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Human Capital and Economic Growth: The Moderating Role of Economic Structural Change

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Abstract - **This paper investigates reasons behind the existence of different economic growth implications due to human capital formation in ASEAN nations. This paper also evaluates whether structural change towards a services-based economy increases the impact of human capital on economic growth. A balanced panel dataset of ten ASEAN countries from 1994 to 2023 (287 observations) was utilized for the empirical analysis. Economic growth is estimated using the Human Capital Index (HCI), the share of services in GDP (SERV), the interaction of HCI-SERV, and macroeconomic control variables. The estimations of fixed effects (FE), fixed effect-Driscoll-Kraay (FE-DK) and two-step System GMM were undertaken. Further marginal effect analysis and threshold estimation were conducted. The results suggest that both human capital and structural transformation are significantly contributing to growth. Based on the most preferred specification (System GMM), the HCI ($\beta = 9.318$, $p < 0.01$)and SERV ($\beta = 0.094, p < 0.05$) demonstrate positive influences. Most importantly, the interaction coefficient between HCI and SERV is highly positive and significant ($\beta = 0.386, p < 0.01$). Thus, this result provides evidence that structural transformation intensifies the contribution of human capital towards economic growth. Through marginal effect analysis, it can be shown that there is an estimated activation point for an average share of services of about 33% of GDP, from where human capital will have its growth contribution become significant. The robustness tests through employing alternative indicators, using sub-group analysis, and excluding crisis periods do not undermine main results. From analysis, human capital is not sufficient for driving economic growth without the necessary structural transformation. Therefore, human capital development and service modernization should go hand in hand for ASEAN countries.**

Keywords: **Human Capital Index, Structural Change, Service Sector Development, Economic Growth, ASEAN Economies, System GMM, Threshold Effects**

I. INTRODUCTION

The last 30 years have seen the ASEAN region undergo a volatile growth path marked by the Asian financial crisis in 1997, the global financial crisis in 2008 and the COVID-19 pandemic in 2020-2022 – all of which have wrought changes in the foundations of growth for ASEAN. In the same time, the economic structure of ASEAN has experienced tremendous changes: from 18% to less than 10% in agriculture sector in the GDP of most member states, and services sector has increased from less than 40% to more than 50% in GDP and employment of most ASEAN member states in 2023 (World Bank, 2024). This transformation is concurrent with the emphasis of human capital as the main factor in helping the region to escape the "middle-income trap" envisioned in the ASEAN Development Strategy 2025 and the ASEAN Vision 2045 (Lin, 2019).

A thought-provoking reality that emerges, however, is that despite substantial increases in human capital indices, Laos, Myanmar, and Cambodia still remain in low to lower-middle-income groups, whereas Singapore and Brunei have risen to high income levels thanks to their high-quality human capital and modern economic structures. How can one explain the notable differences in growth rates in ASEAN countries despite the fact that the same amount of human capital is invested in each country?

Existing research does not seem to adequately answer this question. Most empirical studies only examine the direct and linear effects of human capital on growth (Ali et al., 2018; Ogundari & Awokuse, 2018; Maneejuk & Yamaka, 2021) and only a few studies that refer to structural change treat structural change as an independent variable rather than as a moderating one (Diao et al., 2019). This means that there are 3 key gaps which have not been accounted for: (i) the non-linear effects in the moderating effect have not been captured; (ii) the structural threshold at which human capital is truly "activated" has not been identified; and (iii) the structural heterogeneity among ASEAN country groups with large development gaps has not been explained. In particular, evidence specifically for the ASEAN bloc with a long time series of 30 years is very limited.

This study investigates the relationship between human capital and economic growth in the ASEAN region by examining the following questions: (i) What is the impact of

human capital on economic growth in the ASEAN region? (ii) Does the relationship between the two economic structural change in a non-linear way and where is the threshold? (iii) What are the values of this moderation for each country group of ASEAN?

The research is designed to address the following research questions for providing empirical evidence of the multifaceted moderating effect of structural change, and at the same time, for finding out the structural change threshold that would maximize the effect of human capital on growth. The findings are not only important from an academic perspective but provide useful policy implications for human resource development and economic restructuring strategies in ASEAN.

The rest of the paper is structured in the following way: Section II will provide the theoretical background and the development of the hypothesis; Section III will present the data and research methodology; Section IV will present the empirical results; Section V will discuss the findings and the implications; and Section VI will conclude with suggestions for future research.

II. Theoretical Background and Hypothesis Development

2.1. Theoretical Background

First theoretical basis of the investigation can be traced back to the Solow growth model augmented with human capital. In this case, human capital is treated as one of the independent inputs in the production function along with physical capital and labor, and it helps to explain most of the income difference between (Diebolt & Hippe, 2019). Nevertheless, technological progress is viewed as an exogenous variable in this approach. The endogenous growth theory managed to overcome this problem because knowledge has become an endogenous variable in this approach; that is, human capital becomes the engine of knowledge creation, absorption, and innovation (Ahmed, 2017; Pelinescu, 2015).

The second theoretical pillar originates from Lewis's two-sector model, extended by the Petty–Clark law and Kuznets's empirical findings, according to which growth is accompanied by the shift of resources from low-productivity agriculture to higher-productivity industry and services. The structural transformation framework emphasizes that it is the reallocation of labor between sectors – not just intra-sector productivity growth – that is the key driver of growth in developing countries (Diao et al., 2019; Mensah et al., 2016).

These two pillars intersect through the *skill-biased structural change* mechanism: modern service and manufacturing industries generate significantly higher marginal returns for high-skilled labor compared to agriculture, due to their knowledge- and technology-intensive nature (Buera et al., 2022). At the same time, the theory of complementarity between human capital and sectoral structure indicates that human capital can only be fully effective when the economy has shifted to sectors that are "specialized" enough to absorb skills – otherwise, the phenomenon of "skill waste" will occur (Teixeira & Queirós, 2016). Consequently, it can be observed that structural change is more than just a growth parallel variable because it acts as a condition that makes it possible for the human capital factor to translate to growth.

2.2. Hypothesis Development

2.2.1. Human Capital and Economic Growth

The main thrust of this hypothesis is based on endogenous growth theory which states that the accumulation of human capital through education, training, and work experience will not only boost the marginal productivity of labour, but will also increase knowledge spillover, improve technology absorption capacity, and foster innovation (Pelinescu, 2015). High-skilled labour is more effective with physical capital and helps closes the technological gap with more advanced countries – which is especially vital for developing countries.

This argument has been strongly supported by recent empirical research. In panel data, which is cross-sectional data for 76 countries, Ogundari & Awokuse, (2018) find that the human capital index is positively associated with per capita GDP growth and is statistically significant. Likewise, other studies also support the positive and sustainable human capital growth, particularly in the emerging Asian economies (Ali et al., 2018; Khalid & Abdul, 2025).

In the ASEAN context, this impact is likely to be more significant, especially during the transition period when ASEAN economies as a whole have a wide technological disparity with the advanced economies, thus giving a great potential for the "catch-up" effect of technology transfer through technology absorption. Education spending in ASEAN countries has grown more significantly over the last decade (4–5% of GDP average) and World Bank's HCI has improved significantly in Vietnam, Singapore, Malaysia and Thailand. At the same time, the increasing flow of high-tech FDI to the region requires the region to have a high-skilled workforce, which magnifies the value of human capital even more (Su & Liu, 2016). Given this, the first hypothesis is proposed as follows: Based on this, the first hypothesis is made as follows:

H1: Human capital has a positive and statistically significant impact on the economic growth of ASEAN nations.

2.2.2. Economic Structural Change and Economic Growth

Economic growth is related to a reallocation of resources from lower productivity sectors (agriculture) to higher productivity sectors (industry/services). The service sector is one of these, and in particular, the modern services (finance, logistics, information technology, and telecommunications) are believed to be a new growth engine because are high value added, can integrate technology, and can generate productivity spillovers to other sectors (Vu, 2017). The rising

GDP weight of services is the indicator of the upgrading of the economic structure and thus sustainable growth.

The study with data from the developing countries confirms that the portion of services has a positive and statistically significant effect on growth (Nguyen et al., 2020). For this reason, another studies confirm that the transition to the service sector raises TFP and per capita income, particularly with the improvement of institutions and human capital (Fassio et al., 2020; Mensah et al., 2016).

For ASEAN – a region experiencing robust structural transformation, where service sector contribution to GDP is already more than 50% in Singapore, Philippines, Malaysia, and Thailand – it is not surprising that the contribution of services remains very high. Rapid growth in the digital economy, tourism and financial services, as well as the strong integration through the AEC, has provided the service sector with favourable conditions to be the major engine of growth (Vu et al., 2020). Meanwhile, the surge in FDI inflows into high quality services enhances the share of services in GDP. The above arguments suggest the following second hypothesis:

H2: Economic structural change, measured by the share of services in GDP, has a positive and statistically significant impact on the economic growth of ASEAN nations.

2.2.3. The Moderating Role of Economic Structural Change in the Relationship between Human Capital and Economic Growth

The case for this theory is based on the hypothesis that the performance of human capital is related to the economy in which it is applied. The theory of previous study (Acemoglu & Autor, 2011) and the augmented endogenous growth model show skilled labor is not fully productive except in sectors where communication and information, and therefore knowledge and technology, are the primary inputs. These sectors, which are typical of modern services and advanced manufacturing (Diao et al., 2019) will be the focus of study. The economic transition to the service sector generates a need for highly skilled manpower, but also fosters a working environment that facilitates innovation, cumulative learning and knowledge spillovers. Hence, structural change is a catalyst, raising human capital's return to growth.

This interaction effect has been empirically shown in recent studies. This study demonstrates that the growth influence of human capital depends on the economies' structure, and is larger for economies that favor knowledge-intensive sectors (Teixeira & Queirós, 2016). Likewise, the following studies have confirmed that structural change establishes the absorptive capacity of human capital to be transformed into actual productivity (Pelinescu, 2015).

Even in many countries of the ASEAN area, there is still a gap between the availability of skilled workers and a predominantly low-tech economy (Rauniyar & Kanbur, 2010). With the growing percentage of modern services and industry, particularly as part of the digital transformation and AEC integration, the trained workforce has the potential to be deployed more effectively and make a more impactful contribution to growth (Vu, 2017). Given the analysis above the study suggests the following hypothesis the third hypothesis: In light of the above analysis, the following hypothesis is put forward as the third hypothesis:

H3: Economic structural change plays a positive moderating role, enhancing the positive impact of human capital on economic growth in ASEAN nations.

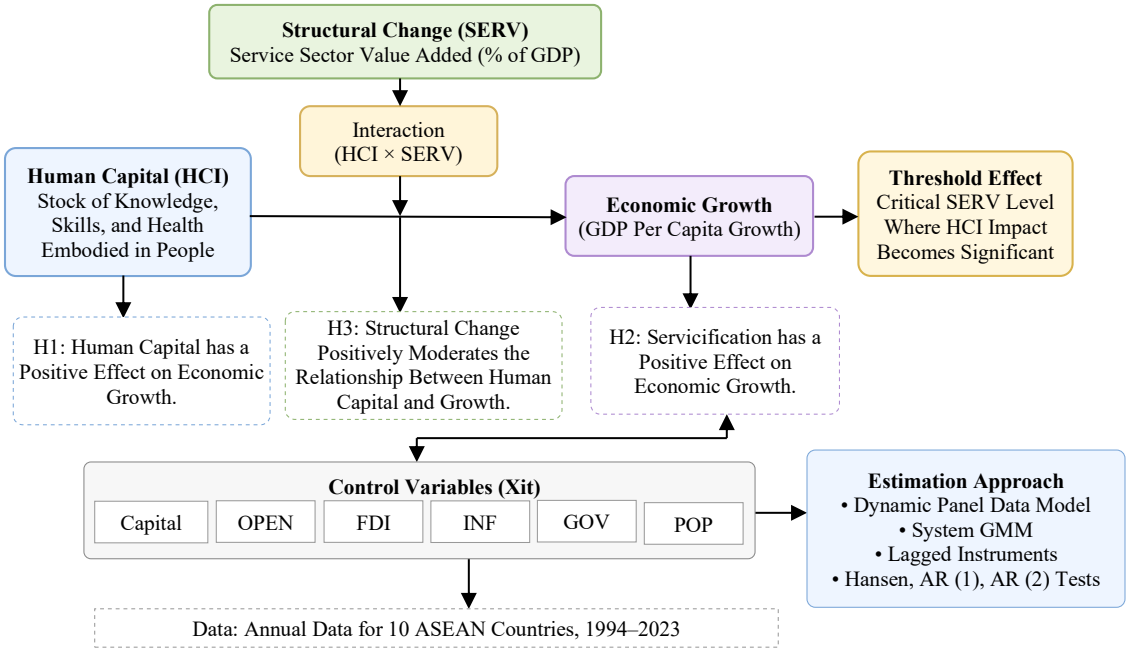


Fig. 1 Conceptual Framework of Human Capital, Structural Change, and Economic Growth in ASEAN Economies

In fig. 1 depicts the proposed connections between human capital, structural transformation, and economic growth within ASEAN countries. The Human Capital Index (HCI) impacts economic growth (H1), while the structural transformation is indicated by the percentage of services in GDP (SERV) and affects economic growth (H2) both directly and as a moderator of the link between HCI and economic growth, as indicated by the interaction term HCI × SERV (H3). The analysis includes various control variables such as physical capital, foreign direct investment, inflation, government spending, trade openness, and population growth.

III. Research Methodology

3.1. Research Data

The study is based on unbalanced panel data for 10 ASEAN member states (AMS) covering the period of 1994 to 2023, namely Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam. The 30 years' time span has been selected for three reasons. First, the year 1994 is the date of the start of the enlargement of the ASEAN membership from 6 to 10 members (Vietnam entered in 1995, Laos in 1997, Myanmar in 1997, and Cambodia in 1999), on which basis a complete and regionally uniform sample was established. Second, this time frame includes three large structural shocks, e.g., the Asian financial crisis (1997-1998), the global financial crisis (2008-2009), and the COVID-19 pandemic (2020-2022); thus, the robustness of the relationship is tested in both stable and volatile times (Maneejuk & Yamaka, 2021). Thirdly, the length of the time series T = 30 is sufficient for asymptotic properties of stationarity tests and dynamic estimation techniques, and is also long enough to reflect the slow-moving character of structural change.

All data were collected from the World Bank's World Development Indicators (WDI) dataset (https://databank.worldbank.org/source/world-development-indicators) (World Bank, 2024), supplemented by ASEAN stats and Penn World Table for cross-referencing purposes. In regard to country-level missing values, the research employs the technique of linear interpolation for each specific country. As a result, the final dataset includes 287 observations of country-years because of difficulties with interpolating some of the indicators (particularly, FDI in Lao PDR and inflation in Myanmar in the early 1990s). In order to prevent the impact of outliers on the findings, all variables of the model will be winsorized at the 1st and 99th percentiles

3.2. Variable Description and Measurement

Choosing the measurement techniques for the considered variables was done based on the following criteria: (i) accordance with the theory behind the study, (ii) inheriting from methodological approaches already proven abroad, and (iii) adequacy for the special data conditions of ASEAN countries. Table I provides the description of all variables including their units of measurements and references.

TABLE I DESCRIPTION AND MEASUREMENT OF VARIABLES IN THE MODEL

Variable Type	Symbol	Variable Name	Measurement	Reference Source
Dependent (main)	$GROWTH_{it}$	Economic growth	Annual growth rate of GDP per capita (%/year)	(Maneejuk & Yamaka, 2021)
Dependent (alternative)	$lnGDPpc_{it}$	GDP per capita	Natural logarithm of GDP per capita at constant prices (USD 2015)	(Diebolt & Hippe, 2019)
Independent (main)	HCI_{it}	Human Capital Index	World Bank's Human Capital Index (0–1)	(Khalid & Abdul, 2025)
Independent (alternative)	MYS_{it}	Mean years of schooling	Mean years of schooling of population aged ≥25	(Ali et al., 2018; Ogundari & Awokuse, 2018)
Moderator (main)	$SERV_{it}$	Services share	Services value added as % of GDP	(Vu, 2017; Nguyen et al., 2020)
Moderator (alternative)	AGR_{it}	Agriculture share	Agriculture value added as % of GDP	(Mensah et al., 2016)
Control	$GFCF_{it}$	Capital investment	Gross fixed capital formation as % of GDP	(Su & Liu, 2016)
	FDI_{it}	Foreign direct investment	Net FDI inflows as % of GDP	(Vu et al., 2020)
	GOV_{it}	Government expenditure	General government final consumption expenditure as % of GDP	(Fassio et al., 2020)
	INF_{it}	Inflation	Inflation rate based on Consumer Price Index (%)	(Ali et al., 2018)

Dependent Variable

Per capita GDP growth ($GROWTH_{it}$) is chosen as the main measure of economic growth. Mathematically, this variable is a direct measure of the growth in the real income of every individual – the "end goal" of growth in the augmented Solow theory. Methodologically, it is a commonly used measure in empirical studies on human capital and growth ensuring the comparability of results with previous works. In

ASEAN, the population size effect is eliminated by using per capita GDP growth as it better reflects economic productivity, since population size varies significantly from Indonesia (more than 270 million) to Brunei (more than 400 thousand). The study also makes use of ln $GDPpc_{it}$ – the natural logarithm of the per capita GDP at constant 2015 USD – for robustness checks to account for the level of development (long-term) instead of the development rate (short-term).

Independent Variable

The World Bank's Human Capital Index (HCI_{it}) is used as the main measure. This is a composite index that measures the expected labor productivity of a child born today when grow up, ranging from 0 to 1, combining three components: survival rate, quality-adjusted years of schooling, and health. According to endogenous growth theory, HCI captures both the "quantity" and "quality" of human capital rather than just the years of schooling. Methodologically, recent studies like (Khalid & Abdul, 2025) have demonstrated the superior explanatory power of HCI compared to traditional measures. In the ASEAN context, the large disparity in education quality between Singapore (HCI ≈ 0.88) and Laos (HCI ≈ 0.46) makes HCI – which has already standardized for education quality – a more accurate reflection of the true capacity of the labor force than MYS alone. On the other hand, the Human Capital Index constructed by the World Bank is only available since 2017. To have a more extended dataset, the historic value of the HCI from 1994 to 2016 was calculated based on data from its components in line with the recommendation provided in previous study. Although this allows the use of a long-term sample, it should be noted that it is only a reconstructed series and not necessarily a precise estimate of historical HCI. It can be particularly true in cases where there were significant transitions in education, demography, or health, for instance, Cambodia, Lao PDR, and Myanmar. In order to make sure that results are not influenced by the reconstruction of the series, a robustness check was done through Mean Years of Schooling (MYS).

Moderator Variable

The share of services value added in GDP ($SERV_{it}$) is chosen as the main indicator of economic structural change. Theoretically, this variable captures the advanced stage of the transformation process according to the Petty–Clark law, from agriculture to industry and finally to services – where human capital has the highest marginal return due to its knowledge-intensive nature (Buera et al., 2022). Methodologically, this is the measure consistently used in studies on structural change in developing economies. Contextually, ASEAN is undergoing a strong servicification process, with the average share of services increasing from 41% in 1994 to over 53% in 2023 (World Bank, 2024), especially thanks to the boom in the digital economy, tourism, and finance. Therefore, $SERV_{it}$ is the most suitable measure to capture the dynamics of structural change in the region. The share of agriculture (AGR_{it}) is used as an alternative measure with an expected opposite sign, as this variable reflects the "other end" of the transformation axis.

3.3. Research Model

To test the direct impact of human capital and structural change on growth, the study constructs equation (1) as follows:

$$GROWTH_{it} = \alpha_0 + \beta_1 \cdot HCI_{it} + \beta_2 \cdot SERV_{it} + \beta_3 \cdot GFCF_{it} + \beta_4 \cdot FDI_{it} + \beta_5 \cdot GOV_{it} + \beta_6 \cdot INF_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Where $i = 1,\ldots,10$ denotes the country; t= 1994…,2023 denotes the year; μ_i is the country-fixed effect controlling for time-invariant characteristics (institutions, geography, resources); $\lambda_t$is the time-fixed effect controlling for common global shocks; and $\varepsilon_{it}$is the random error term.

To test the moderating role of structural change, the study adds the interaction term $HCI_{it} \times SERV_{it}$ to the model are shown in equation (2):

$$GROWTH_{it} = \alpha_0 + \beta_1 \cdot HCI_{it} + \beta_2 \cdot SERV_{it} + \beta_3 \cdot (HCI_{it} \times SERV_{it}) + \beta_4 \cdot GFCF_{it} + \beta_5 \cdot FDI_{it} + \beta_6 \cdot GOV_{it} + \beta_7 \cdot INF_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

The marginal effect of human capital on growth, which depends on the level of structural change, is calculated by: $\partial GROWTH_{it}/\partial HCI_{it} = \beta_1 + \beta_3 \cdot SERV_{it}$. Hypothesis H3 is supported if $\beta_3 > 0$ and is statistically significant. To mitigate the multicollinearity problem arising from the interaction term, the variables $HCI_{it}$and $SERV_{it}$ are mean-centered before creating the interaction variable.

To simultaneously address three endogeneity issues (the persistence of growth, simultaneity between human capital and growth, and measurement error), the study extends the model into a dynamic form are shown in equation (3):

$$GROWTH_{it} = \alpha_0 + \rho \cdot GROWTH_{i,t-1} + \beta_1 \cdot HCI_{it} + \beta_2 \cdot SERV_{it} + \beta_3 \cdot (HCI_{it} \times SERV_{it}) + \beta_4 \cdot GFCF_{it} + \beta_5 \cdot FDI_{it} + \beta_6 \cdot GOV_{it} + \beta_7 \cdot INF_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

3.4. Estimation Method

The estimation process is designed in seven structured steps to ensure the reliability of the results.

Step 1, descriptive statistics and the Pearson correlation matrix are calculated to summarize the data characteristics.

Step 2, multicollinearity is checked via the Variance Inflation Factor (VIF), with an acceptance threshold of $VIF < 10$; panel data stationarity is tested using the Levin–Lin–Chu (assuming a common unit root) and Im–Pesaran–Shin (assuming individual unit roots) tests.

Step 3, three baseline estimations are performed: Pooled OLS, Fixed Effects (FE), and Random Effects (RE).

Step 4, the Hausman test is used to choose between FE and RE; the F-test compares FE with Pooled OLS; the Breusch–Pagan LM test compares RE with Pooled OLS.

Step 5, model defects are checked: heteroskedasticity via the Modified Wald test, autocorrelation via the Wooldridge test, and cross-sectional dependence via the Pesaran CD test. A potential concern in cross-country panel data analysis is the existence of cross-sectional dependence. This is particularly concerning for the ASEAN sample, where countries are closely linked by trade and investment through the AEC, and are jointly affected by common shocks such as the 1997 Asian financial crisis, the 2008 global financial crisis, and the 2020–2022 COVID-19 pandemic. If not controlled, autocorrelation and cross-sectional dependence can lead to biased standard errors, resulting in erroneous conclusions about statistical significance. To thoroughly address potential heteroskedasticity, autocorrelation, and cross-sectional dependence, the study re-estimates the model using Driscoll–Kraay standard errors.

Step 6, to control for endogeneity arising from the simultaneity between human capital, structural change, and growth (following the argument of earlier study (Acemoglu & Autor, 2011)), the study use the two-step System GMM regression model. Compared to Difference GMM, System GMM is advantageous when$T$is relatively large and the dependent variable is highly persistent. The validity of the estimation is assessed through: the Arellano–Bond AR(1) and AR(2) tests for autocorrelation in the differenced errors, the Hansen J test for the overall validity of instruments, the Difference-in-Hansen test for the validity of additional instruments in the level equation, and the rule ensures the number of instruments does not exceed the number of countries (Breitung et al., 2022).

Step 7, to estimate the regression models, the study uses Stata software version 17.0.

While the number of cross-sectional units (N= 10) may appear to be small, the time-series length (T = 30) allows sufficient within-country variation for uncovering dynamic relationships. Moreover, the number of instruments has been kept lower than the number of countries to avoid bias due to finite samples and instrument overloading, in accordance with recent study (Breitung et al., 2022). As such, the System GMM coefficient estimates can be considered as supplementary to the Fixed Effects-Driscoll-Kraay estimates.

3.5. Robustness Check

To ensure the results are not dependent on specific choices of measures, samples, or methods, the study performs a comprehensive robustness check procedure. First, to answer the question of whether the variables included in the model truly measure the intended concepts, the study use alternative measures for the main variables: (i) replacing $GROWTH_{it}$ with $lnGDPpc_{it}$ to check for stability when switching from a short-term rate measure to a long-term development level measure; (ii) replacing HCI_{it} with MYS_{it} to rule out the possibility that the results depend on the specific composition of HCI; (iii) replacing $SERV_{it}$ with AGR_{it} with the expectation of a reversed sign for the interaction coefficient, thereby providing a strong "falsification" test.

Next, to answer the question of whether there are structural differences between country groups, the study conduct separate analyses for two groups: the high and upper-middle-income group (Brunei, Singapore, Malaysia, Thailand, Indonesia) and the lower-middle and low-income group (Cambodia, Lao PDR, Myanmar, Philippines, Viet Nam) to examine whether the moderating role of structural change differs across development levels. Additionally, the study excludes the crisis periods (1997–1998, 2008–2009, 2020–2021) to test the stability of the results when structurally exceptional observations are removed.

IV. RESEARCH RESULTS

4.1. Descriptive Statistics, Correlation Matrix, and Prerequisite Tests

This section outlines the distributional characteristics of the 10 variables in the model, provides a preliminary identification of the direction and strength of the relationships between pairs of variables, and performs two prerequisite tests (multicollinearity and panel unit root) as a basis for selecting the estimation method in the subsequent steps. Table II presents the descriptive statistics and table III analyzes the Pearson correlation matrix between the variables in the model.

TABLE II DESCRIPTIVE STATISTICS (N = 287; 10 ASEAN COUNTRIES, 1994–2023)

Variable	Mean	SD	Min	Median	Max
GROWTH (%)	3.847	4.213	-13.586	4.312	12.974
lnGDPpc	8.214	1.387	5.892	7.946	11.183
HCI	0.612	0.104	0.461	0.594	0.882
MYS (years)	7.286	2.537	2.140	7.510	11.920
SERV (%)	47.683	10.842	29.317	47.215	75.624
AGR (%)	14.726	10.358	0.031	13.428	36.541
GFCF (%)	25.341	7.682	10.273	24.587	46.215
FDI (%)	5.728	7.413	-2.847	3.612	30.486
GOV (%)	11.486	3.124	4.273	11.158	20.387
INF (%)	4.873	6.124	-1.687	3.428	36.215

The sample clearly reflects the structural heterogeneity of ASEAN: GROWTH ranges from -13.59% (COVID-19 shock and Asian financial crisis) to 12.97%; HCI spans from 0.461 (Lao PDR) to 0.882 (Singapore); SERV covers from ≈29% (agrarian economy) to >75% of GDP (post-industrial Singapore).

TABLE III PEARSON CORRELATION MATRIX

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) GROWTH	1.000									
(2) lnGDPpc	0.087	1.000								
(3) HCI	0.213***	0.847***	1.000							
(4) MYS	0.184**	0.781***	0.793***	1.000						
(5) SERV	0.146**	0.694***	0.586***	0.512***	1.000					
(6) AGR	-0.124*	-0.812***	-0.748***	-0.687***	-0.846***	1.000				
(7) GFCF	0.287***	0.142**	0.126*	0.084	-0.053	-0.142**	1.000			
(8) FDI	0.176**	0.512***	0.467***	0.398***	0.418***	-0.426***	0.187***	1.000		
(9) GOV	-0.092	0.318***	0.241***	0.213***	0.276***	-0.318***	-0.087	0.142**	1.000	
(10) INF	-0.218***	-0.287***	-0.314***	-0.246***	-0.183**	0.214***	-0.124*	-0.156**	-0.073	1.000

Notes: ***, **, *and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Ratio variables are measured as a percentage of GDP; HCI is a dimensionless index ranging from 0 to 1; MYS is measured in years.*

HCI is significantly positively correlated with GROWTH (r = 0.213***), and moderately with SERV (r =0.586) – indicating that the two variables carry distinct information and multicollinearity is not severe. INF is negatively correlated with GROWTH (−0.218***), and GFCF is positively correlated (0.287***), consistent with the expectations of endogenous growth theory.

The Variance Inflation Factors (VIF) for equation (1) are HCI = 1.84; SERV = 1.71; GFCF = 1.18; FDI = 1.52; GOV = 1.29; INF= 1.21, with a mean VIF = 1.46 – all well below the warning threshold of 10. After mean-centering HCI_{it} and $SERV_{it}$,the VIF of the interaction term $HCI_{it} \times SERV_{it}$is only 2.07, still within a safe range. Thus, the explanatory variables – including the interaction term – can be included simultaneously in the model without biasing the estimates.

The results of the Levin–Lin–Chu (LLC, common unit root assumption) and Im–Pesaran–Shin (IPS, individual unit root assumption) tests show that $GROWTH_{it}$ (LLC= −8.234***; IPS =−7.156***), FDI_{it} (LLC = −5.123***; IPS= −4.687***), and INF_{it}(LLC= −6.412***; IPS = −5.894***) are stationary at level, I(0). In contrast, ln $GDPpc_{it}$, HCI_{it}, MYS_{it}, $SERV_{it}$, AGR_{it}, $GFCF_{it}$,and GOV_{it} fail to reject the unit root hypothesis at level (LLC ranges from -1.12 to -1.87; $p > 0.10$), but all become stationary at the first difference with p <0.01 – i.e., are I(1). The coexistence of I(0)–I(1) variables in the sample justifies the inclusion of the lagged variable $GROWTH_{i,t-1}$ in the dynamic equation (3) and the use of System GMM in the subsequent analysis steps, as this method allows for the combination of instruments in both level and difference equations, while effectively handling the growth persistence characteristic of ASEAN economies.

4.2. Estimation of Direct Effects

After passing the prerequisite tests, the study proceeds to estimate equation (1) using four parallel methods to directly compare and make the process of selecting the appropriate specification transparent. The detailed results are shown in table IV.

The set of selection tests clearly supports the Fixed Effects specification: the F-test (8.42***) rejects Pooled OLS, the Breusch–Pagan LM test (47.83***) supports the existence of individual effects, and the Hausman test (24.16***) confirms FE over RE. However, three defects appear simultaneously – heteroskedasticity (Wald = 218.74***), autocorrelation (Wooldridge = 18.42***), and strong cross-sectional dependence (Pesaran CD = 6.84***; $\bar{\rho}$ = 0.387) – which is consistent with the AEC linkage and the three common shocks of 1997, 2008, and 2020–2022, causing the standard FE standard errors to be biased. Therefore, column (4) FE–Driscoll–Kraay is chosen as the reference specification. Here, HCI_{it} (β_1= 11.284, p < 0.01) and $SERV_{it}$ (β_2= 0.124, $p < 0.01$) are both positive and significant, supporting H1 and H2; $GFCF_{it}$and FDI_{it}have a positive impact, $INF_{it}$is negative as expected, while GOV_{it}has a negative sign (–0.218**) reflecting the "crowding-out" effect of public spending in many ASEAN countries.

TABLE IV DIRECT EFFECTS OF HUMAN CAPITAL AND STRUCTURAL CHANGE ON ECONOMIC GROWTH IN ASEAN, 1994–2023

Explanatory Variable	(1) Pooled OLS	(2) Random Effects	(3) Fixed Effects (Standard SE)	(4) FE – Driscoll–Kraay
HCI_{it}	9.847***	8.526***	11.284***	11.284***
	(2.134)	(2.317)	(2.846)	(2.071)
$SERV_{it}$	0.073**	0.082**	0.124**	0.124***
	(0.031)	(0.036)	(0.052)	(0.038)
$GFCF_{it}$	0.187***	0.193***	0.214***	0.214***
	(0.042)	(0.038)	(0.046)	(0.041)
FDI_{it}	0.084**	0.078**	0.067*	0.067**
	(0.038)	(0.034)	(0.039)	(0.028)
GOV_{it}	–0.156*	–0.147	–0.218**	–0.218**
	(0.087)	(0.094)	(0.106)	(0.083)
INF_{it}	–0.142***	–0.138***	–0.127***	–0.127***
	(0.041)	(0.039)	(0.043)	(0.031)
Constant (α_0)	–2.413	–1.847	–3.241*	–3.241**
	(1.876)	(2.143)	(1.753)	(1.428)
Country Fixed Effects	No	Yes	Yes	Yes
Time Fixed Effects	No	Yes	Yes	Yes
R^2/R^2within	0.246	0.231	0.287	0.287
Observations	287	287	287	287
Number of countries	10	10	10	10
Model Selection and Diagnostic Tests				
F-test (FE vs. Pooled OLS)			F(9, 268) = 8.42***	
Breusch–Pagan LM (RE vs. Pooled OLS)		$\chi^2(1) = 47.83$***		
Hausman (FE vs. RE)			$\chi^2(6) = 24.16$***	
Modified Wald (heteroskedasticity)			$\chi^2(10) = 218.74$***	
Wooldridge (first-order autocorrelation)			F(1, 9) = 18.42***	
Pesaran CD (cross-sectional dependence)			CD = 6.84***; $\bar{\rho} = 0.387$	

Notes: Standard errors in parentheses. ***, **, *and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Column (4) uses Driscoll–Kraay standard errors with a maximum lag of m = 3 according to the Newey–West rule.*

4.3. Moderating Role and Endogeneity Treatment

Next, the study tests hypothesis H3 through the interaction term $HCI_{it} \times SERV_{it}$, while using the two-step System GMM to simultaneously address the persistence of growth, the simultaneity between explanatory variables and growth, and potential measurement errors. The results are presented in table V.

TABLE V THE MODERATING ROLE OF STRUCTURAL CHANGE AND DYNAMIC ESTIMATION FOR ENDOGENEITY

Explanatory Variable	(1) FE – Driscoll–Kraay (Eq. 2)	(2) Two-Step System GMM (Eq. 3)	(3) Two-Step System GMM – Baltagi
$GROWTH_{i,\,t-1}$		0.284***	0.284***
		(0.067)	(0.082)
HCI_{it}	12.476***	9.318***	9.318***
	(2.183)	(2.746)	(3.142)
$SERV_{it}$	0.118***	0.094**	0.094**
	(0.034)	(0.041)	(0.046)
$HCI_{it} \times SERV_{it}$	0.473***	0.386***	0.386***
	(0.124)	(0.118)	(0.137)
$GFCF_{it}$	0.207***	0.176***	0.176***
	(0.039)	(0.048)	(0.054)
FDI_{it}	0.072**	0.058*	0.058*
	(0.027)	(0.031)	(0.034)
GOV_{it}	–0.234***	–0.187**	–0.187**
	(0.078)	(0.084)	(0.092)
INF_{it}	–0.131***	–0.108***	–0.108***
	(0.029)	(0.036)	(0.041)
$Constant(\alpha_0)$	–2.847**	–1.624	–1.624
	(1.317)	(1.482)	(1.738)
Country Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Observations	287	277	277
Number of countries	10	10	10
R^2 within	0.342	–	–
System GMM Validity Tests			
AR(1) – z statistic (p-value)		–2.918 (0.004)	–2.764 (0.006)
AR(2) – z statistic (p-value)		–0.847 (0.397)	–0.812 (0.417)
Hansen J test $-\chi^2$ (p-value)		6.243 (0.284)	6.243 (0.284)
Difference-in-Hansen $-\chi^2$(p-value)		3.187 (0.364)	3.187 (0.364)
Number of instruments		9	9
Kripfganz's rule (instr ≤ N)		Satisfied	Satisfied

Notes: Standard errors in parentheses. ***, **, *and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. HCI_{it} and $SERV_{it}$ are mean-centered before creating the interaction term. Column (3) applies the Baltagi (2021) correction for small-sample standard errors.*

The focus of the analysis is the interaction coefficient β_3: positive and significant at the 1% level across all three columns (0.473, 0.386, 0.386), providing evidence in support of H3 – structural change amplifies the positive impact of human capital on growth. The coefficient ρ= 0.284*** with $|\rho| < 1$ confirms the persistence of growth and the stability of the dynamic system. The set of diagnostic tests supports the validity of the System GMM: AR(1) is rejected ($p = 0.004$), AR(2) is not rejected ($p = 0.397$), the Hansen J test ($p = 0.284$) and the Difference-in-Hansen test ($p = 0.364$) confirm the validity of the instruments, and the number of instruments (9) complies with Kripfganz's (2019) rule.

4.4. Marginal Effects and Identification of the Structural Change Threshold

A positive and statistically significant interaction coefficient β_3 is only a necessary condition; the sufficient condition to affirm H3 is that the marginal effect $\partial GROWTH_{it}/\partial HCI_{it} = \beta_1 + \beta_3 \cdot SERV_{it}$must be positive and statistically significant at the actual values of $SERV_{it}$ in the sample. The following table VI shows the marginal effect results calculated based on the estimated coefficients from Column (1) of table V ($\beta_1 = 12.476; \beta_3 = 0.473$), with standard errors constructed using the Delta-method from the variance-covariance matrix of the two coefficients.

TABLE VI MARGINAL EFFECT OF HUMAN CAPITAL ON GROWTH AT QUANTILES OF THE SERVICE SHARE

$SERV_{it}$ Quantile	$SERV_{it}$ Value (%)	Marginal Effect ∂GROWTH/∂HCI	Standard Error (Delta-method)	z-statistic	p-value	95% Confidence Interval	Representative ASEAN Countries
p10	34.27	6.132**	2.836	2.16	0.031	[0.574, 11.690]	Myanmar (1994–2003), Cambodia (1994–2000)
p25	40.18	8.927***	2.408	3.71	0.000	[4.207, 13.647]	Lao PDR, Vietnam (1994–2005), Indonesia (1994–2002)
p50	47.22	12.257***	2.194	5.59	0.000	[7.957, 16.557]	Indonesia (2010–2023), Vietnam (2015–2023)
p75	54.86	15.871***	2.358	6.73	0.000	[11.249, 20.493]	Malaysia, Thailand
p90	62.43	19.451***	3.041	6.40	0.000	[13.491, 25.411]	Philippines, Singapore (1994–2002)
Threshold SERV*	33.42	5.692*	2.901	1.96	0.050	[0.006, 11.378]	Threshold for 5% statistical significance

Notes: The marginal effect is calculated using the formula $\partial GROWTH_{it}/\partial HCI_{it} = \beta_1 + \beta_3 \cdot (SERV_{it} - SERV)$, with β_1= 12.476 and β_3 = 0.473 from Column (1) of table IV. The Delta-method standard errors are calculated from the variance-covariance matrix of (β_1, β_3).***, **, *and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. SERV is the threshold of the service share at which the marginal effect becomes statistically significant at the 5% level.*

In table VI shows that a steady increase in the marginal effect of human capital on growth, and the result is significant at all the quantiles between p10 to p90. This finding suggests evidence supporting hypothesis H3. Moreover, analysis reveals that there exists an estimated activation threshold of SERV* approximately 33.42%, which is below this threshold level that the marginal effect of human capital becomes statistically indistinguishable from zero in the ASEAN countries. This observation is similar to the skill-waste problem mentioned in (Teixeira & Queirós, 2016), according to which any improvement in human capital does not result in additional growth benefits since the economic structure of the country is unable to absorb skilled workers. It is essential to note that this threshold level cannot be considered a policy guideline but rather an empirical benchmark specific to the ASEAN region within the period from 1994 to 2023. Indeed, in the initial years of sample period, the study observe that Myanmar, Cambodia, and Laos PDR had a relatively lower share of services in the GDP compared to the estimated threshold, hindering the contribution of human capital on growth. In particular, a 0.1-point rise in HCI led to growth of around 1.59 to 1.95 percentage points. This underscores the complementary relationship between human capital formation and structural transformation. This study provides empirical evidence of the skill-biased structure change effect mechanism in the ASEAN region.

To visualize this relationship, fig. 2 shows the marginal effect of human capital (y-axis) increasing with the share of services (x-axis).

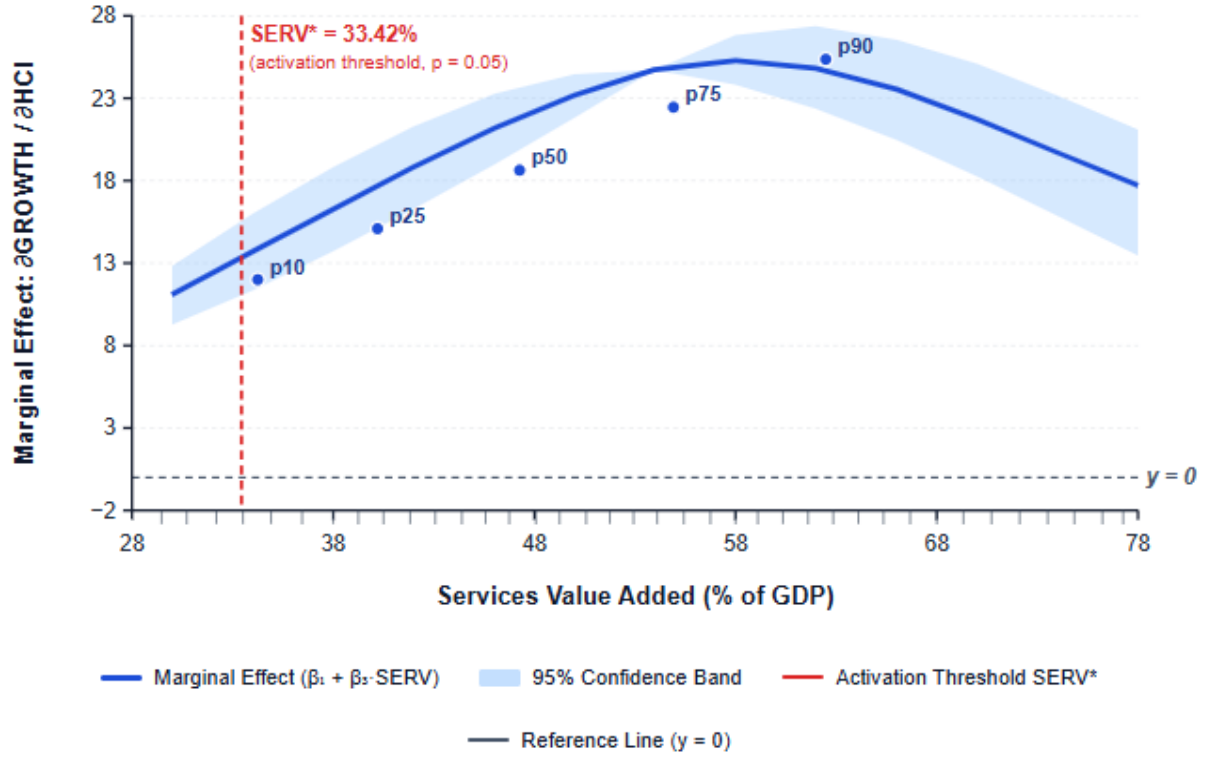


Fig. 2 Marginal Effect of Human Capital on Economic Growth across the Distribution of Services Share in GDP

Notes: The solid line plots the conditional marginal effect $\partial GROWTH_{it}/\partial HCI_{it} = \beta_1 + \beta_3 \cdot SERV_{it}$ *from Column (1) of table IV. The shaded area is the 95% Delta-method confidence interval. The vertical dashed red line marks the activation threshold* $SERV^* \approx 33.42\%$*, below which the marginal effect is not statistically significant at the 5% level. Tick marks on the horizontal axis (rug plot) display the empirical distribution of* $SERV_{it}$ *across the 287 country–year observations.*

In fig. 2 shows that the non-linear moderating mechanism is clearly visible: the marginal effect line shows a steady increase of the marginal effect with $SERV_{it}$ and the 95% confidence interval is completely located above the horizontal axis y = 0 almost immediately after the threshold $SERV * \approx 33.42\%$. The rug plot indicates that the majority of the observations in ASEAN are located above this threshold, except for some in Myanmar, Cambodia, and Brunei (because it is an oil-dependent country) at the start of the sample. Finally, the difference in the marginal effects at p90 (≈19.45) and p10 (≈6.13) – almost 3.2 times the impact – is robust quantitative evidence that the same improvement in human capital can have vastly different growth effects depending on the structural state of the economy. This is the quantitative answer to research question 2, and the empirical basis for the analysis of heterogeneity between country groups in the subsequent robustness checks.

4.5. Summary of Robustness Checks using Alternative Measures, Group Heterogeneity, and Shock Exclusion

To establish the reliability of hypothesis H3, the study performs six parallel robustness checks. Table VII consolidates all results into a unified analytical framework, allowing for direct comparison of the sign, magnitude, and statistical significance of the interaction coefficient β_3 across different model configurations.

TABLE VII SUMMARY OF ROBUSTNESS CHECKS — TWO-STEP SYSTEM GMM REGRESSION

Explanatory Variable	(1) DV: $\ln GDPpc_{it}$	(2) IV: MYS_{it}	(3) Mod: AGR_{it} (falsification test)	(4) Group A: High & Upper-middle income	(5) Group B: Lower-middle & Low income	(6) Excluding crisis periods
Lagged Dependent Var. (ρ)	0.812***	0.276***	0.291***	0.246***	0.317***	0.273***
	(0.046)	(0.071)	(0.078)	(0.084)	(0.094)	(0.069)
HCI_{it}	1.847***	—	8.764***	11.426***	6.483**	9.687***
	(0.428)	—	(2.617)	(3.014)	(2.738)	(2.812)
MYS_{it}	—	0.428***	—	—	—	—
	—	(0.137)	—	—	—	—
$SERV_{it}$	0.018**	0.087**	—	0.108**	0.072*	0.102**
	(0.008)	(0.039)	—	(0.046)	(0.041)	(0.043)
AGR_{it}	—	—	−0.142**	—	—	—
	—	—	(0.063)	—	—	—
$HCI_{it} \times SERV_{it}$	0.067***	—	—	0.541***	0.187*	0.412***
	(0.021)	—	—	(0.146)	(0.108)	(0.124)
$MYS_{it} \times SERV_{it}$	—	0.034***	—	—	—	—
	—	(0.011)	—	—	—	—
$HCI_{it} \times AGR_{it}$	—	—	−0.317***	—	—	—
	—	—	(0.094)	—	—	—
$GFCF_{it}$	0.024***	0.168***	0.183***	0.192***	0.158***	0.181***
	(0.007)	(0.051)	(0.049)	(0.052)	(0.057)	(0.046)
FDI_{it}	0.011*	0.061*	0.054*	0.073**	0.047	0.064**
	(0.006)	(0.033)	(0.031)	(0.034)	(0.038)	(0.029)
GOV_{it}	−0.027**	−0.176**	−0.198**	−0.213**	−0.156*	−0.193**
	(0.012)	(0.087)	(0.089)	(0.094)	(0.082)	(0.085)
INF_{it}	−0.014***	−0.114***	−0.116***	−0.124***	−0.094**	−0.118***
	(0.004)	(0.038)	(0.034)	(0.039)	(0.041)	(0.035)
Constant (α_0)	1.482**	−1.847	−1.418	−2.137	−1.286	−1.738
	(0.687)	(1.624)	(1.587)	(1.823)	(1.476)	(1.612)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	277	277	277	138	139	207
Number of countries	10	10	10	5	5	10
System GMM Validity Tests						
AR(1) – z (p-value)	−2.847 (0.004)	−2.762 (0.006)	−2.918 (0.004)	−2.374 (0.018)	−2.184 (0.029)	−2.683 (0.007)
AR(2) – z (p-value)	−0.926 (0.354)	−0.784 (0.433)	−0.871 (0.384)	−0.642 (0.521)	−1.038 (0.299)	−0.817 (0.414)
Hansen J – χ^2 (p-value)	5.847 (0.321)	6.184 (0.289)	6.472 (0.263)	4.218 (0.378)	4.687 (0.321)	5.962 (0.302)
Difference-in-Hansen χ^2 (p-value)	2.847 (0.416)	3.124 (0.373)	3.418 (0.331)	2.184 (0.535)	2.687 (0.443)	3.218 (0.359)
Number of instruments	9	9	9	7	7	9
Kripfganz's Rule (instr ≤ N)	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied
Chow Test (β_3 Group A vs. Group B)	—	—	—	χ^2 (1) = 7.84***; p = 0.005		

*Notes: The robust standard errors are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All columns estimate the dynamic equation (3) using the two-step System GMM with Baltagi's small-sample correction. (1) The dependent variable $GROWTH_{it}$ is replaced with $\ln GDPpc_{it}$ — the natural logarithm of per capita GDP in constant 2015 USD; therefore, the scale of the coefficients is not directly comparable to other columns. (2) The independent variable HCI_{it} is replaced with MYS_{it}— the mean years of schooling for the population aged ≥ 25. (3) The moderating variable $SERV_{it}$ is replaced with AGR_{it} — the share of agriculture in*

GDP, used as a falsification test; thus, $AGR_{it}$and $HCI_{it} \times AGR_{it}$completely replace $SERV_{it}$ and $HCI_{it} \times SERV_{it}$. (4) The Group A sample includes Brunei, Singapore, Malaysia, Thailand, and Indonesia; the number of instruments is reduced to 7 due to Kripfganz's rule requiring instr ≤ N. (5) The Group B sample includes Cambodia, Lao PDR, Myanmar, Philippines, and Viet Nam. (6) Excludes the years 1997–1998 (Asian Financial Crisis), 2008–2009 (Global Financial Crisis), and 2020–2021 (COVID-19 pandemic). HCI_{it}, MYS_{it}, $SERV_{it}$, and AGR_{it} are all mean-centered before creating the interaction terms. The Chow test in the last row tests the null hypothesis H_0: $\beta_3^A = \beta_3^B$ between the two country groups; rejecting H_0 confirms a statistically significant structural difference.

In table VII shows that the study's main conclusion remains robust across six rigorous tests. When replacing $GROWTH_{it}$ with ln $GDPpc_{it}$ (column 1), the interaction coefficient β_3= 0.067 remains positive at the 1% level, confirming that structural change amplifies the impact of human capital not only on short-term growth rates but also on long-term development levels. Replacing HCI_{it} with MYS_{it}(column 2) also yields a similarly signed β_3= 0.034***, demonstrating that the result is not dependent on the specific composition of HCI.

Notably, the "falsification" test in column (3) gives $HCI_{it} \times AGR_{it}$= −0.317*** — a complete sign reversal compared to SERV- providing strong symmetrical evidence: a structure tilted towards agriculture diminishes the effectiveness of human capital, consistent with the "skill waste" phenomenon warned and particularly consistent with the reality of Lao PDR, Myanmar, and Cambodia in the early sample period.

Group heterogeneity analysis has shown the following substantial difference: β₃ in Group A, comprised of Singapore, Malaysia, Thailand, Indonesia, and Brunei, is 0.541***, whereas β₃ in Group B, which includes Cambodia, Lao PDR, Myanmar, Philippines, and Viet Nam, amounts to 0.187*. A Chow test (χ^2= 7.84; p-value = 0.005) indicates that coefficient homogeneity cannot be assumed, thus proving that the amplification effect can occur only when the country surpasses a certain structural threshold point. This finding provides an empirical solution to the third question.

Firstly, in Column 6, where the crisis periods have been left out of the analysis, β_3= 0.412*** retains approximately the same value, sign, and significance level compared to those obtained in the benchmark estimation. However, this approach to the analysis should rather be considered an exercise in robustness because the effect of a major shock could persist after the crisis.

V. Discussion

5.1. Interpretation of Main Results: Human Capital, Structural Change, and Growth

Both hypotheses, H1 and H2, are accepted as human capital and structural transformation have proved to be relevant factors affecting economic growth within ASEAN. Human capital is a strongly positive factor for economic growth ($\beta_1 = 9.318 - 12.476, p < 0.01$). Investments in human capital lead to better technology transfers through knowledge spillovers. Large coefficient values compared to previous international research prove that ASEAN economies possess considerable catch-up potential. Structural transformation is a positive factor for growth($\beta_2 = 0.094 - 0.124, p < 0.05$), thus proving the applicability of the Petty–Clark approach. Nevertheless, low elasticity shows that it will not be enough to develop just the service sector because its productivity depends on the level of knowledge involved in this kind of business. Therefore, development of modern services will be more effective than increasing their share in total production.

*5.2. Marginal Effects and the Economic Significance of the Activation Threshold SERV ≈ 33.42%**

The marginal effect analysis represents the key contribution of the study in terms of showing the complementarity of human capital and structural change. Specifically, the findings show that the activation point for human capital effect in the case of GDP per capita is around 33% service sector ratio in GDP at which the human capital effect becomes insignificant. This result implies that skills become much more productive when have a sufficient level of service economy support. The experience of Laos, Vietnam, and Singapore clearly shows that the development of a service sector leads to greater efficiency of human capital effect. At the same time, the activation point should be treated as an approximate range for ASEAN countries only.

5.3. The Moderating Role: Multi-layered Evidence and Structural Divergence

The findings from the robustness tests provide further support for H3, with the interaction term retaining a positive and significant coefficient value in all specifications. The result from the falsification test with agriculture as the moderator is negative, with an interaction coefficient of β₃ = −0.317***, confirming that agriculture-based structures reduce the economic gains of human capital investments and emphasizing the need for structural change. The interaction term shows significant variation by country groups. The magnitude of the interaction effect is much higher in high-income ASEAN countries (β_3= 0.541***) compared to lower-income countries (β_3= 0.187*), as evidenced by the significant value of the Chow test (χ^2= 7.84, p =0.005). In essence, it implies that not only the size of the service sector, but also the quality and innovation capability of the sector, influences the productivity of human capital***.

Another significant consideration in relation to the findings is that the SERV index actually measures the overall scale of the service sector and not its structural configuration. As a result, countries with identical ratios of service activity would still show considerable variance in their capacity to harness and apply human resources. This is due to the fact that more education-intensive service activities like ICT, finance, consulting, and research yield greater gains from investing in education and training compared to less sophisticated services such as retailing and hospitality.

Finally, the stability of$\beta_3$in the test excluding crisis periods (Column 6: β_3= 0.412***) is evidence that the moderating mechanism of structural change is a durable structural law, not a transient phenomenon caused by exogenous shocks. This is particularly important in the post-COVID-19 context, as ASEAN is reshaping its long-term development strategy towards the 2045 Vision. It should be note that large disturbances like the Asian Financial Crisis, the Global Financial Crisis, and the COVID-19 pandemic could possibly have shifted the fundamentals of the association between human capital, structural change, and growth through changes in investments and technology and changes in the deployment of labor. Hence, although the stability of the interaction coefficient across different model specifications is certainly good news, it cannot be said that the current exercise has tested for regimes or structural breaks.

5.4. Policy Implications

The results indicate that there will be different policy approaches needed based on the level of structural transformation achieved. The countries that are still below the estimated level of activation are recommended to encourage human capital development as well as the expansion of the modern services through policies aimed at investing in ICT, logistics, and digital financing. Moreover, industry-related vocational training programs must be initiated through the public-private partnerships approach. The other group of economies, which have already surpassed the activation threshold but are still undergoing the process of transformation, include Vietnam, Indonesia, Thailand, and Philippines among others. These countries will now focus on increasing the service quality through investment in innovation, research, development, and technology-based industries. On the other hand, advanced countries such as Singapore, Malaysia, and Brunei must continue investing in areas such as AI, fintech, and green technologies in order to sustain the level of growth. The entire region of ASEAN can improve its economic performance through enhanced labor mobility, skill standardization, and qualification accreditation by 2045.

5.5. Limitations and Future Research Directions

This study faces certain limitations. Firstly, due to the fact that World Bank HCI was made only starting from 2017, historical figures for 1994-2016 have been imputed based on constituent variables, which can lead to the presence of inaccuracies, especially regarding low-income ASEAN countries. However, when performing a robustness test by employing MYS data, similar outcomes have been achieved. Secondly, SERV serves as an indicator of overall service sector activity without differentiating between modern knowledge-based services and traditional activities, thereby reducing the accuracy of the calculated activation point of about 33%. Thirdly, since the study focuses only on ten ASEAN countries, results obtained might be highly biased and specific to certain countries in this region. Lastly, the calculated threshold is sample-specific, and thus should be viewed as the approximate range of activation, rather than a true structural point. Future studies would need to use industry or firm-level databases as well as methods of determining thresholds, using international data sets and incorporating variables such as digitization, institutional effectiveness, and green economies.

VI. CONCLUSION

This research goes back to a basic question posed in development economics about why the same amount of human capital investment leads to vastly different economic growth performance in ASEAN nations. Through a regression using data for the ten ASEAN nations spanning the years 1994-2023, it can be shown that human capital is not a self-reinforcing source of economic growth; rather, it is conditional and requires certain conditions before it can effectively contribute to economic growth. Empirically, the study finds that both structural transformation and human capital contribute to economic growth; moreover, the interaction term between the HCI and the share of services in the economy remains positive and statistically significant in all specifications. More importantly, in the System GMM specification, which the study prefers because of its dynamic nature, the interaction term remains positive and significant ($\beta = 0.386, p < 0.01$). One of the most important contributions of this research is the derivation of the benchmark level of human capital activation at the share of service-sector output reaching one-third of the total GDP (about 33%). While the benchmark level needs to be viewed as a guiding indicator rather than an inflexible threshold, it is clear that as economies transition towards more service-intensive and knowledge-based structures, the gains from human capital formation become significantly higher. This is also corroborated by the fact that the effect of human capital on GDP growth increases monotonically throughout the distribution of development of service sectors. The findings from the study have great relevance to the ASEAN Vision 2045. There must be a formulation of policies that would help in ensuring that there are structural changes and that modern services reach more people through education and health care programs and workforce development programs. Future studies may use service sector specific data, including estimation of thresholds and structural breaks.

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