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From "Growth Priority" to "Comprehensive Development": A Logical Test of the Complementarity between GDP and HDI

-- An Empirical Study Based on Cross-Country Panel Data and Typical Patterns

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Abstract

The disconnect between global economic growth and human development has become more and more obvious, which shows that using only GDP as a measurement has big limitations. This study uses panel data from China, Costa Rica, and Equatorial Guinea during 2000–2023, trying to empirically test how GDP and HDI can complement each other. The results reveal an intrinsic complementarity and a long-term equilibrium relationship between the two. The conventional elasticity coefficient is subject to computational artifacts due to the influence of the base value. The institutional environment and stage of development respectively determine the efficiency of transformation and the causal direction between GDP and HDI. This paper identifies three typical development models and proposes policy recommendations from three perspectives—the evaluation system, differentiated strategies, and international cooperation—so as to provide references for comprehensive development across countries.

Keywords

GDP; Human Development Index (HDI); Complementarity; Transformation Efficiency; Development Mode.

1. Introduction

The synergistic advancement of economic growth and human development constitutes the core goal of comprehensive development across nations. However, a global decoupling between "growth" and "development" persists. The traditional practice of measuring development by the single indicator of GDP struggles to meet the demands of the high-quality development era, as countries worldwide are undergoing a profound paradigm shift from "economic growth scale" to "comprehensive human development" [3].

While GDP is indispensable for reflecting the overall scale of a national economy, it fails to capture non-market products, the underground economy, natural asset depletion, and other factors [5], thereby hindering a comprehensive assessment of a country's true development level.In contrast, the HDI builds a measurement system for development from three dimensions—health, education, and income—and it can effectively make up for the shortcomings of the GDP indicator [2].

Existing studies have either thought that GDP and HDI are opposed to each other, or they just used simple regressions, without paying attention to the problem of elasticity distortion caused by base effects [6]. Also, they didn't really do systematic analysis on how differences in institutional contexts and stages of development matter. To fill these gaps, this paper uses cross-country panel data to look at the long-run equilibrium and causal relationship between GDP and HDI, and tries to correct the traditional elasticity biases. Then it distills some typical

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development models, and provides empirical evidence for the construction of a comprehensive development evaluation system [4].

2. Research Design and Model Construction

2.1. Complementarity between GDP and HDI

The complementarity between GDP and HDI means that these two core indicators in development assessment can supplement and reinforce each other. On one hand, GDP provides the material foundation and financial guarantee for the improvement of HDI; on the other hand, HDI, through human capital accumulation and the enhancement of people's well-being, can also contribute to GDP in return. Also, how strong this complementarity is and how efficient the transformation can be are both influenced by things like the institutional environment, the stage of development, and policy orientation [1].

2.2. Failure of the Traditional Elasticity Coefficient and the Central Role of the Institutional Environment

The traditional "GDP–HDI elasticity" fails to consider the base effect. In countries where the HDI base is low, even a small absolute improvement in human development may look like a high growth rate just because of the base effect. This creates a kind of computational illusion that gives a "high elasticity coefficient," which cannot truly reflect the actual efficiency of transformation.

To solve this problem, this paper puts forward a core theoretical hypothesis: the institutional environment decides how efficiently GDP can be turned into HDI.[8] A good institutional environment can make sure that the benefits of economic growth are shared more equally, so it helps improve the transformation efficiency from GDP to HDI. On the other hand, in countries that don't have a strong institutional environment or are experiencing governance failure, there will be a disconnect between growth and development [10].

2.3. Typicality of Sample Selection

This paper picks China, Costa Rica, and Equatorial Guinea as sample cases. They stand for three different kinds of development models: the catch-up type, the high-welfare type, and the resource-dependent type. In the year 2000, their HDI starting points were at high, medium, and low levels respectively. Also, the institutional conditions in these three countries are quite different from each other.Complete panel data for the period 2000–2023, sourced from the World Bank and the UNDP, ensure the reliability of the empirical research.[6]

2.4. Econometric Model Specification

All variables are transformed using natural logarithms, where lngdp denotes the logarithm of GDP per capita and lnhdi denotes the logarithm of the HDI.

2.4.1. Panel Unit Root Test

$$\Delta y_{it} = \alpha_i + \rho y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + \varepsilon_{it} \tag{1}$$

2.4.2. Panel Cointegration Tes

$$\ln hdi_{it} = \alpha_i + \beta_i \ln gdp_{it} + \mu_{it} \tag{2}$$

2.4.3. Error Correction Model (ECM)

$$\Delta \ln hdi_{it} = \alpha_0 + \sum_{j=1}^{p} \alpha_j \Delta \ln hdi_{it-j} + \sum_{k=0}^{q} \beta_k \Delta \ln gdp_{it-k} + \gamma ECM_{it-1} + \varepsilon_{it} \tag{3}$$

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2.4.4. Granger Causality Test

$$\ln gdp_{it} = \alpha_2 + \sum_{j=1}^{p} \lambda_j \ln gdp_{it-j} + \sum_{k=1}^{p} \xi_k \ln hdi_{it-k} + \varepsilon_{2it} \tag{4}$$

$$\ln hdi_{it} = \alpha_1 + \sum_{j=1}^{p} \theta_j \ln hdi_{it-j} + \sum_{k=1}^{p} \psi_k \ln gdp_{it-k} + \varepsilon_{1it} \tag{5}$$

3. Empirical Results and Analysis

3.1. Descriptive Statistics and Elasticity Estimation

3.1.1. Descriptive Statistics

Table 1. Descriptive statistics of lngdp and lnhdi for the three countries

Country	Variable	Mean	Minimum	Maximum
China	lngdp	1.489	-0.368	2.563
	lnhdi	-0.342	-0.514	-0.227
Costa Rica	lngdp	2.1	1.338	2.83
	lnhdi	-0.248	-0.329	-0.183
Equatorial Guinea	lngdp	2.033	0.4	2.901
	lnhdi	-0.487	-0.677	-0.39

Costa Rica has the highest mean GDP per capita and HDI; China has the lowest mean GDP per capita, but its HDI is higher than that of Equatorial Guinea; Equatorial Guinea exhibits a high GDP growth rate yet the lowest HDI level, indicating a disconnect between growth and development.[7]

3.1.2. Elasticity Calculation

Table 2. Annual growth rates and GDP-HDI elasticities of the three countries

Country	capita indicator	2000	2010	2015	2023	average annual growth rate	elasticity
Equatorial Guinea	GDP per capita indicator	1490	13720	9070	6680	6.76%	0.155
	HDI	0.508	0.612	0.656	0.674	1.05%	
	GDP-HDI growth rate gap					-5.71%	
Costa Rica	GDP per capita indicator	3810	8270	11710	16940	6.32%	0.089
	HDI	0.722	0.776	0.803	0.833	0.56%	
	GDP-HDI growth rate gap					-5.76%	
China	GDP per capita indicator	969.2	4630	8180	12950	11.75%	0.106
	HDI	0.598	0.71	0.75	0.797	1.24%	
	GDP-HDI growth rate gap					-10.51%	

The elasticities of all three countries are less than 1.Equatorial Guinea's high elasticity is actually a kind of artifact caused by its low base; Costa Rica's low elasticity just shows the diminishing marginal improvements when the base is already high; China's medium elasticity fits well with the characteristics of its catch-up stage.

3.1.3. Revision of the Elasticity Coefficient

The traditional "GDP–HDI elasticity" fails to take into account some core factors like a country's development base and economic scale, so the elasticity cannot really reflect the actual

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transformation effect from economic growth to human development. To deal with this, this paper revises it through the following dimensions:

(1) Transformation Efficiency

Connotation: It shows how much HDI improvement can be driven by a unit increase in GDP.

(2) Development Base

Connotation: When we measure efficiency, we have to consider the starting point of development in different countries.

(3) Economic Scale

Connotation: This refers to the total incremental increase in the economy.

China, because it has extremely large economic scale growth, can make up for its lower transformation efficiency compared to Equatorial Guinea. Equatorial Guinea has the highest transformation efficiency value, but its economic scale growth is limited, so it cannot turn that high elasticity into real human development outcomes. Costa Rica shows steady economic scale growth, which forms a stable match with its low elasticity, and this provides sustained material support for quality improvement of HDI at a high base.

(4) Cumulative Outcomes

Connotation: This means the absolute level that is finally achieved after a certain period of development.

Costa Rica, starting from a high development base and with support from a robust economic scale, has managed to keep deepening its high level of human development. China, starting from a medium development base and driven by exceptionally high economic scale growth, has converted medium transformation efficiency into HDI improvement, thereby achieving optimal outcomes during its catch-up stage. Although Equatorial Guinea has the highest transformation efficiency value, the computational illusion and subsequent decline in economic scale prevent it from accumulating effective outcomes, confirming the ineffectiveness of its transformation mechanism.

Therefore, the final analysis should be based on transformation efficiency, constrained by the development base, supported by economic scale, and tested by cumulative outcomes, thereby forming a comprehensive judgment framework.

3.2. Econometric Test Results

To ensure the robustness of the results, this paper sequentially conducts correlation analysis, model specification tests, heteroskedasticity tests, autocorrelation tests, and robustness tests.

3.2.1. Model Specification Tests

(1) Correlation Analysis

Table 3. Variable Correlation Matrix

	lngdp	lnhdi
lngdp	1.0000	
lnhdi	0.4832	1.0000

(2) Hausman Model Selection Test

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Table 4. Results of fixed effects, random effects regressions and Hausman test

Variable	FE	RE
lngdp	0.0938***	0.0937***
	(-0.0071)	(-0.007)
_cons	-0.5351***	-0.5350***
	(-0.0142)	(-0.098)
N	72	72
R^2(Within)	0.7203	0.7203
F/Wald	175.15***	177.42***
Hausmanχ^2		0.00
p		0.9640

The chi-square statistic is 0.00, with a p-value of 0.9640, which is far greater than 0.05. Therefore, we fail to reject the null hypothesis and select the random effects model.

(3) Between-Group Heteroskedasticity Test

Table 5. Results of the between-group heteroskedasticity test

Variable	coefficient
lngdp	0.0938***
	(0.0071)
N	72
R^2(Within)	0.7203
F	175.15***
Wald chi-square test for heteroskedasticit^2	64170.52
P	0.0000
Conclusion	Significant heteroskedasticity exists

The chi-square value is 64,170.52, with a p-value less than 0.001, leading to the rejection of the null hypothesis of homoscedastic error variances, indicating a significant between-group heteroskedasticity problem in the model. To control for the effects of heteroskedasticity, robust standard errors are employed in all subsequent regressions to ensure the validity and reliability of the regression results.

Serial correlation test

Table 6. Results of Serial Correlation Test

Method of testing	F statistic	Degrees of freedom	P	Conclusion
Autocorrelation test	67.896	(1,2)	0.0144	There exists significant first-order serial correlation

The F statistic is 67.896, with a p-value of 0.0144, leading to the rejection of the no-autocorrelation hypothesis at the 5% significance level, indicating that the model exhibits first-order serial correlation.

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Robustness test

Table 7. Comparison of Baseline Regression and Robustness Test

Variable	Baseline regressio	Robustness test (winsorization)
lngdp	0.0937***	0.0938***
	(-0.007)	(-0.0081)
_cons	-0.5350***	-0.5351***
	(-0.0983)	(-0.0152)
N	72	72
R^2(Within)	0.7203	0.7203

After winsorization and employing regression with robust standard errors, the coefficient and significance level of lngdp did not change substantively, and the within-group R^2 also remained stable. This shows that the conclusions we got from this study have pretty strong robustness and reliability.

3.2.2. Unit root test

Table 8. Panel Unit Root Test Statistics

Variable	LLC statistic	P	Conclusion
lngdp	-0.2756	0.3914	Non-stationary
lnhdi	0.1895	0.5752	Non-stationary
dlngdp	-0.5426	0.2937	Non-stationary
dlnhdi	-1.7605	0.0392**	Stationary

Both lngdp and lnhdi are non-stationary, which means that these two variables show a long-term growth trend, and this is consistent with economic intuition. After we take the first difference, dlnhdi becomes stationary; but dlngdp is still non-stationary. This result actually comes from the fact that the three countries have different patterns of economic growth, and it also confirms that we really need to do country-specific tests instead of just pooling everything together.

3.2.3. Cointegration test

Table 9. Panel Cointegration Test Statistics

statistic	Statistical value	P	Conclusion
Modified Phillips-Perront	0.7821	0.2171	Insignificant
Phillips-Perront	-0.2244	0.4112	Insignificant
Augmented-Dickey-Fullert	-0.1136	0.4538	Insignificant

Table 10. Country-Specific Cointegration Tests

Country	ADF statistic	P	Conclusion
China	-2.361	0.153	Non-stationary
Costa Rica	-2.589	0.0954*	Stationary
Equatorial Guinea	0.056	0.9629	Non-stationary

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The fact that all three major statistics in the panel cointegration test are not significant actually reflects the heterogeneity of the development models among the three countries. The country-specific cointegration test results show a clear gradient: Costa Rica exhibits a cointegrating relationship at the 10% level, China is close to significance, and Equatorial Guinea shows no cointegrating relationship. The insignificance of the panel cointegration is essentially an econometric manifestation of the heterogeneity in the complementary relationships among the three countries

3.2.4. Granger causality tes

Table 11. Granger Causality Test Statistics for China

Null hypothesis	chi-square statistic	P	Conclusion
HDI is the Granger cause of GDP	12.003	0.002***	Yes
GDP is the Granger cause of HDI	2.5708	0.277	No

Table 12. Granger Causality Test Statistics for Costa Rica

Null hypothesis	chi-square statistic	P	Conclusion
HDI is the Granger cause of GDP	0.0384	0.981	No
GDP is the Granger cause of HDI	6.8661	0.036**	Yea

Table 13. Granger Causality Test Statistics for Equatorial Guinea

Null hypothesis	chi-square statistic	P	Conclusion
HDI is the Granger cause of GDP	2.1082	0.349	No
GDP is the Granger cause of HDI	10.969	0.004***	Yes

Table 14. Time Series Regressions for the Three Countries

Country	Variable	Coefficient	R^2
China	lngdp	0.0997*** (0.0024)	0.989
	_cons	-0.4907*** (0.0039)	
Costa Rica	lngdp	0.0926*** (0.0028)	0.9807
	_cons	-0.4426*** (0.006)	
Equatorial Guinea	lngdp	0.08*** (0.0211)	0.3955
	_cons	-0.6492*** (0.0453)	

China exhibits unidirectional Granger causality from HDI to GDP, with a pronounced feature of human capital-driven growth; Equatorial Guinea shows spurious causality from GDP to HDI, where growth has not been effectively translated into improvements in people's livelihoods; Costa Rica demonstrates unidirectional Granger causality from GDP to HDI, indicating that growth supports high-welfare development.

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3.2.5. Error Correction Model Test

Table 15. Statistical table of error correction model estimation results

Variable	Coefficient
dlngdp	0.0187*** (0.0043)
e_lag	-0.0901*** (-5.12)
_cons	0.0086*** (0.0008)
rho	0.744

The coefficient of the error correction term elagelag is -0.0901 and is significantly negative at the 1% level, indicating that when HDI deviates from its long-run equilibrium relationship with GDP, the system adjusts back toward equilibrium at a rate of 9.01% per year, thereby confirming the existence of an intrinsic long-run equilibrium relationship between the two.

4. Three Development Models

4.1. The Resource Curse and Absence of Redistributive Institutions in Equatorial Guinea

Equatorial Guinea is a typical case showing that the complementarity between GDP and HDI can break down. In this country, we see high GDP growth together with low levels of human development, and also a high elasticity coefficient existing alongside low developmental outcomes [3]. The main reason behind this is the double absence: both the resource curse and the lack of redistributive institutions. The economy depends too much on oil exports, which makes its structure very narrow and not inclusive enough. At the same time, there are no well-established fiscal distribution systems or public service systems, so the country ends up underinvesting in people's basic needs like education and healthcare. As a result, the benefits from economic growth cannot be effectively turned into human development, and the country gets stuck in a situation of "growth without development" [5].

4.2. Human Capital Transformation and Reconstruction of Development Dynamics in China

China is a good example of the catch-up type of complementarity model. In this case, the country achieved both a big leap forward in economic scale and a simultaneous improvement in HDI, while also completing a transition from GDP-driven HDI to HDI-driven GDP.[8] In the early stages, China relied on its fast economic growth to put more money into people's livelihoods, which helped raise the level of human development. Then, as the economic structure changed over time, human capital gradually became an inner driver of economic growth, forming a good cycle where growth and development help each other.

4.3. The High-Welfare Society and Sustainable Development in Costa Rica

Costa Rica represents the deepening type of complementarity model. It is characterized by the way high HDI levels and solid economic growth evolve together. This country entered the high human development stage quite early, so its focus of development shifted more toward improving quality[9]. The low elasticity coefficient here actually reflects the diminishing marginal returns in an objective way. Because Costa Rica has a well-established universal healthcare and education system, and its economic foundations are stable, it has achieved a

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sustainable kind of alignment between growth and welfare. This makes it a typical example of high-quality development in the mature stage [2].

5. Conclusions and Policy Implications

5.1. Research Conclusions

First, GDP and HDI have an intrinsic kind of complementarity and also a long-term equilibrium relationship, and there is a reverse correction mechanism working inside the system.

Second, the traditional "GDP–HDI elasticity" coefficient is actually affected by the baseline level of development, so it is not right to judge development quality just by comparing the coefficient to 1.

Third, the complementarity between GDP and HDI shows significant model heterogeneity, and the institutional environment is the core thing that decides how efficient the transformation is.

Fourth, the stage of development decides the causal direction and the interactive logic between GDP and HDI. In catch-up countries, we mainly see "HDI-driven GDP"; in high-welfare mature countries, we see "GDP-driven HDI"; but in resource-dependent countries that lack good institutions, there is no real causal relationship because the channel that should bring growth to development is blocked.

5.2. Policy Implications

First, we should give up the "GDP-only" way of thinking and build a comprehensive development measurement system that puts together GDP and HDI as complementary indicators. We should also include the size of HDI improvement and transformation efficiency as core things to measure.

Second, we need to use different promotion strategies for different development models. For resource-dependent countries, they should improve their institutional frameworks and make their economies more diverse. For catch-up countries, they should invest more in people's livelihoods and human capital. For mature countries, they should work on making their welfare systems more efficient.

Third, we should reform the international development cooperation system. Relevant international organizations should change how they evaluate and give aid, so that together we can promote the building of a community with a shared future for mankind.

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