

Determinants of Economic Growth: Evidence from High and Low-Income Country Panels

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Abstract. The global economic recovery is not balanced. There are significant differences in the growth rates of different countries. At the same time, the connections between various markets are becoming increasingly close. Businesses and policymakers need to assess which countries have greater growth potential. They also have to think about some risks like supply chain disruptions, geopolitical conflicts, and trade barriers. Our research considers the determinants of economic growth in countries at different stages of development. The research uses a panel regression model. The model incorporates dummy variables for high-income countries and interaction terms. This enables a comparison of the growth patterns between high-income economies and low-income economies. The research mainly focuses on five factors. They are investment, human capital, infrastructure, institutional quality and research and development expenditure. This study will compare the roles of these factors in different income countries. The research results can provide references for corporate investment. They also help governments formulate policies.

Keywords: Economic growth, Panel data, Income heterogeneity, R&D intensity, Infrastructure

1. Introduction

Our research is aimed at understanding the determinants of economic growth in countries at different levels of income. It also compares the growth patterns of low income and high-income countries. The world economic recovery is uneven at present. Different countries develop at different rates. International markets are becoming more interconnected. Supply chain disruptions, trade conflicts or political risks in one country can have a knock-on effect for other countries. In this situation, enterprises must be more careful in selecting investment locations [1]. They should not only think about short term profits. They also need to consider future growth potential, stability and long-term risk of the market [2]. For example, Apple has moved some of its manufacturing to India and Vietnam. This helps to disperse the production locations. Hence, it is important to identify factors that can drive future economic growth. The present study deals with few factors. The main

determinants are total factor productivity, physical capital, human capital, infrastructure and institutional quality.

Some studies have emphasized the importance of total factor productivity, physical capital and human capital. These factors may have different impacts on countries at different stages of development. However, many existing studies analyze different countries within the same model and assume that they have similar growth patterns. This approach may overlook the structural differences among countries.

High-income countries usually have more complete infrastructure and education systems. Therefore, the growth of these countries may be more dependent on technological innovation, research and development expenditures, and productivity improvement. The problems faced by low-income countries may be different. They may lack capital, educational resources and infrastructure. Therefore, increasing investment, improving education and building infrastructure may be even more important.

Our research uses the panel data from the Penn World Table. The research will compare the roles of various growth factors in high-income countries and low-income countries. It will determine which indicators can predict future economic growth. Our research results not only assist enterprises in identifying potential investment markets, but also help the government formulate more targeted growth policies.

2. What drives future economic growth? Evidence from cross-country data

2.1. Neoclassical roots to the institutional turn

Empirical studies of growth determinants have experienced a significant methodological development, which this review divides into three stages.

The first stage based its analysis on the empirical implications of the Solow-Swan framework. The cross-sectional analysis by Barro of 98 economies in 1960-1985 provided some early evidence of conditional convergence: once conditioned on steady-state variables, economies with lower initial output per capita had significantly higher subsequent growth rates [1]. His specification found four conditioning variables (initial income, schooling enrollment as a proxy to human capital formation, share of investment in GDP and government consumption) that together explained a large part of cross-country variation in living standards, leaving a large residual to technological differences. This model defined factor accumulation as the main conduit by which policy variables affected long-run results.

A second stage shifted focus to more institutional factors. Acemoglu, Johnson, and Robinson rejected the geographic arguments of the time by developing an instrumental-variables approach that relied on colonial-era settler mortality rates as a proxy for the quality of current institutions, which they considered the root cause of persistent income differences [2]. This identification strategy triggered a plethora of research testing the "institutional primacy" hypothesis. Easterly and Levine later presented evidence that institutional quality trumped both geographic endowments and trade openness in accounting for prosperity gaps [3]. However, this interpretation was strongly challenged: Glaeser et al. showed that human capital stocks preceded institutional changes, implying that the settler-mortality instrument may reflect human capital endowments rather than just institutional legacies [4]. This conundrum remains unresolved empirically, with recent research by Acemoglu, Gallego, and Robinson seeking to untangle the two effects using subnational regional data [5].

The third stage was the transition between explanatory and predictive goals. Sala-i-Martin used Bayesian model averaging with millions of cross-sectional specifications, finding that only a small number of variables survived out-of-sample testing- most variables that seemed significant in single-equation models failed to pass systematic tests of robustness [6]. This caution on methodology has been used to guide future forecasting activities. More recently, Coulombe and Tremblay have determined that five-year growth forecasts can only be reasonably accurate when parameter heterogeneity across income strata is explicitly modeled, recording that the same variables can have opposite signs of coefficients in frontier and developing economies [7]. Their result is what directly inspires our interest in income-specific growth processes.

2.2. Structural transformation debate: factor accumulation and TFP

Development accounting provides a theoretical framework that can be used to explain why growth processes may change in a systematic way with development stage. The classic decompositions of Caselli and Hsieh and Klenow broke cross-country income differences into the contribution of factor accumulation and total factor productivity (TFP) and produced an impressive result: in the poorest economies, physical and human capital accumulation accounts for most of the income gap compared to the United States; in advanced economies, TFP differentials prevail [8, 9]. This structural pattern has the implication that successful growth strategies must be stage contingent.

This prediction is supported by fragmentary empirical evidence. Kumar and Russell used non-parametric frontier methods to show that the closeness of an economy to the technological frontier is what defines whether capital deepening or efficiency improvements are the most prevalent growth channel [10]. This intuition was formalized by Aghion and Howitt in a Schumpeterian framework: innovation based on R&D creates growth mostly at the frontier, but technology adoption and capital accumulation take on more importance when applied to distant followers [11]. Vandenbussche, Aghion, and Meghir offered complementary data that skilled labor improves growth primarily in frontier economies, whereas unskilled labor has a greater impact in technologically remote countries [12].

These results do not have the unanimous approval. Easterly claimed that factor accumulation often does not lead to sustained growth due to productivity traps, investment without complementary institutional or policy changes has disappointing returns [13]. Likewise, Klenow and Rodriguez-Clare showed that TFP growth, as opposed to factor accumulation, explains most of the cross-country growth variation even in developing economies directly challenging the stage-specific perspective [14].

The new consensus is thus subtle: although the growth of TFP assumes a relatively higher importance as economies grow, the absolute contribution of factor accumulation is still high at all levels of income. The remaining debate is about policy priorities: whether developing economies should focus on getting the basics right (education, infrastructure, investment) or leap to the frontier of productivity through innovation policy and institutional reform.

2.3. Governance indicators: measurement, validity and predictive power

The institutional turn created a huge demand on quantifiable measures of governance, which resulted in several competing datasets. Early studies by Barro used composite political-rights indices of Freedom House [1]; Acemoglu, Johnson and Robinson developed their own historical measure using settler mortality [2]. Modern scholars have to face a wider menu: the International Country Risk Guide (ICRG, since 1984), Polity IV (since 1800), the Worldwide Governance Indicators

(WGI, since 1996), and the Varieties of Democracy project (V-Dem, since 1789). This proliferation presents analytical possibilities as well as methodological difficulties.

There is a methodological agreement on measurement error. Kraay and Tawara reported that the error of measurement in governance scores is large compared to actual variation, and that most year-to-year changes are noise unless they are greater than one standard deviation [15]. Their practical suggestion, which has become very popular, is that governance indicators need to be averaged over multi-year periods to enhance signal-to-noise ratios. This conclusion was supported by Langbein and Knack who showed that within-country differences in WGI rule-of-law measures can only predict investment growth when averaged over five-year periods; annual differences are virtually meaningless [16].

There is, however, a disagreement among scholars as to which institutional dimension has primary causal significance. Acemoglu and Johnson contrasted between property rights institutions (guarding against state expropriation of private agents) and contracting institutions (facilitating private transactions), and they provide evidence that only the former is strongly predictive of growth [17]. Rodrik further developed the argument that various bundles of institutions can be suitable at various stages of development and that democratic institutions can inhibit growth at low incomes but are necessary at higher levels [18]. This institutional sequencing perspective is controversial. Acemoglu, Naidu, Restrepo, and Robinson responded that inclusive political institutions increase growth at all income levels, and authoritarian growth episodes are inherently unsustainable [19].

Institutional indicators are especially controversial in their predictive ability to forecast growth over the medium term. Although there is a high correlation between institutions and long-run income levels, within-country differences often do not explain short- to medium-term growth accelerations [15, 16]. This prediction gap can be an indication of the slowness of institutional change, or it can be an indication that researchers have not yet discovered the particular institutional margins that react to policy on horizons relevant to forecasting.

2.4. Human capital: quantity, quality and the measurement challenge

The human capital treatment in growth regressions has been subject to a lot of refinement. The initial literature, after Barro, used school enrollment rates or average years of schooling as proxies [1]. This quantity method was criticized both theoretically and empirically. Nelson and Phelps have stressed that education influences growth by adoption of innovations and diffusion of technology, rather than as an input factor- suggesting that the quality and type of education is more important than years accrued [20-23].

Hanushek and Woessmann offered compelling empirical evidence to this view. They used harmonized international assessment data (TIMSS, PISA, PIRLS) to show that cognitive skills, as captured by student achievement, trump years of schooling in predicting both individual earnings and aggregate growth [24-26]. Their cross-country study indicates that an increase in test scores by one standard deviation would translate to about two more percentage points of annual growth. This revolution in quality has transformed the policy debate, moving away on school building and focusing on learning outcomes.

The measurement issues for empirical studies are daunting. Standardized test scores start only in 2000, and are available mostly for middle- and high-income countries, excluding much of the low-income sample that is of interest to development economists. Cohen and Sot and Barro and Lee have broadened schooling data sets, but quality-adjusted measures are still scarce for historical and poor economies [27, 28]. The literature has come up with hybrid solutions: employing enrollment rates for long panels (1960–present) where test scores are not available, and using test scores for

robustness checks in shorter more recent samples. This trade-off between coverage and accuracy remains unresolved and limits the comparability of quality-adjusted results.

Another discussion is the timing of human capital effects. The empirical evidence largely supports the idea that education is a predictor of long-run income levels, but tends to lack correlation with short- to medium-term growth accelerations. This temporal disconnect can be an actual lag structure-education has an impact on growth via slow demographic and occupational changes-or it can be a sign that conventional measures reflect schooling quantity and not economically relevant skills. Recent research by Heckman and Kautz on soft skills and Autor, Levy, and Murnane on task-specific human capital indicate that traditional measures fail to capture significant aspects of economically valuable capabilities [29, 30].

2.5. Research gaps and our contribution

This synthesis reveals four gaps which inspire our analysis.

First, even though theory suggests that growth mechanisms vary with the stage of development, no existing research systematically tests the hypothesis that the ranking of predictors is reversed between high- and low-income countries holding the forecast horizon and specification constant. Development accounting gives the intuition that factor accumulation is important for poor countries and TFP growth is important for rich countries, but this has not been formalized as a comparative forecasting exercise [8, 9]. We use an interaction-term specification to test directly whether the magnitudes and significance levels of coefficients differ across income groups.

Second, the literature has tested the hypothesis that institutional quality moderates the contemporaneous effects of real exchange rate undervaluation on growth, but not whether institutional quality enhances or weakens the predictive ability of other growth determinants, including investment, R&D, and infrastructure, to medium-term growth [19, 21]. We consider institutional indicators as slow-moving filters and test their moderating effect in our core forecasting equation.

Third, governance indicator selection in forecasting equations tends to be ad hoc. We compare WGI, ICRG and Polity IV systematically in the same forecasting framework, determining which of these measures is most predictive of medium-term growth when added to standard economic controls.

Fourth, the trade-off between measurement of human capital- quantity (enrollment) and quality (test scores) has not been systematically considered in forecasting. As Hanushek and Woessmann do, we take a two-pronged approach: secondary-school enrollment rates cover the entire 19602019 panel, whereas harmonized test scores are used as a robustness check on the 20002019 subsample [26]. This makes the forecast operational and recognizes the quality-quantity debate.

In filling these gaps, we provide a practitioner-friendly framework: know your horizon, know your income group, know which variable to watch--and know that these variables work differently in different places in the global income distribution.

3. Human capital and growth: interpretation and literature integration

The findings reveal an empirically negative and statistically significant association between human capital and GDP growth rate in both low-income countries and high-income countries. In particular, we find the coefficient estimates equaling to -0.0111366 and -0.00141063 for low-income countries and high-income countries, respectively; these are both significant at 1%. This outcome would seem

contradictory according to standard growth theory given that human capital should positively contribute to economic performance

Nevertheless, this surprising finding can be explained in light of a number of key measurement and structural factors.

First, the educational proxy used to measure human capital—either enrollment rates or years of schooling—captures quantity, not quality. As Nelson and Phelps (1966) pointed out, education promotes growth primarily through learning for technology adoption and innovation, and not just as a simple factor input [23]. The recent cross-country economic growth literature also clearly shows that cognitive skills and educational outcomes are more important than schooling years in explaining economic growth [24-26]. Hence, an increase in enrollment does not lead to a greater stock of human capital unless schooling is of high quality or it is suited for the labor market.

Second, the relationship between human capital and economic growth is characterized as inherently with lags. Education may affect productivity in a gradual manner through the accumulation of human capital, the reallocation of employment to different occupations, and the ability to innovate, all of which take time to develop. As a result, human capital is highly associated with the income level in the long run but not necessarily with growth over shorter timescales, and in turn, it is possible that this leads to the emergence of "temporal disconnect" [26]. Hence, the possible lag in human capital in short-run growth may bias the estimated parameter in this study toward the lower end.

Moreover, such a negative coefficient could not only signal structural inefficiency, but also hint at skill misallocation, especially present in low-income countries. An increase in the number of graduates without a proportionate rise in job opportunities or simultaneous structural transformation in the sector may generate a discrepancy between the skills obtained and the demand for them in the labor market as a whole, at least an underemployment of specialist. Such a situation is supported by some literature suggesting that standard human capital indicators do not always reflect economically relevant competencies, embracing among other things occupational specific knowledge, task specific and non-cognitive ones.

Finally, econometric problems might exist that explain the finding. Human capital can be strongly connected to other variables such as physical infrastructure, sound institutions, R&D spending. Overlapping, in this case, can hide the channel for this influence, thus creating the bias in such extent, that coefficients' estimates will even change the sign in regression equations.

These patterns do not imply that capital human has a negative influence on economic expansion, nor do they downplay its significance. Rather, they reveal issues related to proxies and the significance of quality, as well as time and structure. Further studies may look into direct or indirect proxies such as high skill and education level, the result of specific tests, the invented capital human used and measure productivity, among others, as well as dynamic panel models in an effort to include lag.

4. Methodology and results discussions

The formula is:

$$Growth_{it} = \alpha + \beta X_{it} + \delta HI_{it} + \gamma (HI_{it} \times X_{it}) + \varepsilon_{it}$$

Specifically, $Growth_{it}$ represents the GDP growth rate of country i at time t while X_{it} refers to explanatory variables. HI_{it} will be the high-income dummy, and ε_{it} in this formula will represents factors affecting GDP growth that is not included in the model. Finally, $HI_{it} \times X_{it}$ is the interactive term capturing differential effects across different income groups.

For low-income countries, where HI , the high-income dummy, is equal to 0, the model simplifies to $Growth_{it} = \alpha + \beta X_{it}$, implying that the coefficient β will simply be the effect of the explanatory variable on GDP growth for low-income countries. However, for high income countries with $HI = 1$, the model becomes $Growth_{it} = (\alpha + \delta) + (\beta + \gamma)X$, such that the effect of the explanatory variable on growth is the sum $(\beta + \gamma)$.

At first, Initial panel regression model was carried on Excel. It was used to organize the panel dataset, run regressions and extract coefficients. Approximate high-income effects were computed by summing the coefficients. While this approach provides useful intuition, it does not yield statistically precise inference for high income p-values. Specifically, calculating p-values requires the covariance term that was not provided in standard regression output from Excel, thus may leads to inaccurate approximation of p-value for explanatory variables relating to high income countries.

To address this limitation, the analysis and data table was later replicated in Stata, which provides tools for exact inference on linear combinations of coefficients. By using command Lincom, Stata provides with the associated p-value for each explanatory variables relating to high-income countries. This approach ensures that the statistical significance of each explanatory variables is evaluated accurately for high-income countries.

Results of the model were summarized in below:

Table 1. The coefficient and p-values of each explanatory variables on low-income countries' growth

Variable	LI Coefficient	LI P-value
Investment Share	-0.0008347	0.399
R&D Intensity	0.0081792	0.022
Institution Index	0.0006118	0.741
Infrastructure	0.0507601	0.033
Human Capital	-0.0111366	<0.001

According to Table 1, Investment share does not exhibit a statistically significant effect on GDP growth due to its high p-value 0.399 and small coefficient -0.0008347, suggesting that additional capital accumulation may not be associated with significant growth in these countries. In contrast, R&D intensity shows a positive and statistically significant relationship with GDP growth, indicating that innovation and technological improvement do correlates with GDP growth for low-income countries. Infrastructure has a positive but slightly less significant role than R&D intensity on correlating with economic growth, highlighting importance in transportation on enhancing productivity. Institutional quality, however, is the least significant factors with p-value 0.741.

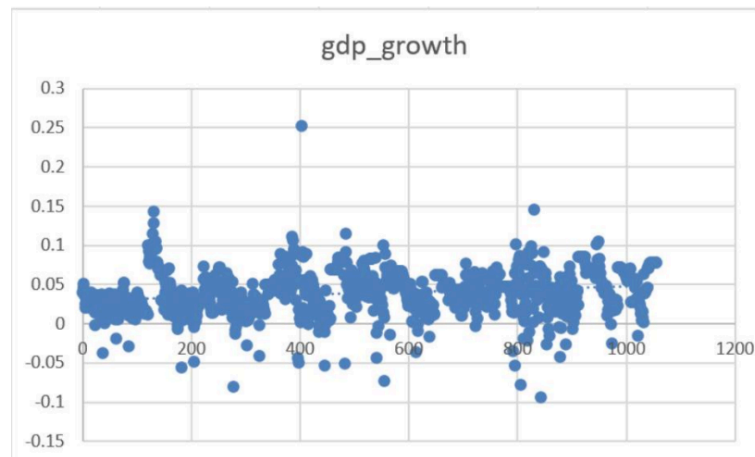


Figure 1. GDP growth vs. human capital for low-income countries

The relationship between human capital and economic growth in low-income countries in Table 1 is found to be significant and negative with number -0.0111366 , a result that appears counterintuitive given standard growth theory. However, close examination of the scatterplot in Figure 1 shows no clear positive linear relationship between growth and the distribution of Human capital index from different countries, suggesting that additional increase in human capital do not associates with higher short-term growth outcomes in low-income economies. This may be caused by several reasons. First, the measure of human capital, often based on years of schooling or enrollment rates, may not adequately capture the quality of education or the relevance of skills to economic productivity. As a result, higher measured human capital may not correspond to higher productivity. Second, benefits of human capital accumulation are typically realized over longer time horizons, while the growth measure used in this model captures shorter-term changes. Finally, limitations like multicollinearity where variables used may correlate to human capital, leading to difficulty of isolating the independent effect each variable and the estimation of negative relationship between human capital and GDP growth.

Table 2. The coefficient and p-values of each explanatory variables on high-income countries' growth

Variable	HI Coefficient	HI P-value
Investment Share	-0.0010861	0.549
R&D Intensity	-0.0037417	0.008
Institution Index	0.0033398	0.438
Infrastructure	0.0492126	0.280
Human Capital	-0.0141063	<0.001

For High-income countries, Investment share does not have a significant effect on GDP growth due to its p-value 0.549, demonstrating that capital accumulation may likely corresponds with diminishing marginal returns in advanced economies where capital stock is already relatively high. Similarly, Institutional quality is also a statistically insignificant factor, likely attributed to the limited variation in institutional frameworks among high-income countries, making its marginal impact difficult to identify empirically. Infrastructure does have positive association with high-income countries' growth; it also fails to be statistically significant as additional improvements in infrastructure investment provides little benefits for economies where infrastructure systems are

already well developed. In contrast, R&D intensity shows a statistically significant but negative relationship with GDP growth, possibly due to R&D investments cannot be immediately realized or may indicate diminishing returns to innovation at higher levels of technological development. Human capital is also found to have a negative and highly significant effect on growth in high-income countries. In this case, the result may drive by measurement limitations, multicollinearity with other variables or factors like skill saturation or delayed returns to education.

A comparison between low-income and high-income countries reveals some difference between the magnitude and significance of these explanatory variables. In low-income countries, R&D intensity and infrastructure are positively and statistically significant, while these variables in high income countries shows little significance or exhibit different relationships with growth. These findings show that technological adoption and improvements in basic capital are essential for economic growth in low-income countries while marginal impact of innovation may diminish or operate over longer time horizons in advanced economies where technological frontiers are already high. Investment share and Institutional quality do not show statistically significant effect in either group, while human capital appears statistically significant and negative effect on economic growth for both groups.

5. Conclusion

In conclusion, this study shows that the factors driving economic growth vary among countries with different income levels. This research uses panel data and interaction terms for analysis. It shows that the intensity of research and development and infrastructure are more important for the growth of low-income countries. In high-income countries, most traditional growth variables have a relatively weak impact and often do not have statistical significance. In both groups of countries, the negative correlation between human capital and growth is clearly not a simple result. This may reflect issues such as measurement limitations, the delay of educational returns, or the overlap with other variables.

These results are useful in real life. For global businesses and investors, these show that the size of the market or the recent growth of the country's gross domestic product isn't the only thing that affects where to invest. The deeper growth structure of each country is also important. Policymakers need to make sure that growth strategies fit with where a country is in its development. In economies with low incomes, it may be important to improve infrastructure. In economies with high incomes, it is very important to make improvements in efficiency, the quality of innovation, and long-term productivity.

This study also has some limitations. Firstly, human capital and institutional quality are difficult to measure accurately. For instance, the enrollment rate can only reflect the number of people receiving education, but it cannot directly indicate the quality of education. Secondly, the regression model used in this study is relatively simple. Economic growth is influenced by multiple factors and there may be time lags, nonlinear relationships, and endogeneity issues. Therefore, this model may not be able to explain all the complex situations.

Future research can use indicators such as learning outcomes and skill levels. Researchers can also adopt more appropriate measurement methods. Middle-income countries are also worthy of separate study. Their growth patterns may differ from those of high-income and low-income countries. Future research can also incorporate more variables. For example, digitalization, trade, political stability and environmental factors.

Overall, countries at different stages of development may rely on different growth drivers. Enterprises and policymakers need to take these differences into account. Our research results

cannot explain all situations. However, it can still provide some reference for investment choices and economic policies.

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