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The Global Circularity Paradox: Reconciling the Value Gap with the Structural Logic of the Circular Economy

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Abstract: This article examines an apparent paradox at the heart of the global transition to a circular economy: despite a growing number of policy commitments and corporate initiatives, the measured global circularity metric has declined in recent years. The aim of the study is to explain this paradox through the structural logic of the circular economy and to quantify the economic cost of the prevailing linear model using the recently introduced Value Gap concept. Drawing on a comparative analysis of secondary data from leading international reports, the study finds that recycling capacity, although growing in absolute terms, expands more slowly than primary raw-material consumption, while a substantial share of extracted materials becomes locked in long-lived assets. The analysis shows that the largest share of avoidable economic loss – 39.4 percent – occurs at the end-of-life stage, confirming the economic priority of collection and recycling loops. A further disaggregation by material type reveals that circular potential is bounded by the physico-chemical nature of materials, ranging from 23.4 percent for metals to 3.8 percent for fossil energy carriers. The findings imply that the circular mechanism must be treated as a systemic whole rather than reduced to the recycling stage alone.

Keywords: circular economy, circularity gap, value gap, material footprint, resource decoupling, closed-loop systems, systemic transition, material flows.

1. Introduction

The linear economic model, characterized by a “take, make, dispose” logic, has dominated industrial production for decades. Under this model, raw materials are extracted, transformed into products, and discarded as waste after use, leading to resource depletion and mounting environmental pressure [1]. With more than two billion tonnes of municipal solid waste generated annually and approximately eight million tonnes of plastic entering the oceans each year, the need for a sustainable alternative has become urgent.

The circular economy has emerged as an alternative that seeks to keep resources, materials, and products in economic circulation for as long as possible, extracting maximum value from them and regenerating natural systems at the end of their service life [2]. This approach is not concerned solely with recycling; it rethinks how goods are designed, used, and reused, thereby minimizing their environmental impact.

Yet a striking empirical observation challenges optimistic narratives about this transition. Although the number of global policy agreements and corporate circular

initiatives has increased, the measured circularity of the world economy has not improved – it has, in fact, declined. This constitutes what may be termed the circularity paradox: rising commitment coexists with falling performance. Understanding this paradox is essential, because it determines whether current policy instruments are correctly targeted.

Accordingly, the aim of this study is twofold: first, to explain the circularity paradox through the structural logic of the circular mechanism; and second, to quantify the economic cost of the linear model using the Value Gap concept introduced by Circle Economy and Deloitte in 2026. The study addresses four research questions. Why does circularity decline despite growing effort? Where in the value chain is economic value lost? How does circular potential vary across material types? And what do these patterns reveal about the priorities of the circular mechanism? The novelty of the study lies in linking the macro-level circularity paradox to the structural logic of the operational mechanism, thereby moving beyond a purely descriptive account [3], [4].

2. Materials and Methods

This study employs a quantitative secondary-data analysis based on authoritative international sources. The analysis proceeds in three stages.

The primary data sources are the Circularity Gap Report series (Circle Economy Foundation), the Global Resources Outlook (UNEP International Resource Panel), the Value Gap methodology developed by Circle Economy Foundation and Deloitte Netherlands, and the circular-material-use statistics compiled by Eurostat and the European Environment Agency.

The principal method is comparative trend analysis, used to contrast two opposing dynamics: the growth of global material extraction and the decline of the secondary-material share. The second method is structural decomposition, applied to disaggregate total avoidable economic loss into distinct channels according to where in the product life cycle it arises. The third method is cross-sectional comparison, used to examine variation in circularity across EU member states and across material types.

Data reliability was ensured by relying exclusively on peer-reviewed literature and the official reports of internationally recognized organizations. The unit of analysis is the aggregate global material flow, expressed in gigatons for physical flows and in euros for economic value. Where several sources reported the same indicator, the most recent value was adopted and cross-checked against an independent source.

3. Result

3.1. The two opposing dynamics

The comparative trend analysis reveals two contradictory tendencies (Figure 1). On the one hand, global material extraction rose from 30 billion tonnes in 1970 to 106 billion tonnes in 2020 – more than a threefold increase – while per-capita daily material consumption grew from 23 to 39 kilograms. On the other hand, the global circularity metric – the share of secondary materials in total material use – declined from 9.1 percent in 2018 to 6.9 percent within a span of eight years [5].

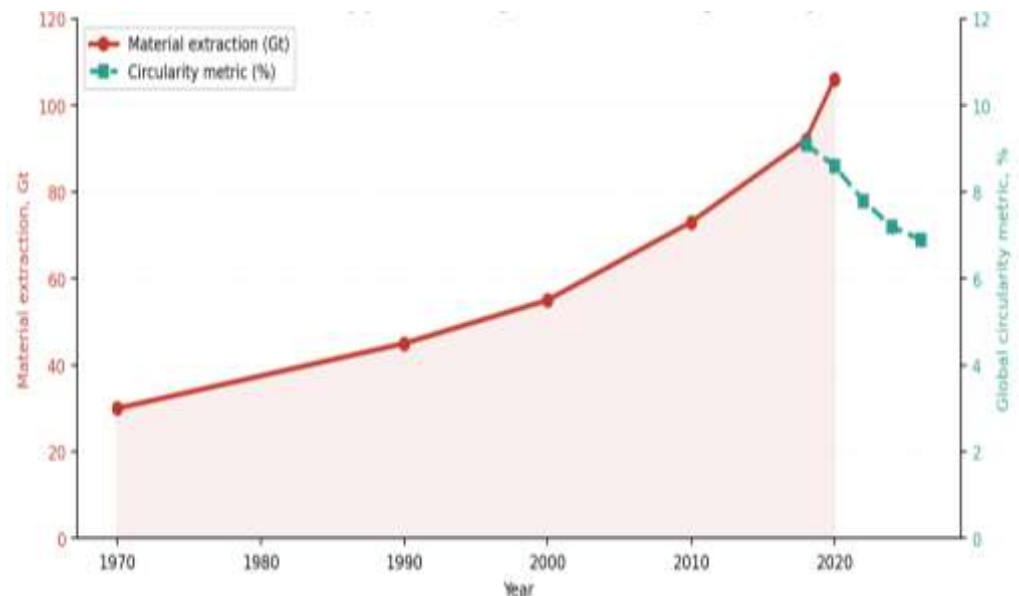


Figure 1. The circularity paradox: rising material extraction against a falling circularity metric

These findings are summarized in Table 1, together with the medium-term targets and projections.

Table 1. Global circularity metrics and the dynamics of material consumption

Indicator	Baseline value	Current value	Target / projection
Global circularity metric	9.1% (2018)	6.9%	17% (2032 target)
Primary raw-material share	90.9% (2018)	93.1%	83% (2032 target)
Material extraction volume	30 Gt (1970)	106 Gt (2020)	160 Gt (2060, baseline)
Per-capita daily material use	23 kg (1970)	39 kg (2020)	Must be reduced
Share of extraction and processing in global emissions	—	>55%	Up to 80% reduction possible

The paradox is explained by the mechanism's internal logic: recycling capacity, although rising in absolute terms, grows more slowly than primary raw-material consumption. Furthermore, a substantial share of extracted materials becomes locked in buildings, infrastructure, and long-lived capital assets, and is therefore unavailable for short-term circulation [6], [7]. This explains why growing recycling effort has not translated into a rising circularity metric.

3.2. The economic cost of linearity

While environmental arguments have traditionally dominated the case for circularity, the Value Gap methodology reframes the problem in purely economic terms. The Value Gap quantifies the economic value that is lost through linear and inefficient resource use but that could, in principle, be recovered. According to the methodology, this annual loss amounts to 25.4 trillion euros, equivalent to approximately 31 percent of global

gross domestic product [8], [9]. In other words, roughly one euro in every three of value created in the world economy is lost from the system. The composition of this loss is presented in Figure 2 and Table 2.

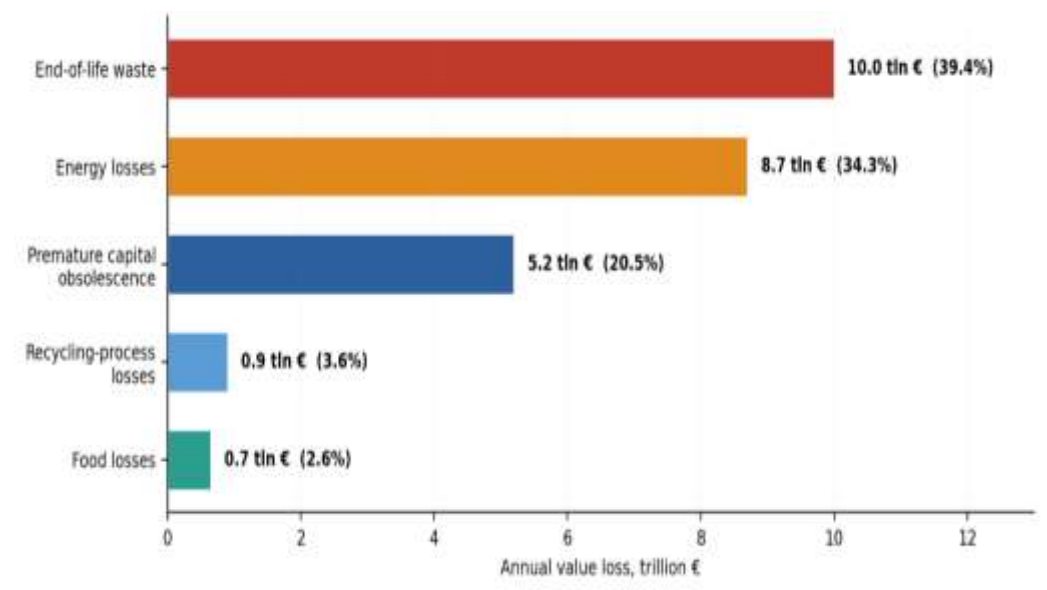


Figure 2. Composition of the Value Gap by loss channel

Table 2. Composition of value losses arising from the linear economic model

Loss channel	Volume (trillion €)	Share (%)	Underlying cause and circular solution
End-of-life waste	10.000	39.4	Products landfilled or incinerated instead of reused; solution: take-back systems and eco-design
Energy losses	8.700	34.3	Inefficiency in extraction, transmission, insulation; solution: efficiency and secondary materials
Premature capital obsolescence	5.200	20.5	Lack of modular design; solution: modularity and predictive maintenance
Recycling-process losses	0.904	3.6	Material waste in conversion; solution: industrial symbiosis
Food losses	0.651	2.6	Losses in logistics and retail; solution: cold chains and redistribution
Total	25.400	100.0	About 31% of global GDP annually

3.3. Circularity across EU member states

Cross-sectional comparison of EU member states reveals substantial stratification (Figure 3). The circular-material-use rate ranges from 32.7 percent in the leading country,

the Netherlands, to just 1.3 percent in Romania – a difference of more than twenty-five-fold. The EU average stood at 12.2 percent in 2024 and has risen by only about one percentage point over the past decade.

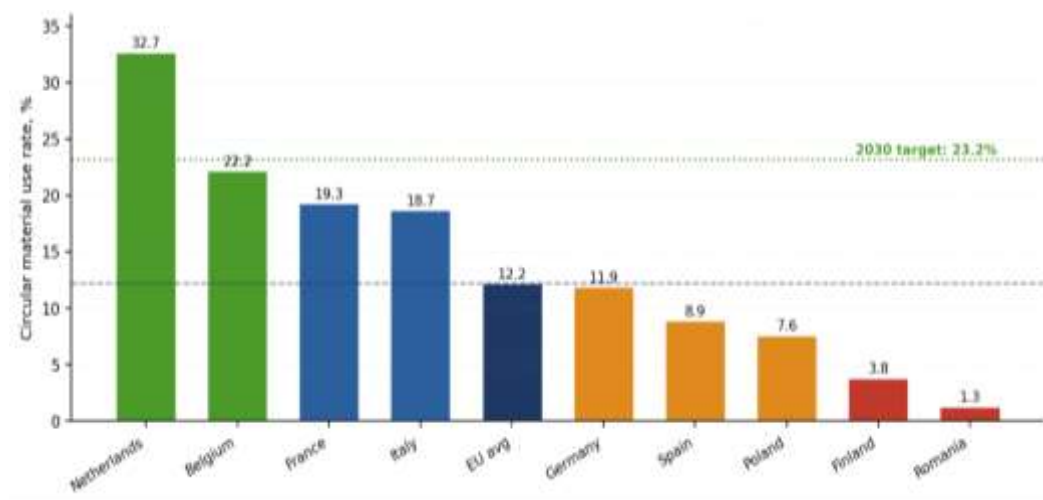


Figure 3. Circular material use rate across EU member states, 2024

The causes of stratification are not confined to recycling capacity. Structural features of national economies are decisive: in countries with a large extractive sector, the primary material flow in the denominator is large, so the circularity coefficient is low. Conversely, densely populated, service-oriented economies with well-developed secondary-material markets record higher rates.

3.4. Circularity by material type

Disaggregation by material type demonstrates that circular potential is bounded by the physic-chemical nature of materials (Figure 4, Table 3). Metals achieve the highest rate at 23.4 percent, owing to the ease with which ferrous and non-ferrous scrap can be remelted [10]. Fossil energy carriers achieve only 3.8 percent, because fuel is irreversibly consumed through combustion.

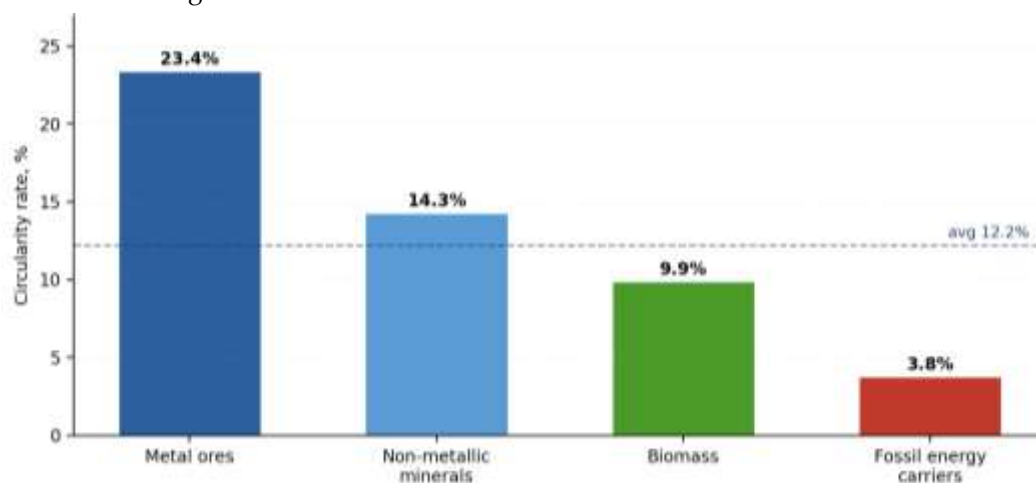


Figure 4. Circularity rate by material type in the European Union, 2024

Table 3. Circularity rate by material type (European Union, 2024)

Material type	Circularity rate (%)	Change vs 2023	Analytical note
Metal ores	23.4	−1.2 pp	Highest rate; ferrous and non-ferrous scrap easily remelted
Non-metallic minerals	14.3	−0.1 pp	Above average through construction-waste recycling; largest flow by volume
Biomass	9.9	+0.2 pp	Growing slowly through composting and paper recovery
Fossil energy carriers	3.8	+0.4 pp	Lowest rate; irreversibly consumed through combustion
Average (all materials)	12.2	0.0 pp	23.2% targeted by 2030

This finding carries a theoretically important implication: because materials differ fundamentally in their recyclability, the circular economy distinguishes biological from technical cycles, and treats energy flows as a separate problem to be solved through the transition to renewable sources rather than through material circulation.

4. Discussion

The results add important nuance to the understanding of the circular economy's structure. The single largest share of avoidable loss — 39.4 percent — occurs at the end-of-life stage, directly confirming the economic significance of the collection and recycling loops within the operational mechanism [11], [12]. The second-largest channel, energy losses at 34.3 percent, demonstrates the intimate link between the circular economy and the renewable-energy transition. Together, the two smallest channels – recycling-process losses and food losses – account for only 6.2 percent, indicating that policy attention should concentrate on product design, end-of-life flows, and capital-asset efficiency rather than on marginal process improvements.

The circularity paradox itself carries a critical methodological lesson. It demonstrates that the operational mechanism of the circular economy cannot be activated effectively by emphasizing the recycling stage alone. Because recycling capacity structurally lags behind primary consumption, genuine progress depends on reducing resource consumption at the outset and on extending product life cycles. This finding is consistent with prior work emphasizing that the circular economy is a systemic reconfiguration rather than an improved waste-management practice [13].

The cross-sectional evidence reinforces this conclusion from two directions. The variation across member states shows that circularity depends on economic structure, not merely on recycling capacity, which implies that policy must be tailored to national conditions. The variation across material types shows that circular potential is physically bounded, which implies that energy flows require a distinct, renewable-energy-based solution rather than material recycling.

The practical implication is that circular policy should priorities upstream interventions – eco-design, product-life extension, and modular architecture – over downstream recycling investment. The Value Gap analysis reinforces this conclusion by showing that end-of-life and early-obsolescence losses jointly represent nearly 60 percent of total avoidable loss, both of which are addressed by design-stage strategies. For

economies with a large extractive sector, this also implies that reported circularity coefficients should be interpreted with caution, since a large primary flow mechanically depresses the ratio.

The limitations of this study stem from its reliance on aggregate global estimates, which mask substantial regional and sectoral variation [14], [15]. Moreover, the Value Gap methodology is recent and its assumptions warrant independent validation. Future research should disaggregate the Value Gap by sector and region, test the sensitivity of its estimates to alternative accounting boundaries, and examine the interaction between material circularity and the energy transition.

5. Conclusion

This study set out to explain the global circularity paradox and to quantify the economic cost of linearity. The principal conclusions are as follows.

First, the decline of the circularity metric from 9.1 to 6.9 percent, despite growing commitment, reflects the structural fact that recycling capacity expands more slowly than primary consumption and that much material is locked in long-lived assets. Second, the linear model imposes an annual economic cost of 25.4 trillion euros, approximately 31 percent of global GDP. Third, the concentration of losses at the end-of-life stage confirms the economic priority of collection and recycling loops, while the prominence of energy losses links circularity to the renewable-energy transition. Fourth, circular potential is bounded by material type, ranging from 23.4 percent for metals to 3.8 percent for fossil energy carriers, which justifies the theoretical distinction between material cycles and energy flows.

Taken together, the findings demonstrate that the circular economy must be pursued as a systemic whole, with particular emphasis on upstream design strategies rather than on recycling in isolation. This systemic perspective offers a more accurate diagnosis of why the transition has stalled and a clearer indication of where corrective effort should be concentrated.

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