THE IMPACT OF FINANCIAL DEVELOPMENT ON THE CIRCULAR ECONOMY: THE MODERATING ROLE OF INSTITUTIONAL QUALITY

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Abstract: ***This study examines whether institutional quality changes the effect of financial development on the circular economy. Using data from 109 countries during 2002-2024, it constructs a macro-level circular economy index through PCA and estimates Bayesian regressions with interaction terms between financial development and six institutional dimensions. The results show that institutional quality is not merely a control variable. It determines whether finance supports circular transition. In developed countries, the interaction effects are positive and have high posterior certainty. In developing countries, they are mostly positive but less stable. The findings imply that financial development does not automatically promote circularity; institutions must direct capital toward clean technology, renewable energy, recycling, remanufacturing, and resource-efficient production.***

• Keywords: *circular economy; financial development; institutional quality; PCA; Bayesian regression.*

JEL codes: C43; G21; O13; Q01; Q56

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1. Introduction

The circular economy has become a central issue in sustainable development because it challenges the linear model of extraction, production, consumption and disposal. A circular economy seeks to keep materials, energy and products in use for longer, reduce waste and lower pressure on natural resources (Ellen MacArthur Foundation, 2015; Chowdhury et al., 2026). Yet global circularity remains limited. Circle Economy (2024) reports that only about 6.9% of materials are cycled back into production, while WRI (2025) shows that global material footprints remain above long-term sustainable levels.

A first problem is measurement. Many studies use recycling, waste, or material consumption as single proxies, but none can fully capture circularity at the national level. A country may recycle more but still have high carbon intensity and material consumption. This study therefore constructs a macro-level circular economy index from four dimensions: carbon efficiency, energy efficiency, energy transition and material pressure. This composite approach supports cross-country comparison while recognizing that circularity is a system-level outcome.

A second issue is finance. Financial development can support the circular economy by mobilizing and allocating capital to clean technology, renewable energy, recycling and remanufacturing (Levine, 1997; Beck et al., 2000). But finance can also reinforce the linear economy if credit flows to fossil energy, real estate, heavy industry or resource-intensive sectors. This dual role means that financial depth alone is not enough.

This study argues that institutional quality determines how finance is translated into circular outcomes. Strong institutions reduce policy uncertainty, enforce environmental standards, limit corruption and improve the credibility of green finance. Weak institutions can distort capital allocation and allow finance to support high-carbon and material-intensive activities (North, 1990; Acemoglu et al., 2005; Kaufmann et al., 2010). The study contributes by linking circular economy measurement, financial development and institutional quality in one empirical framework.

2. Literature review and theoretical background

2.1. Circular economy and macro-level measurement

The circular economy is an economic system that maintains the value of products, materials and resources while reducing waste and the extraction of virgin resources (Ellen MacArthur Foundation, 2015; Lieder and Rashid, 2016). Although the R-framework, from Reduce, Reuse and Recycle to

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broader 9R strategies, explains the logic of circularity (Kirchherr et al., 2017), it is difficult to convert firm- or product-level practices into a cross-country index. Macro measurement therefore needs observable country-level outcomes. Prior work has examined products, firms, eco-industrial parks and national systems (Geng et al., 2012; Parchomenko et al., 2019; Claudio-Quiroga and Poza, 2024; Emami et al., 2025). The remaining gap is a measure that is simple enough for a large country sample but broad enough to reflect carbon, energy and material dimensions.

2.2. Financial development and the circular economy

Financial intermediation theory argues that finance reduces information frictions, mobilizes savings, allocates capital, monitors investment and supports innovation (King and Levine, 1993; Levine, 1997; Beck et al., 2000). These functions matter for the circular economy because circular projects often require large upfront capital and long payback periods. However, the environmental effect of finance depends on allocation. Finance can support clean technology and circular business models, but it can also expand material consumption and waste if it funds resource-intensive sectors (Chen et al., 2026; Fang et al., 2024).

2.3. Institutional quality as a moderating condition

Institutional theory explains why similar financial development can produce different outcomes across countries. Institutions shape incentives, reduce uncertainty and define the quality of enforcement (North, 1990; Acemoglu et al., 2005). In the circular economy, control of corruption, government effectiveness, political stability, rule of law, regulatory quality and voice and accountability can determine whether financial capital is directed toward circular investment or toward short-term, resource-intensive activities. The expected mechanism is therefore conditional: finance provides resources, while institutions decide how those resources are used.

3. Research methodology

The study uses annual panel data for 109 countries from 2002 to 2024, classified into 30 developed and 79 developing countries following the IMF grouping. Data are drawn from the World Bank WDI, Our World in Data, the World Resources Institute and the Worldwide Governance Indicators. The dependent variable is the circular economy index (CE), constructed using PCA from carbon efficiency, energy efficiency, energy transition and material pressure. The main explanatory variable is financial development (FD), measured by private sector credit as a share of GDP. Institutional quality (IQ) is measured through six WGI dimensions: CC, GE, PS, RL, RQ and VA. Control variables include GDP growth, FDI, inflation, unemployment, urbanization and Internet use.

Table 1. Core variables and measurement

Symbol	Variable	Measurement
CE	Circular economy index	PCA index from CAE, EE, ET and reversed RE/CAE
FD	Financial development	Private sector credit (% of GDP)
IQ	Institutional quality	Six WGI dimensions: CC, GE, PS, RQ, RL, VA
FD × IQ	Interaction term	Product of financial development and institutional quality
X	Controls	GDP growth, FDI, inflation, unemployment, urbanization, Internet use

Source: Authors' calculations

Table 2. Component indicators of the circular economy index

Symbol	Measurement	Direction	Meaning	References
CAE	CO2 emissions per unit of GDP	Negative	Carbon efficiency / lower emissions per output	Circle Economy (2024); WRI (2025)
EE	GDP per unit of energy use	Positive	Energy productivity	Geng et al. (2012); Emami et al. (2025)
ET	Renewable energy share in primary energy consumption	Positive	Energy transition	Ellen MacArthur Foundation (2015)
RE	Domestic material consumption per GDP	Negative	Material pressure	Mayer et al. (2019); Haas et al. (2020)

Source: Authors' calculations

The moderating model is specified as:

$$CE_{it} = \beta_0 + \beta_1 FD_{it} + \beta_2 IQ_{it} + \beta_3 (FD_{it} \times IQ_{it}) + \beta_x X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

The key coefficient is beta3. A positive beta3 indicates that institutional quality strengthens the effect of financial development on the circular economy. Bayesian regression is used because it reports posterior distributions and posterior probabilities, which are useful in heterogeneous cross-country panels where the direction and certainty of effects matter (Gelman et al., 2013).

4. Results

4.1. Construction of the circular economy index

The PCA diagnostics support the construction of a composite CE index. The KMO value is 0.7620 and Bartlett's test is statistically significant, indicating that the component indicators share sufficient common variation. PC1 has an eigenvalue of 2.3149 and explains 57.87% of total variance. PC2 is close to the Kaiser threshold, but it is not retained because only PC1 exceeds 1.0 and all adjusted indicators load positively on PC1. The

index therefore captures a common macro-level structure of circular transition rather than a single energy or material indicator.

Table 3. PCA diagnostics and index construction summary

Statistic	Value	Interpretation
KMO	0.7620	Good sample adequacy for PCA
Bartlett χ^2	3641.76	p-value = 0.0000; variables are sufficiently correlated
PC1 eigenvalue	2.3149	Retained under Kaiser criterion
PC1 explained variance	57.87%	Main component used for CE index
PC2 eigenvalue	0.9706	Below 1.0; discussed as a limitation, not retained

Source: Authors' calculations

Table 4. PC1 loadings used for the CE index

Indicator	PC1 loading
CAE*	0.4126
ET	0.5939
EE	0.5919
RE*	0.3558

Note: CAE and RE* are reversed variables used in PCA to ensure that higher values indicate better circular economy performance.*

Source: Authors' calculations

4.2. Descriptive evidence

Table 6 reports descriptive statistics for the full sample and for the two country groups. The results show clear differences between developed and developing countries in circular economy performance, financial development, institutional quality, and macroeconomic conditions. This supports the decision to estimate the model separately for the two groups.

The circular economy index has a full-sample mean of 0.537, with developed countries recording a much higher mean value than developing countries (0.864 compared with 0.413). This gap suggests that developed countries have stronger technological capacity, environmental infrastructure, governance quality, and ability to organize production in a less resource-intensive way.

Financial development also differs sharply across groups. The full-sample mean is 58.553, while the mean is 105.062 for developed countries and only 40.891 for developing countries. This indicates that developed economies have deeper financial systems and greater capacity to mobilize capital for clean technology, renewable energy, recycling infrastructure, and circular production.

The institutional indicators show the same pattern. Developed countries have positive and relatively high scores across all six dimensions of institutional quality, including control of corruption, government effectiveness, political stability, rule of law, regulatory quality, and voice and accountability. By contrast, developing countries report negative average values for all six indicators. This institutional gap is important because the study examines whether institutional quality changes the effect of financial development on the circular economy.

Table 5. Selected mean values by country group

109 countries in the sample								
Variable	Mean	SD	Min	Country with minimum	Year of minimum	Max	Country with maximum	Year of maximum
CE	0.537	0.279	0.000	Madagascar	2024	1.000	Sweden	2024
FD	58.553	45.151	1.695	Chad	2006	301.019	Iceland	2006
CC	0.046	1.050	-1.688	Nigeria	2002	2.397	Finland	2006
GE	0.148	0.986	-2.060	Haiti	2021	2.322	Finland	2002
PS	-0.073	0.887	-2.712	Pakistan	2011	1.656	Finland	2002
RL	0.031	0.983	-1.894	Zimbabwe	2006	2.109	Finland	2020
RQ	0.198	0.943	-2.402	Myanmar	2004	2.260	Luxembourg	2002
VA	0.056	0.976	-2.231	Myanmar	2004	1.984	Norway	2021
GDP	2.347	4.298	-30.363	Sudan	2023	32.997	Azerbaijan	2006
FDI	6.160	29.333	-391.555	Luxembourg	2022	452.221	Malta	2018
UR	61.438	21.383	12.203	Uganda	2002	100.000	Bahrain	2010
INF	6.295	16.997	-24.655	Sudan	2023	557.202	Zimbabwe	2020
UNE	7.330	5.755	0.100	Qatar	2019	37.320	North Macedonia	2005
INT	45.719	32.685	0.000	Myanmar	2002	100.000	Bahrain	2021
30 developed countries								
Variable	Mean	SD	Min	Country with minimum	Year of minimum	Max	Country with maximum	Year of maximum
CE	0.864	0.110	0.3014	Iceland	2014	1.000	Sweden	2024
FD	105.062	42.931	23.785	Ireland	2024	301.019	Iceland	2006
CC	1.385	0.678	-0.076	Greece	2011	2.397	Finland	2006
GE	1.412	0.547	0.084	Greece	2016	2.322	Finland	2002
PS	0.833	0.472	-1.183	Israel	2003	1.656	Finland	2002
RL	1.337	0.502	-0.069	Croatia	2002	2.109	Finland	2020
RQ	1.375	0.485	0.119	Croatia	2014	2.260	Luxembourg	2002
VA	1.284	0.422	-0.098	Singapore	2004	1.984	Norway	2021
GDP	1.566	3.715	-14.64	Latvia	2009	23.452	Ireland	2015
FDI	12.616	54.581	-391.555	Luxembourg	2022	452.221	Malta	2018
UR	78.027	12.133	49.762	Slovenia	2012	100.000	Singapore	2002
INF	2.331	2.473	-4.448	Ireland	2009	19.705	Lithuania	2022
UNE	7.227	3.964	2.251	Iceland	2007	27.686	Greece	2013
INT	75.447	19.452	14.67	Greece	2002	99.769	Denmark	2024
79 developing countries								
Variable	Mean	SD	Min	Country with minimum	Year of minimum	Max	Country with maximum	Year of maximum
CE	0.413	0.216	0.000	Madagascar	2024	0.920	China	2008
PTTC	40.891	31.304	1.695	Chad	2006	194.166	China	2024
CC	-0.463	0.639	-1.688	Nigeria	2002	1.622	Uruguay	2021
GE	-0.333	0.625	-2.060	Haiti	2021	1.416	United Arab Emirates	2014
PS	-0.417	0.756	-2.712	Pakistan	2011	1.325	Qatar	2009
RL	-0.465	0.587	-1.894	Zimbabwe	2006	1.329	Chile	2005
RQ	-0.249	0.641	-2.402	Myanmar	2004	1.618	Chile	2005
VA	-0.410	0.675	-2.231	Myanmar	2004	1.314	Chile	2007
GDP	2.644	4.464	-30.363	Sudan	2023	32.997	Azerbaijan	2006
FDI	3.708	5.931	-40.108	Hungary	2018	105.636	Hungary	2020
UR	55.139	20.757	12.203	Uganda	2002	100.000	Bahrain	2010
INF	7.800	19.701	-24.655	Sudan	2023	557.202	Zimbabwe	2020
UNE	7.370	6.304	0.100	Qatar	2019	37.320	North Macedonia	2005
INT	34.430	29.452	0.000	Myanmar	2002	100.000	Bahrain	2021

Source: Authors' calculations based on Bayesian model results.

4.3. Bayesian interaction results

The interaction results show that institutional quality changes the way financial development affects the circular economy. In developed countries, all six interaction terms are positive with posterior probabilities of 1.0000. In developing countries, the interaction effects are also mostly positive, but their posterior certainty is weaker for control of corruption and government effectiveness. Rule of law, regulatory quality, political stability and voice and accountability provide stronger evidence in developing countries. This pattern suggests that finance supports circularity more reliably when institutions are strong enough to direct, monitor and enforce capital allocation.

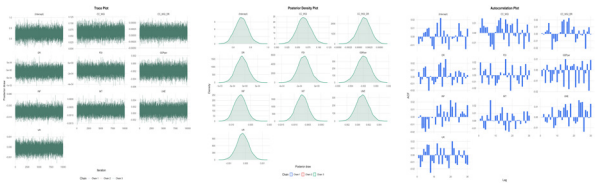
Table 6. Summary of Bayesian interaction results

Interaction	Developed mean	P(>0)	Developing mean	P(>0)	Interpretation
FD × CC	0.0009	1.0000	0.0001	0.8078	Positive in both groups; stronger evidence in developed countries.
FD × GE	0.0014	1.0000	0.0001	0.6666	Government capacity strengthens finance more clearly in developed countries.
FD × PS	0.0008	1.0000	0.0002	0.9978	Political stability supports long-term circular investment in both groups.
FD × RL	0.0008	1.0000	0.0006	0.9961	Rule of law is one of the clearest channels in both groups.
FD × RQ	0.0009	1.0000	0.0004	0.9654	Regulatory quality helps direct finance toward circular objectives.
FD × VA	0.0004	1.0000	0.0005	0.9517	Accountability and transparency support the finance-CE link.

Source: Authors' calculations based on Bayesian model results.

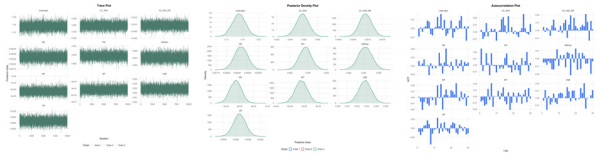
MCMC diagnostic plots are used to check the reliability of the posterior simulation before interpreting the Bayesian regression results. Specifically, trace plots indicate whether the simulated chains converge and fluctuate around a stable value region. Posterior density plots show the shape of the parameter distribution after simulation, helping assess concentration and interpretability of the estimated coefficients. Autocorrelation plots examine the dependence of MCMC samples across lags; a rapid decline in autocorrelation usually indicates relatively independent posterior samples. The diagnostic results show that the simulated chains have an acceptable level of stability. The trace plots fluctuate around relatively stable value regions and do not show a long drifting trend. The posterior density plots are relatively smooth, suggesting that the simulated samples produce interpretable posterior distributions. Autocorrelation generally declines with lags, implying that the posterior samples have a relatively good degree of independence. These diagnostics therefore support the use of Bayesian results to discuss the moderating role of institutional quality in the relationship between financial development and the circular economy. However, interpretation should remain cautious for coefficients with lower posterior probabilities or strong differences between the two country groups (Figure 1-Figue 12).

Figure 1. Trace, posterior density, and autocorrelation plots for the Bayesian model with CC as the interaction variable in the developed-country group



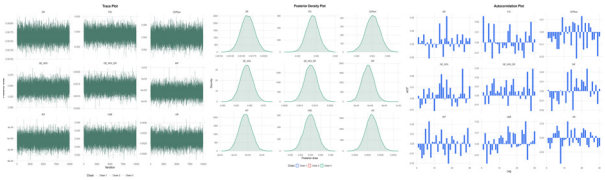
Source: Authors' calculations based on Bayesian model results.

Figure 2. Trace, posterior density, and autocorrelation plots for the Bayesian model with CC as the interaction variable in the developed-country group



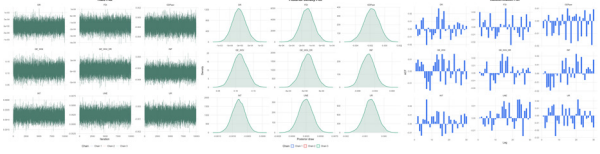
Source: Authors' calculations based on Bayesian model results.

Figure 3. Trace, posterior density, and autocorrelation plots for the Bayesian model with GE as the interaction variable in the developed-country group



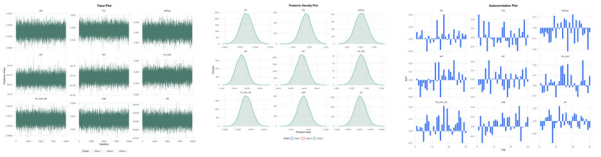
Source: Authors' calculations based on Bayesian model results.

Figure 4. Trace, posterior density, and autocorrelation plots for the Bayesian model with GE as the interaction variable in the developing-country group



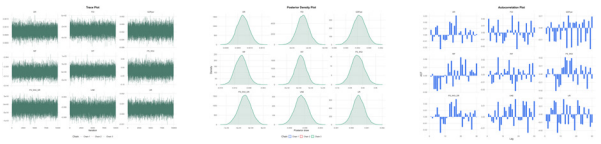
Source: Authors' calculations based on Bayesian model results.

Figure 5. Trace, posterior density, and autocorrelation plots for the Bayesian model with PS as the interaction variable in the developed-country group



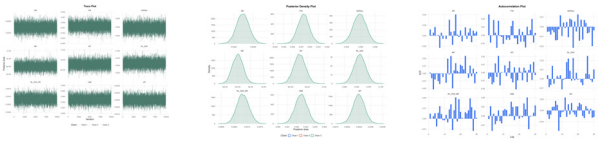
Source: Authors' calculations based on Bayesian model results.

Figur 6. Trace, posterior density, and autocorrelation plots for the Bayesian model with PS as the interaction variable in the developing-country group



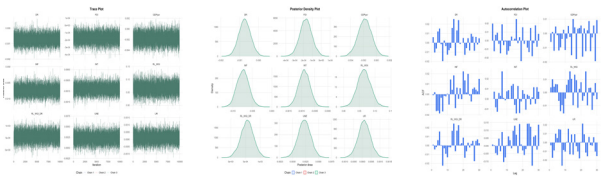
Source: Authors' calculations based on Bayesian model results.

Figure 7. Trace, posterior density, and autocorrelation plots for the Bayesian model with RL as the interaction variable in the developed-country group



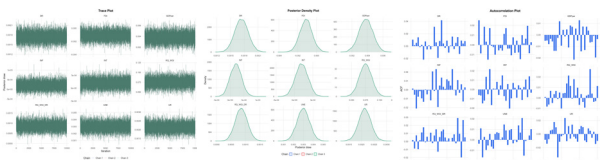
Source: Authors' calculations based on Bayesian model results.

Figure 8. Trace, posterior density, and autocorrelation plots for the Bayesian model with RL as the interaction variable in the developing-country group



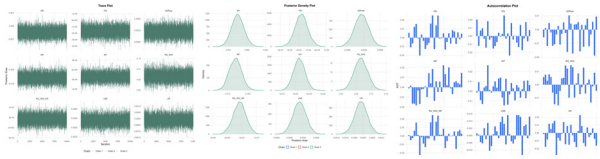
Source: Authors' calculations based on Bayesian model results.

Figure 9. Trace, posterior density, and autocorrelation plots for the Bayesian model with RQ as the interaction variable in the developed-country group



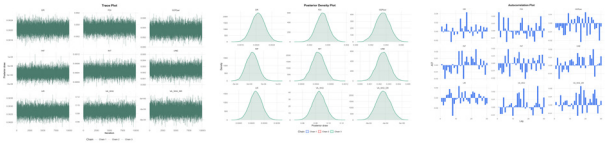
Source: Authors' calculations based on Bayesian model results.

Figure 10. Trace, posterior density, and autocorrelation plots for the Bayesian model with RQ as the interaction variable in the developing-country group



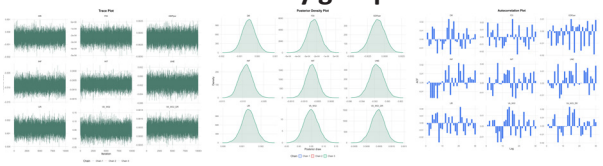
Source: Authors' calculations based on Bayesian model results.

Figure 11. Trace, posterior density, and autocorrelation plots for the Bayesian model with VA as the interaction variable in the developed-country group



Source: Authors' calculations based on Bayesian model results.

Figure 12. Trace, posterior density, and autocorrelation plots for the Bayesian model with VA as the interaction variable in the developing-country group



Source: Authors' calculations based on Bayesian model results.

4.4. Discussion

The results support financial intermediation theory but also qualify it. Finance matters because it can mobilize capital for clean technology, renewable energy, recycling, and remanufacturing. This is consistent with Levine (1997) and Beck et al. (2000), who argue that financial systems improve capital allocation and support innovation. It also aligns with Ellen MacArthur Foundation (2015, 2020) and UNEP (2020), which emphasize the role of finance in circular transition. However, the findings also support the caution raised by Chen et al. (2026) and Fang et al. (2024): financial development is not automatically circular. If capital flows into carbon- and material-intensive sectors, finance can reinforce the linear economy rather than support the circular economy.

The results also support institutional theory. Institutions determine whether financial resources are converted into circular investment. This is consistent with Acemoglu et al. (2005) and

Kaufmann et al. (2010), who argue that institutions shape resource allocation, enforcement, and accountability. Control of corruption limits rent-seeking and misallocation. Government effectiveness improves the implementation of green finance policies. Political stability reduces long-term investment risk. Rule of law secures contracts and strengthens environmental enforcement. Regulatory quality supports green taxonomies and disclosure rules. Voice and accountability increase social pressure for cleaner production. Compared with prior studies that examine finance or institutions separately, this study shows that institutional quality acts as a moderating condition: finance supports the circular economy more clearly when institutional capacity is strong. The stronger results in developed countries reflect better institutional capacity, while weaker results in developing countries point to constraints in enforcement, financial depth, green data, and regulatory design.

5. Conclusion and policy implications

This study constructs a macro-level circular economy index and tests whether institutional quality moderates the relationship between financial development and the circular economy. The evidence shows that developed countries have higher circular economy performance, deeper financial systems and stronger institutions. More importantly, the Bayesian interaction results indicate that institutional quality strengthens the ability of financial development to support circular transition, especially in developed countries. In developing countries, the moderating role is positive but less stable, suggesting that finance needs stronger institutional guidance to become circular.

The main theoretical implication is that financial intermediation theory should be read together with institutional theory in the circular economy context. Finance provides resources, but institutions determine the direction and quality of resource use. For policy, countries should not only expand credit. They should improve the institutional conditions that guide finance toward clean technology, renewable energy, recycling, remanufacturing and resource-efficient production. Developed countries should deepen green and circular finance instruments. Developing countries should strengthen rule of law, regulatory quality, government effectiveness and anti-corruption mechanisms so that financial development does not drift toward resource-intensive sectors.

The study has limitations. The CE index is a macro-level measure and does not capture all firm- or product-level circular practices. Financial development is measured by private sector credit and does not directly capture green credit or green bonds. Institutional quality is measured by WGI indicators and may not fully reflect implementation capacity. Future research should use sectoral data, firm-level circular indicators, and direct green finance measures to test the finance-institution-circular economy mechanism in more detail.

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