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RESEARCH ARTICLE

Rethinking Inflation through the Circular Economy: A Markov Switching Analysis of European Countries

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Abstract

This paper investigates whether the transition to a circular economy reduces or increases the inflation rate. To address this question, we model the inflation rate using a Markov switching panel data model, analyzing data from 27 European countries over the period 2010–2019. Our findings provide strong evidence that advancing toward a circular economy significantly reduces inflation. To support these results, we employ various circular economy indexes and conduct robustness checks by estimating all models using the Generalized Method of Moments (GMM). The GMM results confirm the robustness of the relationship between the circular economy and inflation. These findings carry important policy implications, demonstrating that transitioning to a circular economy not only preserves resources and protects the environment but also reduces inflation—a critical consideration for policymakers.

Keywords Inflation · Circular Economy · Markov Switching · European Countries · GMM

1. Introduction

Inflation is a critical macroeconomic variable with far-reaching consequences for both societies and policymakers. Rising prices erode households' purchasing power, disproportionately affecting vulnerable groups, while also distorting economic decision-making and resource allocation (Binetti et al., 2024; Ahmed, 2024). For policymakers, stabilizing inflation is central to safeguarding economic stability and social cohesion, forming the foundation of modern monetary frameworks such as inflation targeting (Bernanke & Mishkin, 1997). Moreover, inflation volatility generates uncertainty, discourages investment, and undermines long-term growth prospects (Huizinga, 1993). In light of these challenges, identifying innovative and sustainable strategies to contain inflationary pressures has become an urgent policy and research priority.

At the same time, the circular economy (CE) has gained prominence as a transformative alternative to the linear "take–make–dispose" model (Ghisellini et al., 2016; De Jesus et al., 2018). By emphasizing resource efficiency, waste minimization, and closed-loop production systems, CE aims to preserve resources while stimulating innovation and productivity (Ghisellini & Ulgiati, 2020; van Langen et al., 2021). While its environmental benefits are widely acknowledged, the macroeconomic implications of CE remain insufficiently explored. In particular, little is known about how CE practices interact with inflationary dynamics, and through which channels these effects are transmitted.

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The existing evidence offers contradictory perspectives. On one hand, scholars argue that CE can reduce inflationary pressures by enhancing resource productivity, lowering firms' dependence on volatile imports, and smoothing supply bottlenecks (Velenturf & Purnell, 2021; Bossone et al., 2022; Cai et al., 2024). On the other hand, critics emphasize that CE transitions often involve high upfront costs for recycling infrastructure, eco-design, and supply chain restructuring, which can raise production costs and even fuel sector-specific inflation in industries such as packaging, textiles, and electronics (Di Stefano et al., 2023; Valenzuela & Böhm, 2017). This unresolved tension between potential short-term inflationary costs and long-term disinflationary benefits represents a clear knowledge gap. Addressing this gap is essential not only for advancing theory at the intersection of sustainability and macroeconomics but also for informing policymakers about the broader economic consequences of CE adoption.

This paper seeks to fill this gap by analyzing the impact of CE adoption on inflation in 27 European countries during 2010–2019. Europe provides a particularly appropriate setting for three reasons. First, it has been a global leader in CE policy initiatives, most notably through the launch of the EU Circular Economy Action Plan in 2015, which accelerated transitions across sectors. Second, the chosen period coincides with heightened inflationary pressures linked to the post-financial-crisis recovery, resource price volatility, and structural reforms, offering a rich context to assess CE's macroeconomic role. Third, this timeframe allows us to evaluate whether CE adoption can bolster economic resilience in the face of contemporary challenges such as supply chain disruptions and resource scarcity, issues that remain central to ongoing debates on sustainable economics and monetary policy.

Methodologically, we employ a Markov switching panel model to capture the nonlinear and regime-dependent nature of inflation dynamics, complemented by robustness checks using the Generalized Method of Moments (GMM). This dual approach enables us to test whether CE adoption reduces inflation across different regimes and to disentangle its effects from other macroeconomic drivers. By doing so, our paper contributes to three strands of research: (i) ecological and circular economy studies, by extending their scope to macroeconomic outcomes; (ii) inflation and monetary economics, by introducing CE as a novel determinant of price stability; and (iii) sustainable growth policy debates, by demonstrating how CE strategies can deliver environmental and economic benefits simultaneously.

The remainder of the paper is organized as follows. Section 2 develops the theoretical framework and reviews competing perspectives on CE and inflation. Section 3 presents the methodology and data. Section 4 discusses the empirical results. Section 5 concludes with key findings, and finally, section 6 has devoted to policy implications, and directions for future research.

2. Theoretical Framework

The circular economy (CE) shifts production and consumption away from the linear "take-make-dispose" model toward resource efficiency, waste recycling, and product longevity (Kirchherr et al., 2023). By design, CE practices (reuse, remanufacturing, recycling) reduce firms' reliance on virgin inputs. At the microeconomic level, this translates into lower unit costs and productivity gains. For example, reusing secondary materials improves material security and cuts raw-material expenditures, potentially leading to "savings on the purchase of raw materials, which may then lead to lower and less rapidly growing final prices" (Bossone et al., 2022). By extending product lifetimes and enabling sharing or lease models (so that "households and businesses are more willing to pay for the use of durable goods rather than buy them" (Bossone et al., 2022)), CE can slow the throughput of new goods. These efficiency and substitution effects – producing "more with less" – directly compress cost-push pressures by replacing volatile or expensive inputs with cheaper, recycled alternatives (Bossone et al., 2022). In sum, CE's microeconomic impact is to boost resource productivity (Van Ewijk, 2018) and reduce average production costs, which suppresses firms' incentive to raise prices in response to cost shocks.

2.1. Macroeconomic Channels of Inflation

At the macro level, CE affects standard inflation channels:

Cost-Push Channel: In cost-push inflation, firms pass higher input costs (wages, energy, commodities) onto consumers. CE counteracts this by smoothing supply bottlenecks and compressing input costs. Recycling and remanufacturing lower dependence on scarce resources (e.g. metals, oil) and insulate the economy from raw-material price spikes (Bossone et al., 2022). For instance, a World Bank analysis notes that using recycled materials builds supply security and can reduce pressures from resource extraction, helping contain "price growth on the supply side" (Bossone et al., 2022). In other words, by enlarging aggregate supply (via higher productivity) and dampening input-price volatility, CE diminishes the typical business-cost–driven price rises. This channel accords with structuralist models emphasizing supply-side factors: when domestic supply is more robust thanks to circular reuse, external shocks have weaker pass-through to inflation.

Circular economy (CE) strategies – recycling, reuse, remanufacturing and eco-design – reduce firms' exposure to volatile commodity inputs. By closing material loops, firms substitute recycled or remanufactured feedstock for expensive virgin raw materials. In effect CE creates more domestic and stable input sources, insulating firms from international price swings. As Velenturf and Purnell (2021) note, a mature circular economy can "limit material costs and price volatility" and cut dependence on imports. For example, using recycled glass cullet to produce new bottles both saves energy and shields producers from fluctuations in silica prices; one lifecycle study found that high cullet use "enables saving material costs [and] dampening price volatility" in the glass supply chain (Wojnarowska et al., 2025). Such recycling and remanufacturing loops directly undermine the usual cost-push channel: firms relying on circular inputs are less vulnerable to commodity boom-bust cycles, reducing the pass-through of input shocks to consumer prices.

CE also raises resource and energy efficiency, lowering unit input requirements. By design, eco-designed products and leaner production require fewer materials and less energy, so firms pay less per unit of output. In the short run this yields immediate cost savings: one review finds that higher resource efficiency can translate into large "private cost-savings" for firms (Van Ewijk, 2018). Empirical analyses of circular business models consistently report improved efficiency and profitability. Crucially, recycled and reused inputs often have lower and more stable prices than virgin materials, since they are decoupled from global commodity markets. As a result, adoption of CE practices lowers firms' average input costs and smooths procurement prices (Velenturf and Purnell, 2021). In practice, sectors with strong circular supply chains (e.g. remanufactured automotive parts or reclaimed metals) enjoy more predictable cost structures compared to those tied to volatile global inputs. By cutting material intensity and diversifying supplies, CE thus directly weakens the transmission of input-price spikes into production costs.

Demand-Pull Channel: CE consumption patterns – such as product-service systems (PSS), sharing and leasing models, reuse/repair schemes, and durable design – fundamentally alter demand for new goods. By selling services (mobility, clothing use, etc.) rather than products, firms allow one durable asset to serve multiple consumers over time. Consequently, aggregate demand for new output grows more slowly. For example, Kolleck (2021) finds that each additional station-based shared car in Germany is associated with roughly nine fewer privately-owned cars. In other words, car-sharing fleets can substitute heavily for new car purchases, flattening vehicle demand. Similarly, collaborative fashion schemes extend garment lifetimes and curb new purchases: rental and resale platforms allow the same clothing to be used by many consumers, "decreasing the demand for new clothing production". More broadly, Kjaer et al. (2019) argue that selling access and performance (instead of ownership) can "decouple economic growth from resource consumption," since PSS models inherently flatten the growth of material throughput. These CE practices – leasing, sharing, repair and remanufacturing – therefore reduce the intensity and growth rate of consumption. By prolonging product lifespans and encouraging reuse, they cut the rate at which aggregate demand must be met with new production.

Because demand-pull inflation arises when aggregate demand outpaces supply, slowing demand growth directly eases inflationary pressures. In CE models, slower expansion of demand for new goods means aggregate expenditures grow more gradually relative to supply capacity. Bossone et al. (2022) note that CE reuse of materials yields substantial cost savings that translate into slower price growth: the resulting "savings on the purchase of raw materials… may then lead to lower and less rapidly growing final prices". In practice, an economy with widespread leasing and sharing will see its demand curve shift more gently, so that increases in demand do not overshoot supply as easily. Indeed, the CE-induced productivity gains and efficiency improvements (for example, through reuse of inputs or more intensive utilization of assets) can further contain price pressures. In sum, by dampening aggregate demand growth and widening the gap between demand and the previous growth path, circular consumption patterns act as a brake on demand-pull inflation. The same level of consumer service is delivered with fewer new resources, flattening demand relative to supply and moderating the inflationary gap.

Structural Resilience Channel: CE offers mechanisms to ease structural constraints. CE promotes reuse, recycling, remanufacture and closed-loop production so that resources circulate indefinitely. By design, CE reduces dependency on virgin inputs and on imports of raw materials. Importantly, it thus bolsters supply-side resilience: recycling and substitution create domestic sources of inputs, helping to avoid the shortages and price shocks central to structural inflation.

The European Investment Bank explains that "a circular economy offers a way to hedge future resource and material supply chain risks" (European Investment Bank, 2020). In practice, by keeping materials in use (for example, turning post-consumer waste into feedstock), CE mitigates commodity scarcities. This weakens the external bottleneck in structuralist models. Because fewer imported raw materials are needed, economies suffer less from exchange-rate or commodity shocks; and when global prices spike, a circular system can switch to lower-cost recycled substitutes. As the EIB guide notes, CE increases "resilience to decreasing supplies and increasing price uncertainty" and in turn "reduce[s] resource dependency" (European Investment Bank, 2020). Thus, one channel by which CE reduces inflationary pressure is by smoothing volatile input costs.

CE also addresses production rigidities. For example, if agricultural land or mining capacity is limited, circular strategies can yield more output from the same resource base: urban farming (nutrient recycling), bio-waste to energy, or using industrial by-products as raw materials all expand effective supply. Recycling infrastructure and remanufacturing industries create domestic productive capacity that substitutes for imports. This is akin to increasing the output of previously underdeveloped sectors (a key structuralist policy goal) and so relieves supply tightness. In addition, circular design (e.g. modular products, extended life-cycles) smooths production across time, reducing the boom-bust cycles of conventional manufacturing. The net effect is a more robust domestic supply side, which structuralist theory predicts will damp inflation.

For firms, CE can enhance supply-chain resilience. As Di Stefano et al. (2023) argue, CE enables companies to "enhance their resilience by reducing the reliance on raw materials and the fragility of the supply chain" (Di Stefano et al., 2023). By diversifying inputs (for instance, sourcing recycled metal rather than importing ore), firms avoid bottlenecks when linear supply chains break. In times of crisis, a circular system can localize inputs (through recycling and sharing networks), countering the very external shocks that would otherwise drive inflation. In effect, CE creates domestic "redundancies" in supply: one CE study notes that producers are increasingly "regionalizing supply chains to increase autonomy and resilience," a trend that circular practices can accelerate (Hartley et al., 2024).

Finally, CE-driven innovation and investment strengthen long-run productive capacity. Recycling and circular manufacturing often spawn new industries (waste processing, remanufacturing services, material recovery) and invest in technology (e.g. advanced sorting, eco-design). These expansions of productive capacity mean more output can meet demand growth, relaxing the real-resource constraints central to inflation. In the words of the EIB, circular approaches "spur innovation and increase competitiveness" (European Investment Bank, 2020). Over time, as circular infrastructure matures, the economy can produce required goods with less resource input – cushioning against future shocks and lowering the structural component of inflation.

In summary, structuralist models highlight how supply shortages and bottlenecks drive inflation in developing economies. Circular Economy strategies directly target those bottlenecks. By reducing raw-material use and import dependency, CE lowers the frequency and severity of supply shocks (Di Stefano et al., 2023). By expanding reuse and recycling, CE raises domestic supply capacity and substitutes for constrained sectors. The cumulative effect is to attenuate the cost-push forces in the economy. Consequently, a transition to circular production can help to reduce inflationary pressures in the long run, not by conventional monetary restraint but by strengthening the supply side – exactly in line with structuralist insights

Monetarist Channel (Output Effect): Monetarist theory (Friedman, 1968) holds that long-run inflation reflects money growth relative to real output. CE can raise real output (GDP) without a proportional increase in money supply. By improving resource efficiency and productivity, CE adds goods and services to the economy for the same monetary base. For example, the *Ellen MacArthur Foundation* (2015) estimates that applying circular principles could raise EU productivity by ~3% and boost GDP by up to 7% by 2030 (Bossone et al., 2022). In monetarist terms, higher real output for given money growth implies lower inflation. In this way, CE acts like an endogenous increase in real supply: if money supply growth is steady, the extra supply of goods from circular innovation exerts downward pressure on the price level. This is consistent with the classical view ("too much money chasing too few goods"): CE effectively increases "goods" and thus dampens inflation for the same monetary conditions.

Expectations Channel: In modern Phillips-curve frameworks, inflation expectations critically shape outcomes (Friedman, 1968; Phelps, 1967). A credible, persistent policy environment of circular investment and stable input costs could help anchor inflation expectations. If businesses and consumers anticipate that CE trends will stabilize supply costs, they will revise expected inflation downward. Lower expected inflation feeds back to lower wage/price setting and actual inflation (the "expectations-augmented" effect). Thus, by creating a credible supply-side anchor (through visible resource savings), CE can contribute to an expectations regime that suppresses inflation. In practice, this means that as CE gains momentum and central banks adjust monetary policy less in response to transitory cost shocks, inflation expectations become more firmly anchored at target rates.

2.2. Critiques of Circular Economy Costs and Inflationary Effects

Critics of the circular-economy (CE) transition often warn that implementing circular practices can raise production costs in the short run. For example, Velenturf and Purnell (2021) note that many authors "criticise" the current CE paradigm for its weak theoretical grounding and lack of clarity on how it delivers sustainable outcomes. In practice, moving to circular production typically requires heavy upfront investments (e.g. new recycling infrastructure or durable design) and supply-chain reconfiguration that can push prices up. Di Stefano et al. (2023) emphasize that the shift to CE technologies is "initially difficult and expensive" for firms before cost savings materialize. Likewise, Valenzuela and Böhm (2017) argue that some so-called circular initiatives may serve mainly as green "licenses" for continued consumption rather than lowering consumer prices in the near term. These critiques suggest that CE mandates (green materials, extended-producer-responsibility schemes, etc.) may translate into higher unit costs and even price inflation in certain industries.

In practice, sector-specific examples illustrate these short-run cost pressures. In packaging and plastics, for instance, new recycling quotas and single-use restrictions force companies to invest in sorting or alternative materials. The EU's recent Circular Economy Action Plan (2020) explicitly requires greater durability, recyclability and recycled content in electronics, textiles and packaging. Such mandates raise processing and material costs for producers in the short run (Di Stefano et al., 2023). Similarly, the battery and electronics industries face new obligations to recover valuable metals and adopt safer chemistries; building this circular supply chain (collection, recycling and remanufacturing) entails higher manufacturing costs initially. In fashion, transitioning to organic or recycled textiles typically commands a price premium: surveys report that consumers are willing to pay up to ~10–20% more for "slow" or sustainable fashion items (Pires et al., 2023). Firms adopting circular-fashion models must absorb these material and process cost increases if they want to meet eco-design standards, at least until scale is reached. In all these cases – packaging, batteries or apparel – the upfront capital and operational adjustments for circularity can be expected to put upward pressure on prices in the near term (Velenturf & Purnell, 2021; Di Stefano et al., 2023).

However, it remains unclear whether the inflationary pressures documented in individual sectors represent merely a gross effect of circular practices—or whether, when aggregated across the entire economy, they translate into a net upward or downward influence on the price level. On one hand, critics have emphasized valid short-run cost increases in industries that invest in new recycling infrastructure, eco-materials, and reverse logistics (Velenturf & Purnell, 2021; Di Stefano et al., 2023). These gross cost effects, whether in packaging, battery recycling, or sustainable fashion, clearly demonstrate that CE mandates can raise unit costs and potentially fuel producer-price inflation for those specific goods. On the other hand, theoretical work suggests that as circular loops mature—through learning-by-doing, scale economies, and process innovation—unit costs should fall sharply (Di Stefano et al., 2023). For example, steep learning curves in renewable energy and battery manufacturing have driven solar PV prices down by ~89% (2009–2019) and Li-ion battery costs by ~97% since the 1990s as cumulative output rose. Analogous dynamics in CE sectors imply that, over time, circular practices could exert downward pressure on input prices and overall inflation, despite the initial price premiums.

This tension between short-run gross inflationary effects and long-run deflationary potential constitutes a clear empirical gap in the literature. While existing studies document sector-level cost hikes or theoretical rebounds, no aggregate analysis has yet determined the net impact of CE adoption on inflation. Resolving this question is critical: if CE's gross cost effects dominate, policymakers must guard against unintended price rises; if its long-run efficiency gains prevail, CE could be a viable inflation-mitigation strategy. Our paper addresses this gap by developing an economy-wide framework that can reconcile these contradictory predictions and clarify whether circular transitions, on balance, tend to raise or lower the price level.

2.3. Multidisciplinary Insights: From Ecological Economics to Consumer Behaviour

A multidisciplinary perspective offers a richer understanding of how CE adoption might influence inflation. Ecological economics frames CE as a strategy to *decouple* economic growth from finite resource consumption, thereby easing resource constraints that can drive cost-push inflation. By designing out waste and keeping products in use, CE practices aim to reduce input demand and price volatility for raw materials. Empirical evidence from life-cycle assessment (LCA) studies emphasizes the potential gains: for example, reusing products can dramatically lower environmental impacts and resource use. Klooster et al. (2024) find that, in the fashion sector, opting for second-hand clothing instead of new production leads to up to ~42% lower greenhouse gas and energy life-cycle impacts, and 42–53% lower freshwater eutrophication and water scarcity impacts *per use*. Such impact reductions reflect substantial efficiency improvements that, in theory, could translate into lower production costs and gentler price pressures over time. However, these benefits are conditional on how CE is implemented and used. The same LCA study cautions that if circular products are not effectively utilized – for instance, a rarely worn second-hand garment – its per-use impact can exceed that of a new item with a long lifetime. This caveat echoes the ecological economics concern for rebound effects: efficiency gains may be partially offset by changes in behavior (e.g. increased or careless consumption when goods become cheaper or perceived as "eco-friendly"). Moreover, as Thopte et al. (2025) argue, many current CE initiatives remain stuck in a "net-zero" mindset that merely *offsets* negative impacts without creating net-positive outcomes. They highlight the need for deeper systemic shifts – changes in business models and cultural mindsets – beyond shallow tweaks in material flows or simple incentive tweaks. In other words, achieving the full inflation-mitigating potential of CE (through sustained resource productivity gains) likely requires transformative changes; otherwise, incremental CE improvements might not fully escape a cycle of diminishing returns or unintended rebounds in consumption.

From a behavioral and institutional economics standpoint, the relationship between CE adoption and prices is mediated by consumer preferences, heterogeneity, and policy contexts. Evidence shows that consumers are unevenly willing to embrace and pay for circular products, which could lead to segmented market effects on prices. Falcone and Fiorentino (2025) demonstrate that socio-psychological factors – such as environmental awareness, sense of responsibility, and even political orientation – significantly influence sustainable consumption behaviors. In their study on circular fashion, individuals with greater awareness and pro-environment values (often associated with higher education and a left-leaning orientation) were more likely to engage in circular practices and exhibit a higher willingness to pay for eco-friendly products. Through cluster analysis, they identified distinct consumer profiles: "enthusiastic" consumers who show high commitment to sustainable purchasing (and presumably tolerate price premiums for green products) versus "skeptics" who display low engagement and responsiveness to environmental initiatives. These findings imply that CE adoption can yield price premiums under certain conditions – *enthusiastic* segments may accept higher prices for circular products – but such effects might be limited to specific cohorts. Large portions of mainstream consumers may remain price-sensitive or indifferent to sustainability without additional incentives or awareness, tempering the overall impact on market prices.

The institutional context further conditions consumer behavior in ways that matter for the CE–inflation link. Socio-political research by Aldieri et al. (2025) indicates that public trust and engagement can significantly shape circular economy practices. In a cross-sectional study of Italian households, they found that higher trust in local government is associated with greater adoption of behaviors like using sustainable transport and buying local circular products, whereas lower civic and political engagement correlates with *increased waste generation* and less sustainable consumption. In essence, communities with strong institutional trust and environmental awareness are more likely to embrace CE behaviors willingly, potentially supporting a smoother transition without requiring large financial incentives. Additionally, education and cultural exposure emerged as influential factors: individuals with higher education levels and greater cultural engagement tended to exhibit more pro-circular habits. This suggests that knowledge and norms can lower the perceived "cost" of adopting CE practices (e.g. valuing long-term environmental benefits over short-term convenience), again affecting how consumers respond to prices. On the other hand, budget constraints still play a role – if circular products or services come with higher upfront costs, low-income consumers may be unwilling or unable to adopt them. Aldieri et al.'s framework recognizes that economic constraints can dampen participation in CE, meaning that without inclusive policies (such as affordable circular options or subsidies), the shift to CE could bifurcate markets. In summary, behavioral and institutional insights highlight that the inflationary impact of CE will not be uniform: it can be moderated by consumer heterogeneity (some will pay a green premium, others will not) and by policy design that builds public trust (thereby reducing the need for price-distorting incentives). Policymakers can leverage these insights by coupling CE initiatives with educational campaigns and trust-building measures, ensuring broader acceptance so that circular business models can scale without simply relying on price hikes to drive change.

Looking upstream, a supply chain and business management perspective sheds light on how CE affects production costs and pricing dynamics over time. Transitioning to circular models often requires firms to redesign processes, invest in new technologies, and coordinate across the value chain. Such changes can introduce short-term cost increases even if they promise efficiency gains later. Thopte et al. (2025) emphasize that CE adoption is a *systemic* shift in a firm's value creation approach, and notably report that higher upfront costs are a primary barrier for early adopters, especially among small and medium enterprises. Lack of coordination in the supply chain can also hinder progress – for instance, insufficient multi-stakeholder collaboration was found to inhibit CE implementation in SMEs. These observations imply that in the early stages of CE adoption, businesses may face rising production costs (e.g. for setting up reverse logistics, retraining staff, or sourcing recycled materials), which could be passed on as higher prices for consumers. Indeed, some regulatory pushes for circularity explicitly internalize costs that were previously external – a clear example is the Extended Producer Responsibility (EPR) emerging in the textile industry, which makes producers financially responsible for end-of-life waste management. Such policies, now implemented in countries like France and the Netherlands, incentivize sustainable product design and recycling, but they also mean manufacturers must allocate funds for collection, sorting, and recycling of products. If firms transfer these new costs into product prices, an inflationary effect in the affected goods is possible in the short run. Balanced against these costs are the efficiency gains and innovation opportunities that CE can unlock. By closing material loops and cutting waste, companies can achieve notable cost savings through improved resource efficiency and waste reduction, as highlighted by Aldieri et al. (2025). Firms adopting circular practices might, for example, spend less on virgin materials, avoid waste disposal fees, or even create new revenue streams from by-products. Over time, these savings can offset initial investments and potentially lead to lower production costs (and prices) relative to a linear model. Additionally, meeting the growing consumer demand for sustainable products can confer a competitive advantage, potentially expanding market share for circular businesses. From a supply chain management view, the net impact of CE on prices thus involves a temporal dimension: upfront investments and compliance costs may put upward pressure on prices in the transition phase, while mature circular supply chains – characterized by resource-efficient operations and innovation – could exert downward pressure on costs and prices in the long term. Managing this transition is critical; it calls for strategies like economies of scale in recycling, industry collaborations, and supportive policies to minimize short-term inflationary bumps on the way to long-term sustainability gains.

Overall, these multidisciplinary insights reveal a comprehensive picture of the CE–inflation relationship. On one hand, circular economy adoption embodies an *innovation-driven pathway* that can increase resource productivity, reduce waste, and ultimately alleviate some inflationary pressures tied to resource scarcity and pollution externalities. On the other hand, behavioral responses and transition costs can introduce inflationary dynamics in the short to medium term – for example, if consumers are willing to pay more for green products or if new circular regulations raise production costs for certain goods. Crucially, the extent of any inflationary impact will depend on factors like rebound effects (will efficiency savings lead to additional consumption?), consumer heterogeneity (will only a niche pay premiums or will sustainable options become the norm?), and policy effectiveness (can governments foster trust and innovation to smooth the transition?). The current study builds on these insights by moving from the micro and meso level to a macro-economic analysis of CE's impact on inflation. Whereas prior research has illuminated specific environmental benefits, behavioral patterns, and institutional conditions, there remains a gap in understanding how these effects aggregate and interact at the level of the whole economy. In the following sections, we leverage the empirical findings and theoretical cues from ecological, behavioral, and institutional domains to construct a novel analysis of how widespread CE adoption might influence inflation dynamics. By integrating environmental impact reductions, consumer behavior variability, and supply-chain adjustments into a cohesive macroeconomic framework, our study aims to evaluate whether the circular economy can help contain inflationary pressures or if it introduces new ones. In doing so, we advance the literature beyond case-specific and sector-specific findings, offering a fresh perspective on the systemic economic implications of the circular transition. This multidisciplinary foundation ensures that our macro-level examination of CE's inflationary impact is grounded in realistic assumptions about human behavior, business constraints, and ecological limits – ultimately contributing a more holistic understanding of the circular economy's role in sustainable economic stability.

3. Methodology and Data

This article investigates the impact of changes in circular economy indexes on inflation rates across 27 European countries between 2010 and 2019, utilizing a Markov switching panel model. This model is particularly well-suited for capturing the complex dynamics of inflation, as it accommodates regime shifts influenced by various factors such as business and political cycles, and exogenous shocks. By employing this approach, we can account for the non-linear and regime-dependent nature of inflation, enabling a more comprehensive evaluation of how circular economy transitions interact with different inflationary regimes. This perspective provides profounder understandings into the complex relationship between sustainability initiatives and macroeconomic stability. Equation (1) has been shown our proposed model:

$$Inf_{it}^{S_{it}} = \alpha_i^{S_{it}} + \beta \Delta CE_{it} + \rho\, Z_{\ it} + \epsilon_{it}^{S_{it}},\ \epsilon_{it}^{S_{it}} \sim N\left(0, \delta_{s_{it}}^2\right) \quad (1)$$

Where s_{it} represents the regime state, assuming two regimes. $Inf_{it}^{S_{it}}$ denotes the inflation rate for country i in the t-th year under regime s_{it}; ΔCE_{it} shows the change of CE indexes in each country in the t-th year. $\alpha_i^{S_{it}}$represents an unknown country-specific constant for regime s_{it}, and $\epsilon_{it}^{S_{it}}$ is the error term that varies between the two regimes. Z_{it} is the vector of control variables, including:

The first lag of inflation (Inf_{it-1}): This serves as a proxy for inflation expectations, reflecting the adaptive expectations theory of inflation, which posits that past inflation influences expectations for future inflation. Including this variable captures inertia in inflation dynamics.

The index of labor cost ($LaborCost_{it}$): This is a critical determinant in the cost-push theory of inflation, which asserts that rising production costs—particularly wages—lead to higher prices as businesses pass costs on to consumers.

Change in the share of budget deficit in GDP ($Deficit_{it}$): According to the fiscal theory of price levels, a persistent budget deficit, when monetized or inadequately offset by future surpluses, can increase aggregate demand and inflation. This variable accounts for fiscal influences on inflation.

The real exchange rate (RE_{it}): Real exchange rate fluctuations capture the impact of trade openness and global integration on inflation. According to open-economy inflation theories, exchange rate depreciation increases the price of imports, contributing to inflation through imported goods.

Interest rate ($Interest_{it}$): Based on the monetary theory of inflation, interest rates reflect central bank policies that influence aggregate demand and inflation. Higher interest rates dampen inflationary pressure, while lower rates stimulate demand and potentially increase inflation.

This combination of above variables reflects a multi-faceted approach to understanding inflation, incorporating theoretical insights from adaptive expectations, cost-push dynamics, fiscal policy, exchange rate pass-through, and monetary policy. These elements enable a comprehensive assessment of the drivers of inflation in the context of circular economy transitions.

Furthermore, the model allows parameters to shift between distinct states, which are determined by a Markov process with associated transition probabilities. Specifically, s_{ti} represents the state at time t for country i, governed by a Markov process with transition probabilities p_{kj}:

$$p_{kj} = P(s_{ti} = j | s_{ti-1} = k) \quad (2)$$

Here, p_{kj} represents the probability of transitioning from state k to state j. Furthermore, by utilizing the conditional distribution of inflation, the inflation dynamics can be expressed as follows:

$$Inf_{it}^{S_{it}} \middle| M_{it-1} \sim \begin{cases} fun\left(\emptyset_{it}^{(1)}\right) \cdot p_{1,it} \\ fun\left(\emptyset_{it}^{(2)}\right) \cdot (1 - p_{1,it}) \end{cases} (s_{it} = 1\ and\ 2) \quad (3)$$

M_{it-1} denotes the information set available for country i at time (t−1). The function $fun(\emptyset)$represents a conditional distribution, assumed to follow a Normal distribution. $\emptyset_{it}^{(s_{it})}$ is a vector of parameters that differ across regimes, specifying the parameters of the conditional Normal distribution, including its mean and variance. The conditional mean corresponds to Equation (1). For each regime, we assume homoskedasticity, implying that a single variance is estimated endogenously by maximizing the likelihood function within each regime. More specifically, $\emptyset_{it}^{(s_{it})}$ is defined as follows.

$$\emptyset_{it}^{(s_{it})} = \left(\mu_{it}^{(s_{it})}, \delta^{(s_{it})}\right) \quad (4)$$

Here, $\delta^{(s_{it})}$ represents the standard deviation for each regime, while $\mu_{it}^{(s_{it})}$ denotes the conditional mean, which is defined as follows:

$$\mu_{it}^{(s_{it})} = E(Inf_{it}^{s_{it}} | M_{it-1}) = E\left(\alpha_i^{s_{it}} + \beta \Delta CE_{it} + \rho Z_{it} + \epsilon_{it}^{s_{it}} \middle| M_{it-1}\right) \tag{5}$$

The logarithm of the likelihood function can be expressed as follows:

$$log\, L = \sum_{i=1}^{n} \sum_{t=1}^{T} log\left[p_{1,it} f(Inf_{it}|s_{it} = 1) + \left(1 - p_{1,it}\right) f(Inf_{it}|s_{it} = 2)\right] \tag{6}$$

Here, $p_{1,it}$ denotes the ex-ante probability that country i is in regime 1 at time t, based on the information available at t−1. This probability is determined by the transition probabilities (Abounoori et al., 2016). Thus, when estimating the Markov model through maximum likelihood, both the parameters of the conditional mean (as specified in Equation 1) and the parameter vector, including $\delta^{(s_{it})}$, representing the standard deviation for each regime, are estimated. Furthermore, in line with Hansen (1992), the LR test was employed to compare the two-regime model with the linear model.

Our study adopts a Markov switching panel model because inflation dynamics are inherently nonlinear and regime-dependent, alternating between high- and low-inflation states. This framework allows us to model transitions between regimes, capturing persistence and volatility that linear models would miss. Alternative approaches, such as threshold regressions or smooth-transition autoregressive models, can also capture nonlinearities, but they do not explicitly model regime probabilities or account for state duration. By contrast, the Markov switching framework provides both transition probabilities and expected regime durations, which are crucial for understanding the persistence of inflationary regimes in relation to CE adoption. Thus, this method best aligns with the study's paradigm of investigating structural, regime-dependent effects of circular economy indicators on inflation.

We complement the regime-based model with the Generalized Method of Moments (GMM), which is well-suited for dynamic panel data. GMM addresses endogeneity by using internal instruments, ensuring unbiased estimates even when explanatory variables are correlated with past errors. It also accommodates lagged dependent variables (inflation inertia), which are essential for testing expectations-augmented models of inflation. Alternative estimators, such as fixed-effects OLS or system-2SLS, lack this robustness to endogeneity and serial correlation. GMM thus strengthens the reliability of the findings by confirming whether the negative CE–inflation relationship is robust under a different econometric paradigm.

Other methods could, in principle, be applied. For example, quantile regressions could explore heterogeneity across the inflation distribution, and Bayesian Markov Chain Monte Carlo (MCMC) methods could allow more flexible priors in regime-switching. Structural VARs could test dynamic feedbacks between CE and inflation. However, these approaches either require more restrictive data assumptions (VARs demand long time series) or serve exploratory rather than confirmatory roles. For the cross-country, decade-long panel we use, the combination of Markov switching and GMM provides the best balance of capturing nonlinearity, addressing endogeneity, and maintaining interpretability in terms of inflation theory.

Table 1 provides an overview and summary statistics of the variables utilized in the model from 2010 to 2019.

Table 1. Definitions and Descriptive Statistics of Variables (Source: Own calculations)

Variable	Definition and source	Descriptive Statistics	
		Mean	**SD**
Inf_{it}	The growth rate of consumer price index (CPI), Eurostat	1.50	1.44
$LaborCost_{it}$	The labour cost index measures the short-term hourly changes in total employment costs for employers, Eurostat	2.89	3.42
$\Delta Deficit_{it}$	The change in government deficit represents the change in general government's net borrowing, expressed as a percentage of GDP, Eurostat	-0.59	1.86
ΔRE_{it}	The change in real effective exchange rate measures change in a country's price or cost competitiveness relative to 42 key trading partners, accounting for exchange rates, cost trends, and double export weights, with an increase in the index indicating reduced competitiveness, Eurostat.	-0.16	1.31
$Interest_{it}$	Maastricht criterion bond yields (MCBY) are long-term interest rates established under the Maastricht Treaty as a convergence criterion for the European Monetary Union, Eurostat.	2.39	2.46
ΔCE_{it}	$\Delta \mathbf{RBW_{it}}$, is changing in the weight of composted or methanized municipal waste divided by the total population, expressed in individuals, Eurostat.	2.32	9.50
	$\Delta \mathbf{RMW_{it}}$, measures the change in proportion of municipal waste recycled relative to the total municipal waste produced, Eurostat.	1.14	3.64
	$\Delta \mathbf{CMU_{it}}$, changing in circular material use, or the change in circularity rate, refers to the change in share of materials reused or recycled within the total material consumption, Eurostat.	0.16	1.17
	$\Delta \mathbf{RPW_{it}}$, represents the change in proportion of recycled packaging waste compared to the total packaging waste produced, Eurostat.	0.40	4.14
	$\Delta \mathbf{REN_{it}}$ is the change in consumption of renewable energy and biofuels in industrial sectors.	17.23	77.95
	$\Delta \mathbf{CEI_{it}}$, change in Circular Economy Index introduced by Nademi and Sedaghat Kalmarzi (2025).	0.09	0.25

4. Empirical Analysis

Table 2 presents the estimation results of the Markov switching models of inflation for 27 European countries from 2010 to 2019. The results, along with the LR Hansen (1992) tests, confirm the presence of two distinct inflation regimes: high mean inflation and low mean inflation, each associated with corresponding levels of variance (or volatility). Specifically, the high inflation regime exhibits higher inflation volatility compared to the low inflation regime, which is characterized by lower volatility. An exception to this pattern is observed in Model 4.

Furthermore, Table 3 shows that the probability of remaining in the high inflation regime is greater than the probability of staying in the low inflation regime. Consistent with these findings, the expected duration of staying in the high inflation regime is longer than that in the low inflation regime across all models, except for Model 4.

Table 2. Markov Switching Models (Source: Own calculations)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant in Regime 1	0.52*** (0.05)	0.61*** (0.06)	0.24*** (0.0006)	0.52*** (0.05)	0.97*** (0.0002)	0.28*** (0.0006)
Log (δ) in Regime 1	-0.31*** (0.05)	-0.30*** (0.05)	-7.33*** (0.29)	-0.32*** (0.05)	-8.29*** (0.35)	-7.33*** (0.48)
Constant in Regime 2	0.46*** (0.0007)	0.36*** (0.002)	0.39*** (0.05)	0.56*** (0.001)	0.47*** (0.05)	0.52*** (0.06)
Log (δ) in Regime 2	-7.42*** (0.29)	-5.71*** (0.35)	-0.31*** (0.05)	-6.82*** (0.22)	-0.33*** (0.05)	-0.29*** (0.04)
Inf_{it-1}	0.37*** (0.001)	0.29*** (0.001)	0.44*** (0.0002)	0.37*** (0.0005)	0.39*** (0.00009)	0.30*** (0.0002)
$LaborCost_{it}$	0.12*** (0.0003)	0.12*** (0.0005)	0.12*** (0.0001)	0.10*** (0.0001)	0.11*** (0.00001)	0.14*** (0.00005)
$\Delta Deficit_{it}$	0.03*** (0.0008)	0.01*** (0.0004)	0.03*** (0.0002)	0.03*** (0.0003)	0.04*** (0.00003)	0.008*** (0.0001)
ΔRE_{it}	0.29*** (0.0004)	0.29*** (0.002)	0.23*** (0.0004)	0.28*** (0.0006)	0.28*** (0.00006)	0.27*** (0.0004)
$Interest_{it}$	-0.13*** (0.0003)	-0.12*** (0.0004)	-0.12*** (0.0004)	-0.11*** (0.0001)	-0.11*** (0.00003)	-0.12*** (0.0002)
ΔRBW_{it}	-0.005*** (0.00001)	-	-	-	-	-
$\Delta \mathrm{RMW}_{\mathrm{it}}$	-	-0.04*** (0.0003)	-	-	-	-
$\Delta \mathrm{CMU}_{\mathrm{it}}$	-		-0.34*** (0.002)	-	-	-
$\Delta \mathrm{RPW}_{\mathrm{it}}$	-		-	-0.03*** (0.0001)	-	-
$\Delta \mathrm{REN}_{\mathrm{it}}$	-		-	-	-0.0006*** (0.0000001)	-
$\Delta \mathrm{CEI}_{\mathrm{it}}$	-		-	-	-	-0.38*** (0.001)
LR Statistic (p-value)	58.70 (0.00)	50.34 (0.00)	51.29 (0.00)	53.17 (0.00)	50.25 (0.00)	50.89 (0.00)
Log Likelihood	-161.86	-162.97	-159.84	-160.06	-157.42	-152.28

Standard errors are reported in parentheses. The symbols *** and ** indicate significance at 1%, 5%, and 10%, respectively.

Table 3. Transition Probabilities and Expected Durations in each regime (Source: Own calculations)

Model	Regimes	1	2
Model 1	1	0.95	0.05
	2	0.99	0.01
	Expected Durations	18.717	1.005
Model 2	1	0.94	0.06
	2	0.75	0.25
	Expected Durations	16.441	1.326
Model 3	1	0.50	0.50
	2	0.04	0.96
	Expected Durations	1.990	28.569
Model 4	1	0.93	0.07
	2	0.99	0.01
	Expected Durations	14.737	1.001
Model 5	1	0.01	0.99
	2	0.05	0.95
	Expected Durations	1.001	18.943
Model 6	1	0.01	0.99
	2	0.07	0.93
	Expected Durations	1.004	13.713

The results indicate that in all models, the first lag of inflation, representing expected inflation, has a significant positive effect on current inflation, consistent with the adaptive expectations theory. Additionally, in all models, the labor cost index exhibits a significant positive impact on inflation, aligning with the cost-push theory of inflation. Furthermore, the change in the government deficit has a significant positive impact on inflation, consistent with the fiscal theory of inflation.

Also, our results show that changes in the real effective exchange rate have a significant positive effect on inflation. This positive effect can be interpreted as the impact of exchange rate volatility or uncertainty on price dynamics. Frequent or significant changes in the real effective exchange rate, reflecting fluctuations in a country's price or cost competitiveness, create uncertainty in international trade and transactions. This uncertainty can lead to cost-push inflation, as businesses pre-emptively raise prices to hedge against potential cost increases caused by volatile exchange rates. Additionally, exchange rate volatility can amplify the pass-through effect, whereby fluctuations in exchange rates more directly impact domestic prices, particularly for import-dependent economies. Such uncertainty may also influence inflation expectations, as firms and consumers anticipate higher prices due to persistent volatility.

The interest rate demonstrates a significant negative effect on inflation, supporting the monetary theory of inflation. This relationship reflects the role of central bank policies in influencing aggregate demand and, consequently, inflation. Specifically, an increase in the interest rate makes bonds more attractive to investors as a risk-free source of profit, leading them to allocate their funds toward bond purchases rather than investing in the real economy. As a result, aggregate demand declines, which subsequently reduces inflationary pressures.

Our findings confirm that all circular economy indexes have a significant negative impact on inflation. These indexes capture the progress and transitions associated with the adoption of circular economy practices. Consequently, our results strongly suggest that advancing toward a circular economy substantially reduces inflation in European countries.

4.1. Robustness Check

For robustness checks, we estimated the models using the Generalized Method of Moments (GMM). The GMM approach offers several advantages for our analysis. First, it is well-suited for dynamic panel models, as it accommodates the inclusion of the first lag of inflation as an explanatory variable, which captures the dynamic behavior of our model. Additionally, GMM effectively addresses endogeneity issues by utilizing instrumental variables.

Table 4 presents the estimation results for all models using the GMM method. These results confirm the robustness of the relationship between inflation and the CE. Specifically, all models consistently demonstrate a significant negative effect of changes in CE on the inflation rate.

Regarding the other coefficients, the results align closely with those obtained from the Markov switching model, except for the interest rate, which does not exhibit robust evidence in the interest rate-inflation nexus.

To address potential endogeneity, we employed the second lags of all variables as instrumental variables. The validity of these instruments was confirmed by the Sargan test, which indicates that the instrumental variables are not correlated with the error terms. Additionally, the Arellano-Bond test results confirm the presence of first-order autocorrelation and the absence of second-order autocorrelation, supporting the use of the first lag of variables in the GMM model.

Table 4. GMM Models (Source: Own calculations)

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
$\boldsymbol{Inf_{it-1}}$	*0.35**** *(0.02)*	*0.36**** *(0.01)*	*0.39**** *(0.02)*	*0.37**** *(0.02)*	*0.41**** *(0.02)*	*0.21**** *(0.02)*
$\boldsymbol{LaborCost_{it}}$	*0.25**** *(0.005)*	*0.23**** *(0.006)*	*0.29**** *(0.007)*	*0.26**** *(0.01)*	*0.26**** *(0.008)*	*0.26**** *(0.009)*
$\boldsymbol{\Delta Deficit_{it}}$	*0.03*** *(0.01)*	*0.02*** *(0.01)*	*0.12**** *(0.02)*	*0.12**** *(0.01)*	*0.13**** *(0.01)*	*0.01* *(0.01)*
$\boldsymbol{\Delta RE_{it}}$	*0.50**** *(0.06)*	*0.36**** *(0.12)*	*0.47**** *(0.03)*	*0.40**** *(0.04)*	*0.48**** *(0.04)*	*0.40**** *(0.03)*
$\boldsymbol{Interest_{it}}$	*0.02* *(0.03)*	*-0.02* *(0.02)*	*0.08**** *(0.02)*	*0.03** *(0.01)*	*-0.02* *(0.02)*	*0.06*** *(0.03)*
$\boldsymbol{\Delta RBW_{it}}$	*-0.03**** *(0.001)*	-	-	-	-	-
$\boldsymbol{\Delta RMW_{it}}$	-	*-0.14**** *(0.03)*	-	-	-	-
$\boldsymbol{\Delta CMU_{it}}$	-	-	*-0.27**** *(0.07)*	-	-	-
$\boldsymbol{\Delta RPW_{it}}$	-	-	-	*-0.03**** *(0.006)*	-	-
$\boldsymbol{\Delta REN_{it}}$	-	-	-	-	*-0.01**** *(0.0007)*	-
$\boldsymbol{\Delta CEI_{it}}$	-	-	-	-	-	*-2.73**** *(0.26)*
Sargan J-Statistics (p-value)	*24.57* *(0.21)*	*23.56* *(0.26)*	*21.41* *(0.37)*	*23.52* *(0.26)*	*20.21* *(0.35)*	*21.23* *(0.38)*
AR (1)-Arellano-Bond (p-value)	*-2.61* *(0.00)*	*-2.38* *(0.01)*	*-2.99* *(0.00)*	*-2.30* *(0.02)*	*-2.67* *(0.00)*	*-2.49* *(0.01)*
AR (2)-Arellano-Bond (p-value)	*-1.16* *(0.24)*	*0.40* *(0.68)*	*-1.67* *(0.09)*	*-1.42* *(0.15)*	*-1.46* *(0.14)*	*0.66* *(0.50)*

Standard errors are reported in parentheses. The symbols *** and ** indicate significance at 1%, 5%, and 10%, respectively.

4.2. Discussion

The empirical findings strongly support the cost-push transmission mechanism. In each model, the labor-cost index has a significant positive coefficient, indicating that higher wage or input costs lead to higher inflation. This aligns with classical cost-push theory (firms pass rising costs to consumer prices). The circular economy result amplifies this interpretation: all CE indices have a significant negative effect on inflation, suggesting that resource-efficient practices have compressed firms' average production costs. In theory, circular activities (recycling, reuse, remanufacturing) "smooth supply bottlenecks and compress input costs," thereby diminishing "business-cost–driven price rises". Our findings fit this view: by reducing dependence on volatile virgin inputs and boosting productivity, circular economy transitions have lowered the cost pressures that normally drive inflation. Additionally, the real effective exchange rate enters with a positive coefficient, reflecting imported inflation pressures (a form of cost-push from external shocks). The fact that CE still reduces inflation despite this pressure implies that circular practices help insulate the economy from exchange-rate–driven cost shocks, consistent with the idea that more robust domestic supply chains weaken the usual cost-push channel. In sum, the positive cost indices and negative CE effects converge with theory: cost increases do raise inflation, but advancing CE adoption counteracts these effects by cutting unit costs and dampening input-price volatility.

The results also confirm key elements of the demand-pull channel. An increase in the budget-deficit share (a proxy for fiscal-driven demand) has a significant positive impact on inflation, consistent with the view that excess aggregate demand raises the price level. Likewise, higher interest rates lower inflation, as predicted by standard monetary theory (tight monetary conditions curb demand). Importantly, the circular economy's negative effect on inflation suggests a mitigating impact on demand-driven inflation pressures. Theoretically, circular consumption models (sharing, leasing, reuse) slow the growth of aggregate demand for new goods. For example, by extending product lifetimes and promoting service-based use, CE can "flatten" demand growth, reducing upward pressure on prices. Our finding that CE progress systematically lowers inflation is consistent with this mechanism: by tempering demand growth (through efficiency gains and reuse of materials), circular transitions curb the inflationary gap between demand and supply. Thus, the evidence suggests convergence with demand-pull theory – government spending boosts inflation, but circular-economy practices dampen aggregate demand pressures, moderating the resulting price rise.

The structuralist channel posits that enhancing economic resilience will reduce inflation by easing supply constraints. Here the empirical evidence is broadly supportive. In theory, circular economy investment builds domestic production capacity and supply-security (through recycling and closed-loop production), thereby weakening the "external bottleneck" that drives structural inflation. Our models do not directly estimate regime persistence, but the strong negative relationship between CE and inflation implies that economies more advanced in circular transition faced less severe price shocks. In other words, consistent with structuralist expectations, CE appears to have increased supply-side resilience so that cost shocks (from commodities or trade) translate less into higher prices. This convergence is underscored by the Cai et al. (2024) finding that circular practices reduce inflation, which in both our European context and theirs reflects CE's role in shielding the economy from resource scarcities. In summary, the downward pressure of circular economy indices on inflation is in line with the theoretical resilience channel – more robust, circular supply chains reduce inflationary pressure, in agreement with structuralist insights.

The monetarist channel emphasizes money growth relative to output. While we do not observe money directly, the negative interest-rate effect in the Markov models is consistent with the idea that tighter monetary policy (or slower demand growth) lowers inflation. Although the interest effect is not robust in the GMM (which could reflect differing dynamic assumptions), the overall pattern still supports a classical output story. Theoretically, circular economy practices raise real output (through productivity gains) without a proportionate increase in money supply so that for a given money growth inflation should decline. Our finding that CE adoption significantly reduces inflation is consistent with this effect: CE-driven efficiency effectively acts as an endogenous expansion of goods available for the same monetary base. Thus, higher output from a more circular economy contributes to the observed inflation drop, in line with the "too much money chasing too few goods" logic. The partial divergence – the weaker interest-inflation link in GMM –

suggests that monetary policy effects are secondary to the real (output/efficiency) gains of CE. Nonetheless, the results converge with the monetarist/output channel in that stronger CE progress is associated with lower inflation, implying enhanced supply relative to nominal demand.

Finally, the adaptive–expectations hypothesis is strongly borne out. In every specification, lagged inflation has a significant positive coefficient, indicating persistent inflation inertia: past inflation feeds into current prices. This is exactly as predicted by standard Phillips-curve or expectations-augmented models, where higher expected inflation begets higher actual inflation. While we do not measure expectations directly, the implication is that observed inflation has been partly self-reinforcing. Crucially, the circular economy effect provides a mechanism to break or reduce this inertia: by stabilizing underlying prices, CE can anchor expectations downward. The theoretical framework suggests that visible cost savings and supply security from CE would lead businesses and consumers to anticipate lower future inflation. Our results are consistent with this channel: by empirically lowering inflation, CE progress likely helps suppress future expected inflation, thus reducing inflation persistence over time. In short, the positive persistence we see matches expectations-based models, and the deflationary influence of CE suggests that the expectations regime has been shifted in a disinflationary direction.

Across all channels, the empirical findings largely converge with theoretical predictions. Cost-push and demand-pull effects operate as expected – higher costs and deficits raise inflation – and CE's negative coefficient consistently counterbalances these pressures, validating the mechanisms outlined earlier. The structural and output channels, which emphasize supply enhancement, are also supported: circular economy development appears to dampen structural inflation pressures and effectively expands real output, thereby reducing inflation. The only modest divergence is that the interest-rate channel is less clear in the GMM results, suggesting monetary policy plays a secondary role in this context. Overall, the theoretical inflation channels of cost-push, demand-pull, structural resilience, monetarist output effects, and expectations-augmentation all find backing in the data. Our discussion shows that progressing to a circular economy operates through multiple inflation channels in the ways predicted by theory, with very few disparities between the expected mechanisms and the observed results.

5. Conclusion

This study has examined the relationship between circular economy (CE) adoption and inflation across 27 European countries during the period 2010–2019. By employing a Markov switching panel framework, complemented with robustness checks using the Generalized Method of Moments, the analysis provides new macroeconomic evidence on how circular practices affect price dynamics. The results demonstrate that greater adoption of CE strategies—including higher recycling rates, greater circular material use, and stronger reliance on renewable energy—exerts a statistically significant disinflationary effect. These findings suggest that circularity is not only an environmental strategy but also a structural determinant of price stability.

Theoretically, the study extends existing models of inflation by embedding resource efficiency, waste minimization, and closed-loop production into the established cost-push, demand-pull, structural, monetarist, and expectations-based channels. Whereas much of the prior literature has treated CE primarily as an environmental or industrial policy domain, the present research shows that CE directly reshapes macroeconomic mechanisms of inflation. In particular, the evidence supports the view that circular practices dampen cost-push pressures by stabilizing input costs, moderate demand-pull effects by slowing the growth of new product demand, and reduce structural vulnerabilities by limiting exposure to external shocks. The results also highlight CE's role in enhancing productivity and anchoring inflation expectations, thereby integrating ecological economics with monetary theory.

Empirically, this study contributes by providing the first systematic cross-country evidence on the CE–inflation nexus at the macroeconomic level. The results demonstrate that circular practices yield measurable disinflationary effects even when accounting for conventional determinants such as labor costs, fiscal balances, and exchange-rate fluctuations. This provides robust support for the claim that CE adoption constitutes an important, yet previously overlooked, factor shaping inflation outcomes.

In conclusion, the analysis confirms that CE transitions have broader economic implications than previously acknowledged. By highlighting the capacity of CE to influence inflationary dynamics, the study refines the theoretical understanding of price formation and expands the scope of macroeconomic inquiry to include material circularity as a fundamental variable.

6. Policy Implications and Future Research

The findings of this study emphasize the potential of CE strategies to serve as a complementary instrument of price stabilization within the European Union. By reducing dependence on volatile imports of raw materials and increasing resource efficiency, CE practices address a structural vulnerability of European economies that has historically amplified cost-push inflation. In this respect, investments in recycling infrastructure, the expansion of remanufacturing capacities, and the integration of eco-design standards into production processes should not be understood merely as environmental policies but as macroeconomic stabilizers that can alleviate inflationary pressures. The creation of a truly integrated European market for secondary raw materials, supported by harmonized standards and regulatory frameworks, would further enhance resilience by ensuring stable access to affordable inputs and smoothing supply bottlenecks across member states.

Fiscal and industrial policies will play a central role in this transition. Redirecting subsidies away from virgin resource extraction toward circular innovation, repair services, and material recovery can accelerate diffusion while limiting sector-specific inflationary risks during the adjustment phase. Public procurement, if systematically aligned with CE criteria, can generate reliable demand for circular products and services, thereby creating economies of scale that gradually lower production costs. At the same time, policymakers must remain attentive to the short-term trade-offs inherent in such transitions. The establishment of new recycling systems, the adoption of sustainable inputs in fashion or packaging, and the redesign of industrial processes may initially raise costs and generate localized price pressures, sometimes referred to as "greenflation." To mitigate these risks, phased implementation combined with targeted subsidies or tax incentives is required, alongside social policies that shield low-income households from disproportionate burdens. Only through such a balanced approach can the long-run disinflationary potential of CE be realized without jeopardizing social equity or competitiveness.

At the macroeconomic level, the results of this paper highlight the need for monetary authorities and finance ministries to broaden their analytical frameworks. Traditional inflation surveillance has emphasized monetary aggregates, labor markets, and exchange rates, but our evidence suggests that the material basis of production is no less critical. A transition to circular production and consumption alters the very structure of inflation dynamics, weakening cost-push and structural inflationary forces while anchoring expectations. Recognizing CE as a structural determinant of inflation invites a rethinking of stabilization policies, where ecological and monetary strategies converge rather than remain in separate domains.

The theoretical contribution of this study lies precisely in this integration. By mapping CE practices onto the established channels of inflation—cost-push, demand-pull, structural, monetarist, and expectations-based—we refine existing theories in both ecological and monetary economics. The evidence presented here demonstrates that CE is not merely an environmental agenda but a supply-side mechanism that conditions macroeconomic outcomes. In doing so, the analysis challenges conventional separations between environmental sustainability and price stability, showing instead that circular transitions can reinforce central banks' pursuit of low and stable inflation. This insight expands the conceptual frontier of inflation theory by embedding resource flows and material circularity into the macroeconomic framework.

Despite these contributions, important questions remain. Our study employs aggregate indicators of circularity at the national level, which, while useful for capturing broad trends, obscure heterogeneity across sectors. Further research should disaggregate the CE–inflation nexus by industry, since price effects in resource-intensive sectors such as construction, textiles, or electronics may differ substantially from those in service-oriented or high-tech industries. Distributional consequences also require closer scrutiny: while aggregate inflation may decline, the transition could impose uneven costs on households and firms, raising issues of fairness and social acceptability. Moreover, the empirical period analyzed here predates the combined shocks of the COVID-19 pandemic and the recent European energy crisis, both of which have profoundly altered inflation dynamics. Extending the analysis to include such episodes would shed light on CE's capacity to cushion extreme shocks. Methodologically, future research should combine macro-panel approaches with micro-level evidence from firms and households, and exploit new data sources—such as product-level price indices or digital platform measures of CE adoption—to test behavioral and institutional mechanisms more directly.

In sum, the evidence presented in this paper suggests that advancing the circular economy is not only a pathway to sustainability but also a strategy for macroeconomic stability. By embedding CE into the policy architecture of the European Union, governments and central banks can jointly pursue environmental and economic resilience, ensuring that the long-run disinflationary benefits of circularity outweigh the short-run costs of transition.

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Declarations

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