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# The New Perspective on Sustainability—Lessons from Amazon's AI Agent Strategy Towards Rational Sustainability

**Yuji Tou [1], Akira Nagamatsu [2,*] and Chihiro Watanabe [3,4]**

[1] Faculty of Business Administration, Tohoku Gakuin University, Sendai 980-8511, Japan; tou.yuji@mail.tohoku-gakuin.ac.jp
[2] Department of Management Science and Technology, Graduate School of Engineering, Tohoku University, Sendai 980-8577, Japan
[3] Department of Industrial Engineering and Economics, School of Engineering, Institute of Science Tokyo, Tokyo 113-8510, Japan; watanabe.c.pqr@gmail.com
[4] International Institute for Applied Systems Analysis (IIASA), A-2361 Laxenburg, Austria
* Correspondence: akira.nagamatsu.e1@tohoku.ac.jp

**Abstract**

This paper addresses the growing sustainability fatigue in advanced economies. By analyzing Amazon's artificial intelligence (AI) agent strategy as a model for "Rational Sustainability", the study identifies a self-propagating growth trajectory that reconciles economic rationality with value creation. It provides a theoretical and empirical framework to overcome technological saturation and strategic homogenization in the generative AI era. To ensure methodological transparency, the analysis was conducted through two distinct stages: (i) Techno-econometric analysis (macro-level): Using an empirical dataset of 160 countries (40 advanced, 70 emerging, and 50 developing) from 2014 to 2024, the study utilized regression models to quantify the correlations and elasticities between three key proxies: GDP per capita (Y); the Human Capital Index (HCI), representing Institutional Capacity Building (ICB); and the E-Government Development Index (EGI), representing Endogenous Institutional Evolution (EIE). (ii) Hybrid AI analysis (case study): Utilizing process-tracing research, the paper examines Amazon's R&D structure and AI agent strategy. This qualitative and structural analysis identifies how Amazon co-evolves EIE and ICB to conceptualize tacit knowledge and operationalize it into a competitive advantage. The findings reveal a marked disruption of the co-evolutionary mechanism in advanced economies, where the elasticity of EGI to GDP has declined since 2019, leading to a withdrawal state. In contrast, Amazon's model demonstrates that the co-evolution of EIE and ICB creates a self-propagating growth engine. This research concludes that "Rational Sustainability"—grounded in evidence, economic rationality, and clear trade-offs—offers a viable pathway for revitalizing sustainability strategies in mature digital economies.

**Keywords:** rational sustainability; comparative institutional analysis; Amazon; AI agent strategy; co-evolution



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## 1. Introduction

Advances in the digital economy—driven by personal computing, the Internet, mobile technologies, and generative AI—have positioned e-government as a foundational pillar not only for enhancing public service delivery but also for underpinning inclusive development and systemic resilience. While a substantial body of research has documented e-government as a catalyst for governance transformation [1], many advanced countries (ACs) now

exhibit symptoms of "sustainability fatigue". This condition, characterized by diminishing marginal returns on digital transformation and rising fiscal burdens, suggests a systematic stagnation that existing fragmented analyses fail to explain.

The primary objective of this study is to empirically test the disruption of the co-evolutionary mechanism [2]—the cycle where economic growth (Y), Institutional Capacity Building (ICB), and Endogenous Institutional Evolution (EIE) reinforce one another. To do so, we employ a macro-level techno-econometric analysis of 160 countries (40 advanced, 70 emerging, and 50 developing) over the period 2014–2024 (See Appendix A). This dataset is uniquely appropriate for isolating "sustainability fatigue"; by comparing developmental stages, we can rule out universal exogenous shocks like the COVID-19 pandemic or global macroeconomic fluctuations. If stagnation were purely due to such shocks, one would expect a uniform decline across all groups; however, our data reveals that while ACs entered a "withdrawal state" after 2019, emerging and developing countries maintained positive growth elasticities.

This paper argues that analyses of corporate strategy and business models are essential for studying e-government because digital transformation in the public sector increasingly resembles the strategic and organizational challenges faced by innovative firms. Corporate strategy research [3] clarifies how organizations align technology and structure—insights directly applicable to digital public services. Historically, developmental state studies [4–6] show that governments have learned from firm-level practices in capability building. Capability-based perspectives [7–10] and innovation policy research further highlight that firms possess critical knowledge about technological opportunities. Therefore, e-government is not merely a technical reform but a strategic transformation that benefits from the analytical lenses developed in business model studies.

Consequently, this study introduces Amazon—the world's top R&D investor, cloud business leader, and a pioneer in generative AI—as a representative case of "Rational Sustainability". Through a hybrid AI analysis—a methodological approach combining quantitative proxy statistics with qualitative process-tracing of technology management—we examine Amazon's AI agent strategy. We hypothesize that Amazon's success in creating a self-propagating growth trajectory lies in its ability to co-evolve two institutional mechanisms: Endogenous Institutional Evolution (EIE), which deepens structures through spontaneous organizational learning, and Institutional Capacity Building (ICB), which enhances capabilities through designed frameworks [11–14].

By aligning these mechanisms, Amazon provides a practical framework for revitalizing sustainability strategies in mature economies that have otherwise succumbed to strategic homogenization and technological saturation.

The remainder of the paper is organized as follows: Section 2 reviews the role of e-government in sustaining socio-economic development. Section 3 outlines the prospective global development landscape shaped by e-government in the AI agent era. Section 4 presents a reform strategy grounded in comparative institutional analysis. Section 5 concludes with key findings, policy implications, and directions for future research.

## 2. The Role of E-Government for Sustainability

### *2.1. E-Government in the Digital Economy*

With the development of the digital economy, e-government is taking on a leading role in growth.

In the digital economy, e-government is a foundation that comprehensively supports the elements necessary for sustainable growth, such as efficiency, transparency, citizen participation, resilience, industrial development, and the achievement of sustainable development goals, as summarized in Table 1 [1,15–19].

**Table 1.** Contributions of e-government to sustainable growth.

| |
|---|
| (i) Improving administrative efficiency<br>(a) Improving productivity through digitalization<br>(b) Reducing costs and optimizing resources |
| (ii) Strengthening transparency and reliability<br>(a) Promoting open data<br>(b) Strengthening governance |
| (iii) Innovation through the use of public and private data<br>(a) Creating new industries<br>(b) Strengthening international competitiveness |
| (iv) Addressing social issues<br>(a) Addressing population decline and an aging population<br>(b) Revitalizing local communities |
| (v) Building a resilient and inclusive social and economic infrastructure<br>(a) Building a resilient social infrastructure<br>(b) Building an inclusive social and economic infrastructure |

These theoretical contributions are empirically validated through a techno-econometric analysis of 160 countries and qualitative process-tracing of representative economies. As demonstrated in Tables 4–6, the impact of e-government on growth and social resilience varies by developmental stage, providing a structural basis for the categories defined in Table 1.

Thus, promoting e-government is essential for sustainable growth, while sustainable growth is essential for capacity building, which is the basis of e-government.

Consequently, co-evolution between economic growth, capacity building and e-government, as illustrated in Figure 1, is indispensable to sustainability.

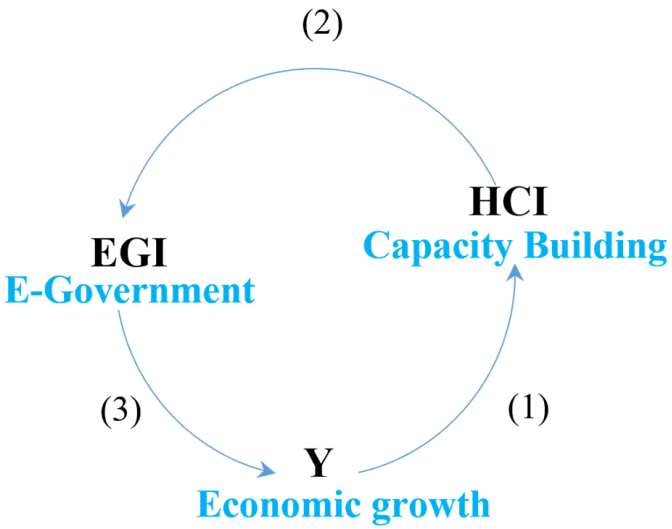


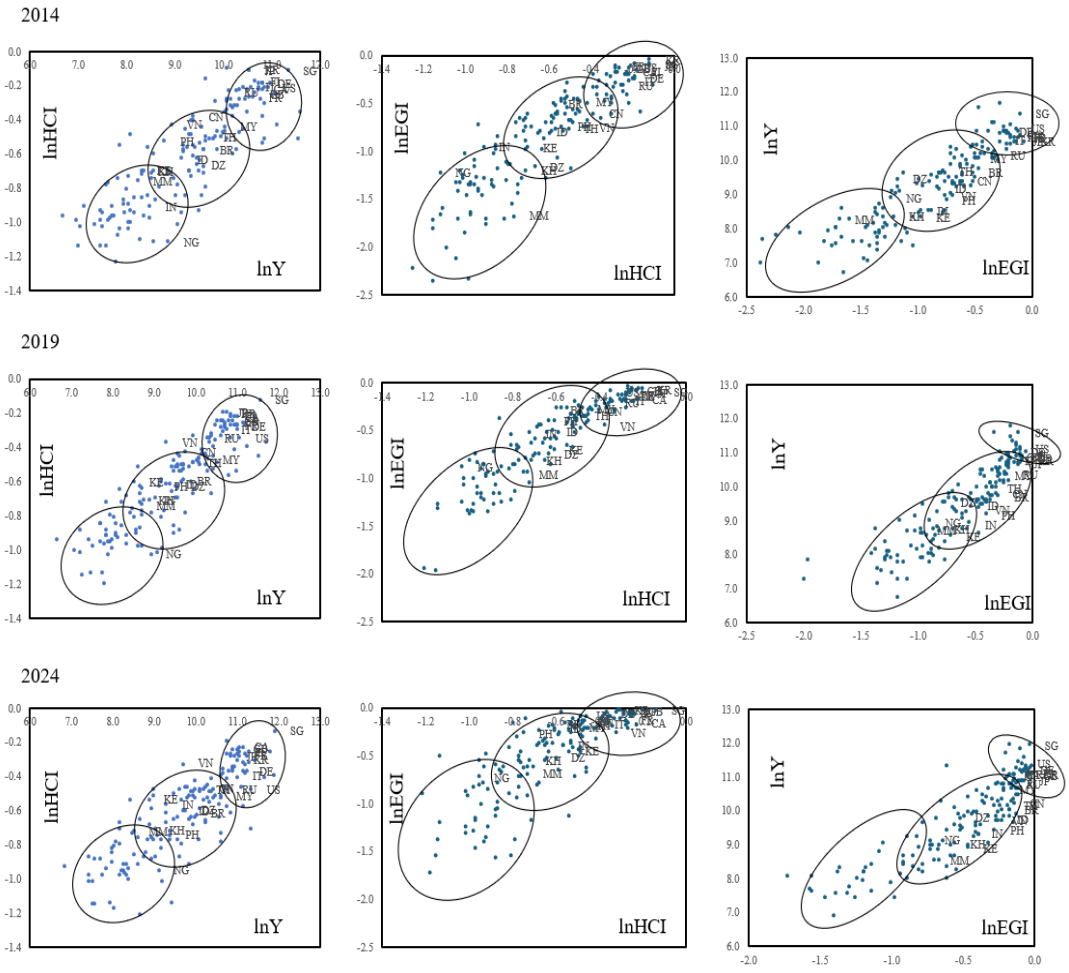

**Figure 1.** Correlation between economic growth, capacity building and e-government. Y: GDP per capita (current US dollars; source: IMF); HCI: Human Capital Index (source: World Bank); EGI: E-Government Development Index (source: United Nations). These definitions and sources are detailed in Table 3.

However, the advancement of e-government often entails "institutional paradoxes" that can undermine its intended benefits. As digital systems reach maturity, institutions frequently encounter unintended structural consequences, such as reduced operational

flexibility, increased fiscal burdens for infrastructure maintenance, the digital exclusion of disadvantaged groups, and the expansion of administrative bureaucracy. These issues are systematically linked to the phenomenon of "sustainability fatigue", where the marginal returns on further digital investment begin to decline despite the intensification of organizational and regulatory efforts. Recognizing these paradoxes is essential for moving beyond normative digital agendas toward a more structural understanding of stagnation in mature economies [20,21].

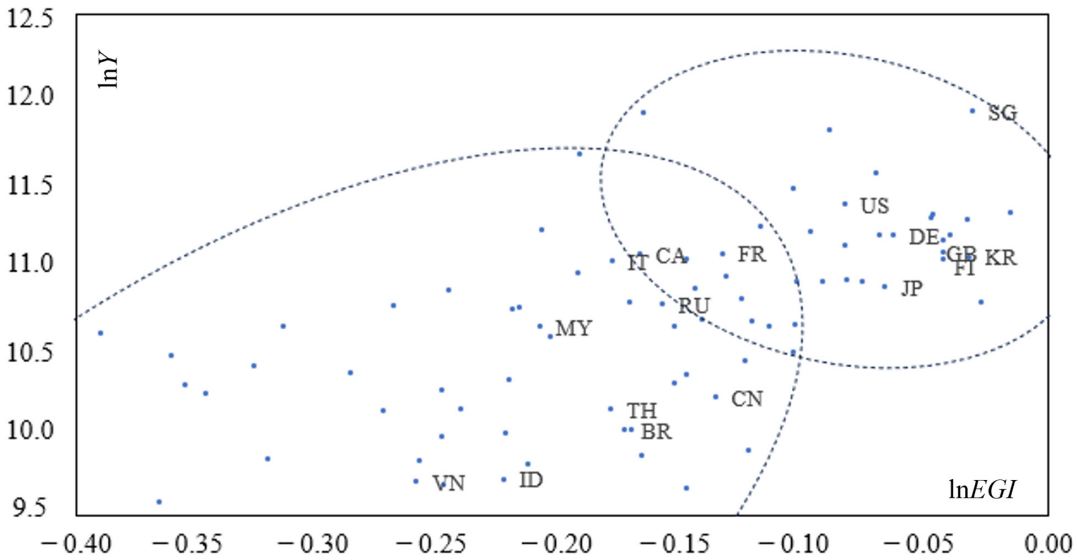
### *2.2. Correlation Between Sustainable Growth, Capacity Building and E-Government*

With this understanding, Figure 2 illustrates this correlation in 160 countries, as tabulated in Table 2, in 2014, 2019 and 2024 by utilizing the proxies tabulated in Table 3. In total, the 160 countries consist of 40 advanced countries (ACs), 70 emerging countries (ECs), and 50 developing countries (DCs) [22–24].




(**a**)

**Figure 2.** *Cont.*




(**b**)

**Figure 2.** (**a**) Correlation between growth, HCI and EGI in 160 countries (2014, 2019, 2024). Y: GDP per capita (current US dollars; source: IMF); HCI: Human Capital Index (source: World Bank); EGI: E-Government Development Index (source: United Nations). (**b**) Correlation between EGI and growth in advanced and emerging countries (2024).

**Table 2.** List of 160 countries classified by AC, EC and DC.

| Advanced Countries | | | | Emerging Countries | | | | | | Developing Countries | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Singapore | SG | Croatia | HR | Qatar | QA | Brazil | BR | Jordan | JO | Palau | PW | Kiribati | KI |
| Luxenbourg | LU | Portugal | PT | Guyana | GY | Armenia | AM | Morocco | MA | Eswatini | SZ | Sierra Leone | SL |
| Ireland | IE | Estonia | EE | UAE | AE | Albania | AL | Nigeria | NG | Angola | AO | Gambia, The | GM |
| Norway | NO | Romania | RO | Saudi Arabia | SA | Bosnia | BA | Nicaragua | NI | Lao PDR | LA | Togo | TG |
| Switzerland | CH | Hungary | HU | Bahrain | BH | Colombia | CO | Ghana | GH | Bangladesh | BD | Chad | TD |
| United States | US | Slovak Rep. | SK | Kuwait | KW | Iran | IR | Samoa | WS | Mauritania | MR | Haiti | HT |
| Denmark | DK | Greece | GR | Russia | RU | Egypt | EG | Tonga | TO | Cambodia | KH | Lesotho | LS |
| Netherlands | NL | Latvia | LV | Kazakhstan | KZ | Grenada | GD | Honduras | HN | Kyrgyz Rep. | KG | Burkina Faso | BF |
| Iceland | IS | Bulgaria | BG | Turkiye | TR | St. Vincent | VC | Kenya | KE | Cote d'Ivoire | CI | Mali | ML |
| Malta | MT | Chile | CL | Panama | PA | Ukraine | UA | Vanuatu | VU | Zimbabwe | ZW | Solomon Island | SB |
| Belgium | BE | | | Oman | OM | Botswana | BW | | | Marshall | MH | Sudan | SD |
| Austria | AT | | | Malaysia | MY | Mongolia | MN | | | Pakistan | PK | Afghanistan | AF |
| Germany | DE | | | Seychelles | SC | Paraguay | PY | | | Congo, Rep. | CG | Niger | NE |
| Sweden | SE | | | Uruguay | UY | Moldova | MD | | | Tuvalu | TV | Madagascar | MG |
| Australis | AU | | | Trinidad | TT | Peru | PE | | | Nepal | NP | Congo, Dem. | CD |
| Finland | FI | | | St. Kitts | KN | Algeria | DZ | | | Tajikistan | TJ | Liberia | LR |
| France | FR | | | Montenegro | ME | Indonesia | ID | | | Cameroon | CM | Malawi | MW |
| Canada | CA | | | Mauritius | MU | Viet Nam | VN | | | Senegal | SN | Yemen, Rep. | YE |
| Korea, Rep. | KR | | | Serbia | RS | Ecuador | EC | | | Myanmar | MM | Mozambique | MZ |
| Cyprus | CY | | | Costa Rica | CR | South Africa | ZA | | | Timor-Leste | TL | | |
| UK | GB | | | Argentina | AR | Iraq | IQ | | | Micronesia | FM | | |
| Italy | IT | | | Dominican Rep. | DO | Sri Lanka | LK | | | Ginea | GN | | |
| Czechia | CZ | | | Georgia | GE | Guatemala | GT | | | Benin | BJ | | |
| Slovenia | SI | | | St. Lucia | LC | Tunisia | TN | | | Zambia | ZM | | |
| Spain | ES | | | North Macedonia | MK | Jamaica | JM | | | Tanzania | TZ | | |
| Lithuania | LT | | | China | CN | El Salvador | SV | | | Ethiopia | ET | | |
| New Zealand | NZ | | | Thailand | TH | Philippines | PH | | | Comoros | KM | | |
| Israel | IL | | | Mexico | MX | Namibia | NA | | | Rwanda | RW | | |
| Japan | JP | | | Azerbaijan | AZ | Lebanon | LB | | | Uganda | UG | | |
| Poland | PL | | | Gabon | GA | India | IN | | | Papua New Guinea | PG | | |

**Table 3.** Proxies of economic growth, capacity building and e-government.

| | | | | |
|---|---|---|---|---|
| Economic growth | Y | GDP per capita | IMF | Country's level of economic development by (i) dividing its nominal GDP (expressed in US dollars at current market exchange rates) by (ii) its total population. |
| Capacity building | HCI | Human Capital Index | World Bank | (i) Survival: Child and neonatal mortality rates; (ii) Education: School enrollment, completion, and quality; (iii) Health: Stunting rates, adolescent fertility, and life expectancy. |
| e-government | EGI | e-government Development Index | UN | (i) Availability of online services; (ii) Telecommunication infrastructure; (iii) Human capacity. |

Table 4 tabulates the correlations for 160 countries by development stage in 2014, 2019, and 2024.

**Table 4.** Correlation between growth, HCI and EGI in 160 countries (2014, 2019, 2024).

| $\ln HCI = a + D_1 b_1 \ln Y + D_2 b_2 \ln Y + D_3 b_3 \ln Y$ | | | | | | |
|---|---|---|---|---|---|---|
| | $a$ | $b_1$ | $b_2$ | $b_3$ | | $adj.\ R^2$ |
| 2014 | −1.75 (−10.04) | 0.10 (4.74) | 0.12 (6.68) | 0.14 (8.50) | | 0.778 |
| 2019 | −1.78 (−12.52) | 0.11 (6.22) | 0.12 (8.41) | 0.14 (10.40) | | 0.823 |
| 2024 | −1.64 (−9.91) | 0.09 (4.62) | 0.11 (6.35) | 0.12 (7.87) | | 0.739 |
| $\ln EGI = a + D_1 b_1 \ln HCI + D_2 b_2 \ln HCI + D_3 b_3 \ln HCI + c\ D$ | | | | | | |
| | $a$ | $b_1$ | $b_2$ | $b_3$ | $c$ | $adj.\ R^2$ |
| 2014 | −0.12 (−1.93) * | 1.46 (19.46) | 0.99 (9.15) | 0.64 (2.47) | | 0.846 |
| 2019 | 0.09 (1.78) * | 1.31 (21.38) | 0.99 (11.08) | 0.91 (4.91) | | 0.877 |
| 2024 | 0.09 (1.31) ** | 1.18 (15.23) | 0.71 (6.37) | 0.50 (2.52) | −0.35 (−5.94) | 0.799 |
| $\ln Y = a + D_1 b_1 \ln EGI + D_2 b_2 \ln EGI + D_3 b_3 \ln EGI + c\ D$ | | | | | | |
| | $a$ | $b_1$ | $b_2$ | $b_3$ | $c$ | $adj.\ R^2$ |
| 2014 | 10.65 (100.84) | 1.87 (23.00) | 1.64 (10.83) | 0.66 (1.75) * | 1.22 (6.83) | 0.846 |
| 2019 | 10.60 (87.78) | 2.23 (18.22) | 1.93 (7.92) | −1.47 (−1.70) * | −0.69 (−2.77) | 0.822 |
| 2024 | 10.67 (112.52) | 2.28 (20.22) | 2.02 (7.63) | −2.17 (−2.40) | | 0.807 |

$D$: Belgium, Canada, Czechia, Portugal, El Salvador, Samoa, St. Lucia, Tonga, Afghanistan, Haiti, Micronesia = 1, others = 0. $D_{2014}$: Luxembourg, Qatar, UAE, Guinea, Mauritania, Papua New Guinea, Sierra Leone = 1, others = 0. $D_{2019}$: Bulgaria, Chile, Croatia, Greece, Latvia, Romania, Slovakia = 1, others = 0. $b_1$: developing countries (DC), $b_2$: emerging countries (EC) and $D_3 b_3$: advanced countries (AC). Di: dummy variables (D1: DC = 1, others = 0; D2: EC = 1, others = 0; D3: AC = 1, others = 0).

Note: Italicized text indicates equations. * and ** indicate statistical significance. Two types of dummy variables are employed in this model to ensure analytical precision:

1 Developmental Stage Dummies (D1, D2, D3): These categorize the 160 countries into developing (DCs), emerging (ECs), and advanced countries (ACs) based on classifica-

tions from the IMF, World Bank, and United Nations. These dummies are essential for estimating stage-specific elasticities, allowing the analysis to statistically pinpoint "sustainability fatigue" (characterized by negative growth elasticity), specifically within advanced economies.

2 Specific Country Dummy (D): This variable accounts for structural deviations and statistical outliers—such as Belgium, Canada, and Afghanistan in the 2024 model—that would otherwise distort general trends. By controlling for these country-specific anomalies, we ensure the robustness of the model (with Adjusted R2 typically above 0.8) and the accuracy of the co-evolutionary multipliers for each developmental tier.

The figures in parentheses indicate *t*-statistics: significant at the 1% level except * (10% level) and ** (20% level).

Looking at Table 4, we note that while Y inducements to HCI increase as the development stage progresses, the remaining two inducements (HCI to EGI and EGI to Y) decrease as the development stage progresses.

This suggests that while e-government is essential for growth, excessive digitalization can lead to the following problems, which could actually hinder sustainable growth, contrary to expectations:

(i) Loss of flexibility, (ii) increased fiscal burden, (iii) exclusion of digitally disadvantaged individuals, (iv) stifling private innovation, (v) concentration of security risks, and (vi) strengthened bureaucracy [25].

Table 5 summarizes the multipliers (elasticities) of the correlation between growth, capacity building, and e-government for 160 countries in 2014, 2019 and 2024 by development stages.

**Table 5.** Elasticities of the correlation between growth, capacity building and e-government in 160 countries by development stages (2014, 2019, 2024).

| | (1) Y-HCI | | | (2) HCI-EGI | | | (3) EGI-Y | | | (1) x (2) x (3) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DC | EC | AC | DC | EC | AC | DC | EC | AC | DC | EC | AC |
| 2014 | 0.10 | 0.12 | 0.14 | 1.46 | 0.99 | 0.64 | 1.87 | 1.64 | 0.66 | 0.28 | 0.20 | 0.06 |
| 2019 | 0.11 | 0.12 | 0.14 | 1.31 | 0.99 | 0.91 | 2.23 | 1.93 | −1.47 | 0.32 | 0.24 | −0.18 |
| 2024 | 0.09 | 0.11 | 0.12 | 1.18 | 0.71 | 0.50 | 2.28 | 2.02 | −2.17 | 0.25 | 0.15 | −0.13 |

Note: Elasticity of Y to HCI (Y elasticity to HCI) of 0.10 implies that a 1% increase in Y leads to a 0.1% increase in HCI. The multipliers of the three elasticities ((1) x (2) x (3)) indicate the co-evolutionary multiplier or the withdrawal state (if negative).

Figure 3 illustrates trends in elasticities of three correlations in ACs, ECs and DCs in 2014, 2019 and 2024.

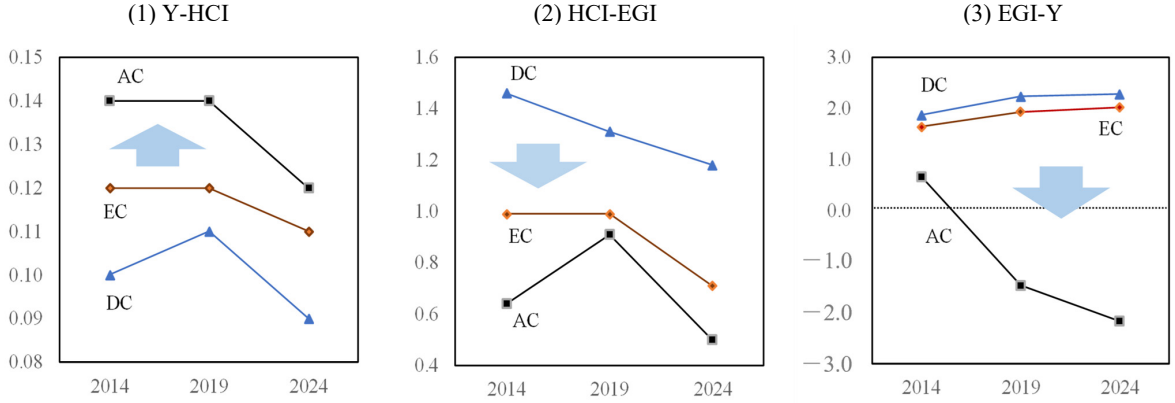



**Figure 3.** Trends in elasticities of Y to HCI, HCI to EGI, and EGI to Y in AC, EC, and DC (2014–2024).

Table 5 suggests that, in contrast to DCs and ECs, which have maintained high levels of multipliers over the long term, these values for ACs have decreased, turning to withdrawal since 2019. Crucially, the decline in e-government elasticity (EGI→Y) observed in advanced countries (ACs) is a structural phenomenon rather than a temporary side effect of the COVID-19 pandemic. Our longitudinal data indicates that this downward trend began prior to 2019 and, significantly, diverges from the trajectories in emerging (ECs) and developing countries (DCs), which maintained positive or even rising elasticities during the same period. This divergence suggests that "sustainability fatigue" results from a structural mismatch between mature institutions and advanced digitalization rather than global exogenous shocks.

To ensure the rigor of this analysis, the dummy variables in Table 4 are justified as a means to adjust the regressions for statistical outliers—such as Belgium, Canada, or Afghanistan—which represent abnormal institutional conditions that would otherwise distort general trends.

Table 5 and Figure 3 suggest that these decreases and withdrawals are due to a decline in the elasticity of EGI to Y, as demonstrated in Table 6 [26–33]. To address the inherent institutional heterogeneity within our broad categories, this study employs a qualitative sub-group analysis of representative nations. The representative countries highlighted in Table 6 were selected through qualitative process-tracing to illustrate typical structural patterns across developmental stages. Specifically, these cases contrast "defensive digitalization" in advanced economies (e.g., Japan and the USA), where high legacy costs and labor shortages result in diminishing returns, against "scalable infrastructure-driven growth" in emerging economies (e.g., India and China), where digital public infrastructure acts as a primary engine for macroeconomic stability and expansion [34]. As detailed in Table 6, while advanced economies collectively face a breakdown in co-evolution, the specific drivers of "sustainability fatigue" vary significantly by institutional context [35]. For instance, the stagnation is driven by legacy system maintenance in the USA, rising security and talent costs in Singapore, and structural labor shortages in Japan. This granular examination ensures that the macroscopic trends identified in our econometric model are supplemented by an understanding of diverse institutional realities [36,37].

**Table 6.** Contrast of the benefits of the advancement of e-government between ACs and ECs (GDP per capita: 2024, k USD; HCI: latest available; EGI: 2024).

| | Country | GDP per Capita (k USD) | HCI | EGI | Noteworthy Features |
|---|---|---|---|---|---|
| Advanced countries (AC) | Singapore | 150.9 | 0.87 | 0.97 | While largely completed, government-led digitalization under the Smart Nation framework; diminishing marginal returns; and rising maintenance, security, and talent costs consequently constrain medium-term growth in a mature, externally dependent economy. |
| | USA | 86.1 | 0.62 | 0.92 | Despite ongoing federal IT modernization initiatives, growth-enhancing transformation is limited, as most public IT spending remains locked into legacy system maintenance, reinforcing productivity stagnation. |
| | Japan | 52.7 | 0.75 | 0.94 | Notwithstanding strengthening government-led DX, structural low growth persists as high legacy renewal costs, labor shortages, and vendor dependence turn digitalization into a defensive rather than transformative strategy. |
| | South Korea | 62.9 | 0.74 | 0.97 | While government-led digital investment under the Digital New Deal has expanded infrastructure and data use, growth remains stagnated, as institutional, labor-market, and redistribution mechanisms lag behind rapid technological deployment. |
| | Finland | 64.7 | 0.77 | 0.96 | Faces sustainability fatigue, where intensified cybersecurity and regulatory compliance costs increasingly offset the growth benefits of advanced digital public services as a highly digitized state. |

**Table 6.** *Cont.*

| | Country | GDP per Capita (k USD) | HCI | EGI | Noteworthy Features |
|---|---|---|---|---|---|
| Emerging countries (EC) | Brazil | 22.3 | 0.54 | 0.84 | Government-led digital strategy has been supporting economic recovery by improving administrative efficiency and expanding digital finance, as the institutional capacity and human capital constraints remain important policy challenges. |
| | Russia | 47.4 | 0.62 | 0.85 | While long-term productivity and innovation prospects remain uncertain, state-led digitalization has helped sustain economic activity under sanctions by reinforcing state coordination and resource mobilization. |
| | India | 11.2 | 0.57 | 0.67 | In addition to domestic demand acting as a major growth driver, digital India has been accelerating economic growth through scalable public digital infrastructure for identification, payments, and service delivery. |
| | China | 27.1 | 0.62 | 0.87 | While policymakers seek to balance efficiency, regulation, and structural adjustment, large-scale government-led investment in IT and data infrastructure continues to support macroeconomic stability and growth. |
| | South Africa | 15.7 | 0.45 | 0.86 | While digitalization helps prevent deeper economic contraction, persistent electricity and infrastructure constraints transform IT investment into a cost-intensive, fatigue-inducing support mechanism rather than a growth engine. |

Provided that the advancement of e-government is the crystallization of the advancement of digital innovation [17,38], this notable trend that leads to distorted sustainability can be attributed to a mismatch with the cutting-edge trend of digitalization. This mismatch can be considered the structural source of sustainability fatigue [39–42].

### *2.3. E-Government in the AI Agent Era*

In the digital economy, e-government has become an essential foundation not only for improving public services through digitalization but also for supporting inclusive development, advancement, and resilience across the entire socio-economic system.

The evolution of e-government has accelerated in parallel with major digital innovations such as the personal computer (PC), the Internet, smartphones, AI/ML (machine learning), and generative AI. While its early stages in advanced countries were characterized by fragmented, technology-driven initiatives within specific sectors, the approach has since expanded to encompass whole-of-government and whole-of-society perspectives in all countries, including emerging and developing economies. This shift marks a transition from a "technology-driven and partial" approach to a "data-centric, policy- and politics-driven, and inclusive" approach. Moreover, the COVID-19 pandemic has further underscored the need to strengthen resilience and agility.

The rapid advancement of AI, particularly generative AI, has significantly enhanced user-driven learning and utilization. At the same time, the emergence of AI agents is pushing e-government toward a model capable of autonomous and continuous evolution.

To explicitly outline the technical path toward this autonomous e-government, AI agents function as intellectual sensors for real-time Institutional Capacity Building and non-routine problem solving. The practical application of AI agents follows two complementary pathways:

(i) Conceptualizing (Visualizing) Tacit Knowledge through Endogenous Institutional Evolution (EIE): AI agents capture spontaneous organizational learning and unformalized routines, making previously hidden tacit knowledge visible and conceptualized within the administrative process.

(ii) Systematic Operationalization via Institutional Capacity Building (ICB): Once conceptualized, this knowledge is integrated into the ICB cycle, where it is codified into systematic frameworks and standard operating procedures, transforming individual learning into a reproducible institutional capability.

This co-evolutionary loop allows e-government systems to evolve autonomously and adaptively, providing a structural solution to the stagnation seen in mature digital economies.

Within this broader global trend, advanced countries are increasingly confronting challenges associated with market maturity in technology and infrastructure, while emerging and developing countries are, in some cases, benefiting from leapfrogging effects as demonstrated in Table 6.

Our empirical analysis of 160 countries demonstrates that the potential for leapfrogging [43] is grounded in current growth elasticities rather than mere theoretical potential. As shown in Table 5, developing countries (DCs) maintained a positive co-evolutionary multiplier of 0.25 in 2024, whereas advanced economies (ACs) entered a "withdrawal state" with a negative multiplier of −0.13. This divergence indicates that digital investment in DCs and ECs still yields substantial returns compared to the institutional saturation seen in ACs.

However, leapfrogging is not automatic and is tempered by significant structural constraints. Drawing on the case studies in Table 6, we explicitly acknowledge that real-world success is often hindered by bottlenecks such as institutional and human capital constraints (e.g., Brazil), infrastructural and energy deficits that can transform IT investment into a source of fatigue rather than growth (e.g., South Africa), and uncertainties regarding long-term innovation under state-led models (e.g., Russia).

In this context, AI agents serve as practical mechanisms for Endogenous Institutional Evolution (EIE). By extracting tacit knowledge and enabling organizations to bypass the "legacy system inertia" and strategic rigidity currently stagnating ACs, AI agents act as intellectual catalysts for bypassing traditional developmental hurdles.

Consequently, the global development landscape centered on e-government is entering a new phase. Going forward, the key for all countries—regardless of their level of development—will be how effectively they adapt to the era of AI agents.

## 3. Global Development Landscape Centered on E-Government in the AI Agent Era

### *3.1. E-Government as a Pillar of Digital Development and Sustainability Fatigue*

The global digital economy has undergone a profound transformation over the past three decades, and throughout this evolution, e-government has functioned as a central pillar of national development strategies. By integrating digital technologies into public administration, governments have been able to enhance transparency, improve service delivery, and stimulate economic activity. More importantly, e-government has historically facilitated a co-evolutionary cycle in which economic growth, capacity building, and digital governance reinforce one another. This dynamic has enabled countries—particularly advanced economies—to sustain competitiveness and institutional resilience in the face of rapid technological change.

However, as digital innovation reaches a stage of maturity, the strength of this co-evolutionary cycle has begun to weaken, as analyzed earlier. Many advanced economies now exhibit signs of "sustainability fatigue"—a condition in which the marginal benefits of traditional digital transformation diminish, even as the costs and complexities of maintaining digital infrastructure continue to rise. This fatigue reflects not only technological saturation but also institutional inertia, regulatory constraints, and the growing difficulty of achieving transformative gains through incremental improvements in existing systems.

The weakening of co-evolution is particularly visible in countries where e-government systems have already achieved high levels of sophistication. In these contexts, further digitalization no longer guarantees proportional improvements in administrative efficiency or economic performance. As a result, governments and firms alike face mounting pressure to identify new sources of differentiation and innovation.

### *3.2. Successive Waves of Digital Innovation and Their Implications*

The trajectory of digital innovation has progressed through several distinct waves: the PC revolution, the rise of the Internet, the proliferation of smartphones, the adoption of AI and ML, the emergence of generative AI, and now the transition toward AI agents capable of autonomous decision-making and task execution. Each wave has reshaped the expectations placed on both public and private sectors, demanding continuous adaptation and strategic recalibration.

In the current era, generative AI and AI agents represent a qualitative shift. Unlike earlier technologies that primarily enhanced productivity or connectivity, these systems increasingly influence organizational cognition, decision-making processes, and customer interactions. Their widespread adoption has begun to standardize business practices across industries, as firms rely on similar models, datasets, and algorithmic frameworks. This convergence reduces strategic diversity and pushes firms toward homogeneous management approaches.

### *3.3. Homogenization of Business Strategy and the Challenge of Differentiation*

The diffusion of generative AI tools has created a paradox: while these technologies are indispensable for maintaining competitiveness, their ubiquity erodes the distinctiveness of firms' strategic positioning. As customer behavior becomes increasingly shaped by AI-mediated interfaces, firms face a landscape in which both supply-side and demand-side behaviors become more synchronized. This synchronization makes it difficult for firms to differentiate themselves through conventional digital capabilities alone.

Consequently, firms must reconsider their strategic foundations. Rather than relying solely on codified knowledge embedded in algorithms, they must turn toward tacit knowledge—the experiential, context-specific insights that are difficult to formalize or replicate [31,32]. Tacit knowledge becomes a critical source of competitive advantage precisely because it resists standardization by AI systems.

## 4. Reframing Strategy Through Comparative Institutional Analysis

### *4.1. Methodological Integration*

To strengthen the linkage between the macro-level econometric analysis and the micro-level case study, this study employs a "Diagnostic-to-Prescriptive" analytical framework grounded in comparative institutional analysis.

(1) Macro-Level Diagnosis (The Problem)

The techno-econometric analysis of 160 countries serves as a structural diagnostic tool. By utilizing GDP per capita (Y), the Human Capital Index (HCI as a proxy for ICB), and the E-Government Development Index (EGI as a proxy for EIE), we statistically pinpoint the "withdrawal state" in advanced economies. This stage of the analysis identifies the "what" and "where" of sustainability fatigue—specifically, the breakdown of the co-evolutionary multiplier between EIE and ICB observed since 2019.

(2) Micro-Level Prescription (The Mechanism)

The hybrid AI analysis of Amazon serves as a functional prescriptive model. While the macro-analysis identifies the stagnation of institutional elasticities, the case study explains the "how"—the specific mechanism required to restart co-evolution in the AI agent era. Amazon's strategy demonstrates how utilizing AI agents as intellectual sensors allows for the conceptualization of tacit knowledge (EIE) and its subsequent operationalization into scalable, reproducible capabilities (ICB).

(3) Unified Conclusion

By integrating these two analytical layers, the paper reaches a unified conclusion: the "sustainability fatigue" diagnosed at the macro-level is a result of a structural mismatch between mature institutions and advanced digitalization. The Amazon model provides the empirical evidence that "Rational Sustainability"—defined as the co-evolution of EIE and ICB—offers a reproducible pathway to overcome this stagnation. This integrated approach allows us to propose the "neo-e-government" framework not as a normative ideal but as a statistically grounded and practically validated solution for revitalizing mature digital economies.

### *4.2. Comparative Institutional Analysis for Tacit Knowledge Management*

The shift toward tacit knowledge necessitates a deeper engagement with comparative institutional analysis, which examines how institutional structures, cultural norms, and organizational practices shape economic behavior. In an environment where digital tools increasingly homogenize operational processes, institutional differences become more salient as sources of strategic differentiation [44].

We refine the role of AI agents as "intellectual sensors" that capture unformalized organizational routines and expert decision-making—the essence of tacit knowledge—which has historically been difficult to formalize or replicate.

By grounding business strategy in an institutional context, firms can resist the homogenizing pressures of generative AI and maintain distinctive value propositions.

These shifts have significant implications for e-government as well. As AI agents become integral to public administration, governments must move beyond traditional digitalization models and embrace strategies that incorporate tacit institutional knowledge, human judgment, and context-sensitive governance. The next phase of e-government development will depend not only on technological adoption but also on the ability of institutions to integrate AI in ways that preserve diversity, resilience, and adaptability.

In comparative institutional analysis, the drivers of institutional transformation underlying economic development are analytically distinguished into (i) Institutional Capacity Building (ICB), which promotes capability enhancement and growth through externally designed institutional interventions, and (ii) Endogenous Institutional Evolution (EIE), whereby institutions deepen through spontaneous, internally generated organizational change [11,27,45–49].

Building on this distinction, the preceding analysis focused on the dynamism of e-government and examined the correlations among per capita GDP (Y), the World Bank's Human Capital Index (HCI), and the United Nations' E-Government Development Index (EGI).

The HCI measures "the extent to which a child can become a productive worker by age 18" by integrating educational attainment, health status, and survival rates, thereby reflecting the degree of development of education and health systems; as such, it is particularly effective for assessing "the extent to which external institutional interventions contribute to human capital formation" and thus serves as a highly suitable proxy for ICB.

Conversely, the EGI integrates the three dimensions of "online service provision," "telecommunication infrastructure," and "human capital" to evaluate countries' relative levels of digital government development, and, by capturing the extent to which governments autonomously advance digitalization and enhance administrative services, it provides a reasonably valid proxy for EIE, especially in enabling comparisons of "how Endogenous Institutional Evolution manifests in digital governance."

Nevertheless, both indicators are outcome measures rather than direct measures of institutional formation processes, and they do not allow for the separation of external influences or international assistance; accordingly, their use as proxies remains approximate.

Recognizing these limitations, the analysis of Y, HCI, and EGI can be employed as a basic proxy for the results of ICB and EIE by being supplemented with qualitative analyses—such as policy history, the degree of external dependence in institutional design, and the agency of domestic reform actors—to more comprehensively capture institutional formation processes and derive policy and strategic implications.

With this understanding, the co-evolutionary dynamism of the institutional system is analyzed based on the dynamism illustrated in Figure 4. This dual co-evolutionary structure provides a theoretically coherent framework applicable to any complex organization. By bridging the gap between spontaneous human judgment and systematic administrative frameworks, the model facilitates a transition from "defensive" automation to a transformative "evolutionary" model, suitable for both corporate entities and public administrations.

In the era of AI agents, the transition toward managing tacit knowledge becomes a structural necessity. We refine the role of AI agents as "intellectual sensors" that capture unformalized organizational routines and expert decision-making—the core of tacit knowledge—that were previously difficult to codify.

Under this framework, the EIE–ICB loop is redefined as a systematic structural process: AI agents visualize spontaneous, internal organizational learning (EIE), which is then codified into systematic, reproducible institutional frameworks (ICB). This mechanism is not limited to corporate strategy but is theoretically applicable to any complex organization, including public administrations, by bridging the gap between human judgment and automated governance [50].

| Institutional State | Proxy | Statistics | Source | Proxy Validity |
|---|---|---|---|---|
| Economic development | Y | GDP per capita | IMF | Promoting e-government is essential for sustainable growth. Sustainable growth is essential for capacity building. |
| ICB level | HCI | Human Capital Index | World Bank | Corresponds to ICB, as this statistic demonstrates capacity building through externally designed systems such as education systems, insurance systems, and international assistance programs. |
| EIE level | EGI | e-Government Development Index | UN | Corresponds to EIE as this statistic evaluates online services, human capital, and communication infrastructure, and reflects the degree to which citizens voluntarily use and deepen the system. |

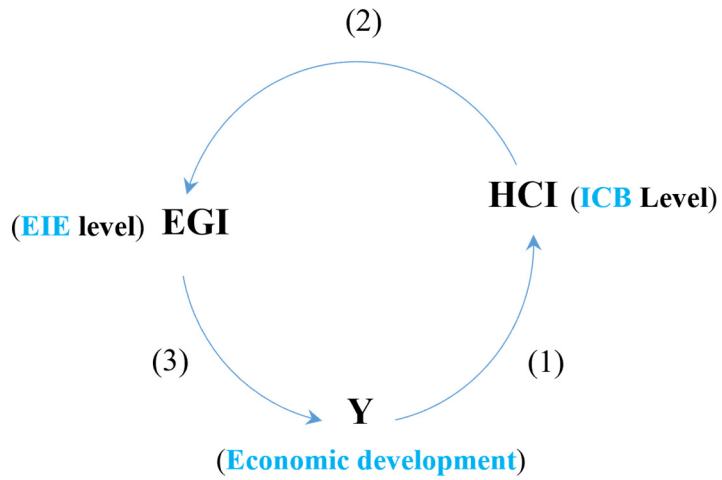



**Figure 4.** Co-evolutionary dynamism between growth, ICB and EIE in 160 countries.

### *4.3. Rational Sustainability*

Sustainability has long been positioned as a universal challenge for the international community, but in recent years, a sense of "sustainability fatigue" has become increasingly evident, particularly in advanced economies, as demonstrated in Table 6, and a backlash against conventional policy and investment models has been growing. The strict environmental regulations in Europe and the institutionalization of ESG (Environment, Social, Governance) investment have imposed excessive burdens on corporate activities, revealing limitations in both effectiveness and durability. In addition, the retreat of the United States from international cooperation and the rise of geopolitical tensions have further highlighted the fragility of idealistic approaches.

Under these circumstances, what is required is "Rational Sustainability," which reconciles value creation with rationality on the basis of evidence and analysis.

Traditional sustainability policies have prioritized ideological values, such as environmental ethics and social justice, imposing high environmental standards and non-financial requirements on firms. However, as energy security concerns and geopolitical risks intensify, such ideal-driven standards are becoming increasingly misaligned with the realities of policy implementation.

Moreover, the rapid expansion of ESG investment has encouraged the spread of greenwashing and the opacity of non-financial information, undermining the rationality of investment decisions. While ideals have been institutionalized, evaluation methods grounded in empirical evidence and analyses of trade-offs have not been sufficiently developed, which has been a major factor behind today's widespread "fatigue" [51].

In this context, the concept of "Rational Sustainability" proposed by Alex Edmans (2024) [52,53] redefines sustainability not as a political or moral ideal but as a rational activity embedded within the firm's value creation process [54]. Its core elements can be summarized in the following three points:

(i) Value creation based on economic rationality

Sustainability should be aligned with the fiduciary duties of the firm and positioned as part of long-term value creation. It must be internalized within the firm's own management strategy rather than pursued as a formalistic response to external evaluations.

(ii) Decision-making grounded in evidence and analysis

As a reflection on ideal-driven approaches, Rational Sustainability emphasizes empirical foundations. With the increasing disclosure of non-financial information, firms are

expected to evaluate the effects of their initiatives both quantitatively and qualitatively, thereby enhancing the transparency of investment decisions.

(iii) Clarification of trade-offs and boundary setting

Sustainability factors cannot be pursued infinitely; they involve diminishing returns and trade-offs with costs. Firms must clearly distinguish between areas they should address and those they should not, based on their comparative advantages.

To further clarify the conceptual contribution of this study, it is necessary to explicitly distinguish Rational Sustainability from prevailing ESG or sustainability frameworks. While traditional ESG models often rely on ideological values or normative compliance—leading to "sustainability fatigue" through high compliance costs and opaque non-financial disclosures—Rational Sustainability redefines the concept as a rational activity intrinsically linked to the firm's core value creation process. The novelty of our approach lies in shifting the focus from "defensive digitalization" (aimed at meeting external standards) to a "proactive institutional evolution", where sustainability is treated as an engine for long-term economic rationality and comparative advantage. By doing so, we move beyond the ideological idealism that has characterized the prior literature and provide a structural solution to the diminishing returns observed in mature digital economies.

Furthermore, this study extends the existing literature on Rational Sustainability (e.g., Edmans, 2024) [53] by operationalizing it through the lens of the AI agent-driven co-evolutionary loop between Endogenous Institutional Evolution (EIE) and Institutional Capacity Building (ICB). While prior studies have discussed sustainability in terms of ethics or risk management, this paper identifies a unique mechanism: utilizing AI agents as "intellectual sensors" to capture and visualize unformalized "tacit knowledge"—organizational routines and expert insights that traditional ESG frameworks failed to capture. This integration of AI agent technology into institutional theory provides a reproducible framework for breaking the "legacy system inertia" of advanced nations, offering a practical pathway for "neo-e-government" that has not been previously conceptualized in the sustainability literature.

### *4.4. Operationalize Rational Sustainability*

One of the firms that most fully embodies the principles of Rational Sustainability is Amazon, the leader in cloud business, a consistent top performer in global R&D investment, and a pioneer in generative AI.

Amazon has combined:

(i) Abundant free cash flow generated through a negative cash conversion cycle (CCC) [55];
(ii) An innovation culture driven by R&D [56];
(iii) The integration of technology and finance (orchestration of techno-financing systems) to construct a self-propagating growth engine [57].

This model aligns closely with the principles of Rational Sustainability, as follows:

(i) Long-term value creation:

Prioritizing the maximization of free cash flow rather than short-term profits, enabling sustained R&D investment.

(ii) Commitment to evidence and analysis:

Building an analytical decision-making system that integrates R&D, operations, and finance.

(iii) Clear boundary setting:

Limiting mergers and acquisitions (M&As) to the reinforcement of comparative advantages and focusing on capturing growth engines.

Amazon's model is an important concrete example demonstrating that Rational Sustainability is not merely an ideal but a practical framework that accelerates corporate growth in a self-propagating manner [58].

The redefinition of sustainability has become even more significant with the rapid diffusion of generative AI and AI agents. AI agents function not merely as tools but as intellectual sensors that can transform institutional structures themselves, with the potential to fundamentally reorganize corporate decision-making and knowledge creation processes [59].

In this new environment, two institutional approaches become essential, as reviewed earlier:

(i) Endogenous Institutional Evolution (EIE)

A process through which tacit knowledge within the organization is made visible and institutional structures are autonomously deepened through interaction with AI agents. EIE has a high affinity for AI agents, which excel at addressing non-routine problems and dynamic adaptation.

(ii) Institutional Capability Building (ICB)

A process of acquiring capabilities through external institutions and partnerships, accumulating explicit (codified) knowledge in a form that can be operationalized.

Since these two institutional approaches each incorporate relative advantages and disadvantages, as compared in Table 7, the co-evolution of EIE and ICB constitutes the core of sustainability strategies in the era of AI agents.

**Table 7.** Relative advantages and disadvantages of EIE and ICB.

| | **Endogenous Institutional Evolution of (EIE)** | **Institutional Capacity Building (ICB)** |
|---|---|---|
| Compatibility with AI agents | High | Limited |
| Conceptualization of tacit knowledge | Exceptional (high flexibility in embedding tacit knowledge into institutional frameworks) | Limited (systematic manipulation is difficult as it relies on spontaneous change) |
| Operationalization of explicit knowledge | Limited (conversion into explicit knowledge is a prerequisite) | Exceptional (knowledge is systematized and standardized through institutions, becoming a reproducible capability) |

By integrating these two institutional mechanisms toward co-evolution, firms can further advance Rational Sustainability.

To ground the relative advantages of EIE and ICB, as compared in Table 7, in empirical practice, the Amazon case study illustrates how these mechanisms function as a dual co-evolutionary system. Endogenous Institutional Evolution (EIE) acts as the "discovery" phase; Amazon utilizes AI agents to conceptualize (visualize) experiential insights and tacit knowledge, facilitating the spontaneous, internally driven learning necessary for the "reinvention of customer experience". Conversely, Institutional Capacity Building (ICB) represents the "scaling" phase. Amazon operationalizes codified knowledge into reproducible capabilities, most notably through Amazon Web Services (AWS), which transforms internal information and technology (IT) infrastructure into a standardized, scalable framework for external enterprises. This synergy ensures that tacit insights are not only discovered but systematically implemented as reproducible institutional capabilities.

The recent trend in advanced countries toward a breakdown in the co-evolution between capacity building (HCI: a proxy for ICB) and digital government (EGI: a proxy

for EIE) mediated by growth, Y, as observed in the previous analysis, indicates features of sustainability fatigue. In order to overcome this situation, it is believed that the knowledge gained from successful examples of the co-evolution of EIE and ICB in leading firms will be informative and supportive.

### *4.5. Lessons from Amazon's AI Agent Strategy Towards Rational Sustainability*

#### 4.5.1. Cloud Service by Top 3 Leaders

Innovation driven by generative AI is entering a stage in which the integration of AI agents has become essential, and the leadership of this transformation is increasingly concentrated in the AI development platforms provided by global cloud leaders, as compared in Table 8.

**Table 8.** Trend in market share of cloud services in the top 3 cloud service leaders. (2024 Q1–2025 Q2): %.

| | 2024 Q1 | 2024 Q2 | 2024 Q3 | 2024 Q4 | 2025 Q1 | 2025 Q2 | Key Features |
|---|---|---|---|---|---|---|---|
| AWS<br>Service Launch: 2006<br>Amazon | 31 | 32 | 31 | 30 | 29 | 30 | (i) The most widely used globally, supported by a highly advanced security framework<br>(ii) Offers a broad range of services with seamless integration with third-party platforms |
| MS Azure<br>2010<br>Microsoft | 25 | 23 | 20 | 21 | 22 | 20 | (i) Excellent compatibility with Microsoft products<br>(ii) Extensive industry-specific solutions |
| Google Cloud<br>2008<br>Google | 11 | 12 | 13 | 12 | 12 | 13 | (i) Leverages Google's infrastructure and cutting-edge technologies<br>(ii) Provides a stable infrastructure environment, with advanced AI and data analytics services |

Source: Synergy Research Group.

Firms such as Amazon, Microsoft, and Google are mobilizing their full technological and managerial capabilities to advance the development of AI agent foundations, as demonstrated in Figure 5 [60,61].

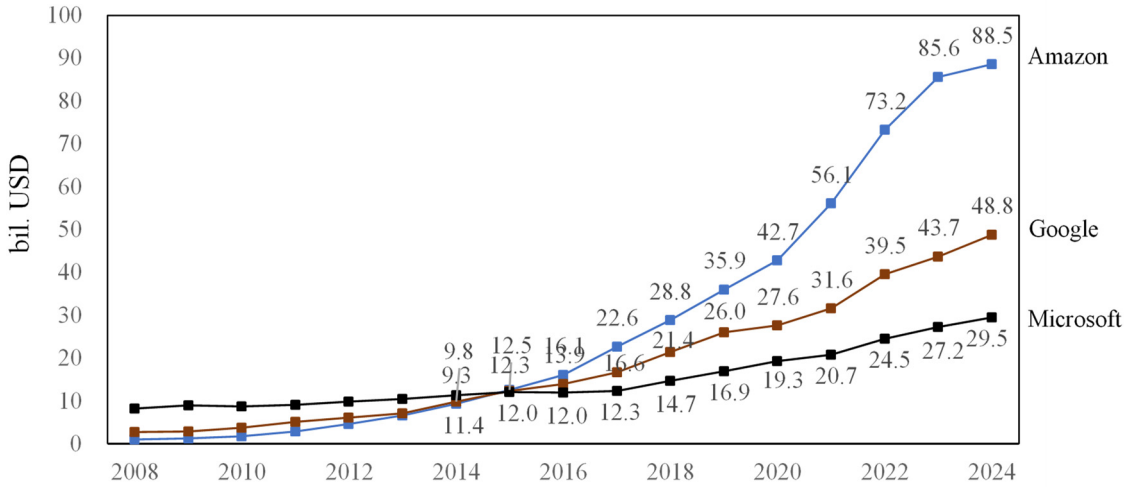



**Figure 5.** Trends in R&D investment for Amazon, Microsoft and Google (2008–2024). Note: Consolidated annual R&D expenditures (including subsidiaries); Amazon's R&D corresponds to its "Technology and Content". Source: Compiled by authors from annual reports of Amazon, Microsoft and Google. Data represents consolidated annual R&D expenditures (including subsidiaries) from 2008 to 2024. For Amazon, figures refer to "Technology and Content" expenses.

Amazon, one of the world's top R&D investors and a company that consistently maintains around 30% of the global cloud market, has led generative AI-driven innovation through Amazon Web Services (AWS). Moreover, it has been quick to recognize the emerging innovation trajectory of the AI agent era and is now pursuing a new phase of institutional innovation [62].

#### 4.5.2. Amazon's Corporate Culture

Amazon's innovation trajectory is grounded in a distinctive corporate culture characterized by four foundational principles: (i) the institutionalization of research and development as a core organizational culture ("R&D as a Culture"), (ii) the inclusive and integrated management of R&D investments ("Technology and Content"), (iii) the systematic transformation of routine operational modifications into substantive performance improvements, and (iv) the strategic mobilization of user capabilities. These principles constitute Amazon's Credo and have shaped its long-standing commitment to R&D driven business development [63,64].

#### 4.5.3. Amazon Web Services

In 2006, Amazon launched Amazon Web Services (AWS), leveraging the IT infrastructure capabilities cultivated through its e-commerce operations and making them available as cloud services to external enterprises. AWS has since expanded to capture approximately one-third of the global cloud services market, as demonstrated in Table 8. AWS embodies the cumulative outcome of Amazon's R&D efforts. Its evolution has generated a self-propagating co-evolutionary cycle in which R&D activities enable the provision of advanced services, and these advanced services, in turn, stimulate further R&D. This reciprocal dynamic between R&D and high-value service provision has been central to AWS's sustained growth.

#### 4.5.4. World Leading R&D

Through AWS, Amazon has established a virtuous cycle wherein cutting-edge technological services enhance customer experience, and the insights derived from customer interactions feed back into Amazon's organizational learning processes. This dual co-evolution—between R&D and service provision and between advanced services and their associated learning effects—has enabled Amazon to maintain a position at the global frontier of R&D, as demonstrated in Figure 6, serving as a benchmark for innovation leadership [32].

#### 4.5.5. Generative AI-Driven Innovation

As a leading actor in digital innovation, Amazon has been an early adopter of AI and generative AI technologies, positioning itself at the forefront of generative AI-driven innovation. AWS functions as a foundational platform for this transformation, offering a prototypical model for generative AI-enabled innovation ecosystems [59].

The rapid diffusion of generative AI has accelerated the homogenization of corporate strategies, thereby elevating the importance of transforming organizational cognitive frameworks within technology management. Firms are increasingly required to design and deliver experiences that exceed customer expectations—what Amazon refers to as the "reinvention of customer experience"—by identifying patterns of convergent customer behavior and transcending conventional service paradigms [65–69]. This shift places the conceptualization and operationalization of tacit knowledge at the center of contemporary strategic management [70].

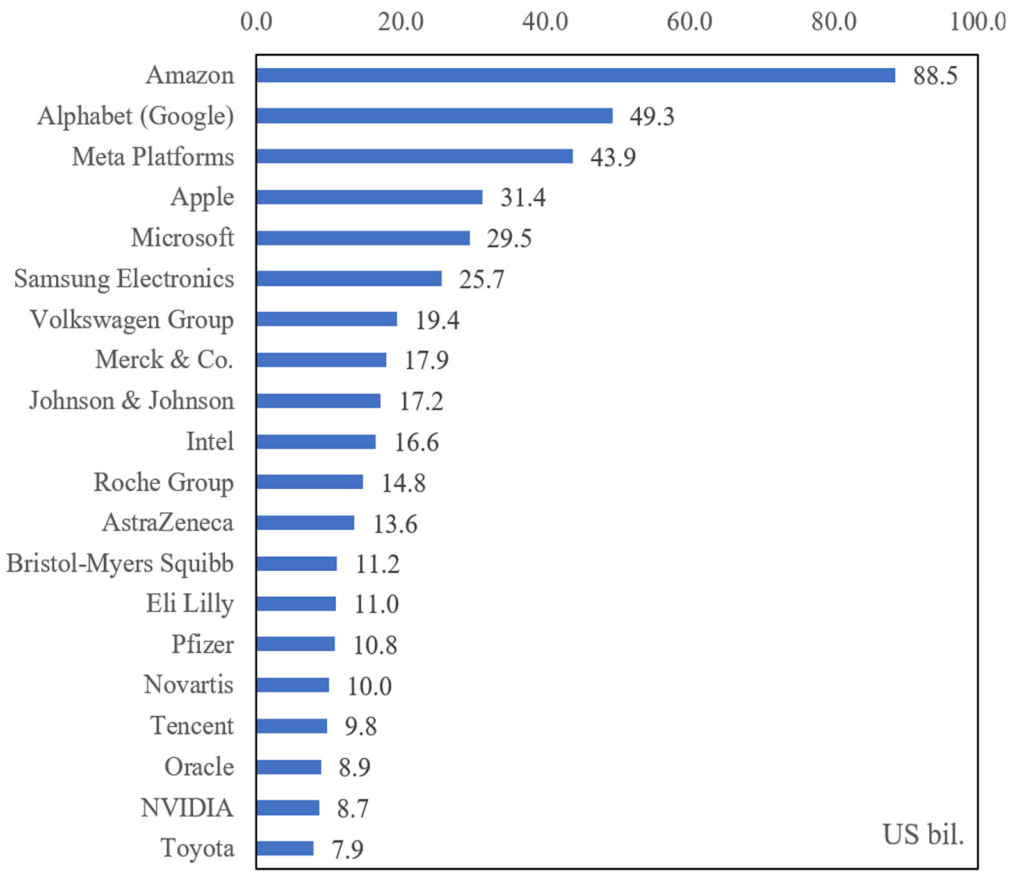



**Figure 6.** Top 20 R&D firms in the world (2024). Note: Fiscal year 2024; values are based on consolidated corporate filings; Amazon's R&D corresponds to its "Technology and Content". Source: Compiled by authors from annual reports of respective companies. Data for fiscal year 2024. Figures are based on consolidated corporate filings. Amazon's R&D reflects its "Technology and Content" investment.

#### 4.5.6. Technology Management Strategy Grounded in Comparative Institutional Analysis

Within this context, Amazon advances its AI agent strategy through a technology management trajectory informed by comparative institutional analysis and anchored in its distinctive Credo. This trajectory is underpinned by two institutional transformation mechanisms as reviewed earlier: (i) Institutional Capacity Building (ICB), which facilitates capability development and organizational growth through externally designed institutional frameworks, and (ii) Endogenous Institutional Evolution (EIE), which deepens institutional structures through spontaneous, internally driven organizational change. These mechanisms collectively constitute the transformation-driven foundation of Amazon's technology management strategy [58,71,72].

#### 4.5.7. An Innovation Model for the AI Agent Era

Amazon's innovation model—rooted in the dual co-evolution of R&D and service provision, and of advanced services and learning effects—exhibits strong structural affinity with AI agent-based architectures. EIE, which excels in the conceptualization (visualization) of tacit knowledge, and ICB, which enables the operationalization of such knowledge, form a complementary co-evolutionary system. This system provides a theoretically coherent and practically effective response to the increasing strategic homogenization observed in the era of generative AI.

#### 4.5.8. A Beacon for Addressing Sustainability Fatigue

Amazon's co-evolutionary approach offers conceptual and practical insights for addressing the phenomenon of sustainability fatigue that has become increasingly salient in mature economies. Its innovation model provides a potential pathway for revitalizing sustainability strategies under conditions of technological and institutional saturation [70].

To clarify how Amazon's model serves as a practical framework for revitalizing growth in institutionally saturated economies, Table 9 provides a direct comparative analysis between the structural problems identified in advanced nations and Amazon's specific addressing mechanisms.

**Table 9.** Comparative analysis: mature economies' challenges vs. Amazon's solutions.

| Structural Challenges in Mature Economies | Amazon's Addressing Mechanisms (Solutions) |
| --- | --- |
| (i) Strategic Homogenization: The rapid diffusion of universal GAI tools leads to an erosion of distinctiveness in corporate and national strategies. | Utilizing EIE and Tacit Knowledge: Visualizing experiential insights and context-specific "tacit knowledge" through Endogenous Institutional Evolution (EIE) to reinvent customer experience and maintain differentiation. |
| (ii) Diminishing Returns: Mature digital economies face a decline in marginal benefits from traditional digitalization despite increasing fiscal and regulatory burdens. | Creating a Self-propagating Trajectory: Establishing a virtuous cycle where R&D investment drives advanced services (like AWS), which in turn stimulate further organizational learning and growth. |
| (iii) Legacy System Inertia: High maintenance costs for outdated systems and structural stagnation hinder transformative innovation. | AI agents as Intellectual Catalysts: Utilizing AI agents to transform routine operational modifications into substantive, autonomous performance improvements and institutional deepening. |
| (iv) Misaligned ESG/Conventional Sustainability: Heavy burdens from non-rational, conventional sustainability models that prioritize moral ideals over economic reality. | Applying Rational Sustainability: Redefining sustainability as a rational activity aligned with economic rationality, long-term value creation, and evidence-based decision-making. |

This structured comparison demonstrates that Amazon's innovation model is not merely a corporate success story but a reproducible institutional system capable of breaking the stagnation characteristic of mature digital economies.

### *4.6. Generalizability, Applicability, and Limitations of the Model*

(1) Generalizability

To address the generalizability of the proposed model, it is crucial to distinguish between Amazon's firm-specific execution and the underlying structural mechanism of EIE–ICB co-evolution. While Amazon possesses unique R&D capabilities, the core of its success lies in its ability to utilize AI agents as "intellectual sensors" to conceptualize tacit knowledge and integrate it into a self-propagating institutional loop.

(2) Applicability to Other Firms and Industries

The "Rational Sustainability" model is applicable to any organization facing "sustainability fatigue" or stagnation in a mature digital economy.

(i) Focus on Tacit Knowledge: For firms in service or manufacturing sectors, the model suggests using AI agents not just for automation, but to capture unformalized organizational routines (tacit knowledge) that are often lost in traditional digitalization.
(ii) Resource-Agile ICB: While smaller firms may lack Amazon-scale R&D, the model's emphasis on "Institutional Capacity Building" (ICB) can be scaled down by prioritizing specific domains where the firm has a comparative advantage.

(3) Applicability to the Public Sector (Neo-e-Government): The findings provide a strategic blueprint for the public sector in "withdrawal states"—advanced nations where e-government growth has stagnated.
(4) Breaking Legacy Inertia: By adopting the EIE–ICB loop, public institutions can move beyond "defensive digitalization" (simply moving paper-based processes online) toward a "neo-e-government" framework. In this context, AI agents function as a bridge between spontaneous social needs (EIE) and designed policy frameworks (ICB), allowing for more responsive and rational public administration.
(5) Limitations and Prerequisites: The primary limitation of this model is the requirement for baseline digital maturity and organizational openness.
(i) Institutional Resistance: The transition from ideological sustainability to Rational Sustainability requires a fundamental shift in leadership mindset—from meeting external compliance to internalizing economic rationality.
(ii) Data Integrity: The effectiveness of AI agents as sensors depends on the quality and transparency of the underlying data infrastructure. Without a commitment to "evidence-based decision-making," the model risks replicating existing biases rather than fostering institutional evolution.

## 5. Conclusions

### *5.1. Overview*

Persistent concerns regarding sustainability fatigue in advanced economies—despite the longstanding role of e-government as a foundational mechanism for enhancing public service delivery, promoting inclusive development, facilitating socio-economic upgrading, and strengthening systemic resilience—underscore the necessity of a more structurally grounded examination of stagnation in mature digital economies. In response, this study reassessed the historical co-evolutionary dynamics linking digital governance, economic performance, and institutional capability.

Drawing on a macro-level empirical analysis of 160 countries between 2014 and 2024, complemented by an in-depth case study of Amazon—one of the world's largest R&D investors, a leading global cloud provider, and a pioneer in generative AI-enabled innovation—this research identified a marked disruption of the co-evolutionary mechanism in advanced economies during the 2020s. In response to the need for methodological transparency and reproducibility, this study relies on standardized, internationally recognized datasets provided by the IMF, World Bank, and United Nations.

By quantifying elasticity across 160 countries over a ten-year period, we provide a rigorous empirical basis for the analysis of sustainability fatigue. This approach allows us to move beyond normative policy assertions and identify the structural sources of stagnation currently confronting mature digital economies.

The rapid diffusion of generative AI has intensified the homogenization of corporate strategies, thereby heightening the imperative for firms to reconfigure organizational cognition and deliver superior customer experiences, encapsulated by Amazon's notion of the "reinvention of customer experience." This transformation places the conceptualization and operationalization of tacit knowledge at the center of contemporary technology and innovation management.

Amazon's institutional innovation model—integrating Institutional Capacity Building (ICB) and Endogenous Institutional Evolution (EIE)—illustrates how externally designed capability frameworks and internally driven learning processes may co-evolve. The dual co-evolution between R&D and service provision, and between advanced services and learning effects, exhibits strong structural affinity with AI agent-based architectures. EIE facilitates the conceptualization of tacit knowledge, whereas ICB enables its system-

atic operationalization. Together, these mechanisms constitute a complementary institutional system capable of counteracting the strategic homogenization characteristic of the generative AI era.

This model provides both conceptual and practical guidance for addressing sustainability fatigue in technologically mature and institutionally saturated economies, offering a viable pathway for revitalizing sustainability strategies under such conditions. From these findings, we emphasize that leapfrogging is subject to strict policy conditionality. Success depends on the deliberate design of stage-specific programs tailored to each country's unique institutional constraints and a sustained investment in human capacity building to complement and oversee AI agent systems.

To resolve the identified failures of current models, this paper proposes a fundamental transition from conventional digitalization to a framework of "Rational Sustainability." This approach prioritizes economic rationality, anchors decision-making in empirical evidence, and proactively manages the trade-offs inherent in technological maturity. Based on this framework, we recommend the following five corrective measures to ensure the long-term viability of e-government systems:

(i) Stage-Specific Alignment: Formulate digital programs in strict accordance with the specific developmental stage (ACs, ECs, or DCs) of each economy to avoid structural mismatches.
(ii) Neo-e-government Integration: Establish a new framework of "neo-e-government" that utilizes AI agents to enable autonomous institutional evolution and non-routine problem solving.
(iii) Evidence-Based Evaluation: Shift from formalistic compliance to rigorous, evidence-based evaluation of digital investments to ensure they contribute to actual value creation.
(iv) Strengthening Co-evolution: Actively facilitate the co-evolutionary loop between internally driven learning (EIE) and external capability frameworks (ICB), as modeled by leading innovators like Amazon.
(v) Human-Centric Investment: Prioritize investment in human capabilities that complement and provide oversight to AI systems, preserving institutional diversity and resilience.

### *5.2. Concrete Policy and Practical Guidance for Rational Sustainability*

To enhance the practical relevance of this study, we provide the following actionable guidance for policymakers and corporate executives, moving beyond abstract recommendations to specific implementation strategies.

(1) Implementing "Neo-e-Government" by Development Stage

- For Mature Economies (e.g., Japan, USA): To overcome "defensive DX" and sustainability fatigue, governments must prioritize AI agent-driven "Institutional Memory Mapping." Instead of simple automation, AI agents should be deployed to visualize and document the tacit knowledge embedded in aging administrative legacy systems. This allows for a structural update of public services without the prohibitive fiscal burden of total system replacement.
- For Emerging Economies (e.g., India and China): These nations should leverage the "EIE-First" Leapfrogging Strategy. By deploying AI-driven personalized public services, they can allow spontaneous organizational learning (EIE) to precede and inform formal capacity building (ICB), effectively bypassing the rigid, paper-based bureaucratic growth phases of the past.

(2) Operationalizing "Rational Sustainability" Audits

- From Compliance to Evidence-Based Value: Organizations should transition from formalistic ESG checklists to "Marginal Return on Digital (MRD)" evaluations. Based on the principle of evidence-based decision-making, practitioners must quantitatively assess whether digital investments are contributing to long-term value creation or merely increasing maintenance costs.
- Strategic Boundary Setting: Practitioners must explicitly define "Non-Digitalization Zones." Following Amazon's model of clear trade-offs, organizations should focus R&D resources only on areas of comparative advantage, consciously avoiding the homogenization of strategy caused by universal generative AI tools.

(3) Fostering a "Co-evolutionary" Organizational Culture

- AI Agents as Tacit Knowledge Sensors: Both public and private sectors should implement AI agents as "intellectual sensors" at the frontline. These agents should be tasked with capturing unformalized, non-routine problem-solving routines (tacit knowledge) from experts.
- Rapid ICB Codification: Captured tacit insights must be integrated into a monthly ICB update cycle, where they are codified into reproducible standard operating procedures (SOPs), transforming individual learning into institutional capability.
- "R&D as a Culture" in Public Administration: Governments must move away from vendor-dependent digitalization. Following the "Amazon Credo," they should cultivate an internal R&D culture that treats administrative routine modifications as substantive performance improvements.

By adopting these concrete measures, institutions can break the cycle of "sustainability fatigue" and establish a self-propagating growth engine suitable for the AI agent era.

### *5.3. A Limitation and Future Research Direction*

A limitation of this study is that the broad classification of 160 countries into three developmental stages (ACs, ECs, and DCs), while facilitating the identification of global co-evolutionary trends, may mask specific institutional nuances and cultural variations within each group. Recognizing this challenge, our current findings should be viewed as a starting point for identifying macroscopic structural shifts.

Consequently, future research directions should include:

(i) Identification of structural impediments that hinder institutional co-evolution;
(ii) Documentation and dissemination of practical experiences that advance rational sustainability;
(iii) Design of cooperative co-evolutionary schemes between advanced economies and emerging/developing countries;
(iv) Implementation of finer-grained sensitivity analyses or further categorization based on specific institutional qualities—such as legal origins, regulatory maturity, or historical administrative traditions—to validate and refine the current developmental groupings.

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## Appendix A. Institutional States in 160 Countries (2024)

| Advanced countries | | | | |
|---|---|---|---|---|
| Name | ISO2 | GDP per Capita (k USD) | HCI | EGI |
| Singapore | SG | 150.9 | 0.87 | 0.97 |
| Luxembourg | LU | 150.0 | 0.68 | 0.85 |
| Ireland | IE | 134.0 | 0.78 | 0.91 |
| Norway | NO | 103.7 | 0.77 | 0.93 |
| Switzerland | CH | 95.2 | 0.74 | 0.90 |
| United States | US | 86.1 | 0.62 | 0.92 |
| Denmark | DK | 81.8 | 0.73 | 0.98 |
| Netherlands | NL | 81.4 | 0.78 | 0.95 |
| Iceland | IS | 78.9 | 0.75 | 0.97 |
| Malta | MT | 75.3 | 0.72 | 0.89 |
| Belgium | BE | 73.6 | 0.77 | 0.81 |
| Austria | AT | 73.1 | 0.68 | 0.91 |
| Germany | DE | 71.8 | 0.69 | 0.94 |
| Sweden | SE | 71.4 | 0.79 | 0.93 |
| Australia | AU | 69.4 | 0.73 | 0.96 |
| Finland | FI | 64.7 | 0.77 | 0.96 |
| France | FR | 64.2 | 0.76 | 0.87 |
| Canada | CA | 63.9 | 0.80 | 0.85 |
| Korea, Rep. | KR | 62.9 | 0.74 | 0.97 |
| Cyprus | CY | 62.3 | 0.76 | 0.86 |
| UK | GB | 62.0 | 0.79 | 0.96 |
| Italy | IT | 61.3 | 0.67 | 0.84 |
| Czechia | CZ | 57.0 | 0.71 | 0.82 |
| Slovenia | SI | 55.9 | 0.76 | 0.88 |
| Spain | ES | 54.7 | 0.71 | 0.92 |
| Lithuania | LT | 54.4 | 0.70 | 0.91 |
| New Zealand | NZ | 54.4 | 0.79 | 0.93 |
| Israel | IL | 54.1 | 0.70 | 0.90 |
| Japan | JP | 52.7 | 0.75 | 0.94 |
| Poland | PL | 52.2 | 0.76 | 0.86 |
| Croatia | HR | 48.7 | 0.69 | 0.88 |
| Portugal | PT | 48.0 | 0.76 | 0.84 |
| Estonia | EE | 47.7 | 0.82 | 0.97 |
| Romania | RO | 47.0 | 0.56 | 0.76 |
| Hungary | HU | 46.6 | 0.66 | 0.80 |
| Slovak Rep. | SK | 46.0 | 0.63 | 0.80 |
| Greece | GR | 43.0 | 0.70 | 0.87 |
| Latvia | LV | 42.5 | 0.69 | 0.89 |
| Bulgaria | BG | 39.2 | 0.53 | 0.81 |
| Chile | CL | 33.8 | 0.62 | 0.88 |

| Emerging countries | | | | |
|---|---|---|---|---|
| Name | ISO2 | GDP per Capita (k USD) | HCI | EGI |
| Qatar | QA | 116.6 | 0.67 | 0.82 |
| Guyana | GY | 83.6 | 0.50 | 0.54 |
| UAE | AE | 79.3 | 0.69 | 0.95 |
| Saudi Arabia | SA | 71.5 | 0.56 | 0.96 |
| Bahrain | BH | 67.0 | 0.63 | 0.92 |
| Kuwait | KW | 51.3 | 0.54 | 0.78 |
| Russia | RU | 47.4 | 0.62 | 0.85 |
| Kazakhstan | KZ | 41.8 | 0.48 | 0.90 |
| Turkiye | TR | 41.5 | 0.68 | 0.89 |
| Panama | PA | 41.5 | 0.46 | 0.73 |
| Oman | OM | 41.3 | 0.59 | 0.86 |
| Malaysia | MY | 41.3 | 0.60 | 0.81 |
| Seychelles | SC | 39.9 | 0.57 | 0.68 |
| Uruguay | UY | 35.4 | 0.60 | 0.90 |
| Trinidad | TT | 34.9 | 0.59 | 0.70 |
| St. Kitts | KN | 32.8 | 0.61 | 0.63 |
| Montenegro | ME | 32.6 | 0.66 | 0.72 |
| Mauritius | MU | 31.2 | 0.62 | 0.75 |
| Serbia | RS | 31.0 | 0.58 | 0.86 |
| Costa Rica | CR | 29.9 | 0.64 | 0.80 |
| Argentina | AR | 29.6 | 0.59 | 0.86 |
| Dominica | DO | 29.2 | 0.52 | 0.70 |
| Georgia | GE | 28.3 | 0.51 | 0.78 |
| St. Lucia | LC | 28.1 | 0.63 | 0.53 |
| N. Macedonia | MK | 27.7 | 0.59 | 0.71 |
| China | CN | 27.1 | 0.62 | 0.87 |
| Thailand | TH | 25.3 | 0.62 | 0.84 |
| Mexico | MX | 25.1 | 0.62 | 0.78 |
| Azerbaijan | AZ | 25.0 | 0.56 | 0.76 |
| Gabon | GA | 24.2 | 0.46 | 0.57 |
| Brazil | BR | 22.3 | 0.54 | 0.84 |
| Armenia | AM | 22.2 | 0.59 | 0.84 |
| Albania | AL | 21.8 | 0.65 | 0.80 |
| Bosnia | BA | 21.7 | 0.53 | 0.63 |
| Colombia | CO | 21.5 | 0.62 | 0.78 |
| Iran | IR | 21.0 | 0.60 | 0.66 |
| Egypt | EG | 20.8 | 0.51 | 0.67 |
| Grenada | GD | 20.4 | 0.61 | 0.65 |
| St. Vincent | VC | 19.9 | 0.53 | 0.59 |
| Ukraine | UA | 19.7 | 0.61 | 0.88 |
| Botswana | BW | 19.1 | 0.40 | 0.61 |
| Mongolia | MN | 19.1 | 0.60 | 0.85 |
| Paraguay | PY | 18.7 | 0.52 | 0.73 |
| Moldova | MD | 18.5 | 0.59 | 0.77 |
| Peru | PE | 18.2 | 0.63 | 0.81 |
| Algeria | DZ | 17.7 | 0.55 | 0.60 |
| Indonesia | ID | 16.6 | 0.55 | 0.80 |
| Viet Nam | VN | 16.4 | 0.72 | 0.77 |
| Ecuador | EC | 16.0 | 0.58 | 0.78 |
| South Africa | ZA | 15.7 | 0.45 | 0.86 |
| Iraq | IQ | 15.3 | 0.42 | 0.46 |
| Sri Lanka | LK | 15.0 | 0.62 | 0.67 |
| Guatemala | GT | 14.4 | 0.46 | 0.57 |
| Tunisia | TN | 14.4 | 0.53 | 0.69 |
| Jamaica | JM | 13.3 | 0.52 | 0.67 |
| El Salvador | SV | 13.3 | 0.61 | 0.60 |
| Philippines | PH | 12.1 | 0.47 | 0.76 |
| Namibia | NA | 11.9 | 0.46 | 0.60 |
| Lebanon | LB | 11.8 | 0.48 | 0.54 |
| India | IN | 11.2 | 0.57 | 0.67 |
| Jordan | JO | 11.0 | 0.54 | 0.68 |
| Morocco | MA | 10.8 | 0.51 | 0.68 |
| Nigeria | NG | 9.1 | 0.39 | 0.48 |
| Nicaragua | NI | 8.7 | 0.48 | 0.53 |
| Ghana | GH | 8.0 | 0.46 | 0.63 |
| Samoa | WS | 7.9 | 0.60 | 0.49 |
| Tonga | TO | 7.7 | 0.56 | 0.52 |
| Honduras | HN | 7.6 | 0.47 | 0.49 |
| Kenya | KE | 7.2 | 0.59 | 0.63 |
| Vanuatu | VU | 3.0 | 0.43 | 0.54 |

| Developing countries | | | | |
|---|---|---|---|---|
| Name | ISO2 | GDP per Capita (k USD) | HCI | EGI |
| Palau | PW | 17.7 | 0.63 | 0.51 |
| Eswatini | SZ | 12.6 | 0.32 | 0.61 |
| Angola | AO | 10.1 | 0.36 | 0.41 |
| Lao PDR | LA | 9.8 | 0.46 | 0.44 |
| Bangladesh | BD | 9.7 | 0.44 | 0.66 |
| Mauritania | MR | 8.4 | 0.42 | 0.35 |
| Cambodia | KH | 8.2 | 0.49 | 0.58 |
| Kyrgyz Rep. | KG | 8.2 | 0.62 | 0.73 |
| Cote d'Ivoire | CI | 7.7 | 0.42 | 0.56 |
| Zimbabwe | ZW | 7.4 | 0.50 | 0.45 |
| Marshall | MH | 7.0 | 0.46 | 0.48 |
| Pakistan | PK | 6.7 | 0.43 | 0.51 |
| Congo, Rep. | CG | 6.4 | 0.42 | 0.34 |
| Tuvalu | TV | 5.9 | 0.30 | 0.40 |
| Nepal | NP | 5.7 | 0.52 | 0.58 |
| Tajikistan | TJ | 5.6 | 0.47 | 0.56 |
| Cameroon | CM | 5.6 | 0.40 | 0.43 |
| Senegal | SN | 5.1 | 0.42 | 0.52 |
| Myanmar | MM | 5.0 | 0.48 | 0.50 |
| Timor-Leste | TL | 4.8 | 0.48 | 0.40 |
| Micronesia | FM | 4.6 | 0.59 | 0.32 |
| Guinea | GN | 4.4 | 0.37 | 0.40 |
| Benin | BJ | 4.4 | 0.39 | 0.46 |
| Zambia | ZM | 4.3 | 0.40 | 0.54 |
| Tanzania | TZ | 4.1 | 0.38 | 0.43 |
| Ethiopia | ET | 4.1 | 0.38 | 0.31 |
| Comoros | KM | 3.9 | 0.40 | 0.26 |
| Rwanda | RW | 3.8 | 0.39 | 0.58 |
| Uganda | UG | 3.7 | 0.39 | 0.45 |
| PNG | PG | 3.6 | 0.49 | 0.31 |
| Kiribati | KI | 3.5 | 0.51 | 0.46 |
| Sierra Leone | SL | 3.5 | 0.38 | 0.30 |
| Gambia, The | GM | 3.5 | 0.45 | 0.26 |
| Togo | TG | 3.2 | 0.46 | 0.39 |
| Chad | TD | 3.1 | 0.31 | 0.18 |
| Haiti | HT | 3.0 | 0.45 | 0.21 |
| Lesotho | LS | 3.0 | 0.44 | 0.41 |
| Burkina Faso | BF | 2.9 | 0.40 | 0.29 |
| Mali | ML | 2.8 | 0.32 | 0.30 |
| Solomon | SB | 2.6 | 0.39 | 0.37 |
| Sudan | SD | 2.3 | 0.38 | 0.28 |
| Afghanistan | AF | 2.2 | 0.42 | 0.21 |
| Niger | NE | 2.0 | 0.32 | 0.21 |
| Madagascar | MG | 2.0 | 0.42 | 0.32 |
| Congo, Dem | CD | 1.9 | 0.36 | 0.27 |
| Liberia | LR | 1.9 | 0.32 | 0.25 |
| Malawi | MW | 1.7 | 0.42 | 0.38 |
| Yemen, Rep. | YE | 1.7 | 0.38 | 0.23 |
| Mozambique | MZ | 1.7 | 0.36 | 0.28 |
| Burundi | BI | 1.0 | 0.40 | 0.25 |

Sources: IMF, World Economic Outlook Databases, 2025. IMF, Washington, DC. World Bank, Human Capital Index, 2025. World Bank, Washington, DC. United Nations, UN e-government Survey, 2024. United Nations, New York.

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