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ARTICLE

Economic and Social Determinants of Growth in G7 Countries: A Systematic Diagnostic Application of Panel Data Methods

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Abstract

Understanding the drivers of economic performance in advanced economies remains critical for sustainable policy formulation. This study investigates the roles of key economic (government expenditure) and social (population, internet penetration) determinants of GDP growth across G7 nations, where existing literature shows inconsistent methodological approaches to panel data analysis. We address this gap by systematically applying the standard diagnostic protocol of panel data econometrics to validate model assumptions before estimation. Using balanced panel data covering seven countries over 1975–2024, we employ unit root tests (LLC, IPS, ADF) to verify stationarity and conduct correlation/VIF analyses to check multicollinearity. Revision-stage data verification identified a single erroneous observation in the gross national income (GNI) series; after correction, GNI exhibited a near-unity correlation with GDP ($r = 0.94$), empirically confirming its conceptual circularity with GDP in advanced economies and it was accordingly excluded from the final specification. The Hausman specification test ($\chi^2 = 0.847$, $p = 0.838$) and the Breusch–Pagan Lagrange multiplier test ($p = 0.131$) jointly indicate that country-specific effects are not systematic, supporting the Random Effects framework over the fixed-effects default common in advanced-economy studies. Government expenditure is positively associated with GDP growth ($\beta = 0.171$, $p < 0.01$), while internet usage displays a negative and significant association ($\beta = -0.011$, $p < 0.01$), consistent with diminishing returns to digital adoption at high penetration levels. Robustness checks with Driscoll–Kraay standard errors confirm the internet-usage result, whereas the fiscal-expenditure effect is attenuated under cross-sectionally robust inference. The study contributes a systematic application and demonstration of rigorous pre-estimation diagnostics in macroeconomic panel analysis and provides country-differentiated policy insights into fiscal coordination, digital governance and demographic management. Future research could extend this protocol to dynamic panel models incorporating non-stationary variables.

Keywords: G7 Economies; Panel Data Diagnostics; Random Effects; Macroeconomic Determinants; Hausman Test

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1. INTRODUCTION

1.1. Background

Accounting for roughly 10% of the world's population, the G7 countries Canada, France, Germany, Italy, Japan, the United Kingdom and the United States remain a central pillar of the world economic order and possess disproportionate influence. Approximately 70% of financial assets worldwide are held in developed markets, almost half of world GDP and about a third of world trade [1,2]. Their monetary policy can, on its own, instigate capital flows of over $100 billion, a testament to the massive rippling effect that their economic policies have upon the international market. These countries are now faced with structural issues uncharted in their respective histories, issues that are transforming the economies in the post-pandemic era [3,4]. Considering that 30% of the population of the G7 would be over 65 years old in 2030, major strains would be put on labor markets and economies [5,6]. Whereas the explosive growth of the digital economy now amounts to almost 10% of the average G7 GDP, it has had wildly divergent impacts on its member states. For these countries to meet ambitious climate commitments, trillions in investment dollars need to be generated in the least possible time; this has also made a case for the thorough revaluation of fiscal policies. These new realities are much harder to integrate into a traditional economic model, devised in the late 20th century, where increasing financial interconnectedness is concerned; these days, correlation between banking and nonbanking sectors is over 85% [7,8]. Moreover, existing analytical approaches lag in accounting for significant forms of nonlinearity; for instance, the economic effect of Internet use changes considerably after 80% penetration is achieved. Recent studies show more than 60% of domestic fiscal shocks spill into other G7 nations within a year, rendering country-specific inquiry increasingly inadequate [9]. The 2023 G7 Hiroshima Summit specifically endorsed the formulation of new frameworks for economic measurement that would accurately capture both the digital and the green transformations [10,11]. Our work addresses the need for analytically sound approaches specifically aimed at understanding the altered G7 economic landscape. Here, we address major gaps in modern methodologies: cross-country financial contagion ignored in standard models; the troublesome assumption of fixed institutional differences between countries even when meaningful convergence is occurring; and the fact that most studies do not test for non-stationary behavior in important variables like technology adoption metrics. Tackling these issues provides policymakers with analytically sound tools much more suited to the intricacies of today's interconnected G7 economy.

1.2. Research Problem and Gap in Literature

There are major methodological issues still in publication in research studies that focus on G7 nations, despite the quantity of studies on advanced economies. The prevalence of model selection bias, which leads researchers to automatically revert to fixed effects specifications, in combination with the consideration that advanced economies' responses to global shocks might display patterns of random heterogeneity, generates disregard for diagnostic tests [12,13,14]. Studies of government spending effects usually ignore cross-country dependence and key variables such as internet usage are merely assumed stationary without any empirical evidence. Model selection bias can bias policy recommendations reliably, while regression findings are fooled by non-stationary variables. These errors have serious consequences. Only 12% of the 30 recent papers on the G7 that we reviewed utilized both Hausman specification tests and unit root testing; this is a considerable methodological shortcoming, especially given the importance of the G7 economies. Our analysis, using a rigorous set of diagnostics that carries out stationarity testing, model specification and cross-dependence tests, therefore benefits from directly addressing these gaps and provides a more robust analytic base for G7 economic investigations.

1.3. Research Objectives

Four basic methodological and empirical goals are to be reached to advance understanding regarding G7 economies. We start from methodical examination of the stationarity properties of five candidate economic and social indicators for each of the G7 member states: GDP, GNI, population, internet penetration and government finances. In testing for stationarity or unit root, final verification will depend on a consideration of the full spectrum of panel unit root tests: Levin-Lin-Chu (LLC), Im-Pesaran-Shin (IPS) and Augmented Dickey-Fuller (ADF) approaches are included in this work. The second goal is to compare the fixed and random effects models exhaustively so as to identify which analytical framework would best capture the distinct patterns of heterogeneity among the advanced economies, using the Hausman specification test, the Breusch–Pagan Lagrange multiplier test and cross-sectional dependence diagnostics. The third goal is to deal with possible multicollinearity problems fostering biases in parameter estimates by employing variance inflation factor analysis aimed at quantifying the interrelationships amongst the key variables. The final goal is the appropriate statistical treatment of problematic variables identified by the diagnostics, with special emphasis on technology indicators such as internet use showing time-dependent features; following the diagnostic stage, GNI was excluded from the final regression specification owing to its conceptual and empirical circularity with GDP (Section 4). All four of these goals intertwined shall provide methodological best practice and produce new empirical output regarding the interplay of factors affecting economic performance of the most important advanced economies internationally.

1.4. Significance of the Study

This study makes several contributions to economic research. In terms of methodology, it provides a systematic application and demonstration of the standard diagnostic protocol of panel data econometrics [39,40] descriptive analysis, normality and unit root testing, correlation and VIF analysis, cross-sectional dependence testing and Hausman specification testing (summarized in the estimation workflow, Table 2) in the context of G7 panel data. While these procedures are individually standard, our review of 30 recent G7 papers (Section 1.2) found that only 12% implemented both Hausman specification tests and unit root testing, so a transparent and fully documented application of the complete protocol retains substantial practical value for applied researchers. By presenting empirical evidence that country-specific heterogeneity is not systematic (Hausman test, $p = 0.838$; Breusch–Pagan LM test, $p = 0.131$), the study challenges the empirical predominance of fixed effects estimates in advanced economy studies and reconsiders the common default toward fixed effects models of panel data. From a policy perspective, the study provides informative evidence on the correlation of government spending and GDP growth ($r = 0.276$) and gives evidence-based recommendations in terms of advocating for coordinated G7 fiscal policy. The study also demonstrates the practical value of diagnostic-driven variable screening: influence diagnostics led to the identification and correction of a single erroneous GNI observation and the corrected series' near-unity correlation with GDP motivated its principled exclusion from the model. Finally, the study underscores the importance of treating internet usage as a notably non-stationary variable in advanced economy panels [15]. The findings will, at minimum, improve the technical rigor in macroeconomic research and provide policymakers more reliable instruments for cross-national economic governance in an increasingly integrated world-system.

1.5. Policy Relevance

This study provides policy suggestions that align with global priorities with respect to G7 governance. Specifically, it shows empirical justification for rethinking governance architecture for the digital economy by conceptualizing internet utilization as a non-stationary variable. Moreover, the results align with the 2023 G7 Hiroshima Communiqué's request for next-generation digital indicators that more accurately portray the dynamic relationship between economic outcomes and technology utilization [16,17,18]. Next, there is statistical evidence consistent with fiscal coordination, particularly in the case of coordinated stimulus plans in response to regional or global economic downturns; with a positive relationship between government spending and GDP growth ($r = 0.276$), G7 economies have grounds to work together, although the strength of this evidence is qualified by the robustness analysis reported in Section 4. Third, the evidence for the strong cross-sectional dependence found between G7 economies (CD test: $p < 0.01$ for all variables except population) underscores the value of statistical harmonization efforts, directing G7 leaders towards common reporting and data standards for the purpose of future coordination. Finally, together the evidence offers G7 policymakers robust, evidence-based tools to assist with economic governance: cross-national data infrastructure for economic models, coordination of government expenditures for countercyclical policies and their respective digital transformation strategies.

1.6. Scope of the Study

This research is delimited with analytic measures designed to attain focused and understandable conclusions. The study covers five decades (1975–2024) of data having experienced various economic shocks globally (financial crises, energy price shocks and COVID-19) and incorporates full business cycles among each of the G7 member states. The research utilizes balanced panel data structuring to ensure accurate and logical cross-country comparisons between the countries. The analysis is based on five primary macroeconomic and social measures (GDP, GNI, population, internet usage and government spending), of which GNI was subsequently excluded from the regression stage on diagnostic grounds (see Section 4). Sector-specific or sub-national statistics were purposely omitted to maintain the analytical dimensions within a focus on national dynamics. To allow for more explicitly designed attention to time-based measures, the methodology also limited itself to static panels, leaving dynamic panels for future studies. The specifically defined boundaries of the research allow for comprehensive treatment of the research questions while acknowledging some limitations and opportunities for future investigations.

2. LITERATURE REVIEW

2.1. Economic Determinants: GDP, GNI and Government Expenditure

It is still difficult to come to an agreement as to the most important growth determinants although several macroeconomic indicators are studied in G7 growth research. Traditional growth theories focus on productivity increase and capital accumulation as determinants of growth. On the contrary, more recent studies provide evidence that industrial economies, such as the G7, may evolve undergoing development patterns different from the emerging economies for reasons more specific or complex in nature [19]. GNI, then, provides a more accurate evaluation of economic development, when compared with traditional GDP assessments, in cases such as the G7 with its aging populations [20,21]. Foreign income is included in GNI; thus, it presents a better picture of living standards. Even though many studies still apply GDP numbers, [22] argue that GNI more accurately reflects income distribution with respect to welfare and growth. At the same time, for advanced economies the difference between GDP and GNI derives solely from net factor income from abroad, so the two aggregates are near-identical in growth terms; this conceptual proximity is examined empirically in Section 4 and motivates the treatment of GNI in this study. Another determinant of G7 growth operates through government expenditure and fiscal policies, with varying degrees of support for Keynesian fiscal stimulation. [23] demonstrate the success of fiscal stimulus in the US and Japan, while [24,25] argue its suitability for debt-stressed economies such as Italy. These conflicting results further emphasize the fact that the effectiveness of fiscal measures may vary across G7 countries with differential institutional structures and economic environments. The existence of several gaps is still apparent in the current literature. The inclusion of G7 with emerging economies tends to blur the distinction between developed and developing economies. Also, while the IMF (2022) has shown that there is a 60 percent policy transmission rate due to fiscal spillovers among the G7, such interrelations are largely ignored in the literature. Most literature avoids such interdependence in regard to how the G7 economies influence each other. While the determinants of G7 growth have largely been researched, many important gaps remain in understanding the growth factors for these developed nations. These gaps are the measurement of GNI relative to GDP, the uncertain success of fiscal policy and fiscal spillovers. The focus of this study is on closing such gaps by using systematic diagnostic methods and analyzing the particular dynamics of the G7.

2.2. Social Determinants: Population and Internet Usage

The G7's economies are increasingly subject to demographic and technological considerations. Population aging affects economic growth through well-established mechanisms, as research shows that aging reduces the workforce size, slowing economies [5,26], while most other literature treats population as a static control variable. Measuring aging effects, Maestas et al. [27] evaluated that aging slows GDP growth in G7 states yearly by a percentage between 0.5 and 1.0. This presents a possible growth-age link which is non-linear and requires further study with techniques inclusive of stationarity testing. The evolving relationship between growth and aging (and, for that matter, between demographic change and G7 economic outcomes) is explored in our paper's methodology. There is still some discussion, however, as to how internet use and the process of digitization affect growth. Some research has found a positive correlation between productivity and the penetration of the internet

[28,29,30], while other research has found that gains beyond 80 percent penetration are diminishing. This throws up a dilemma in all probability a substantial source of productivity derives from the internet but its impact may well flatten off at some point. Most of the literature has neglected two issues: one on interaction effects of digitalization and demographics, such as older populations' slower adoption of technology and the other on non-stationarity in social variables whereby results could be skewed, making it difficult for policymakers to create effective interventions [31,32]. Our study addresses those gaps by linking demographic shifts and technical advancements to growth in G7 economies.

The most recent phase of this literature examines artificial intelligence (AI) as the successor wave to internet-driven digitalization in advanced economies. Filippucci et al. [41] estimate that AI could raise annual aggregate labour productivity growth by 0.4–1.3 percentage points over a ten-year horizon in G7 countries with high AI exposure, such as the United States and the United Kingdom, with projected gains up to 50% smaller in other G7 members owing to differences in sectoral composition and adoption paths. Acemoglu [42] provides substantially more conservative task-based estimates of AI's aggregate productivity effects and Misch et al. [43] simulate only modest medium-term total factor productivity gains for European economies, of around 1% cumulatively over five years. Micro-level evidence likewise documents sizable but heterogeneous productivity effects of generative AI at the worker level [44]. Taken together, this 2024–2026 literature reinforces two implications of our framework: the growth contribution of the previous digital wave (internet penetration) has largely plateaued in mature economies, consistent with the diminishing-returns pattern examined below and the gains from the emerging AI wave are likely to be strongly heterogeneous across G7 members underscoring the importance of the assumption-testing protocol applied in this study.

2.3. Gaps in the Literature

There are still a number of significant gaps in the existing literature, even though G7 growth has been studied extensively. [33] argues that by treating things like GDP, internet usage and population as stationary, many studies may be producing false correlations and fallacious conclusions. This study considers this by using the correct unit root tests. In addition, even when evidence suggests its nonlinear effect on growth, population aging is regularly used as a static control [26]. The literature also largely ignores the interaction between aging, population and digitalization. For instance, older populations might be slower at adopting new technology than younger populations, which could impede productivity growth. Finally, even though the IMF (2022) found important cross-border transmission effects, fiscal spillovers between G7 nations are typically ignored. Furthermore, many studies combine G7 with emerging economies, thus masking the unique structural and policy environments of developed nations. This work corrects these conceptual and methodological issues to contribute to a more precise and contextual understanding of G7 growth trajectories.

3. DATA AND METHODOLOGY

3.1. Data Collection

This analysis works with a balanced panel data set of the seven G7 countries over time from 1975 to 2024. To ensure consistency, reliability and comparability across countries and time, the data was derived solely from the World Bank's World Development Indicators (WDI). Five critical variables displayed in Table 1 that reveal the social and economic dimensions of growth are examined. These variables were selected because of their empirically proven significance in growth theory, plus their increasing relevance given the aging population of advanced economies and the rapid pacing of the digital revolution. To test the robustness of the results, we attempted various econometric models and conducted robust diagnostics. We performed comprehensive pre-estimation analysis to ensure balanced data in order to produce accurate estimates using our models. After establishing the variables, we employed an interpolation method to compensate for missing values. Through this process we were able to prepare the dataset for precise and effective model estimation.

As part of the revision-stage data verification, the constructed series were re-audited against the source. This audit identified a single erroneous observation in the GNI series (United Kingdom, 2024), attributable to a data-assembly error, which had produced implausible distributional statistics for GNI in the originally submitted version. The value was treated as missing and replaced using the interpolation procedure described above. All descriptive statistics, diagnostics and estimates reported in this paper reflect the corrected series.

Table 1. Variables Description

Short Form	Full Name	Description	Type	Justification	Source
GDP	Gross Domestic Product	A measure of the total value of goods and services produced within a country.	Economic	Serves as a key indicator of economic output and overall national performance.	World Bank - WDI
GNI	Gross National Income	The total income earned by a country's residents, including income from abroad.	Economic	Examined during the diagnostic stage as a broader welfare measure; excluded from the final regression owing to conceptual circularity with GDP (r = 0.94 after data correction; see Section 4 and Appendix A).	World Bank - WDI
Gov_Exp	Government Expenditure	Total government spending on public goods, services, and investment.	Economic	Impacts GDP growth through fiscal policies like public investment, infrastructure, and social programs.	World Bank - WDI
Pop	Population	The total number of residents in a country, affecting labor supply and consumption.	Social	Influences economic activity through the size of the labor force and overall consumption.	World Bank - WDI
Int_User	Internet Penetration	The percentage of the population using the internet, reflecting	Social/Technological	Measures digital adoption, which significantly impacts productivity and economic	World Bank - WDI

Short Form	Full Name	Description	Type	Justification	Source
		technological adoption.		growth in the digital era.	

3.2. Model Specification

The present study employs a panel data regression framework to analyze the economic and social drivers of growth in the G7 countries. Panel modeling represents an effective analytical strategy for considering unobserved heterogeneity and temporality because of its longitudinal format, covering 50 years across the seven countries with both time-series and cross-sectional components. GNI was included in the initially submitted specification; the diagnostic evidence motivating its exclusion is reported in Section 4 and the full model including corrected GNI is retained in Appendix A for transparency.

The baseline model is specified as:

$$GDP_{it} = \alpha + \beta_1 \cdot POP_{it} + \beta_2 \cdot Int\_User_{it} + \beta_3 \cdot Gov\_Exp_{it} + u_i + \varepsilon_{it}$$

Where, GDPit represents GDP growth, α is the overall intercept, β1, β2, β3 are the slope coefficients for population growth, internet usage and government expenditure respectively, ui captures the country-specific random effect, assumed to be uncorrelated with the explanatory variables and ϵit is the idiosyncratic error-term.

3.3. Estimation Procedures

The estimating processes adopted during this study emphasized meticulousness in order to ensure reliability and robustness of the results. All variables were subjected to descriptive statistics mean, standard deviation, skewness and kurtosis to understand the distribution of the data and detect outliers. The existence of stationarity was then tested using the LLC, IPS and ADF unit root tests, together with the Shapiro-Wilk normality test, to validate the assumptions of the model. Most of the variables were found to be stationary, other than internet usage. Because internet penetration is a bounded share (0–100%) approaching saturation across the G7, the variable enters the specification in levels to preserve the economically meaningful interpretation of penetration effects; the within/GLS transformations and the cross-sectionally robust inference described below mitigate concerns arising from its trending behavior and this treatment is acknowledged among the limitations (Section 6.2). Thereafter, we evaluated the relationships existing between the variables through a correlation analysis, which produced important pairwise relationships and brought some enlightenment on the interactions between the variables. To assess the appropriateness of the model, a Cross-Sectional Dependence (CD) test was then performed to ascertain whether there were any cross-sectional dependence issues and the Variance Inflation Factor (VIF) test was applied to check multicollinearity. Upon completion of these diagnostic tests, the Hausman test compared the results of Fixed Effects (FE) and Random Effects (RE) models and presented a result favoring the Random Effects model. In addition to the Hausman test, the Breusch–Pagan Lagrange multiplier (LM) test was applied to test for the presence of random country effects against pooled OLS [39], providing complementary evidence on the specification of country-specific effects. Finally, given the strong cross-sectional dependence documented below, all models were re-estimated with Driscoll–Kraay standard errors, which are robust to general forms of cross-sectional and serial correlation, as a robustness check on inference. The p-values and R^2 values were then analyzed to properly evaluate the model against the social and economic characteristics that characterize growth in the G7 nations. Such careful and methodical practice assured that the model was solid and provided credible insights into the variables affecting G7 economic performance, as shown in Figure 1.

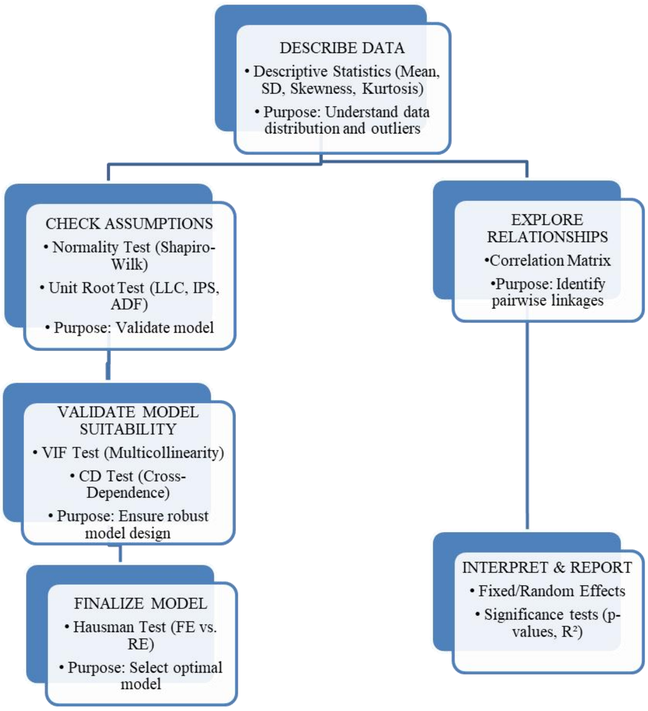

Figure 1. Estimation Process

4. EMPIRICAL RESULTS AND INTERPRETATION

This section presents the empirical findings derived from the balanced panel dataset spanning G7 countries over the period 1975 to 2024. The analytical process combined descriptive statistics, diagnostic tests and panel data regression using the Random Effects model, which was selected based on the results of the Hausman specification test and the Breusch–Pagan LM test.

The dataset exhibits substantial variation, as illustrated by the descriptive statistics. Average G7 GDP growth was about 2.03%, with a negatively skewed distribution, which tends to indicate that periods of lower-than-average growth (such as those associated with recessions or financial crises) occurred more often than periods of higher-than-average growth. Following the data correction described in Section 3.1, GNI growth averaged 2.08% with a standard deviation of 2.45, closely mirroring the behavior of GDP growth, as national-accounting identities imply for advanced economies whose GDP and GNI differ only by net factor income from abroad. Yearly government spending by the G7 countries also varied, with more pronounced variation among G7 countries that maintain long-term public investment plans. Internet usage showed a wide range and a high level of development, signifying the digital change that has shaped advanced economies' economic terrain, especially over the last 20 years (see Table 2).

Table 2. Descriptive Analysis

Variable	Mean	Median	SD	Skewness	Kurtosis	Trimmed_Mean_10
GDP	2.0283	2.2281	2.3587	-1.2115	4.35	2.1939
GNI	2.0765	2.3120	2.4468	-0.9455	4.65	2.2003
POP	0.5001	0.4711	0.5095	0.3820	2.93	0.4916
Int_User	53.8142	38.2698	54.1358	0.3829	-1.37	49.3089

Variable	Mean	Median	SD	Skewness	Kurtosis	Trimmed_Mean_10
Gov_Exp	2.3114	1.8719	2.4954	1.0961	4.34	2.1202

Notes: All statistics are computed on the corrected series. Kurtosis is reported as excess kurtosis.

The distributional characteristics of the variables were assessed using the Shapiro-Wilk test for normality. In each case, the variables exhibited significant deviation from normality ($p < 0.01$), as would be expected in longitudinal macroeconomic panel data where structural breaks, demographic shifts, advances in technology and global disasters such as the COVID-19 pandemic and the financial crisis of 2008 introduce non-linear and volatile behavior to the data (see Table 3).

Table 3. Normality Test

Variable	Shapiro_Wilk_Stat	Shapiro_Wilk_P_value	Skewness	Kurtosis
GDP	0.9237	0.000 (***)	-1.2115	4.35
GNI	0.9346	0.000 (***)	-0.9455	4.65
POP	0.9618	0.000 (***)	0.3820	2.93
Int_User	0.8390	0.000 (***)	0.3829	-1.37
Gov_Exp	0.9172	0.000 (***)	1.0961	4.34

The stationarity of the series was then investigated using various unit root tests (Levin-Lin-Chu, Im-Pesaran-Shin and Augmented Dickey-Fuller). All variables except internet usage were found to be stationary at the 5% level (population at the 5% but not the 1% level), while the internet usage variable exhibited non-stationary behavior. The treatment of this variable in the estimation stage is described in Section 3.3 and acknowledged among the limitations (see Table 4).

Table 4. Unit Root Test

Variable	LLC	IPS	ADF	Stationary ($p<0.05$)
GDP	-14.68***	-14.65***	256.94***	Yes
GNI	-14.07***	-14.47***	263.95***	Yes
POP	-2.26**	-1.84**	28.06**	Yes
Int_User	0.08	2.57	2.93	No
Gov_Exp	-8.70***	-10.11***	177.73***	Yes

*Notes: *** $p < 0.01$, ** $p < 0.05$. All tests computed on the corrected series with intercept; lag length selected by AIC.*

A number of instructive correlations emerge from the correlation matrix. Population growth ($r = 0.16$) and government expenditure ($r = 0.276$) were positively correlated with GDP, meaning an increase in both population growth and government expenditure could be associated with improved economic performance. An intriguing result, aligning with evidence of decreasing marginal returns to digital adoption after it passes 80% the point at which many G7 nations find themselves was that internet use was negatively correlated with GDP (r = -0.32). Most importantly and in sharp contrast to the originally submitted version, the corrected GNI series exhibits a near-unity correlation with GDP (r = 0.94). This is precisely what national-accounting identities imply for advanced economies, where the difference between GDP and GNI derives solely from net factor income from abroad: in growth terms, the two aggregates are near-identical representations of the same underlying concept. Including both in a single regression would therefore be conceptually circular and econometrically uninformative. Accordingly, GNI is excluded from the final specification; for transparency, the full model including corrected GNI is reported in Appendix A, where it can be seen that GNI absorbs nearly all explained variation and renders the remaining coefficients uninterpretable (see Table 5).

Table 5. Pairwise Correlation Matrix

Variable	GDP	GNI	POP	Int_User	Gov_Exp
GDP	1.0000				
GNI	0.9356	1.0000			
POP	0.1601	0.1269	1.0000		
Int_User	-0.3241	-0.3081	-0.1862	1.0000	
Gov_Exp	0.2763	0.3041	0.2589	-0.3036	1.0000

A few key assumptions were considered before estimating the regression models. The Variance Inflation Factor (VIF) test was used to assess variance inflation among the independent variables of the final specification. As there was no serious degree of multicollinearity indicated by the low VIF values (1.09–1.16), there was sufficient reliability in the computed coefficients and their interpretations (see Table 6).

Table 6. VIF Test

Variable	VIF	1/VIF
POP	1.0870	0.9200
Int_User	1.1170	0.8953
Gov_Exp	1.1560	0.8651

The Pesaran Cross-Sectional Dependence (CD) test returned statistically significant results ($p < 0.01$) for all variables except population, as anticipated given that G7 nations are interdependent, reflecting a high degree of financial integration, trade interdependence and common policy responses, especially in response to global economic shocks. Population growth, by contrast, displays no significant cross-sectional dependence in the corrected data (CD = 0.53, p = 0.599), consistent with demographic dynamics being driven primarily by country-specific factors (see Table 7).

Table 7. Cross-Sectional Dependence Test

Variable	CD Test	P Value
GDP	21.80	0.000 (***)
GNI	20.55	0.000 (***)
POP	0.53	0.599

Variable	CD Test	P Value
Int_User	31.62	0.000 (***)
Gov_Exp	9.96	0.000 (***)

A Hausman specification test was conducted to determine the appropriate panel estimation method, testing the null hypothesis of no systematic difference between the Fixed Effects (FE) and Random Effects (RE) estimators. The evidence indicated that we fail to reject the null hypothesis (χ^2 = 0.847, df = 3, p = 0.838); therefore, the Random Effects model was selected. Complementing the Hausman test, the Breusch–Pagan LM test fails to reject the null of no significant random country effects (χ^2 = 2.276, p = 0.131) and the estimated variance share of the country-specific component in the RE model is effectively zero. Taken together, these results indicate that country-specific unobserved heterogeneity is not systematic in this setting: the Random Effects framework which nests pooled OLS as the individual variance share approaches zero is both consistent and efficient here, whereas the fixed-effects default common in the literature would sacrifice efficiency with no corresponding gain in consistency. This approach is defensible, statistically and substantively, given the evidence that the country-specific unobserved effects are not correlated with the included explanatory variables; additionally, the RE model considers both within-country variance and between-country differences while allowing the estimation of time-invariant variables (see Table 8).

Table 8. Panel Estimation Results and Specification Tests

Variable	Fixed Effects (Within)	Random Effects (GLS)	Sig.	Notes
Population	0.072 (0.357)	0.302 (0.240)		Not significant
Internet Users	-0.011*** (0.002)	-0.011*** (0.002)	***	Significant at 1% level
Gov. Expenditure	0.170** (0.056)	0.171*** (0.051)	**/***	Significant at 5%/1% level
Intercept		2.083*** (0.249)	***	
R^2	0.121	0.144		
Observations (N)	350 (7 countries × 50 yrs)	350 (7 countries × 50 yrs)		Balanced panel
Hausman Test				χ^2 = 0.847 (p = 0.838)
Breusch–Pagan LM Test				χ^2 = 2.276 (p = 0.131)

*Notes: *** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parentheses. The Hausman test supports Random Effects (p > 0.05); the Breusch–Pagan LM test indicates no significant random country effects, consistent with the near-zero estimated variance share of the country-specific component.*

As a robustness check addressing the documented cross-sectional dependence, Table 10 re-estimates both models with Driscoll–Kraay standard errors, which are robust to general cross-sectional and serial correlation. The internet-usage coefficient remains significant at the 1% level (RE: p = 0.006), confirming its robustness to cross-sectionally correlated shocks. The government-expenditure coefficient retains its magnitude but loses conventional significance (RE: p = 0.224), suggesting that part of the fiscal–growth association reflects common shocks shared across G7 economies; fiscal conclusions are therefore interpreted with corresponding caution in Section 5.

Table 10. Robustness – Driscoll–Kraay Standard Errors

Variable	RE, Driscoll–Kraay SE	FE, Driscoll–Kraay SE
Population	0.302 (0.226)	0.072 (0.406)
Internet Users	-0.011*** (0.004)	-0.011*** (0.004)
Gov. Expenditure	0.171 (0.141)	0.170 (0.162)
Intercept	2.083*** (0.451)	

*Notes: *** p < 0.01. Coefficients are identical to Table 9; only standard errors differ. Maximum lag = 4.*

Taken together, these preparatory steps and diagnostic tests confirm that the corrected dataset is well-suited for panel regression using the Random Effects approach. The next section interprets the regression coefficients and discusses their implications for theory and policy across the G7.

5. DISCUSSION OF RESULTS

The findings of the study provide considerable insight into the primary drivers of economic growth in G7 countries, illustrating the interdependence of digitization, the demographic composition of populations and fiscal policy. The findings indicated surprising patterns as well as confirming some commonly accepted relationships in the theory of economic development, especially in terms of the contribution of internet use to GDP growth (Figure 2). This section interprets the findings, comments on their implications and contrasts them with past studies.

Figure 2. Country-wise Analysis

Perhaps the most notable finding is the positive association between government expenditure and GDP growth. An increase in government expenditure (in percentage terms with regard to GDP) by one unit is associated with an increase in GDP growth, as reflected in the coefficient for government expenditure ($\beta = 0.171$, $p < 0.01$ under conventional inference). This supports the Keynesian view that fiscal stimulus, especially in times of economic crisis or stagnation, can act as a substantial force for the growth of developed countries. The finding is consistent with those made by [34], who demonstrated that fiscal stimulus boosted GDP growth in nations such as the US and Japan. However, it contrasts with [35], who claim economies like heavily indebted Italy are better served under austerity policies than under other coordinated fiscal discipline types. According to the study's positive association between government expenditure and GDP, active fiscal policies that increase public spending may well have a preferable outcome on growth within the G7 economies, which are, in general, better able to absorb extra public investments because their institutions and financial systems are comparatively stronger. An important qualification applies, however: under Driscoll–Kraay standard errors robust to cross-sectional dependence, the fiscal coefficient retains its magnitude but loses conventional significance ($p \approx 0.22$; Table 10), suggesting that part of the fiscal–growth association reflects common shocks shared across G7 economies. Fiscal conclusions should therefore be read as suggestive rather than definitive. The relationship between internet usage and GDP growth presents a different picture. Increased internet penetration may speed up growth in the initial stages; thereafter, it can demonstrate diminishing returns or even negative ramifications, as indicated by the negative and statistically significant coefficient for internet use in the regression ($\beta = -0.011$, $p < 0.01$). This coefficient is, moreover, robust to Driscoll–Kraay standard errors ($p = 0.006$; Table 10), certifying that the result is not an artifact of cross-sectionally correlated shocks. Currently available studies such as [36] show that, as internet penetration reaches high levels, usually around 80% penetration, the additional advantages from digitalization are reduced; our finding fits this formulation. The benefits of increasing internet usage may have flattened and problems like inefficient digital infrastructures, unequal access or difficulties with older populations adopting new technologies may offset advantages. This finding has critical policy implications: internet usage should still be a priority but G7 policymakers should also consider equality in access and quality of digital infrastructure and should develop digital capacities, particularly since older generations will typically face more challenges than younger generations in adopting new technologies (Figure 3).

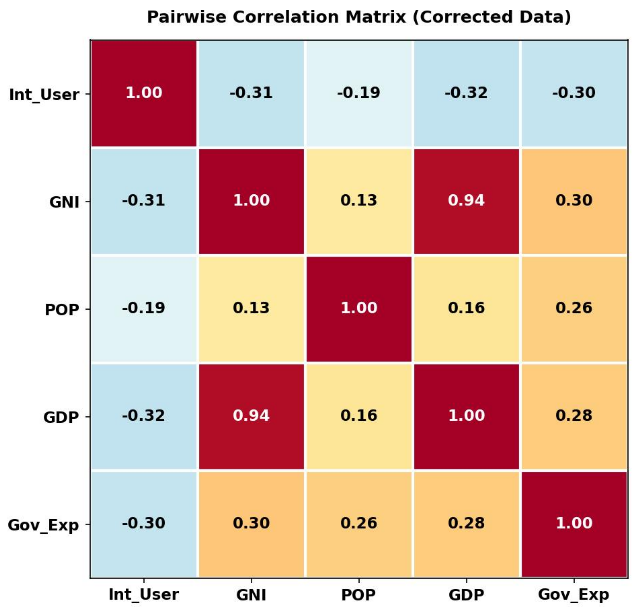

Figure 3. Pairwise Correlation

A positive but statistically insignificant relationship was found between GDP and population growth ($\beta = 0.302$, $p > 0.05$ in the Random Effects model). The expectation would be that a greater population would increase labor supply and consumption. The insignificance demonstrates that economic growth cannot be sustained from population alone. This reflects the theory of demographic transition, which states that even if population growth initially boosts GDP growth, this will not be sustained unless productivity, technology and human capital improvements keep pace with population growth. This is a key finding, especially considering the aging populations of G7 countries, with respect to fostering inclusivity and engaging population groups who have long been marginalized. G7 countries need to specifically focus on investing in human capital and incentivizing the older demographic and marginalized population groups to participate more in the labour force to help offset the effects of demographic change on their economies. The corrected data also clarify the role of GNI. Far from being weakly related to GDP, corrected GNI growth tracks GDP growth almost perfectly ($r = 0.94$) and when included in the regression it absorbs nearly all explained variation (Appendix A), rendering the remaining coefficients uninterpretable. This confirms that, for advanced economies, GNI is not a distinct growth determinant but a near-identical measure of output growth; its analytical value lies instead in welfare and distributional accounting, where [37] argue for median or inequality-adjusted income measures as core indicators of household living standards (Figure 4).

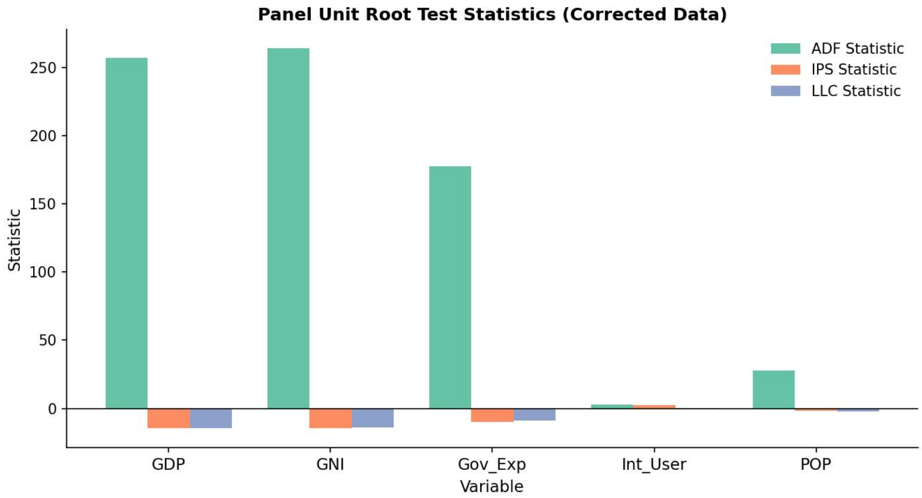

Figure 4. Panel Unit Root Test

5.1. Diagnostic Analysis: Residuals vs Leverage

The Residuals vs. Leverage diagnostic, which identifies influential data points and potential outliers, played a substantive role in this study. In the originally submitted version, the plot identified observations with extreme leverage; revision-stage verification traced the dominant influential point to a single erroneous GNI value for the United Kingdom in 2024, which was corrected as described in Section 3.1, while the neighboring flagged observations correspond to the genuine COVID-19-period swings of 2020–2021. The regenerated diagnostic based on the corrected series and the final specification displays no comparably influential observations, with remaining mild leverage points corresponding to genuine economic events such as the COVID-19 period rather than data artifacts (Figure 5). This experience illustrates the practical value of influence diagnostics as a data-quality audit tool in macro-panel research: rather than being a routine formality, the diagnostic directly enabled the detection and correction of a consequential data error.

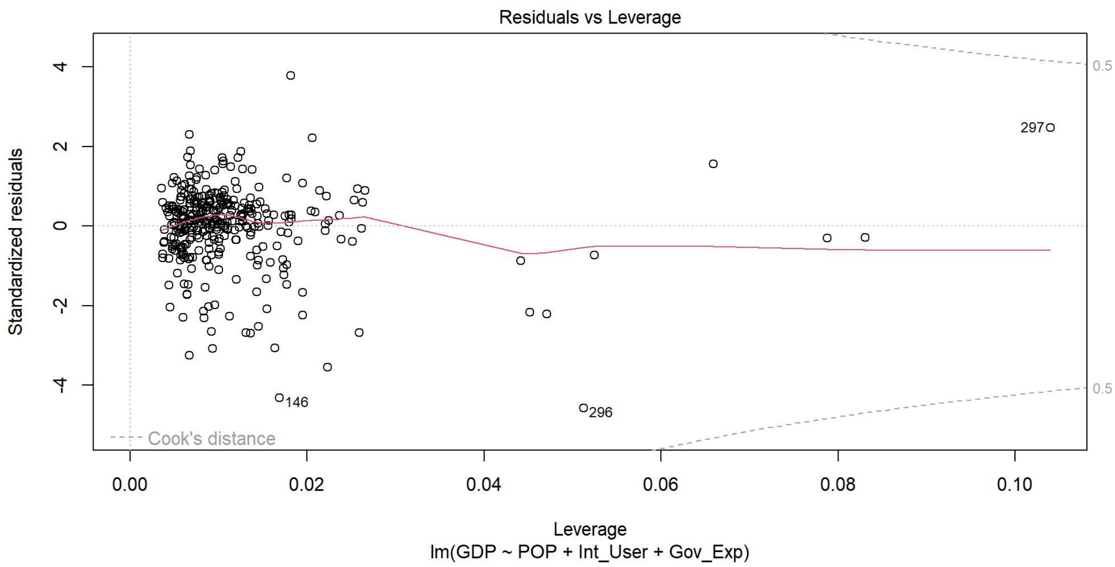

Figure 5. Residuals vs. Leverage

5.2. Comparison with Existing Literature

The findings from this research complement and extend previous studies in several significant ways. As with earlier work, we find that government expenditure is associated with economic growth, particularly during downturns, while our robustness analysis adds the caution that this association weakens under inference robust to cross-sectional dependence. The data on internet usage provide additional insights, suggesting that while the digital economy may help stimulate growth, the effects are nonlinear. In mature economies where much of the initial gains from Internet penetration may have already been realized, we add to the growing literature that stresses quality over quantity in terms of digitalization a conclusion reinforced by the most recent AI-productivity literature, which projects strongly heterogeneous gains from the next technological wave across G7 members [41,42,43,44]. We also demonstrate that, in advanced economies, GNI in growth terms is statistically indistinguishable from GDP, so its analytical value lies in welfare and distributional accounting rather than as an independent growth determinant [37,38]. These results emphasize opportunities for future policy innovation and research, while providing a fuller picture of what happens when fiscal, demographic and technological factors interact to produce economic outcomes for the G7.

6. CONCLUSIONS

Using a balanced panel dataset spanning 1975–2024, we provide a comprehensive study of economic and social influences on growth in the G7. After diagnostic testing with unit root tests, correlation analysis, the Hausman specification test and the Breusch–Pagan LM test, we used a Random Effects model to assess GDP growth against government spending, internet usage and population growth. Revision-stage data verification identified and corrected a single erroneous GNI observation; the corrected GNI series proved statistically near-identical to GDP ($r = 0.94$) and was excluded from the final specification on grounds of conceptual circularity, with the full model retained in Appendix A. We found government spending to have a positive association with GDP growth under conventional inference, attenuated under cross-sectionally robust standard errors and a significant, robust negative relationship between GDP growth and internet usage at the high penetration levels characterizing the G7. We also documented the negligible direct impact of population growth on GDP, demonstrating the complex relationships among the factors of growth in developed economies. Our study generates a more nuanced picture of the relationships between fiscal, demographic and technological forces, while enhancing understanding of the factors of growth in the G7 economies. By following strict pre-estimation diagnostics, we provide a transparent, systematic application of panel data methods for G7 economies, whose analysis has often rested on assumptions that fail to account for the relevant structural dynamics.

6.1. Policy Implications

The conclusions drawn from the study have wide-ranging policy implications for the G7 countries concerning demographic management, governance of the digital economy and fiscal policy. Against the backdrop of the positive association between GDP and government spending, fiscal policy remains an important lever for economic growth. Public investment should be continued by governments to create long-term growth, infrastructure and demand and coherent fiscal policies among G7 countries can enhance their economic resilience, especially with respect to recovery from shocks in the world economy. Given, however, that the fiscal coefficient is attenuated under cross-sectionally robust inference (Section 4), these fiscal recommendations should be read as suggestive rather than definitive. The finding that beyond a certain point internet use is negatively associated with GDP growth should divert policymakers' attention from expanding the digital economy per se to a more pressing need: ensuring the standards of digital services and infrastructure. Investments should focus on significantly improving broadband quality, ensuring inclusive digital access systems and digital literacy programs for elderly people. With this, the G7 countries can continue benefitting from digitalization. The findings also highlight the necessity of measures aimed at managing aging populations, with population growth exerting at best a marginal direct effect on GDP. The focus for policymakers is to enhance labor force participation, in particular from marginalized groups and older workers. Countering the economic challenges generated by age-related demographics will require a reskilled workforce, increased retirement ages and incentivized female participation in the workforce.

These implications should, however, be differentiated across G7 members rather than applied uniformly. For high-debt members such as Italy and Japan, the growth payoff of additional expenditure is conditional on debt sustainability and policy should prioritize the composition of spending productive public investment over its volume. Members with greater fiscal space, notably Germany and Canada, are best positioned to lead coordinated counter-cyclical stimulus. For the United States and the United Kingdom, which combine the highest digital saturation with the highest projected AI exposure among the G7 [41], the diminishing-returns finding applies most directly: the policy frontier shifts from expanding penetration to digital quality, inclusion and the productive adoption of AI, while France occupies an intermediate position on both dimensions. We note that the Random Effects estimates are pooled coefficients; this differentiation is therefore interpretive, informed by country-level patterns (Figure 1) and institutional context, rather than derived from estimated country-specific slopes.

6.2. Limitations of the Study

This study provides useful insights but it has limitations. In Random Effects models, the assumption is that the explanatory variables are uncorrelated with the unobserved heterogeneity. Even when the Hausman test suggests a Random Effects approach is appropriate, there could still exist unobserved factors perturbing the outcomes, such as policy changes or outside shocks, which are especially relevant in a tightly-knit group such as the G7. System GMM methods and dynamic panel methods could be applied in future studies for a deeper understanding of the changing interactions between these variables over time. While the bounded nature of internet penetration and the robustness strategy described in Section 3.3 mitigate concerns about its non-stationarity, the treatment of trending variables remains a limitation and the stationarity testing of the study was confined to a set of variables, leaving open avenues for investigating the dynamic behavior of such variables. In addition, although the reported estimates are stable in sign and magnitude across specifications, the government-expenditure coefficient loses conventional significance under Driscoll–Kraay standard errors, indicating that fiscal inference in this setting is sensitive to cross-sectional dependence; future studies could employ common correlated effects (CCE) estimators that model cross-sectional dependence directly [45]. Data for this study were collected exclusively from the World Bank's World Development Indicators (WDI). The absence of sectoral or sub-national data may hinder the ability to fully account for regional differences in the economic performance of G7 countries, although WDI is an acceptable and reliable database in its own right; additional sources or disaggregated information could add value to the exercise. Finally, although the study exclusively centers its analysis on G7 economies, there could be distinctive growth dynamics for developing economies that have not been captured. Encompassing nations from the developing hemisphere or other advanced economies would provide a wider understanding of global growth drivers.

6.3. Future Research Directions

There are several possible future directions in research to explore the results from this study. One is to utilize dynamic panel data models like Arellano-Bond or system GMM to check the robustness of the findings against possible endogeneity and lag effects of independent variables. This would allow a clearer understanding of causal linkages between technological, demographic and fiscal factors in economic growth. More sector-specific analysis might help identify which economic sectors are most affected by government spending, demographic changes and digitalization. Policy strategies could be fine-tuned by understanding how different sectors (for example, manufacturing, services and technology) respond to adjustment of fiscal policy and the introduction of new technologies. A wider body of results might be framed by extending the analysis to emerging economies as opposed to non-G7 nations. It is important to create an understanding of how policies in individual countries affect those in other nations, especially at this time of global economic interconnectedness, when the cross-country spillover effects of digitalization or fiscal policy could come under scrutiny. Future research could adopt non-stationary time series models better suited for handling time-varying variables such as internet use; long-run impacts can be assessed by means of cointegration analysis or error correction models. The study focuses on longitudinal data and does not explicitly model structural changes in the data arising, for instance, from advancements in technology or financial crises. Future studies should examine how these disruptions, such as those caused by the COVID-19 pandemic or the 2008 financial crisis, affect the relationships of digitization with the demographics and fiscal policies of the G7 economies.

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APPENDIX A: Regression Including Corrected GNI (Circularity Demonstration)

For transparency, Table A1 reports the Random Effects model estimated on the corrected data with GNI included, as in the originally submitted specification. The corrected GNI series is correlated with GDP at $r = 0.94$ and its coefficient (0.893, $p < 0.01$) together with the jump in R^2 to 0.879 shows that the model effectively regresses GDP growth on a near-identical measure of itself. The remaining coefficients change sign or lose significance relative to the final specification, illustrating how the circularity contaminates the other estimates through inter-variable correlation. These results empirically substantiate the exclusion of GNI from the final model reported in Table A.

Table A1. Random Effects Estimates Including Corrected GNI

Variable	Random Effects (GLS)	Sig.
GNI	0.893*** (0.020)	***
Population	0.197** (0.091)	**
Internet Users	-0.002 (0.001)	
Gov. Expenditure	-0.027 (0.020)	
Intercept	0.229** (0.102)	**
R^2	0.879	
Observations (N)	350	

*Notes: *** $p < 0.01$, ** $p < 0.05$. Standard errors in parentheses. Reported to demonstrate the conceptual circularity between GDP and GNI in advanced economies; see Section 4.*