INVESTIGATE THE IMPACTS OF FISCAL POLICY ON HUMAN CAPITAL AND ECONOMIC GROWTH IN THE OPTIMAL CONTROL APPROACH*

Piyasiri Kongwiriyapisal[1], Warinthorn Maneerat[2] and Adirek Vajrapatkul[3]
[1,3]School of economics, Sukhothai Thammathirat Open University, Thailand
[2]School of Agriculture and Cooperatives, Sukhothai Thammathirat Open University, Thailand
Corresponding Author's Email: a.vajrapatkul@gmail.com
Received 30 October 2025; Revised 10 December 2025; Accepted 12 December 2025

Abstract

This study examines the relationships between fiscal policy, human capital accumulation, and economic growth using a two-sector model adapted from the Uzawa-Lucas model. The model incorporates dual economic sectors, in which a social planner optimizes societal welfare through consumption, human capital, and economic growth. The results of the model simulation demonstrate that increased government spending in the education sector enhances both physical and human capital accumulation but has a neutral relationship with consumption. The analysis of the proportion of human capital H indicates that redistributing human capital between the production and education sectors affects consumption and physical capital accumulation but has minimal impact on human capital accumulation. These findings support the effectiveness of government spending as a tool for increasing human capital

Citation:
BY NC ND

* Piyasiri Kongwiriyapisal, Warinthorn Maneerat and Adirek Vajrapatkul. (2026). Investigate The Impacts Of Fiscal Policy On Human Capital And Economic Growth In The Optimal Control Approach. Journal of Interdisciplinary Social Development, 4(1), 94-125.;
DOI: https://doi.org/10.
Website: https://so12.tci-thaijo.org/index.php/JISDIADP/

accumulation and suggest that policymakers should maintain or increase educational investments while implementing complementary measures to maintain consumption levels while pursuing educational investment.

Keywords: Human Capital, Economic Growth, Fiscal Policy, Uzawa-Lucas Model

Introduction

Human capital, encompassing the workforce's skills, knowledge, and capabilities, serves as a fundamental driver of economic productivity and growth (Blair 2011). This concept has evolved beyond basic skills to include diverse forms, such as firm-, industry-, occupation-, and task-specific human capital (Sanders & Taber, 2012). Its significance is quantitatively demonstrated through its explanation of one-third of labor earnings variation within countries and half of that across nations (Deming, 2022). Human capital operates as both a direct productive input and a catalyst for growth through innovation and technological advancement (Gould & Ruffin, 1995). The impact of this capital on economic growth extends through multiple channels, including direct and indirect production effects through R&D activities (Cinnirella & Streb, 2017).

Human capital, measured by the HDI, is closely intertwined with economic growth, typically measured by GDP (Elistia & Syahzuni, 2018; Štilić et al., 2023), which creates employment opportunities, facilitates knowledge transfer, drives innovation (Meyer & Jongh, 2018), and improves long-term societal welfare (Szreter, 2001). However, the relationship between human capital and economic growth is mediated by various policy instruments, particularly fiscal policy, which typically serves as a crucial tool for managing economic growth, inflation, and employment (Alesina & Giavazzi, 2013). The impact of fiscal policy on human capital formation operates through both direct channels, such as supported education and training programs, and indirect channels, such as economic growth and labor markets (Angrist et al., 2021).

This means that the effectiveness of fiscal policy in human capital formation varies based on several attributes, such as policy implementation approaches, level of economic development, quality of institutions (Canh, 2018), country debt levels, and specific policy measures (Miller & Russek, 1997).

Several studies have examined the impact of fiscal policies on human capital and economic growth using various methods. For instance, Ghosh and Gregoriou (2007) investigated the effects of public expenditure on economic growth in 15 developing countries over 28 years using GMM techniques. They found that capital, health, and education expenditures positively impact growth. This study links optimal fiscal policy parameters to productivity in an endogenous growth framework that incorporates human capital. Chakraborty and Chakraborty (2018) used dynamic panel models and GMM estimations to analyze economic convergence across Indian states. They found that public capital spending has a positive and significant relationship with economic growth. They also highlight the importance of human capital in economic growth. Ramirez and Nazmi (2003) analyzed the impact of public investment spending and human capital on economic growth in nine major Latin American countries from 1983 to 1993. Using panel data analysis, they found that public expenditure on education and healthcare had a positive and statistically significant effect on private capital formation and long-term economic growth. However, Bushashe and Bayiley (2023), who examined the impact of fiscal decentralization on Ethiopia's subnational economic growth using a two-step System GMM, found the opposite, showing that expenditure had a negative effect on regional economic growth. They also found that human capital has no significant effect on regional economic growth.

This research is motivated by the complex interactions among fiscal policy, human capital accumulation, and economic growth, as revealed in previous studies. While the existing literature establishes these relationships, gaps remain in understanding the mechanisms through which government education spending affects both human and physical capital accumulation, which reflects the growth of the economy. The mathematical modeling approach addresses these gaps by quantifying the relationships between these variables and providing specific insights into policy effectiveness. This study contributes to the literature by adapting the Uzawa-Lucas model to examine a dual-sector economy. The remainder of this paper is organized as follows. The following section reviews the literature focusing on human capital theory and the Uzawa-Lucas model. Next, it describes the methodology, details the mathematical framework, and specifies the model. The empirical results, discussion, and policy implications are then presented.

Objectives

This study examines the effects of fiscal policy on human capital accumulation, consumption, and economic growth using a two-sector model adapted from the Uzawa-Lucas model.

Literature Reviews

This section focuses on two pivotal topics that form the foundational framework of this study: human capital and the Uzawa-Lucas model.

1. Human capital

Human capital theory, pioneered by neoclassical economists Gary Becker and Theodore Schultz, establishes a fundamental connection between educational investment and prosperity at both the individual and national levels (Fleming, 2017). This theoretical framework has become instrumental in shaping public policy across the education and labor sectors, significantly influencing various academic disciplines, including economics, education, and sociology. Human capital encompasses a comprehensive set of knowledge, skills, abilities, and characteristics that individuals possess, contributing directly to their economic productivity and value (Deming, 2022). The theory suggests that individuals can enhance their value through education and training, leading to improved skills, greater autonomy, and enhanced socioeconomic well-being (Fleming 2017). Therefore, investment in human capital generates impacts that manifest throughout an individual's lifetime, with particularly significant returns observed during childhood and early adulthood (Deming, 2022).

Human capital encompasses both innate abilities and acquired skills that individuals develop throughout their lives (Laroche et al., 1999). However, the fundamental dimensions of human capital include innate abilities, acquired skills, and external effects. Innate abilities, including intrinsic physical, intellectual, and psychological capacities present at birth, which are influenced by heredity, parental decisions, and random factors, represent an individual's potential to acquire skills without any direct action of their own. The acquired skills represent the actualization of potential through intergenerational knowledge transfer, personal contact, work experience, on-the-job training, education, and socialization. These skills can be further categorized as general skills, which are transferable across individuals, and specific skills, which are limited to particular activities. External effects or spillovers include both productivity spillovers and social externalities. Productivity spillovers occur when individuals influence others' productivity. Social externalities manifest through enhanced democratic institutions, freedom of thought, varied communication, and strengthening social institutions, collectively termed "social capital" (Laroche et al., 1999).

According to Ruggeri and Yu (2000), human capital encompasses four key dimensions that form a comprehensive framework. *The first dimension* is potential, which represents the foundational source of human capital and focuses on early childhood development and innate abilities before formal education. *The second dimension* is acquisition, which aligns with the traditional human capital theory and involves the conscious accumulation of knowledge and skills through formal education and training throughout one's life. *The third dimension* is availability, which distinguishes between the human capital possessed by a country's residents and that which is actually available for productive activity, addressing issues such as brain drain and international mobility. *The fourth dimension* is effectiveness, which concerns how human capital is utilized and performed in practical settings, emphasizing unused human capital, such as unemployed scientists. These dimensions are interconnected and flow from one stage to another, with policy implications affecting each stage differently. The framework demonstrates that human capital formation is not just an economic process but a complex social phenomenon that requires a holistic approach to policy and development.

The influence of human capital operates through two distinct but interconnected mechanisms. First, it directly enhances labor productivity in the production processes. Second, it indirectly accelerates technological advancement through enhanced R&D capabilities (Cinnirella & Streb, 2017). These mechanisms create a multiplicative effect that extends far beyond individual productivity and significantly impacts economic growth, inequality, and fiscal stability within societies. Thus, strategic investments in education, health, and skill development consistently yield positive outcomes for labor productivity, social equity, and public finance (Abrigo et al., 2018), which, in turn, support economic growth. However, the exact mechanisms by which human capital contributes to growth remain complex and are not fully understood (Deming, 2022). The significance of human capital investment has become even more critical in the context of an aging population and a rapidly evolving economy. Therefore, sustained investment in human capital development remains fundamental for maintaining economic growth and fostering sustainable development, despite the challenges of precisely measuring its full impact across all dimensions of economic and social progress.

2. The Uzawa-Lucas model

The "Uzawa-Lucas model" refers to the model of economic growth developed by Robert E. Lucas, Jr. in his 1988 paper, which builds upon the structure introduced by Hirofumi Uzawa (1965) emphasizing the role of human capital accumulation as an engine of sustained growth. The model is fundamentally a two-capital system that features both physical (K(t)) and human capital (h(t)). Key characteristics of this model are as follows: 1) Endogenous Growth via Human Capital, which is the central feature adapted from Uzawa's work, is the human capital accumulation technology. This technology postulates that the growth rate of human capital, h(t), is linear in the level already attained, h(t), and the effort devoted to acquiring more, 1-u(t). This relationship, which Lucas refers to as the Uzawa-Rosen formulation, is crucial because it permits sustained per-capita income growth from endogenous human capital accumulation alone, unlike traditional neoclassical models that require an exogenous technological change; (2) Time Allocation in that the model incorporates the decision of an individual to allocate time between two uses: current production, u(t), and human capital accumulation, 1-u(t); and (3) External Effects, which Lucas introduces an external effect of human capital, where the average level of skill or human capital (h_a) in the economy also contributes to the productivity of all factors of production. This external effect is significant because it creates a divergence between the social valuation formula and the private valuation of human capital; and 4) Dynamics such that when viewed as a closed economy, the system's dynamics predict that economies will converge to a balanced growth path where the long-run rate of income growth is the same for all, but the specific income level attained depends on the initial conditions. This means that initially poor economies can remain permanently below initially better-endowed economies, even though they grow at the same rate (Lucas, R. E., Jr., 1988). According to Lucas, R. E., Jr. (1988), the model is built upon three primary mathematical components, i.e., the production technology for goods, the accumulation technology for human capital, and the resulting formulas for the balanced growth rate. Goods Production Technology relates the total output of goods to the inputs of physical capital (K), effective labor (uhN), and the average level of human capital (h_a), which captures external effects. The equation that replaces the standard Solow model's production function is

$$N(t)c(t)+\dot{K}(t)=AK(t)^{\beta}[u(t)h(t)N(t)]^{1-\beta}h_a(t)^{\gamma}$$

where $N(t)c(t)+\dot{K}(t)$ represents total output (consumption plus net investment in physical capital, $\dot{K}$). K(t) denotes the total stock of physical capital. N(t) is the total population/labor force, growing at a rate λ. h(t) is the individual skill level or human capital. u(t) is the fraction of time devoted to current production. A is a constant technology level. β is the share of output attributed to physical capital ($0<\beta<1$). $h_a(t)$ is the average level of human capital, which represents the external effect on productivity (the Lucas component), governed by the elasticity γ. When all workers are identical, the average skill level h_a is equal to the individual skill level h.

For Human Capital Accumulation, which is the key mechanism for endogenous growth, adapted from Uzawa (1965), assumes that the growth rate of human capital is linear in the existing stock and the effort devoted to accumulation. This assumption avoids the diminishing returns that would otherwise cause growth to stop. The accumulation technology for human capital $\dot{h}(t)$ is:

$$\dot{h}(t)=h(t)\delta[1-u(t)]$$

where $\dot{h}(t)/h(t)$ is the rate of change of human capital. 1 - u(t) is the effort (time) devoted to human capital accumulation. δ is the maximum possible growth rate of human capital. This linear relationship ensures that a constant level of effort, 1-u(t), produces a constant growth rate of the human capital stock, ν, regardless of the level already attained, which is essential for sustained growth.

In terms of the Balanced Growth Rates, it states that on a balanced growth path, where per-capita consumption and capital grow at a constant rate κ, and human capital grows at a constant rate ν. The common growth rate of consumption and per-capita physical capital (κ) is determined by the growth rate of human capital (ν) and the technology parameters (β and γ):

$$\kappa = \frac{1-\beta+\gamma}{1-\beta}\nu$$

The specific rate of human capital growth, ν, is determined by whether the economy operates efficiently (optimal path) or competitively (equilibrium path), due to the external effects (γ).

In this model, the efficient growth rate (ν^*) which represents the socially optimal outcome, where a social planner internalizes the positive external effect γ is:

$$\nu^* = \sigma^{-1}\left[\delta - \frac{1-\beta}{1-\beta+\gamma}(\rho-\lambda)\right]$$

In addition, the competitive equilibrium growth rate (ν) represents the market outcome, where individual agents take the external effect $h_a(t)$ as given is:

$$\nu = [\sigma(1-\beta+\gamma)-\gamma]^{-1}\left[(1-\beta)(\delta-(\rho-\lambda))\right]$$

In these formulas, ρ is the discount rate, σ is the coefficient of relative risk aversion, and λ is the population growth rate. When the external effect $\gamma = 0$, the efficient (ν^*) and equilibrium (ν) growth rates coincide. Since κ and ν are endogenously determined by the parameters of the model ($\delta, \beta, \gamma, \rho, \sigma, \lambda$), this framework predicts sustained growth without needing an exogenous technological driver.

Therefore, the Uzawa-Lucas model acts like a mathematical perpetual motion machine for growth, i.e., as long as a society dedicates a constant fraction of its effort (1-u) to improving skills ($\dot{h}$), those skills multiply the existing stock, which, in turn, boosts overall productivity and physical capital accumulation ($\dot{K}$), leading to sustained economic expansion.

Scholars have identified several important attributes of the model. The model uniquely addresses structural change by allowing for sector-specific technical progress, thereby clarifying the conditions required for balanced growth in multi-sector economies (Chamley, 1993). Structurally, it represents a significant advancement over the neoclassical growth theory by introducing a two-sector framework that distinguishes between the production of consumer and capital goods (De Vroey, 2015). The concept of balanced growth in this framework helps specify the relationships between technological progress, capital accumulation, and labor allocation (Grossman et al., 2016). Essentially, the model is a cornerstone of endogenous growth theory, focusing specifically on human capital accumulation (Galbács 2022). It explains economic growth through the interaction between physical and human capital, which is driven by individuals' decisions to allocate their time between production and education (Bella et al., 2023). A key outcome of this mechanism is the model's ability to generate sustainable long-run growth without relying on exogenous technological progress, owing to the self-reinforcing nature of human capital investment (Hobara & Kuwahara, 2023). Recent extensions have incorporated various elements, including demographic aging (von Gaessler & Ziesemer, 2016), financial development (Bucci & Marsiglio, 2018), and labor-leisure choices (Hobara & Kuwahara, 2023). The model has proven particularly valuable in explaining why some countries fail to accumulate human capital, attributing this to boundary solutions, where economies allocate all available time to production rather than education (Bella et al., 2023).

The Uzawa-Lucas model has found extensive applications in various economic domains. Von Gaessler and Ziesemer (2016) demonstrated that when populations face aging, the optimal strategy is to increase education investment to enhance productivity and offset the negative effects of a rising dependency ratio. In financial development studies, Bucci, Calcagno, and Marsiglio (2021) extended the model to show how financial literacy affects economic growth through two distinct channels: the "financial return channel" and the "human capital channel," revealing that financial literacy positively impacts long-term economic development. The model has proven valuable for analyzing retirement policies and human capital accumulation patterns. Masuyama and Ohdoi (2022) utilized this framework to examine how the mandatory retirement age influences human capital investment decisions, finding that individuals always invest in their children's education but only invest in their own human capital when the retirement age is sufficiently high. In development economics, the model helps explain the persistence of poverty and middle-income traps. Hobara and Kuwahara (2023) incorporated "industriousness" into the model to demonstrate how economies with lower consumption utility shares can remain trapped in zero-growth steady states. The model has also been adapted to study environmental economics, with Bosi et al. (2023) introducing "living capital" as a comprehensive measure encompassing all living things and their interconnections, extending the traditional human capital focus to include environmental considerations.

These applications have been extended to public policy analyses. Melkumyan et al. (2023) applied the model to study educational reforms, showing that government taxation of consumption to fund education, despite decreasing short-term consumption, leads to higher long-term consumption levels through enhanced human capital accumulation. In international economics, Wafula and Njaramba (2024) employed the model to examine the relationship between foreign debt and literacy rates, whereas Ezefibe et al. (2024) used it to analyze how human capital flight impacts economic growth in developing nations. Most recently, Bucci and Prettner (2025) adapted the model to examine economic growth under population decline, showing that economies can sustain positive growth despite negative population growth when human capital investment sufficiently compensates for declining workforce size.

Empirical evidence indicates that human capital and economic growth are interrelated through multiple direct and indirect channels. Studies have shown that human capital investment can be stimulated by policies that reduce uninsurable labor income risk, leading to enhanced growth and improved welfare (Krebs, 2003). Historically, the accumulation of basic human capital, particularly literacy, was a crucial precondition for the transition to modern economic growth during the Second Industrial Revolution (Cinnirella & Streb, 2017). In contemporary contexts, investments in human capital have been found to directly boost labor productivity and output (Abrigo et al., 2018) while also positively affecting GDP growth and employment opportunities, especially in developing countries (Khan et al., 2019). However, this relationship is not without complexity and is subject to contextual factors. Early research suggested reciprocal causality, wherein technological changes also influence the demand for skilled workers, meaning that growth can drive human capital accumulation just as human capital can drive growth (Mincer, 1989). More recent studies caution that human capital alone may not significantly contribute to economic growth in all contexts (Aslam, 2020). Instead, its impact is often conditional on the context. The positive effects of human capital on growth are significantly reinforced by the presence of high-quality institutions, sufficient economic opportunities, and a favorable business environment (Ali et al., 2018; Aslam, 2020).

Furthermore, human capital is linked to consumption patterns, primarily through its influence on individuals' economic and employment prospects. However, this relationship is not direct. According to Coronel and Díaz-Roldán (2024), the impact of human capital on consumption is complex and contingent on the specific context and time frame being analyzed. The effect is ultimately mediated through various channels, such as productivity improvements, wage increases, and broader economic growth that human capital accumulation facilitates.

Government policies are a critical mechanism for supporting human capital formation and stimulating economic growth. A body of empirical research supports this relationship. For instance, studies have demonstrated that public spending on education and healthcare positively impacts human capital formation and promotes long-term economic growth (Ramirez and Nazmi, 2003). In a similar vein, Oluwatobi and Ogunrinola (2011) found that recurrent government expenditure specifically aimed at human capital development is positively correlated with the level of real output.

Methodology

This study employs a two-sector analytical framework adapted from Lucas, R. E., Jr. (1988) and Zhang (2017). The model's structural foundation incorporates dual economic sectors, in which a social planner aims to optimize societal welfare through three key parameters: consumption, human capital, and economic growth, which are measured through capital accumulation.

Producers in the production sector utilize the following Cobb-Douglas production technology:

$$Y_{G,t} = A_G \left(K_t\right)^{\alpha_1} \left(u_t H_t\right)^{1-\alpha_1}, \tag{1}$$

The producer's constraint is defined as

$$\dot{K}_t = Y_{G,t} - \delta K_t - C_t, \tag{2}$$

where $Y_{G,t}$ denotes quantity of goods. A_G, K_t, H_t, and C_t represent innovation, physical capital, human capital, and consumption. u is a proportion of human capital (reflecting time allocation) H in the production sector. α_1 represent the output proportion of capital. δ is the depreciation rate.

In the education sector, the producer uses the same production technology, defined by:

$$Y_{H,t} = A_H \left(1-u_t\right)\left(H_t\right)^{\alpha_2} \left(G_t\right)^{1-\alpha_2}, \tag{3}$$

The constraint of the producer is defined by the following human capital constraint

$$\dot{H}_t = Y_{H,t} - \delta H_t. \tag{4}$$

where $Y_{H,t}$ and G_t are knowledge stock and government spending, respectively. (1-u) denotes the proportion of human capital H in this sector. Thus, decreasing (u) increases the proportion of resources devoted to education and skill development, thereby enhancing the accumulation of human capital.

Household utility is assumed to be a function of consumption and human capital and can be expressed as follows:

$$U(C,H)=\frac{(C^{(1-\sigma)})}{(1-\sigma)}+\omega H^{\eta} \ , \tag{5}$$

where C represents consumption. H represents human capital. σ is the coefficient of relative risk aversion, where $\sigma > 1$ implies that individuals prefer smoother consumption over time, showing higher risk aversion. ω and η are parameters that determine the utility of human capital and η < 1 implies decreasing marginal utility of human capital.

Production and education sector constraints are used to solve the following current Hamiltonian:

$$Max_{C_t,u_t}\frac{C_t^{1-\sigma}}{1-\sigma}+\omega H_t^{\eta}+\lambda_{G,t}f_1\left(K_t,u_t,H_t,C_t,\dot{K}_t\right)+\lambda_{H,t}f_2\left(u_t,H_t,G_t,\dot{H}_t\right), \tag{6}$$

The solutions to this problem can be expressed as:

$$\frac{\dot{\lambda}_{G,t}}{\lambda_{G,t}}=\delta-\alpha_1 uA_G K_t^{\alpha_1-1}H_t(u_tH_t)^{-\alpha_2}, \tag{7}$$

$$\frac{\dot{\lambda}_{H,t}}{\lambda_{H,t}}=\frac{1}{A_G(\alpha_2-1)}\begin{pmatrix}\left(C_t^{\sigma}K_t^{-\alpha 1}(u_tH_t)^{\alpha 2}\eta\omega H_t^{\eta+\alpha 2-2}+H_t^{\alpha 2-1}(\alpha_2-1)\left((u_t-1)\alpha_2-u_t\right)A_G\right)\\ A_H G^{1-\alpha 2}+\delta A_G(\alpha_2-1)\end{pmatrix}. \tag{8}$$

Further modification by applying (2) and (4), we have the motion for consumption and the amount of human capital, respectively:

$$\dot{C}_t=\frac{C_t}{\sigma}\left(\alpha_1 A_G K_t^{\alpha_1-1}(u_tH_t)^{1-\alpha_2}-\delta\right), \tag{9}$$

$$\dot{u}_t = \frac{1}{\alpha_2 H_t A_G(\alpha_2 - 1)K_t}\left(2\begin{pmatrix} A_H(C_t^{\sigma}(u_t H_t)^{\alpha 2} H_t^{n+\alpha 2-1}\eta\omega K_t^{1-\alpha 1} \\ +((u_t-1)\alpha_2 - 1)K_t(-1+\alpha_2)A_G H_t^{\alpha 2}) \end{pmatrix} G^{-1-\alpha 2} \atop +\left(\delta K_t H_t + \alpha_1 H_t(\delta K_t + C_t)\right)(\alpha 2-1)A_G)\left(\alpha 2 - \frac{1}{2}\right) \right). \quad (10)$$

Results

In the following, the stability condition is investigated using the Jacobian matrix, determinant (Det), and Tract criteria.

$$J = \begin{bmatrix} a_1 & a_2 & a_3 & a_4 \\ a_5 & a_6 & a_7 & a_8 \\ -1 & A_G K^{\alpha 1} H(uH)^{-\alpha 2}(1-\alpha 2) & K^{\alpha 1-1} A_G \alpha 1 uH(uH)^{-\alpha 2} - \delta & A_G K^{\alpha 1} u(uH)^{-\alpha 2}(1-\alpha 2) \\ 0 & -A_H H^{\alpha 2} G^{1-\alpha 2} & 0 & -\alpha 2 A_H H^{-1+\alpha 2}(u-1)G^{1-\alpha 2} - \delta \end{bmatrix}$$

,

where

$$a_1 = \frac{{}_G\alpha 1 K_1^{\alpha l-1} A u_t H_1(u_1 H_1) - \alpha^2 - \delta}{\sigma},$$

$$a_2 = -\frac{K^{\alpha l-1} A_G \alpha l H(uH) - \alpha^2(-1+\alpha 2)C}{\sigma},$$

$$a_3 = \frac{K^{\alpha l-2}(\alpha l-1)A_G \alpha ln H(uH) - \alpha^2 C}{\sigma},$$

$$a_4 = -\frac{K^{\alpha l-1} A_G \alpha ln(uH) - \alpha^2(-1+\alpha 2)C}{\sigma},$$

$$a_5 = \frac{2\left(H^l K\eta\omega C^{-1}\sigma + \alpha l H\right)\left(-\frac{1}{2} + \alpha 2\right)u}{\alpha 2HK},$$

$$a_6 = \frac{2\left(2(\alpha 2+1)\right)\left(u - \frac{1}{2}\right)\begin{pmatrix} \alpha^2 K \alpha_H^2 G^{-1-\alpha^2} \\ +2\alpha_G^2 G^{-1+\alpha 2} K^{2\alpha l+1}(uH)^{-2\alpha^2} u(-1+\alpha 2)^3 H^{2-\alpha^2} \\ +(H^l K\eta\omega C^{\alpha} + (\delta(\alpha l+1)K + C\alpha l)H)A_H \end{pmatrix}\left(-\frac{1}{2}+\alpha 2\right)}{\alpha 2 H_4^l H^k}$$

,

$$a_7 = -\frac{2u\left(-\frac{1}{2}+\alpha 2\right)\left(2\alpha_G^2 G^{-1+\alpha 2} K^{2\alpha l+1} (uH)^{-2\alpha^2} u(-1+\alpha 2)^2 H^{2-\alpha^2} + CHA_H\right)\alpha l}{\alpha 2 H_4^l HK^2}$$

,

$$a_8 = \frac{1}{\alpha 2 H^2 A_H^l K}\left(6u\left(\begin{array}{l}\frac{1}{3}\alpha_H^2 K(u-1)(\alpha 2+1)(HH^{-1}+\alpha 2H^{\alpha 2}-H^{\alpha^2})G^{-\alpha 2} \\ +G^{-1+\alpha 2}u(-1+\alpha 2)^2\left(\begin{array}{l} H\left(\alpha 2-\frac{2}{3}\right) \\ H^{\alpha}H^{l-\alpha 2} \\ +\frac{1}{3}H^{2-\alpha 2}\end{array}\right)\alpha_G^2(uH)^{-2\alpha^2}K^{2\alpha l+1}\end{array}\right)\right)\left(-\frac{1}{2}+\alpha 2\right)$$

.

By assuming $\alpha_1 = 0.4$, $\alpha_2 = 0.8$, $\delta = 0.11$, $A_G = 1.1$, $A_H = 1.1$, $\sigma = 1.1$,, $\omega = 0.2$, $\eta = 0.6$, $C = 2$, $u = 0.6$, $K = 20$, $H = 40$, and $G = 1$, it provides that Det = 0.00094, Trace = -0.02304 , and $Trace^2/4$ = 0.00013, implying stability according to the stability conditions $Det(J) > 0, Tr(J) < 0$, and $Det(J) > Tr^2/4$.

We now analyze the impact of government spending on education. Figure 1 presents our baseline scenario, where government spending (G) is set to 1, and the utilization rate (u) is 0.6. These baseline values were used as reference points for subsequent comparisons.

The simulation results provide a detailed analysis of the model's dynamics under different policy scenarios, revealing the complex interactions between fiscal policy, consumption (C), physical capital (K), and human capital (H).

First, an analysis of increased government spending (G) in the education sector (Figure 2) demonstrates that fiscal policy is an effective tool for promoting capital accumulation. The simulation shows that a rise in government educational expenditure leads to enhanced levels of both physical capital (K) and human capital (H), as shown in Figures 2(c) and 2(d), respectively. In contrast, consumption (C) remained largely stable, with no significant changes (Figure 2a).

Next, the model investigates the effect of reallocating human capital by adjusting its utilization rate (u), which is the proportion allocated to the production sector. When 'u' is increased, directing more human capital toward production, the simulation results in Figure 3 show a distinct increase in physical capital (K) (Figure 3c). However, both human capital (H) and consumption (C) remain largely unchanged (Figures 3d and 3a, respectively).

Conversely, Figure 4 illustrates the consequences of decreasing the utilization rate (u), thereby shifting more resources to education. This reallocation leads to a decrease in both physical capital (K) (Figure 4c) and consumption (C) (Figure 4a). Notably, despite the increased allocation to the education sector, the level of human capital (H) does not exhibit a precise change (Figure 4d).

The principal finding of the model is that direct government spending is a highly effective instrument for increasing human capital accumulation, whereas simply reallocating existing human capital between sectors yields more ambiguous and potentially negative short-term outcomes for consumption and physical capital accumulation.

Discussion

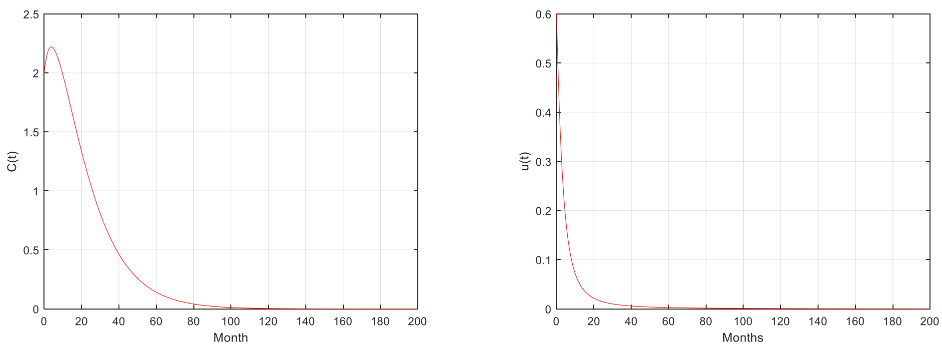
The empirical results demonstrate a relationship between government spending on education, human capital accumulation, and growth. Our analysis reveals that increased government education spending positively influences both human and physical capital accumulation, which aligns with the findings of Ramirez and Nazmi (2003), who established that public investment in education contributes to human capital formation and economic growth. Also, this finding corresponds to Khan et al.'s (2019) findings on the positive relationship between education expenditure and economic growth, represented by physical capital accumulation in this study. However, in this case, the consumption (C) remained largely stable. This result may be manifested through two competing effects: while government spending in education tends to increase human and physical capital accumulation, which should, in turn, **promote consumption growth**, that spending transfers the resources that should be allocated to foster **consumption**. These opposing forces may effectively neutralize the potential positive effects of consumption, resulting in minimal changes in consumption. This dynamic supports the findings of Laroche et al. (1999), who emphasized the multidimensional nature of human capital development and its complex interactions with economic variables.

The results regarding u provide additional insights into the dynamics of human capital. The findings indicate that adjustments to u can impact consumption and physical capital accumulation but have minimal effects on human capital accumulation. This observation connects to Ruggeri and Yu's (2000) dimensional framework, particularly their emphasis on the effectiveness dimension, which focuses on how human capital is utilized in practice. The limited impact of utilization rate changes on human capital accumulation suggests that the mere reallocation of resources between the production and education sectors does not guarantee improved human capital.

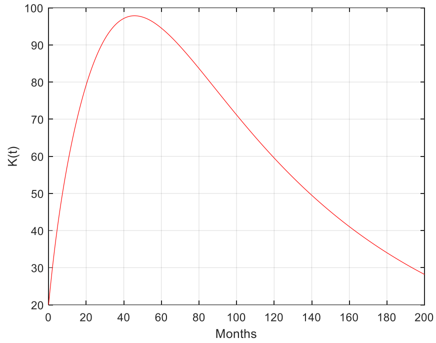
In aggregate, the findings support Cinnirella and Streb's (2017) and Abrigo et al.'s (2018) assertion that human capital operates through multiple channels, directly enhancing labor productivity and indirectly accelerating technological advancement, which supports economic growth. Thus, government spending on education, which supports human capital accumulation, can encourage economic growth. Additionally, the simulation evidence from this study reinforces a broader understanding of how fiscal policies can promote human capital and economic growth, as documented in previous studies by Ramirez and Ogunrinola (2011) and Oluwatobi and Nazmi (2003).

New knowledge

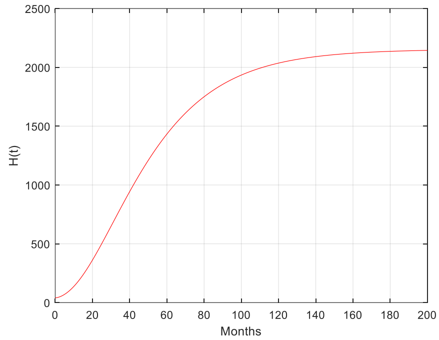
This study examines the relationship between fiscal policy, human capital accumulation, and economic growth using a theoretical framework. The analysis employed a two-sector analytical framework adapted from the Uzawa-Lucas model, incorporating dual economic sectors, in which a social planner optimizes societal welfare through consumption, human capital, and economic growth parameters. Mathematical modeling has revealed several interesting findings regarding the impact of government education spending and human capital utilization. The results demonstrate that increased government spending in the education sector leads to enhanced levels of both physical and human capital without impacting consumption. The analysis of u indicates that redistributing human capital between the production and education sectors affects consumption and physical capital accumulation but has a minimal impact on human capital accumulation. The findings reveal that government spending is an effective tool for increasing human capital accumulation, suggesting that policymakers should maintain or increase educational investment. However, the neutral relationship between consumption and government spending indicates the need for complementary measures to maintain consumption levels while pursuing educational investments.



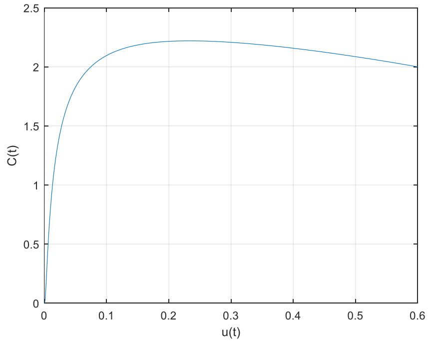
(a) (b)



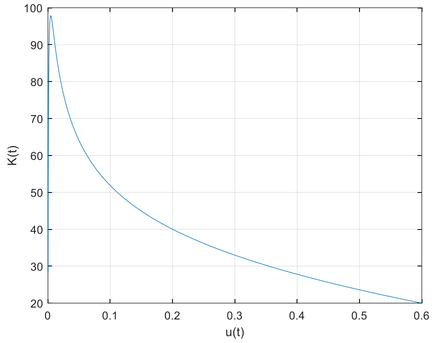
(c)



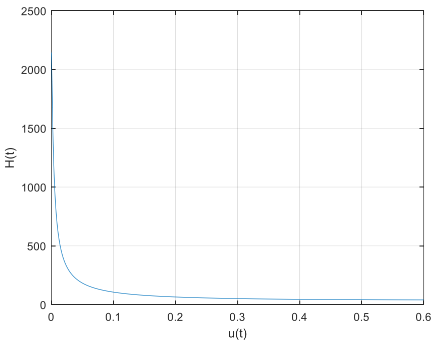
(d)



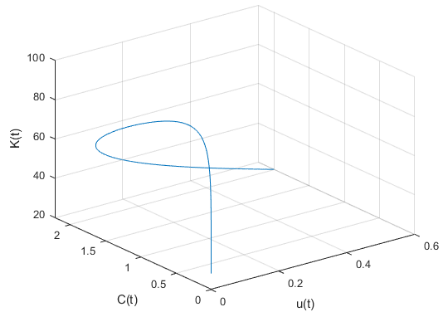
(e)



(f)

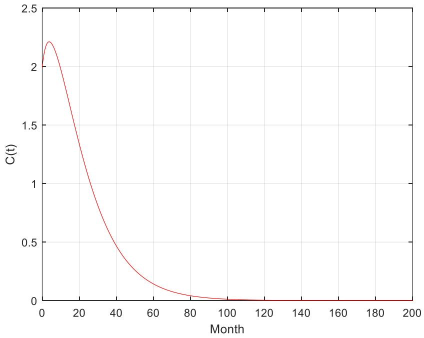


(g)

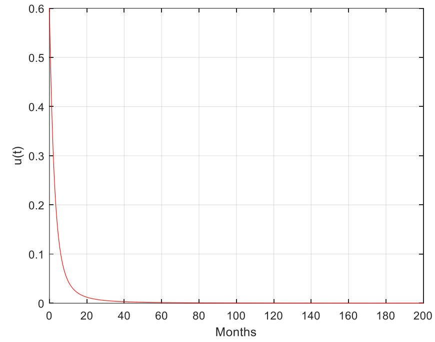


(h)

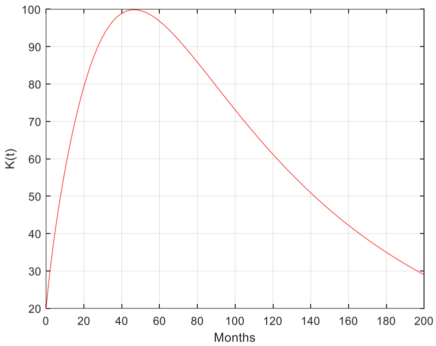
Figure 1 G=1, u=0.6


C(t)
0
0.5
1
1.5
2
2.5
0 20 40 60 80 100 120 140 160 180 200
Month

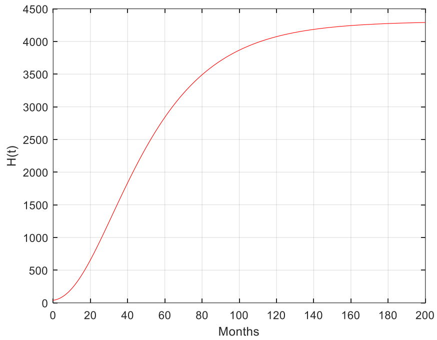
(a)


u(t)
0
0.1
0.2
0.3
0.4
0.5
0.6
0 20 40 60 80 100 120 140 160 180 200
Months

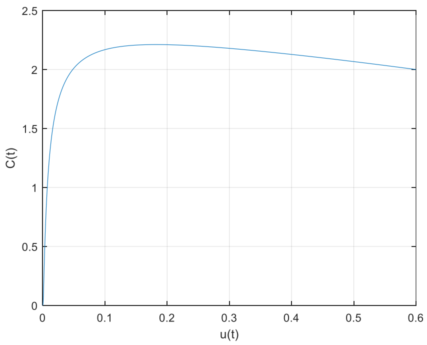
(b)


K(t)
20
30
40
50
60
70
80
90
100
0 20 40 60 80 100 120 140 160 180 200
Months

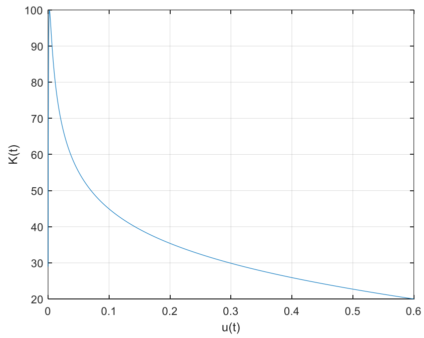
(c)


H(t)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0 20 40 60 80 100 120 140 160 180 200
Months

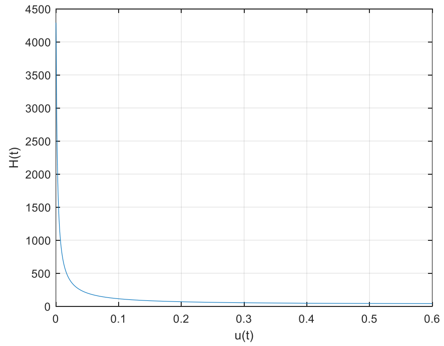
(d)


C(t)
0
0.5
1
1.5
2
2.5
0 0.1 0.2 0.3 0.4 0.5 0.6
u(t)

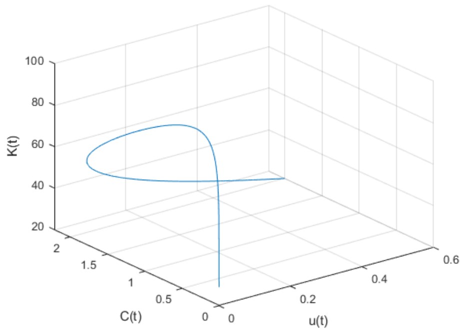
(e)


K(t)
20
30
40
50
60
70
80
90
100
0 0.1 0.2 0.3 0.4 0.5 0.6
u(t)

(f)

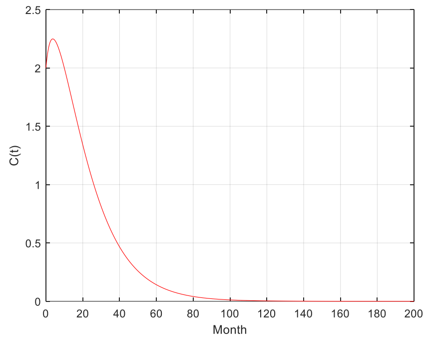


(g)

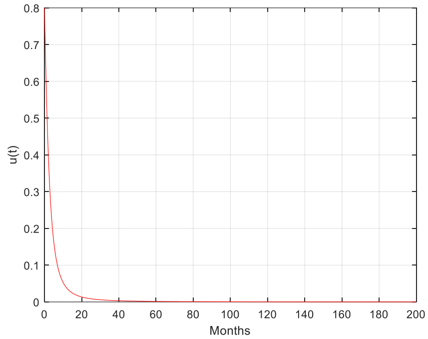


(h)

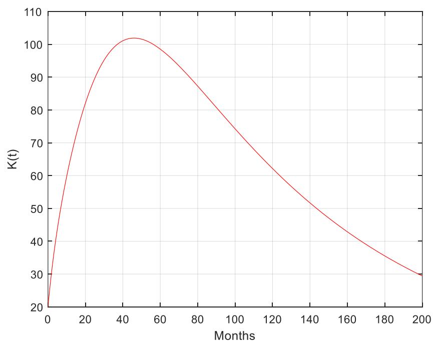
Figure 2 G=2, u=0.6



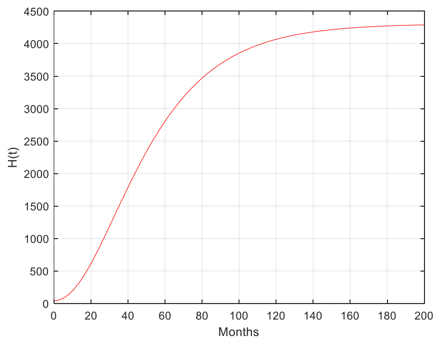
(a)



(b)



(c)



(d)

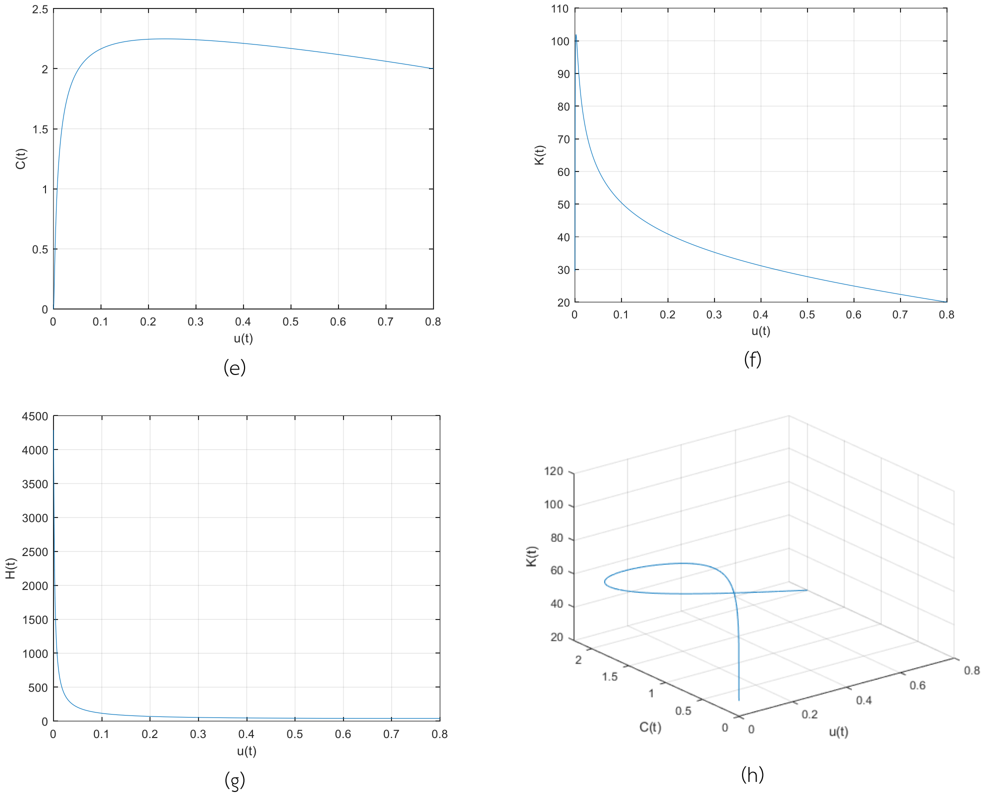
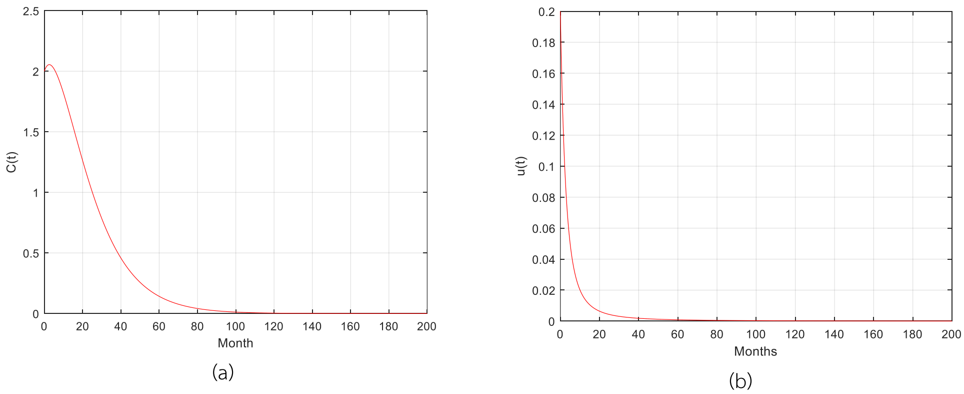


Figure 3 G=2, u=8



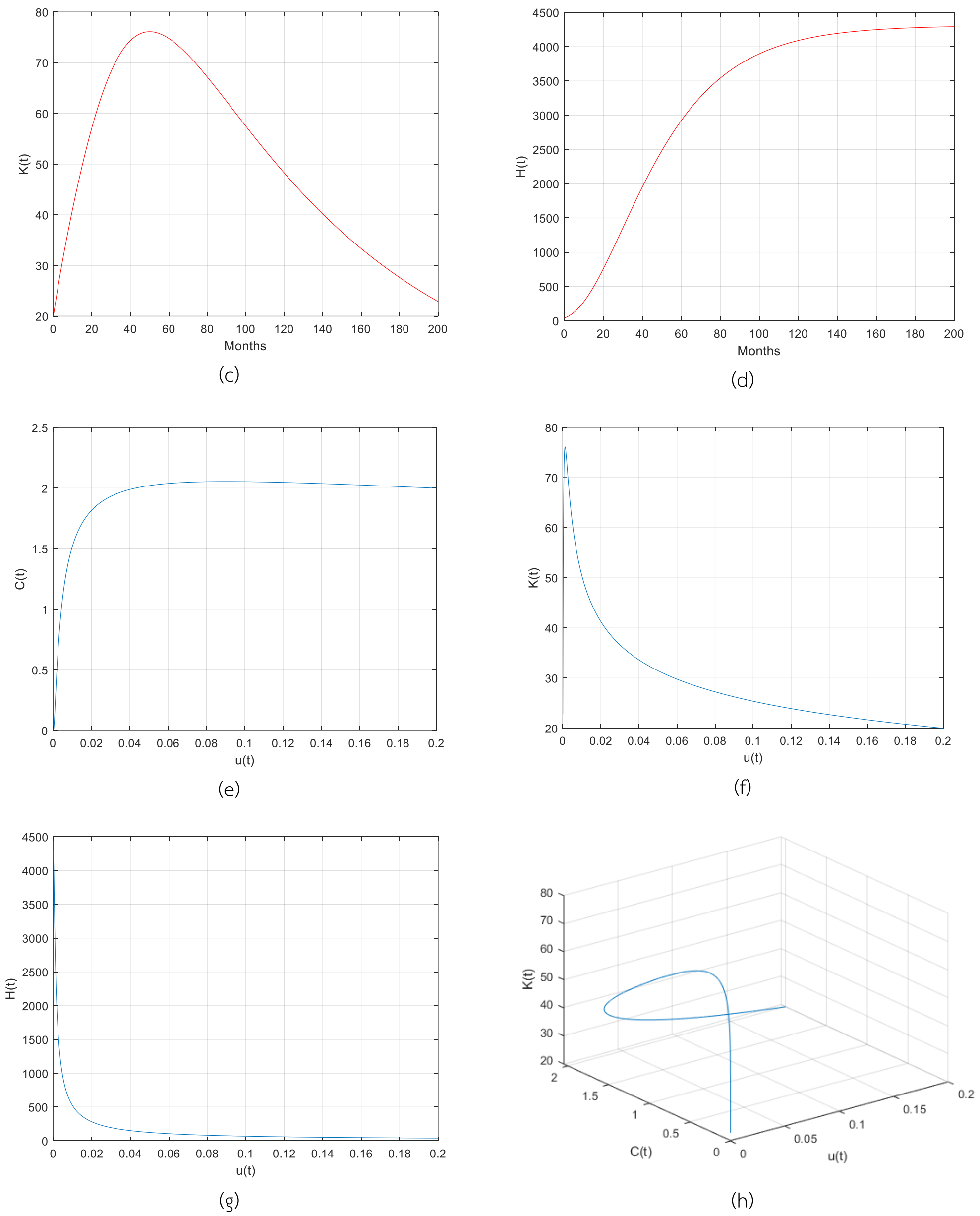


Figure 4 G=2, u=2

Recommendation

Based on the results of the analysis, we propose several key policy implications for enhancing human capital and economic growth. As the model demonstrates that government educational spending generates positive effects on both human and physical capital accumulation, but has a neutral relationship with consumption, the government should increase this spending while implementing complementary measures to encourage consumption levels while pursuing educational investment. This could include targeted support programs of educational spending to maximize the positive effects on consumption or provide financial assistance or subsidies to households that may be negatively impacted by the government spending shift to the education sector.

Moreover, the finding that u adjustments have a limited impact on human capital accumulation indicates that policies should focus on the quality and effectiveness of educational production, for instance, better teaching methods, updated curricula, and technologies that genuinely enhance skills, rather than just shifting effort to this production or merely redistributing resources between the production and education sectors.

Future research

Our findings suggest directions for future research on fiscal policy, human capital accumulation, and economic growth. Researchers should explore the optimal balance between government spending on education and its effects on consumption across different model formulations. Furthermore, future research may empirically investigate, especially in cross-country comparisons, the relationship between government education spending, human capital accumulation, and economic growth to verify the findings of this simulation study.

Acknowledgement

This research was supported by the School of Economics, Sukhothai Thammathirat Open University, Thailand. This research was also supported by the School of Agriculture and Cooperatives, Sukhothai Thammathirat Open University, Thailand.

Reference

Abrigo, M. R. M., Lee, S.-H., & Park, D. (2018). Human Capital Spending, Inequality, and Growth in Middle-Income Asia. Emerging Markets Finance and Trade, 54(6), 1285–1303. https://doi.org/10.1080/1540496x.2017.1422721

Adafre Bushashe, M., & Takele Bayiley, Y. (2023). The effect of fiscal decentralization on economic growth in sub-national governments of Ethiopia: A two-step system general methods of moments (GMM) approach. Public and Municipal Finance, 12(2), 32–42. https://doi.org/10.21511/pmf.12(2).2023.03

Alesina, A., & Giavazzi, F. (2013). Fiscal Policy after the Financial Crisis. University of Chicago. https://doi.org/10.7208/chicago/9780226018584.001.0001

Ali, M., Egbetokun, A., & Memon, M. (2018). Human Capital, Social Capabilities and Economic Growth. Economies, 6(1), 1-18. https://doi.org/10.3390/economies6010002

Angrist, N., Patrinos, H. A., Djankov, S., & Goldberg, P. K. (2021). Measuring human capital using global learning data. Nature, 592(7854), 403–408. https://doi.org/10.1038/s41586-021-03323-7

Aslam, A. (2020). The hotly debate of human capital and economic growth: why institutions may matter? Quality & Quantity, 54(4), 1351–1362. https://doi.org/10.1007/s11135-020-00989-5

Bella, G., Kogan, K., Mattana, P., Tsadikovich, D., & Venturi, B. (2023). Does boundary solutions of the Lucas endogenous growth model explain why some countries are not accumulating human capital? [Research Article]. https://doi.org/10.21203/rs.3.rs-3473211/v1

Blair, M. M. (2011). An Economic Perspective on the Notion of 'Human Capital' (pp. 49–70). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199532162.003.0002

Bosi, S., Camacho, C., & Le Van, C. (2023). A model of growth with living capital. HAL Open Science. https://hal.science/hal-04287255v1

Bucci, A., Calcagno, R., & Marsiglio, S. (2021). Financial Literacy, Human Capital and Economic Growth. https://gflec.org/wp-content/uploads/2022/04/Calcagno-Riccardo-Financial-Literacy-Human-Capital-and-Economic-Growth.pdf

Bucci, A., & Marsiglio, S. (2018). Financial development and economic growth: long-run equilibrium and transitional dynamics. Scottish Journal of Political Economy, 66(3), 331–359. https://doi.org/10.1111/sjpe.12182

Bucci, A., & Prettner, K. (2025). Endogenous depopulation and economic growth (GLO Discussion Paper No. 1585). Global Labor Organization. https://hdl.handle.net/10419/314331

Chakraborty, L., & Chakraborty, P. (2018). Federalism, fiscal asymmetries and economic convergence: evidence from Indian States. Asia-Pacific Journal of Regional Science, 2(1), 83–113. https://doi.org/10.1007/s41685-018-0087-z

Chamley, C. (1993). Externalities and Dynamics in Models of "Learning or Doing." International Economic Review, 34(3), 583-609. https://doi.org/10.2307/2527183

Cinnirella, F., & Streb, J. (2017). The role of human capital and innovation in economic development: evidence from post-Malthusian Prussia. Journal of Economic Growth, 22(2), 193–227. https://doi.org/10.1007/s10887-017-9141-3

Coronel, V. J., & Díaz-Roldán, C. (2024). Government Expenditure, Education, and Productivity in the European Union: Effects on Economic Growth. Economics, 18(1), 1-24. https://doi.org/10.1515/econ-2022-0081

De Vroey, M. (2015). A History of Macroeconomics from Keynes to Lucas and Beyond. Cambridge University Press. https://doi.org/10.1017/cbo9780511843617

Deming, D. J. (2022). Four Facts about Human Capital. Journal of Economic Perspectives, 36(3), 75–102. https://doi.org/10.1257/jep.36.3.75

Elistia, E., & Syahzuni, B. A. (2018). The Correlation Of The Human Development Index (Hdi) Towards Economic Growth (Gdp Per Capita) In 10 Asean Member Countries. Jhss (Journal Of Humanities And Social Studies), 2(2), 40–46. https://doi.org/10.33751/jhss.v2i2.949

Ezefibe, C., Eze, A. E., & Okoli, U. V. (2024). Human capital flight and economic growth in Nigeria. Journal of Economic Studies, 21(2), 113-127.

Fleming, P. (2017). The Human Capital Hoax: Work, Debt and Insecurity in the Era of Uberization. Organization Studies, 38(5), 691–709. https://doi.org/10.1177/0170840616686129

Galbács, P. (2022). Lucas's early engagement in endogenous growth theory. Retrieved from https://ssrn.com/abstract=4674071

Ghosh, S., & Gregoriou, A. (2007). The composition of government spending and growth: is current or capital spending better? Oxford Economic Papers, 60(3), 484–516. https://doi.org/10.1093/oep/gpn005

Gould, D. M., & Ruffin, R. J. (1995). Human capital, trade, and economic growth. Weltwirtschaftliches Archiv, 131(3), 425–445. https://doi.org/10.1007/bf02707911

Grossman, G. M., Oberfield, E., Sampson, T., & Helpman, E. (2016). Balanced Growth Despite Uzawa. American Economic Review, 107(4), 1293–1312. https://doi.org/10.1257/aer.20151739

Hobara, N., & Kuwahara, S. (2023). An economic growth model with education and industriousness. Journal of Economic Development, 48(1), 31-57.

Khan, R., Farooq, F., & Chaudhry, I. S. (2019). Impact of Human Capital on Employment and Economic Growth in Developing Countries. Review of Economics and Development Studies, 5(3), 487-496. https://doi.org/10.26710/reads.v5i3.701

Krebs, T. (2003). Human Capital Risk and Economic Growth. The Quarterly Journal of Economics, 118(2), 709–744. https://doi.org/10.1162/003355303321675491

Laroche, M., Mérette, M., & Ruggeri, G. C. (1999). On the concept and dimensions of human capital in a knowledge-based economy context. Canadian Public Policy, 25(1), 87-100.

Lucas, R. E., Jr. (1988). On the mechanics of economic development. Journal of Monetary Economics, 22, 3–42.

Masuyama, M., & Ohdoi, R. (2022). The relationship between mandatory retirement and patterns of human capital accumulation. Economics Bulletin, 42(2), 1192-1202.

Melkumyan, M., Igityan, H., Sahakyan, M., & Baharyan, F. (2023). Introducing educational reforms in the neoclassical model. Economic Studies (Ikonomicheski Izsledvania), 32(6), 41-53.

Meyer, N., & De Jongh, J. (2018). The Importance of Entrepreneurship as a Contributing Factor to Economic Growth and Development: The Case of Selected European Countries. Journal of Economics and Behavioral Studies, 10(4(J)), 287–299. https://doi.org/10.22610/jebs.v10i4(j).2428

Miller, S. M., & Russek, F. S. (1997). FISCAL STRUCTURES AND ECONOMIC GROWTH: INTERNATIONAL EVIDENCE. Economic Inquiry, 35(3), 603–613. https://doi.org/10.1111/j.1465-7295.1997.tb02036.x

Mincer, J. (1989). Human Capital Responses to Technological Change in the Labor Market. National Bureau of Economic Research. https://doi.org/10.3386/w3207

Oluwatobi, S. O., & Ogunrinola, O. I. (2011). Government Expenditure on Human Capital Development: Implications for Economic Growth in Nigeria. Journal of Sustainable Development, 4(3), 72-80. https://doi.org/10.5539/jsd.v4n3p72

Phuc Canh, N. (2018). The effectiveness of fiscal policy: contributions from institutions and external debts. Journal of Asian Business and Economic Studies, 25(1), 50–66. https://doi.org/10.1108/jabes-05-2018-0009

Ramirez, M. D., & Nazmi, N. (2003). Public Investment and Economic Growth in Latin America: an Empirical Test. Review of Development Economics, 7(1), 115–126. https://doi.org/10.1111/1467-9361.00179

Ruggeri, G. C., & Yu, W. (2000). On the dimensions of human capital: An analytical framework (Working Paper Series 2000-05). Department of Economics, The University of New Brunswick, Fredericton, Canada.

Sanders, C., & Taber, C. (2012). Life-Cycle Wage Growth and Heterogeneous Human Capital. Annual Review of Economics, 4(1), 399–425. https://doi.org/10.1146/annurev-economics-080511-111011

Štilić, A., Mastilo, A., Mastilo, D., & Vuković, K. (2023). Innovative Solutions for Economic Growth: Exploring the Impact of Economic Freedoms on Foreign Direct Investment Attraction. ECONOMICS, 11(1), 29–44. https://doi.org/10.2478/eoik-2023-0013

Szreter, S. (2001). Economic Growth, Disruption, Deprivation, Disease, and Death: On the Importance of the Politics of Public Health for Development (Vol. 23, Issue 4, pp. 76–116). Palgrave Macmillan UK. https://doi.org/10.1057/9780230524248_5

Uzawa, H. (1965). Optimum technical change in an aggregative model of economic growth. International Economic Review, 6(1), 18–31.

von Gaessler, A. E., & Ziesemer, T. (2016). Optimal education in times of ageing: The dependency ratio in the Uzawa–Lucas growth model. The Journal of the Economics of Ageing, 7, 125-142. https://doi.org/10.1016/j.jeoa.2016.03.001

Wafula, G. M., & Njaramba, S. G. (2024). Effect of foreign debt on literacy rate in Kenya. European Journal of Economic and Financial Research, 8(3), 60-77. https://doi.org/10.46827/ejefr.v8i3.1697

Zhang, W. B. (2017). A Multi-Country Trade and Tourism with Endogenous Capital and Knowledge. Business Systems Research, 8(1), 71-91. https://doi.org/10.1515/bsrj-2017-0007