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Innovation without an Aggregate SDG Dividend? Evidence on the Level and Balance of Social Progress in Developing Economies

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Abstract: This study asks a question that is often presumed rather than tested: does greater innovation capacity translate into broad and inclusive progress across the Sustainable Development Goals (SDGs) in developing economies? Using a balanced panel of 43 economies observed annually from 2005 to 2023 (817 country-year observations), the analysis combines an aggregate SDG index with all 17 goal scores, four multidimensional SDG groupings, and a new distinction between the level and the balance of social progress. Innovation is measured primarily by an innovation index and is cross-checked with research-and-development expenditure and high-technology exports. Country fixed effects, year effects, clustered standard errors, extended controls, nonlinear specifications, and two-step system GMM are used to distinguish cross-sectional associations from within-country change. The results overturn the simple innovation-dividend narrative. Innovation is strongly negative in country fixed-effects models that omit common time shocks, but the coefficient collapses to statistical insignificance once year effects are introduced (β = -0.031, p = 0.492) and remains insignificant with extended controls, alternative innovation measures, nonlinear terms, and system GMM. Across the 17 SDGs, only SDG 6 shows a conventional 5% association with innovation, and the sign is negative (β = -0.178, p = 0.028). Innovation is also insignificant for social, productive-economic, environmental, and institutional SDG composites. However, a different pattern emerges when inclusion is defined as balance across core social goals (SDGs 1, 2, 3, 4, 5, and 10): innovation does not raise their average level (β = -0.009, p = 0.939), but it significantly reduces cross-goal dispersion (β = -0.184, p = 0.043). The paper therefore argues that innovation may contribute more to the distribution and coordination of social progress than to its aggregate level. This finding shifts the policy question from how much innovation an economy produces to how innovation systems are directed, governed, diffused, and connected to social objectives.

Keywords: innovation; Sustainable Development Goals; inclusive social progress; development; fixed effects; system GMM; SDG synergies; developing economies.

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الابتكار دون عائد إجمالي لأهداف التنمية المستدامة؟ أدلة حول مستوى وتوازن التقدم الاجتماعي في الاقتصادات النامية

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ملخص: تطرح هذه الدراسة تساؤلاً غالباً ما يُفترض صحته دون إخضاعه للاختبار: هل تترجم القدرة الأكبر على الابتكار إلى تقدم واسع وشامل عبر أهداف التنمية المستدامة (SDGs) في الاقتصادات النامية؟ بالاعتماد على بيانات بانل (panel data) متوازنة تشمل 43 اقتصاداً تمت متابعتها سنوياً في الفترة من 2005 إلى 2023 (بإجمالي 817 مشاهدة لبيانات الدول عبر السنوات)، يجمع التحليل بين مؤشر إجمالي لأهداف التنمية المستدامة ودرجات الأهداف السبعة عشر جميعها، وأربع مجموعات متعددة الأبعاد للأهداف، بالإضافة إلى تمييز جديد بين مستوى التقدم الاجتماعي وتوازنه. ويُقاس الابتكار في المقام الأول من خلال مؤشر للابتكار، مع التحقق من النتائج ومقارنتها ببيانات الإنفاق على البحث والتطوير وصادرات التكنولوجيا المتقدمة. وقد استُخدمت تقنيات تشمل التأثيرات الثابتة للدول، وتأثيرات السنوات، والأخطاء المعيارية المجمعة (clustered standard errors)، ومتغيرات التحكم الموسعة، والمواصفات غير الخطية، وطريقة "نظام العزم المعمم" (System GMM) المكونة من مرحلتين، وذلك للتمييز بين الارتباطات المقطعية (بين الدول) والتغيرات التي تحدث داخل الدولة الواحدة. وتدحض النتائج السردية المبسطة التي تربط الابتكار بعائد مباشر (أو "عائد تنموي") تلقائي. تُظهر العلاقة مع الابتكار طابعاً سلبياً قوياً في نماذج "التأثيرات الثابتة للدول" التي تغفل الصدمات الزمنية المشتركة، إلا أن قيمة المعامل تفقد دلالتها الإحصائية بمجرد إدراج تأثيرات السنوات ($\beta = -0.031$، $p = 0.492$)، وتظل غير دالة إحصائياً عند استخدام متغيرات ضابطة موسعة، أو مقاييس بديلة للابتكار، أو حدود غير خطية، أو طريقة "نظام العزم المعمم" (System GMM). ومن بين أهداف التنمية المستدامة السبعة عشر، يظهر الهدف السادس (SDG 6) وحده ارتباطاً بالابتكار عند مستوى دلالة تقليدي قدره 5%، وتكون إشارة العلاقة سالبة ($\beta = -0.178$، $p = 0.028$). كما تبيّن عدم وجود دلالة إحصائية للعلاقة بين الابتكار والمؤشرات المركبة لأهداف التنمية المستدامة في المجالات الاجتماعية، والاقتصادية الإنتاجية، والبيئية، والمؤسسية. ومع ذلك، يبرز نمط مختلف عندما يُعرَّف "الشمول" على أنه حالة من التوازن بين الأهداف الاجتماعية الجوهرية (الأهداف 1 و2 و3 و4 و5 و10): إذ لا يؤدي الابتكار إلى رفع متوسط مستواها ($\beta = -0.009$، $p = 0.939$)، ولكنه يقلل بشكل ملموس من التشتت بين هذه الأهداف ($\beta = -0.184$، $p = 0.043$). ولذا، تجادل الورقة بأن الابتكار قد يسهم في توزيع وتنسيق التقدم الاجتماعي أكثر من إسهامه في رفع مستواه الإجمالي. وتُحوّل هذه النتيجة محور النقاش في السياسات العامة من مسألة "حجم الابتكار الذي ينتجه الاقتصاد" إلى كيفية توجيه أنظمة الابتكار، وحوكمتها، ونشرها، وربطها بالأهداف الاجتماعية.

الكلمات المفتاحية: الابتكار؛ أهداف التنمية المستدامة؛ التقدم الاجتماعي الشامل؛ التنمية؛ التأثيرات الثابتة؛ نظام العزم المعمم (System GMM)؛ التآزر بين أهداف التنمية المستدامة؛ الاقتصادات النامية.

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1. Introduction

The contemporary development agenda assigns innovation a pivotal role in raising productivity, creating new technologies, improving public services, supporting ecological transition, and widening access to information and markets. SDG 9 embeds innovation directly in the 2030 Agenda, while innovation also enters indirectly into the achievement of goals related to health, education, clean energy, decent work, climate action, and institutional capacity. Yet the policy proposition that more innovation necessarily produces more sustainable and inclusive development is stronger than the empirical evidence warrants. Innovation can generate productivity and capability gains, but it can also be spatially concentrated, skill-biased, resource-intensive, institutionally captured, or disconnected from the sectors in which social deprivation is most acute.

Recent multidisciplinary research increasingly treats sustainable development as an interconnected system rather than a collection of separable targets. Moallemi et al. (2022) conceptualize recurring patterns of SDG synergies and trade-offs and argue that progress depends on understanding the mechanisms through which one goal accelerates or constrains another. Xiao et al. (2023) similarly show that indirect interactions matter and that a policy focus on isolated goals can miss important system-wide effects. In African settings, nexus-oriented research stresses that water, energy, food, poverty, health, and ecological outcomes are jointly determined and therefore require coordinated policy responses (Mabhaudhi et al., 2021). This systems perspective makes a simple innovation-to-SDG regression conceptually incomplete: the same innovation process can raise one dimension, leave another unchanged, and widen or narrow gaps among goals.

The distinction between the level and the distribution of development outcomes is therefore central. A country may record a higher aggregate SDG score while leaving poverty, inequality, gender equality, or basic services behind. Conversely, an intervention may have a modest effect on the average level of social achievement while reducing dispersion across social goals. The latter is substantively important because the 2030 Agenda is explicitly universal and integrated. A development process that advances only the easiest or most technology-proximate goals cannot automatically be described as inclusive.

This concern is particularly salient in developing economies, where innovation systems often coexist with infrastructure deficits, large informal sectors, uneven state capacity, limited research financing, and substantial differences in institutional quality. Peter (2021) emphasizes that sustainable transitions in sub-Saharan Africa must be understood in the context of poverty, inequality, infrastructure gaps, and formal-informal dualism, and argues for locally embedded social innovation ecosystems. Ouma-Mugabe et al. (2024) document limited institutionalization of science, technology and innovation foresight in sub-Saharan Africa and identify weak capacity and a thin foresight culture as constraints on steering research and innovation toward long-run development goals. These arguments imply that innovation capacity and social conversion capacity are not identical.

The empirical literature also gives reason to expect conditional rather than automatic effects. Forson et al. (2021) find a positive but relatively small growth contribution of innovation in sub-Saharan Africa and show that institutional conditions shape its performance across regimes. Bekana (2021) finds strong direct and indirect roles for institutional quality in explaining economic performance, including channels operating through innovation. At the broader SDG level, Barbier and Burgess (2021) report that institutional quality and lower country risk are associated with long-run welfare gains linked to the SDGs. More recent African evidence likewise places governance at the centre of sustainable development performance (Adebayo et al., 2025; Oppong, 2025). Alabani et al. (2026) go further by showing that innovation capacity alone does not automatically close the sustainability gap in sub-Saharan Africa. Taken together, this literature suggests that innovation should be evaluated by what it enables across the development system, not simply by whether innovation indicators rise.

This paper contributes to that debate in four ways. First, it distinguishes raw cross-sectional association from within-country effects under country and year fixed effects. Second, it uses three alternative innovation measures to test whether conclusions depend on a single proxy. Third, it moves beyond the aggregate SDG index to all 17 goals and to social, productive-economic, environmental, and institutional composites. Fourth, and most importantly, it operationalizes inclusive social progress in two parts: the mean achievement of six core social SDGs and the dispersion among them. This permits a direct empirical distinction between raising average social achievement and making social development more balanced.

The results are unusually clear in what they reject and more subtle in what they support. A simple fixed-effects specification suggests a large negative association between innovation and the aggregate SDG score. The negative coefficient persists after adding macroeconomic controls. Once year fixed effects are added, however, the effect shrinks by almost 90% and becomes statistically indistinguishable from zero. The same null result survives an extended control set, R&D expenditure, high-technology exports, logged innovation inputs, nonlinear models, and dynamic system GMM. The 17-goal analysis also shows little direct association, with a significant negative coefficient only for SDG 6. Nevertheless, innovation significantly reduces dispersion across the social SDGs even though it does not increase their average level. The emerging interpretation is therefore not an innovation dividend in levels, but a potential balancing effect across social outcomes.

This distinction matters for both theory and policy. It cautions against treating innovation indices as development outcomes, challenges innovation strategies that presume automatic spillovers into social welfare, and suggests that the design of innovation systems should be evaluated by diffusion, coordination, accessibility, institutional steering, and cross-sectoral complementarities. The remainder of the paper develops this argument, presents the data and empirical strategy, reports the results, and discusses implications for innovation and social-development policy.

2. Literature Review and Analytical Framework

2.1 Innovation as a development capability rather than a development outcome

Innovation is commonly linked to development through productivity growth, new products and processes, knowledge diffusion, organizational change, and the creation of new markets. In developing economies, however, these channels operate through institutions and structural conditions that can amplify or block diffusion. The national-innovation-systems perspective is useful because it shifts attention from isolated R&D activity to the relationships among firms, universities, public agencies, finance, human capital, infrastructure, and policy institutions. This makes innovation a system-level capability whose social returns depend on how effectively knowledge and technologies travel through the economy.

Empirical studies from Africa illustrate the conditional nature of these returns. Forson et al. (2021) treat innovation as multidimensional and find that it is positively related to growth, but the magnitude is small and differs across institutional regimes. Bekana (2021) similarly argues that institutions matter both directly and indirectly through innovation. Research on digital infrastructure further reinforces the complementarity logic by linking innovation capacity to the availability of human capital and enabling infrastructure (Osei, 2024). Studies of employment outcomes also broaden the criterion of success beyond GDP by asking whether innovation improves the quantity and quality of jobs (Twumasi Baffour et al., 2024).

This paper therefore treats innovation as an input into a conversion process. The central theoretical question is not whether innovation is intrinsically desirable, but whether innovation capacity is converted into multidimensional development outcomes. Conversion may fail when innovation is concentrated in enclaves, directed toward capital-intensive sectors, weakly connected to basic services, dependent on imported technologies, or constrained by institutional and infrastructural bottlenecks.

2.2 SDG interactions, synergies and trade-offs

The SDGs provide a natural framework for evaluating the multidimensional conversion of innovation because they combine economic, social, environmental, and institutional objectives. Their strength is also an empirical complication: the goals interact. Renaud et al. (2020) emphasize synergies and trade-offs among targets, while Moallemi et al. (2022) systematize recurrent interaction patterns and argue that policy resistance can emerge from the structure of interdependencies. Xiao et al. (2023) demonstrate that indirect interactions can be large and that the relative importance of goals changes when these channels are incorporated.

African evidence likewise cautions against siloed evaluation. Osman et al. (2022) examine spatial patterns of SDG synergies and trade-offs in Africa, while Mabhaudhi et al. (2021) show how nexus planning can reveal cross-sectoral connections among water, food, energy, health, poverty, and environmental sustainability. Huang et al. (2025) provide a recent multidimensional example: digitalization supports economic, environmental, and social sustainability, whereas financial development and the energy mix generate gains in some dimensions and costs in others. Such results underscore that the sign of an innovation-related effect depends on the outcome being evaluated.

This interdependence motivates two empirical decisions in the present study. The first is to report results for all 17 goals rather than infer inclusiveness from the aggregate SDG index. The second is to evaluate balance. If innovation raises one group of goals while leaving others behind, the aggregate may conceal divergence; if it reduces gaps among social goals, that balancing effect may be missed by mean-based analysis.

2.3 Institutions and the social direction of innovation

Institutional quality determines the incentives, coordination mechanisms, accountability structures, and implementation capacity through which innovation is translated into social outcomes. Barbier and Burgess (2021) find that long-run SDG-related welfare gains are associated with institutional quality and lower country risk. Adebayo et al. (2025), using GMM for African countries, report a robust link between governance quality and economic, social, and environmental dimensions of sustainable development. Oppong (2025) similarly shows that several governance dimensions, including control of corruption, rule of law, political stability, and voice and accountability, are associated with composite SDG performance.

These findings are important because they imply that the 'direction' of innovation is institutionally produced. Public procurement, regulatory standards, research funding, infrastructure priorities, science-granting councils, and public-sector foresight can orient innovation toward or away from socially valuable objectives. Ouma-Mugabe et al. (2024) argue that foresight remains weakly institutionalized in sub-Saharan African STI systems, limiting the ability of governments to steer research and innovation toward long-term goals. At the local level, Peter (2021) emphasizes decentralized social innovation and economic ecosystems as mechanisms for connecting innovation to unmet needs.

From this perspective, a statistically weak average effect of innovation on SDG performance should not be interpreted as evidence that innovation is irrelevant. It may instead indicate a missing conversion architecture. This is consistent with Alabani et al. (2026), who find that innovation alone does not close the sustainability gap and argue that innovation systems need explicit alignment with sustainability objectives.

2.4 Analytical expectations

The empirical analysis is organized around four expectations. First, innovation may be positively associated with aggregate SDG performance in raw comparisons, but the relationship may weaken after controlling for time-invariant country characteristics and global time shocks. Second, innovation effects are expected to be heterogeneous across individual SDGs because goals differ in their technological proximity, institutional requirements, and exposure to trade-offs. Third, alternative innovation measures should not necessarily yield identical coefficients because R&D inputs, innovation-system performance, and high-technology exports capture different stages of the innovation process. Fourth, inclusive social progress should be assessed separately as a level effect and a balance effect. Innovation can therefore be socially relevant even when its mean effect is small if it narrows disparities across core social goals.

3. Data and Methods

3.1 Panel structure and variables

The study combines SDG performance data from Sachs et al. (2024), a United Nations–commissioned assessment of progress toward the 2030 Agenda, with macroeconomic indicators from the World Bank's World Development Indicators (WDI). The datasets were merged by country and year to construct the panel used for the analysis. The analytical sample is a balanced panel of 43 developing economies over 2005-2023, yielding 817 observations. The balanced structure is useful for model comparability because each country contributes 19 annual observations.

The principal outcome is the SDG Index Score. To avoid treating this composite as sufficient evidence of broad-based progress, the analysis additionally uses the 17 individual goal scores.

The primary explanatory variable is Innovations_Index. Robustness models replace it with R&D expenditure as a percentage of GDP, high-technology exports as a percentage of manufactured exports, and logged versions of R&D expenditure and high-technology exports. The baseline control vector contains log GDP per capita, the annual rate of real GDP growth, foreign direct investment as a percentage of GDP, and labour-force participation. The extended model adds domestic credit to the private sector, trade freedom, and government debt as a percentage of GDP.

Governance indicators in the dataset include control of corruption and regulatory quality. They are retained for descriptive and theoretical interpretation in this version of the manuscript; the posted results do not yet contain a completed set of interaction estimates that would justify presenting governance moderation as a main empirical finding. The final submission can extend the analysis in this direction.

3.2 Multidimensional and inclusive-development measures

Four SDG dimensions are constructed as simple within-observation means. The social dimension combines SDGs 1, 2, 3, 4, 5, and 10. The productive-economic dimension combines SDGs 8 and 9. The environmental dimension combines SDGs 6, 7, 11, 12, 13, 14, and 15. The institutional dimension combines SDGs 16 and 17. These groupings are used as interpretive devices rather than substitutes for the individual goals.

To operationalize inclusive social progress, two additional measures are constructed from SDGs 1, 2, 3, 4, 5, and 10. social_mean is the arithmetic mean of the six goal scores and captures the level of social achievement. social_sd is their within-country-year standard deviation and captures imbalance; a larger value indicates that progress is more uneven across social objectives. A balance-adjusted index, Inclusive_Social_Progress = social_mean - social_sd, is used as a supplementary robustness measure. This decomposition is central to the paper because an innovation process may reduce imbalance without materially increasing the mean.

3.3 Empirical strategy

The baseline fixed-effects model is: SDG_it = β Innovation_it + γ'X_it + μ_i + λ_t + ε_it, where μ_i captures time-invariant country heterogeneity and λ_t captures common year shocks. Standard errors are clustered by country. The model sequence is deliberately cumulative: country fixed effects alone; fixed effects with baseline controls; two-way fixed effects with year dummies; and an extended two-way fixed-effects model.

To assess whether conclusions depend on the innovation proxy, the preferred two-way fixed-effects model is re-estimated using R&D expenditure and high-technology exports in level and logged form. Nonlinear specifications include the innovation index and its square. Dynamic persistence and potential endogeneity are explored using two-step system GMM with a lagged dependent variable and collapsed instruments over lags 2-3. Instrument validity is assessed with Hansen and Sargan tests and serial correlation with Arellano-Bond AR(1) and AR(2) tests.

Two diagnostics are especially important. First, variance-inflation factors are used to evaluate multicollinearity. Second, Pesaran's test is used to detect cross-sectional dependence. The latter rejects cross-sectional independence in the posted results; consequently, the final journal version should add a cross-sectional-dependence-robust estimator such as Driscoll-Kraay or common-correlated-effects estimation. The attempted Driscoll-Kraay command in the posted run failed because of a Stata macro/variable-name parsing error, so no unexecuted result is reported as evidence.

4. Results

4.1 Descriptive profile

Variable	N	Mean	SD	Min	Max
SDG Index Score	817	53.222	6.297	39.515	70.821
Innovation Index	817	25.131	4.494	10.320	40.900
R&D expenditure (% GDP)	817	0.284	0.166	0.010	0.810

High-tech exports (% manufactured exports)	817	5.414	8.108	0.000	95.620
Control of corruption	817	-0.660	0.626	-1.850	1.160
Regulatory quality	817	-0.697	0.599	-2.550	1.200
Log GDP per capita	817	7.048	0.898	4.999	9.363
Real GDP growth (%)	817	4.120	4.465	-36.390	21.450
FDI (% GDP)	817	4.497	7.951	-17.290	103.340
Labour-force participation (%)	817	63.984	11.527	33.710	88.350
Domestic credit to private sector	817	21.311	20.442	1.200	142.420
Trade freedom index	817	65.912	9.132	23.000	89.000
Government debt (% GDP)	817	53.659	46.031	5.980	488.460

Table 1. Descriptive statistics.

The descriptive data show substantial variation in both development and innovation. The mean SDG Index is 53.22, compared with an Innovation Index mean of 25.13. R&D spending averages only 0.284% of GDP. High-technology exports are highly dispersed, with a mean of 5.41% and a maximum of 95.62%. FDI and public debt are also strongly right-skewed; government debt reaches 488.46% of GDP in the most extreme observation. These tails reinforce the importance of fixed effects and robustness checks rather than relying on pooled cross-country associations.

The panel decomposition also indicates that much of the variation in governance and income occurs between countries rather than within countries. For the Innovation Index, the between-country standard deviation (3.706) exceeds the within-country standard deviation (2.601). This is important because a positive cross-sectional relationship can coexist with a weak within-country effect if high-SDG countries are structurally more innovative but increases in innovation within a given country do not immediately raise its SDG performance.

4.2 From a large negative coefficient to a null within-country effect

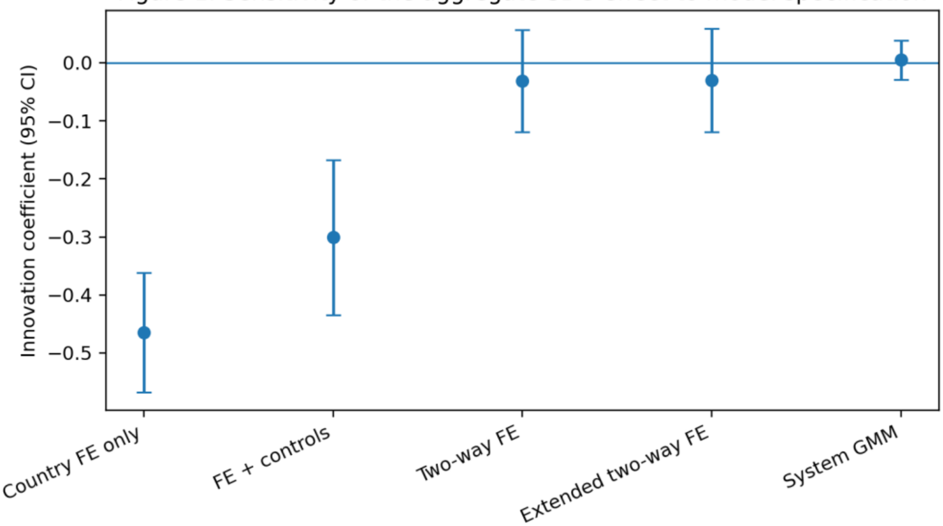
Specification	**β Innovation**	**SE**	**p-value**	**Within R^2**
Country FE only	-0.465	0.052	0.000	0.234
FE + baseline controls	-0.301	0.068	0.000	0.481
Country + year FE	-0.031	0.045	0.492	0.800
Extended country + year FE	-0.030	0.045	0.510	0.804
System GMM	0.005	0.017	0.779	

Table 2. Evolution of the aggregate innovation coefficient across specifications.

The model sequence is one of the paper's most important empirical findings. With country fixed effects but no controls, the innovation coefficient is -0.465 ($p < 0.001$). Adding the baseline controls reduces the magnitude to -0.301 but it remains highly significant. Once year fixed effects are included, the coefficient falls to -0.031 and becomes insignificant ($p = 0.492$). Adding domestic credit, trade freedom, and government debt does not change this conclusion ($\beta = -0.030$, $p = 0.510$). The within R^2 rises sharply from 0.481 in the controlled one-way fixed-effects model to 0.800 after year effects are added.

This collapse indicates that the earlier negative coefficient was substantially confounded by common temporal movements. SDG performance rises strongly through the sample period, and innovation also exhibits time variation. When the model compares countries with themselves while simultaneously absorbing global year-specific shocks and common progress, the residual innovation variation is not systematically associated with the aggregate SDG score. This makes the two-way fixed-effects specification substantively preferable to a model that attributes common temporal change to innovation.

Figure 1. Sensitivity of the aggregate SDG effect to model specification



4.3 Alternative measures of innovation

Innovation measure	**Coefficient**	**SE**	**p-value**
Innovation Index	-0.031	0.045	0.492
R&D expenditure (% GDP)	2.647	2.129	0.221
High-tech exports (% manufactured exports)	-0.009	0.011	0.400
Log R&D expenditure	0.665	0.448	0.145
Log high-tech exports	-0.018	0.148	0.901

Table 3. Alternative innovation measures in two-way fixed-effects models.

The null aggregate result is not an artifact of the main innovation index. R&D expenditure is positive but statistically insignificant (β = 2.647, p = 0.221), and its logged version is also positive but insignificant (β = 0.665, p = 0.145). High-technology exports are negative and insignificant in both level and logged specifications. This is important because the three measures capture different parts of the innovation process: system performance, knowledge investment, and technologically intensive export output. The absence of a consistent aggregate SDG coefficient across these measures weakens any claim that innovation has a general contemporaneous SDG dividend in the sample.

4.4 Innovation across four SDG dimensions

Dimension	**β Innovation**	**SE**	**p-value**	**Within R^2**
Social: SDGs 1,2,3,4,5,10	-0.009	0.119	0.939	0.661
Productive-economic: SDGs 8,9	-0.119	0.097	0.225	0.734
Environmental: SDGs 6,7,11,12,13,14,15	-0.029	0.041	0.485	0.600
Institutional: SDGs 16,17	-0.004	0.084	0.965	0.094

Table 4. Innovation and multidimensional SDG composites.

Aggregating goals into broader dimensions does not reveal a hidden positive effect. The innovation coefficient is insignificant for the social, productive-economic, environmental, and institutional dimensions. This is notable for the productive-economic grouping because SDGs 8 and 9 are often considered the most directly connected to innovation. The result suggests that an innovation system can improve technologically without generating a contemporaneous, measurable increase in these composite development scores after country and year effects are absorbed.

4.5 The 17-goal map: broad null effects with one significant adverse association

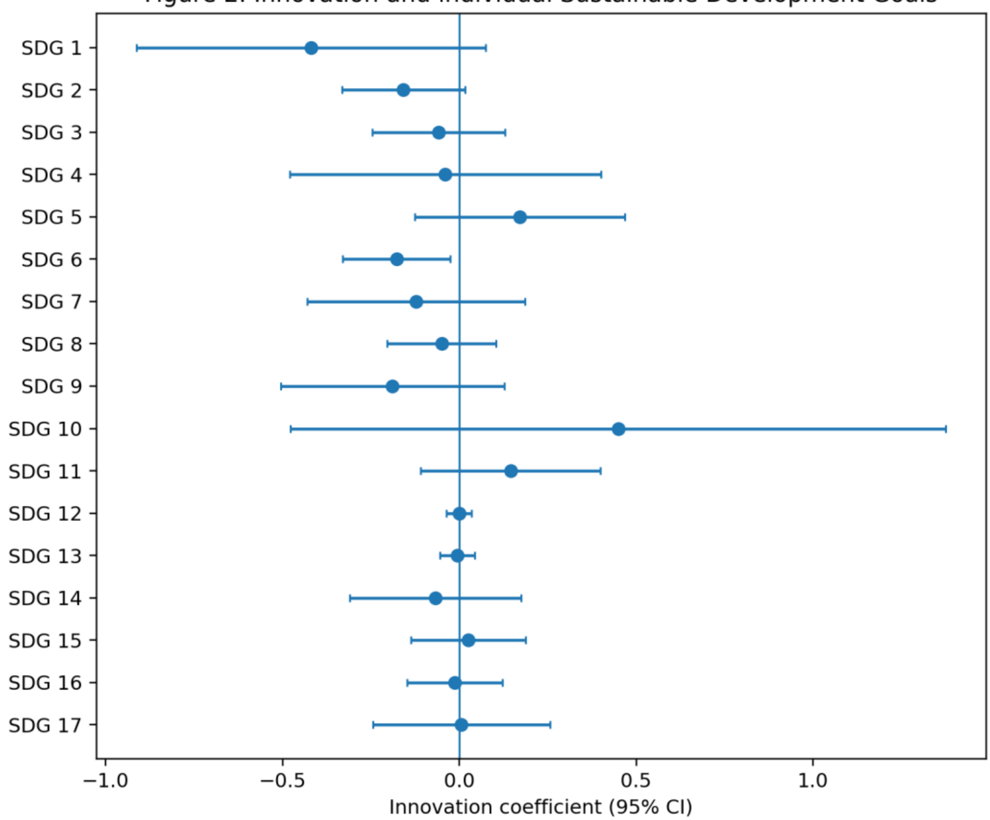
SDG	Goal	β Innovation	SE	p-value	Significance
1	No poverty	-0.419	0.252	0.103	
2	Zero hunger	-0.158	0.089	0.083	*
3	Good health and well-being	-0.058	0.096	0.546	
4	Quality education	-0.040	0.225	0.860	
5	Gender equality	0.170	0.151	0.267	
6	Clean water and sanitation	-0.178	0.078	0.028	**
7	Affordable and clean energy	-0.123	0.157	0.439	
8	Decent work and economic growth	-0.050	0.079	0.530	
9	Industry, innovation and infrastructure	-0.189	0.161	0.247	
10	Reduced inequalities	0.449	0.473	0.347	
11	Sustainable cities and communities	0.145	0.130	0.268	
12	Responsible consumption and production	-0.001	0.018	0.965	
13	Climate action	-0.005	0.025	0.834	
14	Life below water	-0.068	0.123	0.586	
15	Life on land	0.025	0.082	0.764	
16	Peace, justice and strong institutions	-0.013	0.069	0.849	
17	Partnerships for the goals	0.006	0.128	0.964	

Table 5. Innovation coefficients across the 17 SDGs. ** $p < 0.05$; * $p < 0.10$.

The disaggregated results are more informative than the aggregate index because they show where the null result comes from. Fifteen of the 17 coefficients are statistically insignificant even at the 10% level. SDG 2 is weakly negative at the 10% level ($\beta = -0.158$, $p = 0.083$), while SDG 1 is negative but falls just outside that threshold ($\beta = -0.419$, $p = 0.103$). The only 5% association is for SDG 6, clean water and sanitation, where innovation is negatively related to the goal score ($\beta = -0.178$, $p = 0.028$).

The SDG 6 result should not be interpreted mechanically as evidence that innovation causes poorer water and sanitation outcomes. It can reflect sectoral allocation, urban-industrial pressure, the lag between innovation and infrastructure expansion, omitted time-varying policy factors, or the possibility that national innovation capacity is concentrated outside basic-service systems. What is clear is that there is no evidence of a broad positive pattern across the goals. Even SDG 9 has a negative and insignificant coefficient ($\beta = -0.189$, $p = 0.247$), indicating that the national innovation index and the SDG 9 score are empirically distinct after fixed effects and common time shocks are controlled.

Figure 2. Innovation and individual Sustainable Development Goals



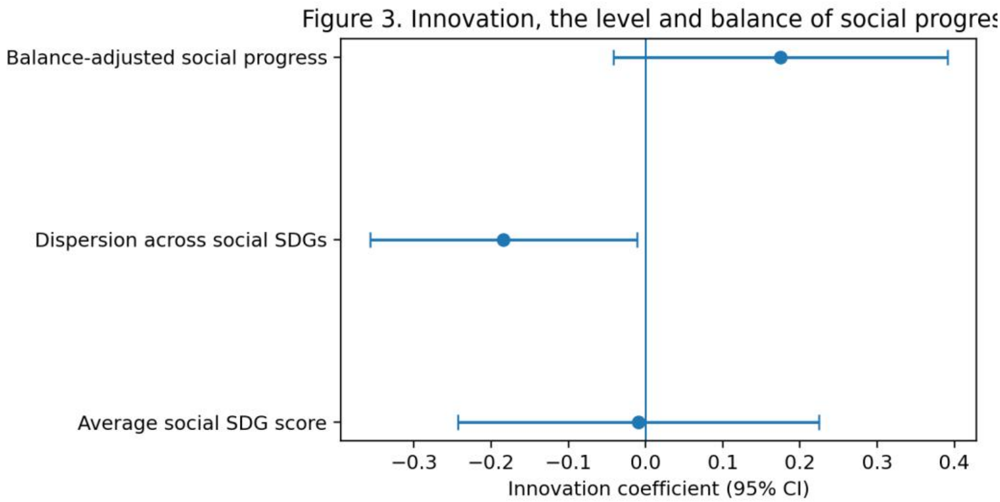
4.6 Inclusion as balance rather than average level

Outcome	β Innovation	SE	p-value	Within R^2
Mean of social SDGs	-0.009	0.119	0.939	0.661
Dispersion across social SDGs	-0.184	0.088	0.043	0.114
Balance-adjusted social progress	0.175	0.110	0.121	0.630

Table 6. Innovation, the level and balance of social progress.

The most distinctive result emerges when social progress is decomposed into level and balance. The average of SDGs 1, 2, 3, 4, 5, and 10 has a mean of 42.29 and is not affected by innovation ($\beta = -0.009$, $p = 0.939$). By contrast, the standard deviation across the same six goals has a mean of 17.69 and falls significantly with innovation ($\beta = -0.184$, $p = 0.043$). Because a lower standard deviation indicates more even achievement across social goals, the coefficient implies that higher innovation is associated with a narrowing of within-country social-goal disparities.

This finding should be interpreted as a balancing association, not as proof that innovation raises the welfare level of disadvantaged groups. Indeed, the balance-adjusted index is positive but statistically insignificant ($\beta = 0.175$, $p = 0.121$). The combination of a null mean effect and a negative dispersion effect suggests that innovation may help equalize the configuration of social progress without shifting the overall frontier. In substantive terms, innovation appears more strongly connected to the distribution of social achievement across goals than to its average level.



4.7 Dynamic persistence and system GMM

Innovation proxy	Lagged SDG	Innovation β	p-value	AR(2) p	Hansen p	Instruments
Innovation Index	1.033	0.005	0.779	0.932	0.420	28
R&D expenditure	1.030	0.688	0.428	0.966	0.208	28

Table 7. Two-step system GMM summary.

The dynamic models reinforce the central null result. With the Innovation Index, the coefficient is 0.0048 (p = 0.779); with R&D expenditure it is 0.688 (p = 0.428). In both specifications the lagged SDG Index is approximately 1.03 and highly significant, indicating very strong persistence. AR(1) is significant as expected in first differences, while AR(2) is comfortably insignificant (p = 0.932 and 0.966). Hansen p-values of 0.420 and 0.208 do not reject the instrument sets. The instrument count is 28 for 43 groups, which is reasonably contained because instruments were collapsed.

The lagged dependent-variable coefficient slightly above unity requires caution. It may reflect near-unit-root persistence, common trends, index construction, or finite-sample behavior in a highly persistent development series. The R&D specification also produced a warning that the two-step covariance matrix of moments was singular and used a generalized inverse. The dynamic results are therefore best treated as robustness evidence for the absence of an innovation effect rather than as the sole basis for long-run interpretation.

4.8 Diagnostics and sensitivity

Multicollinearity is not a material concern: the mean VIF is 1.81 and the largest reported values are only slightly above 2. Cross-sectional dependence is more consequential. Pesaran's test rejects cross-sectional independence (statistic = -2.507, $p = 0.0122$), and the average absolute off-diagonal residual correlation is 0.415. This is plausible in a sample of developing economies exposed to common commodity cycles, financial conditions, technology diffusion, geopolitical shocks, pandemics, and the global SDG policy regime.

Nonlinearity does not alter the findings. In the aggregate SDG model, the linear innovation term is insignificant ($\beta = 0.088$, $p = 0.681$) and the squared term is also insignificant ($\beta = -0.0026$, $p = 0.573$); the joint test has $p = 0.678$. The corresponding social-dimension nonlinear model is likewise insignificant. These results provide no evidence of a simple inverted-U or U-shaped innovation-SDG relationship over the observed range.

5. Discussion

The empirical evidence supports a more cautious and institutionally grounded interpretation of innovation-led development. The first implication is that innovation capacity should not be equated with sustainable-development performance. The positive raw correlation between the SDG Index and the Innovation Index ($r = 0.280$) disappears as a within-country effect once year shocks are controlled. This distinction is conceptually important: more developed countries can simultaneously have stronger innovation systems and higher SDG scores without year-to-year improvements in innovation being the cause of year-to-year SDG gains.

This result is compatible with a national-innovation-systems view in which innovation is a capability that requires complementary institutions, infrastructure, human capital, finance, and policy direction. Forson et al. (2021) and Bekana (2021) both show that institutional conditions matter for the economic returns to innovation in sub-Saharan Africa. Ouma-Mugabe et al. (2024) identify weak institutionalization of foresight as a constraint on the strategic direction of STI policy. The present findings extend this reasoning beyond economic growth: if innovation systems are not explicitly connected to social-sector delivery and sustainability objectives, higher innovation scores need not raise aggregate SDG performance.

The second implication concerns multidimensionality. The absence of significant coefficients for all four SDG dimensions and almost all individual goals rejects a simple expectation that innovation should be strongest for economic and technological goals and then spill over into social and environmental objectives. The result for SDG 9 itself is especially instructive. It implies that a general innovation index is not interchangeable with progress on an SDG that includes infrastructure, industrialization, and innovation-related targets. National innovation capacity may grow through sectors or actors that are only partially captured by the broader development infrastructure embedded in SDG 9.

The negative SDG 6 coefficient also illustrates why the language of synergy and trade-off is more useful than the language of a universal innovation dividend. Moallemi et al. (2022) argue that SDG interactions can generate policy resistance and recurring trade-off structures, while Xiao et al. (2023) show that indirect effects alter the apparent importance of goals. In developing economies, technology-intensive growth can increase urbanization, industrial water demand, pollution loads, or fiscal competition for infrastructure resources before water and sanitation systems catch up. The coefficient therefore raises a policy question about the sectoral direction of innovation rather than supporting an anti-innovation conclusion.

The third and most original implication is the distinction between level and balance. The significant decline in dispersion across social SDGs suggests that innovation may support a more even configuration of social progress without raising the average. Several mechanisms are plausible. Digital and organizational innovations may lower coordination and information costs across social sectors; innovations in identification, payments, data systems, logistics, and service administration may diffuse across multiple goals; or innovation may help lagging social domains catch up without materially shifting already stronger domains. Huang et al. (2025) report that digitalization can support multiple sustainability pillars, while Peter (2021) emphasizes social innovation ecosystems oriented to local needs. These literatures provide plausible channels for a balancing effect.

However, the balancing result must be interpreted conservatively. The mean social score is unchanged, the balance-adjusted index is positive but statistically insignificant, and the result is based on dispersion among six SDG scores rather than household-level inequality. It is therefore more accurate to describe the finding as balanced social-goal progress than as redistribution toward disadvantaged persons. Future work should connect this cross-goal balance measure to within-country inequality, poverty depth, gender gaps, spatial deprivation, or distributional household data.

The fourth implication is methodological. The progression from a large negative innovation coefficient to a null coefficient after year effects shows how easy it is to overstate innovation effects in trending panel data. Sustainable-development indicators and innovation indicators both evolve with global technological change, international policy regimes, measurement improvements, and common shocks. Two-way fixed effects are therefore essential. The presence of cross-sectional dependence further indicates that conventional clustered standard errors may not fully capture regional and global spillovers. This point is particularly relevant to the innovation literature because technology diffusion itself is a mechanism of cross-country dependence.

The dynamic GMM results add a final layer. They show that SDG performance is highly persistent, which is substantively plausible because health, education, infrastructure, institutions, and environmental stocks change gradually. The lack of a significant innovation coefficient in a dynamic model suggests that innovation does not generate a short-run shift large enough to dominate this persistence. Yet the coefficient on lagged SDG performance being slightly above one advises against interpreting the GMM model as a stable long-run equilibrium without additional unit-root and cross-sectional-dependence analysis.

5.1 Policy implications

Policy should move from innovation quantity to innovation direction. Raising R&D expenditure, patenting, digitalization, or high-technology exports is not sufficient if innovation portfolios are disconnected from basic services and social priorities. Innovation policy should therefore include explicit mission-oriented targets linked to lagging SDGs, particularly water and sanitation, food security, poverty reduction, education, and inequality.

Second, the balancing result suggests value in horizontal innovation infrastructure. Interoperable digital public systems, public-sector data capability, procurement innovation, open standards, and cross-ministerial learning can create spillovers across multiple social goals. Such capabilities are less visible than high-technology exports but may be more important for inclusive social conversion.

Third, governments should institutionalize foresight and cross-sectoral evaluation. The foresight gap identified by Ouma-Mugabe et al. (2024) is directly relevant: STI policy should be evaluated ex ante and ex post for its expected effects across multiple SDGs, including potential trade-offs. Nexus and systems approaches provide practical frameworks for this purpose (Mabhaudhi et al., 2021; Moallemi et al., 2022).

Fourth, governance remains a central enabling condition even though the current posted results do not yet include a complete moderation analysis. The broader literature indicates that institutional quality is associated with SDG progress (Barbier & Burgess, 2021; Adebayo et al., 2025; Oppong, 2025). A final extension of the paper should therefore test whether regulatory quality and control of corruption condition the effect of innovation on social balance.

6. Conclusion

This paper evaluates whether innovation produces a broad and inclusive SDG dividend in a balanced panel of 43 developing economies over 2005-2023. The answer depends on what is meant by progress. Innovation is positively correlated with the SDG Index in raw comparisons, but there is no robust within-country effect on the aggregate index after country and year effects are included. The same conclusion holds with an extended control set, R&D expenditure, high-technology exports, logged alternatives, nonlinear specifications, and system GMM.

The disaggregated evidence is equally important. Innovation is insignificant for the four broad SDG dimensions and for almost all individual goals. The only conventional 5% association is a negative coefficient for SDG 6. These findings reject the assumption that a stronger innovation system automatically spreads gains across the 2030 Agenda.

Yet the analysis also uncovers a more nuanced social effect. Innovation significantly reduces dispersion across six core social SDGs while leaving their average level unchanged. The result suggests that innovation may be associated with a more balanced social-development profile even when it does not generate an aggregate SDG dividend. This is a different and potentially more policy-relevant conception of inclusiveness.

The central policy implication is therefore not that developing economies should innovate less, but that they should govern innovation differently. Innovation systems must be connected deliberately to social missions, basic-service systems, public-sector capabilities, and cross-SDG coordination. The empirical agenda should likewise move beyond asking whether innovation raises a single composite index and toward identifying who benefits, which goals respond, which goals lag, and what institutional conditions convert technological capacity into inclusive development.

Data and analytical limitations

Three limitations should be addressed before journal submission. First, the exact original source and harmonization rule for every variable should be inserted from the project data dictionary; this working manuscript deliberately does not invent source attributions that were not contained in the posted Stata output. Second, the detected cross-sectional dependence requires a successful Driscoll-Kraay, common-correlated-effects, or related robustness estimator. Third, the balance measure captures dispersion across SDG goal scores rather than interpersonal inequality. These limitations do not overturn the reported estimates, but they delimit the claims that can be made from them.

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Appendices

Appendix A. Variable construction and empirical role

Variable	Definition / construction	Role
SDG_Index_Score	Overall sustainable-development outcome	Main dependent variable
goal1-goal17	Individual Sustainable Development Goal scores	Disaggregated outcomes
Innovations_Index	Composite innovation performance measure	Primary explanatory variable
RD_ExpGDP	R&D expenditure as % of GDP	Alternative innovation input
Hightech_exportsManuf_exports	High-technology exports as % of manufactured exports	Alternative innovation output
log_GDP_per_capita	Natural log of GDP per capita	Development-level control
economic_growth_the_rate_of_chan	Annual real GDP growth rate	Macroeconomic control
foreign_direct_investment_percen	FDI as % of GDP	External-capital control
Labor_forceParticipationRate	Labour-force participation rate	Labour-market control
domestic_credit_to_the_private_s	Domestic credit to private sector	Extended financial control
trade_freedom_index_0100	Trade freedom index	Extended openness control
government_debt_as_percent_of_gd	Government debt as % of GDP	Extended fiscal control
CoC_Index	Control of corruption	Governance measure; moderation extension
REQ_Index	Regulatory quality	Governance measure; moderation extension
SDG_social	Mean of goals 1,2,3,4,5,10	Social-development composite
SDG_economic	Mean of goals 8,9	Productive-economic composite
SDG_environmental	Mean of goals 6,7,11,12,13,14,15	Environmental composite
SDG_institutional	Mean of goals 16,17	Institutional composite
social_mean	Mean of goals 1,2,3,4,5,10	Level of social progress
social_sd	Within-row SD of goals 1,2,3,4,5,10	Imbalance across social goals; lower is more balanced
Inclusive_Social_Progress	social_mean - social_sd	Balance-adjusted social-progress robustness index

Appendix B. Complete innovation coefficients by SDG

Goal	Name	Coefficient	SE	t	p	95% CI
1	No poverty	-0.4190	0.2516	-1.67	0.103	[-0.912, 0.074]
2	Zero hunger	-0.1579	0.0888	-1.78	0.083	[-0.332, 0.016]
3	Good health and well-being	-0.0583	0.0958	-0.61	0.546	[-0.246, 0.129]
4	Quality education	-0.0399	0.2246	-0.18	0.860	[-0.480, 0.400]
5	Gender equality	0.1704	0.1514	1.13	0.267	[-0.126, 0.467]
6	Clean water and sanitation	-0.1776	0.0778	-2.28	0.028	[-0.330, -0.025]
7	Affordable and clean energy	-0.1227	0.1572	-0.78	0.439	[-0.431, 0.185]
8	Decent work and economic growth	-0.0498	0.0786	-0.63	0.530	[-0.204, 0.104]
9	Industry, innovation and infrastructure	-0.1891	0.1612	-1.17	0.247	[-0.505, 0.127]
10	Reduced inequalities	0.4491	0.4727	0.95	0.347	[-0.477, 1.376]
11	Sustainable cities and communities	0.1455	0.1296	1.12	0.268	[-0.109, 0.400]
12	Responsible consumption and production	-0.0008	0.0182	-0.04	0.965	[-0.036, 0.035]
13	Climate action	-0.0053	0.0249	-0.21	0.834	[-0.054, 0.044]
14	Life below water	-0.0677	0.1233	-0.55	0.586	[-0.309, 0.174]
15	Life on land	0.0250	0.0825	0.30	0.764	[-0.137, 0.187]
16	Peace, justice and strong institutions	-0.0132	0.0687	-0.19	0.849	[-0.148, 0.122]
17	Partnerships for the goals	0.0057	0.1277	0.05	0.964	[-0.244, 0.256]

Appendix C. Model and diagnostic checklist

Item	Result / action
Panel structure	43 countries × 19 years = 817 observations; balanced panel.
Country fixed effects	Strongly supported by large country-level variance shares; F test for country effects $p < 0.001$.
Year fixed effects	Essential: adding year effects reduces the innovation coefficient from -0.301 ($p < 0.001$) to -0.031 ($p = 0.492$).
Hausman test	$\chi^2(5) = 35.22$, $p < 0.001$, but variance-difference matrix is not positive definite; interpret alongside

	substantive FE rationale.
Multicollinearity	Mean VIF = 1.81; no material multicollinearity.
Cross-sectional dependence	Pesaran statistic = -2.507, p = 0.0122; average absolute off-diagonal correlation = 0.415.
Nonlinearity	Innovation and innovation-squared jointly insignificant for aggregate SDG outcome, p = 0.678.
System GMM, innovation index	Innovation p = 0.779; AR(2) p = 0.932; Hansen p = 0.420; 28 instruments.
System GMM, R&D	R&D p = 0.428; AR(2) p = 0.966; Hansen p = 0.208; 28 instruments; singular covariance warning.
Required final robustness	Successfully rerun Driscoll-Kraay or common-correlated-effects model because cross-sectional dependence is present.