers to investment, governments frequently rely on targeted subsidies and grants. Such incentives are central to European and national sustainability agendas: the EU's Green Deal, Cohesion Policy, and the Recovery and Resilience Facility (RRF) all include earmarked funds for circular economy initiatives. These programs are meant to stimulate capital formation, accelerate technological adoption, and compensate for externalities associated with environmental innovation [Arrow, 1962, Acemoglu et al., 2012]. Yet, while the macroeconomic rationale for these subsidies is clear, their micro-level fiscal consequences are often ambiguous [Aghion et al., 2005]. Local governments—the entities responsible for implementing most of these projects—must reconcile the benefits of increased investment with the burden of covering new operational costs.

In many European countries, environmental services such as waste management, water treatment, and energy distribution are provided by municipalities or semi-autonomous local utilities (see, e.g., [Bel and Warner, 2008]). These entities operate under fiscal decentralization: although higher tiers of government may finance investment, recurrent costs are typically borne by local budgets and recovered through user fees or local taxation (see evidence on waste management costs in Bel and Fageda [2010]). This institutional configuration creates a fundamental fiscal link between investment incentives and local tax outcomes. A subsidy that encourages additional investment can, depending on the structure of costs, either lower taxes (by improving efficiency) or raise them (by increasing complexity or administrative overhead). Understanding when and why these effects occur is critical for designing sustainable fiscal frameworks.

The fiscal tension underlying circular investments mirrors a classic problem in fiscal federalism. As shown by Oates [1972] and further developed in the fiscal federalism literature (e.g., Boadway and Shah [2009]), decentralization creates incentives for local efficiency but also the risk of fiscal fragmentation. In the context of the circular economy, this tension is magnified: while central or supranational institutions provide funding, local governments retain operational responsibility and face hard budget constraints. If subsidies induce investments that reduce long-run costs, they alleviate local fiscal pressure. But if they trigger short-term diseconomies—due to learning, parallel systems, or regulatory adaptation—local taxes may increase, at least temporarily. This potential non-monotonicity in the relationship between subsidies and local fiscal outcomes remains underexplored in both the theoretical and policy literatures.

This paper addresses three related questions. First, how do public investment subsidies affect local fiscal burdens in the context of circular economy reforms? Second, under what conditions do they lead to higher or lower local taxes? Third, how do these effects evolve over time, particularly when transition costs are present? While these questions have clear empirical relevance—especially in EU member states with active circular economy programs—they have received limited theoretical attention. Most existing contributions focus either on the macroeconomic design of green subsidies or on the environmental performance of circular investments, with less emphasis on their local fiscal consequences. This note contributes to filling that gap.

To do so, we develop a simple but flexible theoretical framework that captures the fiscal trade-offs faced by municipalities engaging in circular reforms. The model is structured as a principal–agent interaction: a local authority (the principal) imposes a quality standard on a service provider (the agent) and offers an earmarked subsidy to induce investment in circular infrastructure. The provider chooses the investment level to minimize operational costs while satisfying the mandated quality. Within this setup, we derive conditions under which subsidies reduce or increase local taxes. A quadratic cost specification reveals a non-monotonic, U-shaped relation between subsidies and the tax burden, highlighting how efficiency gains can be reversed beyond an optimal investment threshold.

To reflect real-world implementation, we extend the framework to include dynamic adjustment costs that capture transitional frictions—such as workforce training, administrative adaptation, and duplication of legacy systems. This extension explains why local taxes may temporarily rise before efficiency gains materialize, a pattern consistent with observed fiscal "humps" in environmental modernization (for instance, during waste reform transitions in Italy or district energy upgrades in Germany)[Baraldi et al., 2025].

Importantly, the framework is intentionally general and can be applied beyond environmental services. It encompasses a wide range of subsidy-driven infrastructure programs—renewable energy, water efficiency, or repair networks—where local governments act as intermediaries between upper-level funding and citizen-level taxation. It also provides a foundation for integrating fiscal instruments into broader circular economy strategies. By clarifying the mechanisms through which subsidies affect local taxation, the model offers insights for designing policies that are not only environmentally sustainable but also fiscally coherent.

2 The Model

Consider a local government (principal) that delegates service provision to a regulated agent (a municipal utility or contractor). The agent chooses investment I to minimize the total cost $C(I)$ of providing a fixed service quality $\bar{q}$.

A higher-level government provides an earmarked subsidy S, expanding the feasible range of investments to $I \in [I_{\min}, I(S)]$ with $I'(S) > 0$.

Interpretation. We model the subsidy as expanding the feasible investment set, rather than entering directly the agent's objective, to capture earmarked transfers that relax binding implementation constraints (e.g., co-financing ceilings, borrowing limits, or administrative capacity constraints). In this interpretation, the transfer increases the maximum implementable investment level $I(S)$. This formulation keeps the comparative statics transparent: as long as S raises the induced investment level, the fiscal effect operates through the sign of the operating-cost gradient $C'(I)$.

The per-capita tax required to finance the service is:

$$\tau(S) = \frac{C(I^*(S))}{N}, \tag{1}$$

where $I^*(S)$ is the optimal investment induced by S, and N is the number of taxpayers. Differentiating with respect to S:

$$\frac{d\tau}{dS} = \frac{1}{N}\frac{dC}{dI}\frac{dI^*}{dS}. \tag{2}$$

Proposition 1. *The fiscal effect of a subsidy depends on the cost gradient. If $\frac{dC}{dI} < 0$, a subsidy lowers local taxes ($\frac{d\tau}{dS} < 0$); if $\frac{dC}{dI} > 0$, it raises them ($\frac{d\tau}{dS} > 0$).*

Remark (standard grants). The same sign logic extends to proportional investment grants (or matching schemes) whenever they increase the chosen investment level. If S enters as a subsidy to investment costs, it still induces $dI/dS > 0$ under standard regularity conditions, and thus

$$\frac{d\tau}{dS} = \frac{1}{N} C'(I) \frac{dI}{dS}.$$

Therefore, whether taxes fall or rise hinges on whether marginal investment reduces or

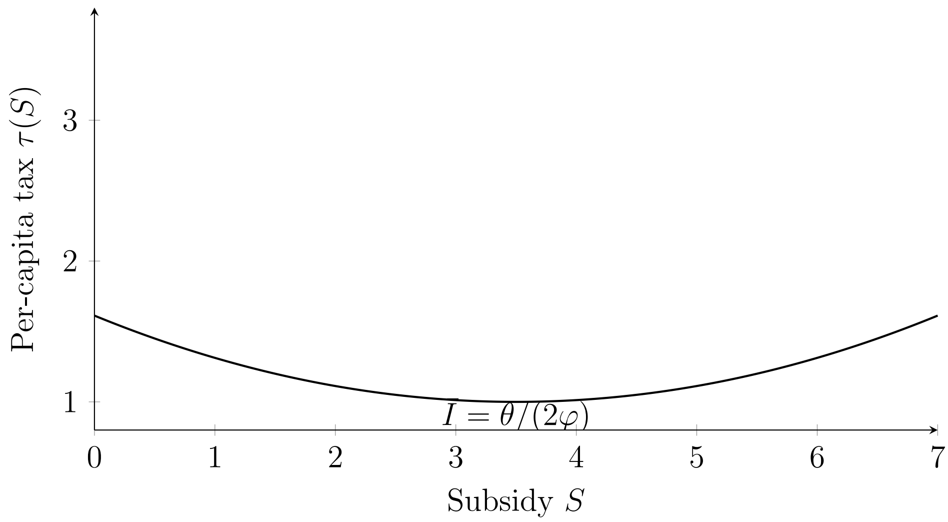

Figure 1: A U-shaped relationship between subsidies and per-capita taxes. Taxes decrease until the efficiency threshold $\bar{I}$, then rise due to complexity and maintenance costs.

increases operating costs, i.e., on the sign of $C'(I)$.

2.1 Analytical Example

Let $C(I) = c_0 - \theta I + \varphi I^2$, with $\theta > 0$, $\varphi > 0$. Then $C'(I) = \frac{dC}{dI} = -\theta + 2\varphi I$, and define the efficiency threshold

$$\bar{I} \equiv \frac{\theta}{2\varphi},$$

i.e., the unique point where $C'(I) = 0$.

Economic interpretation. The threshold $\bar{I}$ is the point where marginal investment stops generating operating-cost savings and starts increasing operating costs. For $I < \bar{I}$, additional investment delivers efficiency gains (e.g., better process efficiency or coordination), so $C'(I) < 0$; for $I > \bar{I}$, further investment reflects over-capitalization, with maintenance and organizational complexity dominating, so $C'(I) > 0$. Therefore, a subsidy that raises investment lowers taxes below $\bar{I}$ but raises them above $\bar{I}$, yielding the U-shaped tax response in Figure 1.

Hence,

$$\frac{d\tau}{dS} \begin{cases} < 0 & \text{if } I^*(S) < \bar{I}, \\ > 0 & \text{if } I^*(S) > \bar{I}. \end{cases}$$

The relationship between subsidy and local tax is non-monotonic: initially negative, then positive as the system becomes overcapitalized.

3 Short-run vs. Long-run Taxes: A Transitional-Cost Remark

Scope of the remark. This section is intentionally reduced-form: rather than modelling a full intertemporal optimization problem and a law of motion for investment, it contrasts short-run taxes (including adjustment costs) with long-run taxes once transitional frictions vanish.

Introducing a dynamic adjustment cost $A(I) > 0$, per-capita taxes in the short and long run become:

$$\tau_1(S) = \frac{C(I) + A(I)}{N}, \quad \tau_2(S) = \frac{C(I)}{N}.$$

Differentiating:

$$\frac{d\tau_1}{dS} = \frac{1}{N}\left(\frac{dC}{dI} + \frac{dA}{dI}\right)\frac{dI}{dS}, \quad \frac{d\tau_2}{dS} = \frac{1}{N}\frac{dC}{dI}\frac{dI}{dS}.$$

Even if $\frac{dC}{dI} < 0$, a positive $\frac{dA}{dI}$ implies temporary tax increases. This dynamic captures fiscal "humps" often observed when modernizing environmental services—for instance, during waste separation reforms in Italy or district heating transitions in Germany.

Takeaway. The purpose of this comparison is simply to highlight that the fiscal effect of investment-inducing subsidies can differ across horizons. In the short run, adjustment costs may generate a temporary increase in taxes even when the long-run effect is tax-reducing; once transitional frictions vanish, the sign is again governed by the operating-cost gradient $C'(I)$ as in Section 2.

4 Policy Implications and European Context

The model shows that subsidies are not fiscally neutral: they alter cost structures and local tax dynamics. This section extends the analysis to real-world fiscal systems, emphasizing the interaction between local autonomy, central transfers, and EU coordination.

4.1 Outcome-based and incentive-compatible design

Equation (2) suggests that fiscal efficiency requires $\frac{dC}{dI} < 0$ in the relevant range. If subsidies reward expenditure rather than outcomes, municipalities may over-invest, leading to $\frac{dC}{dI} > 0$. Outcome-based schemes—linking transfers to performance metrics such as recycling rates, waste reduction, or cost per unit of service—can restore alignment between financial incentives and efficiency. This corresponds to the first-order condition for an optimal contract in a principal–agent setting where the central authority minimizes total fiscal cost under incentive compatibility:

$$\min_S [C(I(S)) - S] \quad \text{s.t.} \quad \frac{dC}{dI} < 0.$$

In practice, this approach is reflected in EU performance-based disbursements under the Recovery and Resilience Facility (RRF).

4.2 Heterogeneity and fiscal equalization

Parameter heterogeneity (θ, ϕ) implies that identical subsidies can produce opposite effects across jurisdictions. In under-invested Southern European municipalities, subsidies often reduce costs ($\frac{dC}{dI} < 0$), while in highly efficient Northern systems, the same support can induce costly duplication ($\frac{dC}{dI} > 0$). This calls for differentiated grant intensities or co-financing rules, consistent with fiscal equalization theory [Oates, 1972, Boadway and Shah, 2009]. Germany's federal system partially internalizes these effects through the *Länderfinanzausgleich*, which redistributes fiscal capacity. Italy and Spain, however, exhibit greater asymmetry between subsidy allocation and local capacity, explaining the higher dispersion of municipal taxes in circular economy projects [Bartolacci et al., 2019].

4.3 Dynamic coordination and transitional fiscal rules

The dynamic model highlights that short-term costs ($A(I)$) can delay net fiscal benefits. In the EU context, rigid balanced-budget rules limit local flexibility during this transition. If local governments cannot borrow to cover temporary deficits, they may underinvest despite long-run efficiency gains. Flexible fiscal frameworks—such as "golden rules" that allow borrowing for green capital expenditure—can mitigate this distortion. Analytically, relaxing short-term constraints lowers $\frac{dA}{dI}$, shifting the short-run tax curve downward without altering long-run optimality. Such mechanisms are currently being debated within the reform of the EU Stability and Growth Pact.

4.4 Institutional and absorptive capacity

The responsiveness $\frac{dI^*}{dS}$ varies with administrative capacity. Municipalities with professionalized procurement and planning capabilities tend to convert subsidies into efficient investments, while smaller entities face transaction and coordination costs that reduce effectiveness. Empirically, this heterogeneity mirrors the patterns found in R&D cooperation [Cantabene and Grassi, 2019, 2024, Capuano and Grassi, 2019, 2020, 2022]. Enhancing technical assistance and inter-municipal cooperation can steepen the efficiency response, ensuring that subsidies translate into cost savings rather than bureaucratic overhead.

4.5 Multi-level fiscal interaction in Europe

The European fiscal architecture involves overlapping layers of responsibility: EU grants, national co-financing, and municipal service provision. This structure generates vertical fiscal externalities analogous to those discussed in Keen [1998]. When central governments subsidize investment but local authorities bear recurrent costs, misalignment arises unless intergovernmental transfers account for $\frac{dC}{dI}$ at the local level. Countries with integrated fiscal monitoring (e.g., Nordic nations) tend to avoid such inefficiencies. In contrast, systems with fragmented governance—such as Italy or Spain—often experience time-inconsistent outcomes: short-run tax hikes and delayed savings.

4.6 Policy synthesis

The analytical results converge on three priorities. First, subsidies must be *outcome-based* and sensitive to local efficiency parameters. Second, transitional fiscal rules should permit temporary flexibility to accommodate adjustment costs. Third, coordination across levels of government is essential to align incentives and internalize fiscal spillovers. In multi-level governance, the derivative $\frac{d\tau}{dS}$ encapsulates not just the local response to a subsidy but also the coherence of fiscal federalism itself.

5 Conclusion

This paper develops a parsimonious model linking subsidies, operating costs, and local taxation in the context of circular economy investments. The results show that subsidies can either alleviate or intensify fiscal pressure depending on whether marginal investment reduces or increases operating costs. The quadratic formulation yields a U-shaped relation between subsidies and taxes, while the dynamic extension accounts for short-run fiscal humps. Policy implications extend beyond local contexts: designing incentive-compatible, outcome-based, and temporally flexible subsidies is key to achieving both environmental and fiscal sustainability across Europe. The model offers a conceptual foundation for future empirical analysis of subsidy–tax interactions under the EU's evolving fiscal framework.

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