

Theoretical and Practical Research in Economic Fields

Quarterly

Volume XV

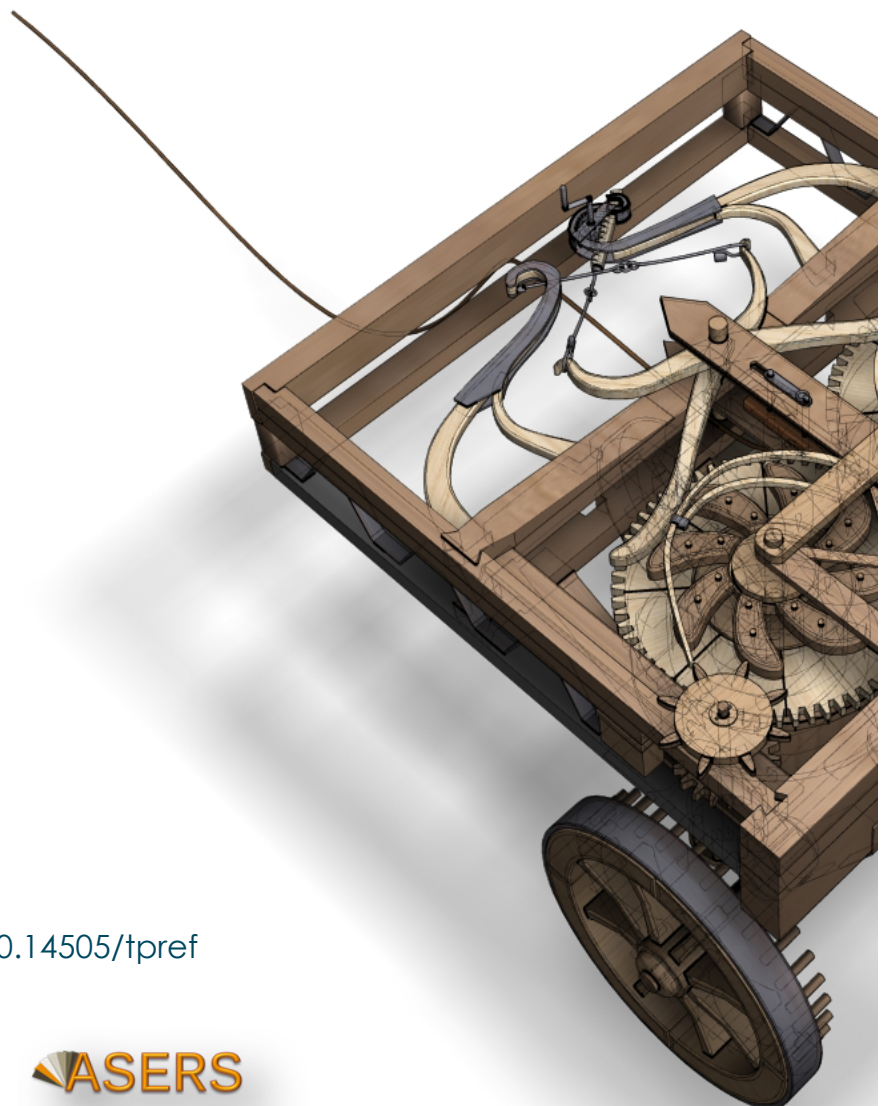
Issue 3(31)

Fall 2024

ISSN: 2068 – 7710

Journal DOI: <https://doi.org/10.14505/tpref>

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ISSN 2068 – 7710

Journal's Issue DOI:

[https://doi.org/10.14505/tpref.v15.3\(31\).00](https://doi.org/10.14505/tpref.v15.3(31).00)

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Many economists today are concerned by the proliferation of journals and the concomitant labyrinth of research to be conquered in order to reach the specific information they require. To combat this tendency, **Theoretical and Practical Research in Economic Fields** has been conceived and designed outside the realm of the traditional economics journal. It consists of concise communications that provide a means of rapid and efficient dissemination of new results, models, and methods in all fields of economic research.

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DOI: [https://doi.org/10.14505/tpref.v15.3\(31\).13](https://doi.org/10.14505/tpref.v15.3(31).13)

The Nexus of Fiscal Policy and Growth in the Optimal Control Framework

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Article info: Received 14 July 2024; Received in revised form 13 August 2024; Accepted for publication 31 August 2024; Published 30 September 2024. Copyright© 2024 The Author(s). Published by ASERS Publishing. This is an open access article under the CC-BY 4.0 license.

Abstract: This research investigates the effect of fiscal policy on economic growth, focusing on the intertwined relationship between public goods provision, taxation policies, and their impact on economic dynamics and growth. The study aims to contribute to this research domain by introducing an economic model within the optimal control framework that integrates taxation policies into the social constraint and incorporates public goods into the social utility function, addressing recent limitations in this research area. Through numerical analysis, the study examines the potential effects of taxes and public goods provision on consumption and economic growth, as reflected by the level of capital. Results indicate that increasing government spending on public goods can decrease private goods consumption without significant economic growth benefits. At the same time, high tax rates could potentially hinder economic growth by overly relying on government intervention. The research findings highlight the importance of an optimal approach to fiscal policy, with policy implications including the need to carefully evaluate public funds' allocation, enhance public spending efficiency, and implement optimal tax to foster economic growth.

Keywords: tax; consumption; public goods; economic growth; optimal control.

JEL Classification: C62; E62; H30.

Introduction

The intertwined relationship between public goods provision, taxation policies, and their impact on economic dynamics has been a subject of intense scholarly inquiry and practical policymaking. Public goods, defined as non-excludable and non-rivalrous resources benefiting society collectively, encompass essential services such as national defence, sanitation, education, and infrastructure. Their provision is vital for societal well-being, economic growth, and the overall prosperity of nations. Public goods shape economic dynamics by influencing resource allocation, societal well-being (Lerch *et al.* 2022), economic growth, and development (Hazelkorn and Gibson, 2019). Taxation policies, on the other hand, serve as a mechanism for governments to finance the provision of public goods and other essential services (Paul and Robin, 2015). The structure and implementation of tax policies can influence business performance, government revenue, and economic growth. Understanding the effects of these public goods provision and taxation policies on the economy is paramount for policymakers and stakeholders to make informed decisions regarding public investments and resource distribution. Therefore, this research tries to explore these effects and provides additional knowledge for those related agents.

The provision of public goods is crucial for promoting societal well-being and addressing various socio-economic challenges. Access to education, healthcare, and infrastructure, for example, are essential components of public goods provision that contribute to economic growth and development (Hazelkorn and Gibson, 2019). Investments in these areas lead to positive externalities that enhance productivity, human capital development,

and overall welfare. For example, education serves as a cornerstone for economic progress by equipping individuals with the skills and knowledge necessary to effectively participate in the labour market. A well-educated workforce fosters innovation, entrepreneurship, and technological advancement, driving economic growth and competitiveness on a global scale. Furthermore, market failures, such as the inability of private markets to efficiently allocate resources, often necessitate government intervention to ensure the equitable distribution and provision of public goods (Paul and Robin, 2015).

Also, taxation policies play a critical role in shaping economic growth, business performance, and government fiscal sustainability, as the structure and level of taxation can influence investment decisions, consumer behaviour, and overall economic activity. While taxation is necessary to finance public expenditures, excessive taxation can hinder economic growth by imposing burdensome compliance costs and distorting market incentives. The impact of taxation on economic growth depends on factors such as the tax structure, tax rates, and the efficiency of tax administration. Personal income tax and social contributions, for example, have positive effects on economic growth, while distortionary taxes, such as those on income and property, can have a depressing effect on growth (Stoilova, 2017). Moreover, it was indicated that a high tax burden can significantly impact the economic viability of businesses. Thus, taxation policies can shape the business environment and economic landscape (Buliková *et al.* 2021) and the fluctuations in the tax burden can exert profound effects on industry and economic development (Cao and Liu, 2023).

The relationship between public goods, tax, and economic growth has been studied using various research methodologies, each providing unique insights into the dynamics of public goods, taxation, and economic growth. One study utilized a dynamic model of the Generalized Method of Moments (GMM) to analyze the effect of government expenditure on goods and services and capital on regional economic growth in Indonesia. It found that public spending positively affects economic growth, while local tax efforts negatively moderate this relationship, reducing the positive impact of capital expenditure on growth (Amri *et al.* 2023). Another research employed a Vector Autoregression (VAR) model to explore the relationship between economic growth and different types of tax revenues, including those on goods and services. The study concluded that tax revenue on income, profit, and capital significantly impacted economic growth, followed by tax revenue on goods, services, and international trade (Lim and Eng, 2023). A study in Nigeria used regression analysis to examine the relationship between taxation policy and economic growth, finding significant positive relationships between various taxes and economic growth (Kehinde *et al.* 2023). In the European Union, a study using ordinary least squares (OLS) and Granger causality tests found that total tax revenue positively impacts economic growth, while government spending has a negative effect. The study suggests that the structure of tax systems supports growth, with direct and indirect taxes being beneficial, whereas social security contributions are detrimental (Stoilova, 2023). In Türkiye, the augmented autoregressive distributed lag (A-ARDL) bound test approach was used to assess the impact of tax and public expenditure on GDP. The findings indicated that tax revenue positively impacts economic growth in the short run but negatively in the long run, while public expenditures generally have a positive impact (Celik and Köstekçi, 2024).

Understanding the complex interplay between public goods provision, taxation policies, and economic dynamics is essential for policymakers and stakeholders to formulate effective strategies for promoting sustainable growth, reducing inequality, and addressing societal challenges. By examining the effects of public goods provision and taxation policies on economic outcomes, policymakers can identify opportunities for enhancing resource allocation, fostering innovation, and promoting inclusive development to benefit the economy's sustainable growth and development.

This research provides a new perspective and contributes to the understanding of the interplay between public goods provision, taxation policies, and economic growth by integrating public goods and taxation into an optimal control framework that integrates taxation policies into the social constraint and incorporates public goods into the social utility function, addressing recent limitations in this research domain and apply stability analysis as well as the numerical approach to understand how these policies influence consumption and economic growth over time. To achieve these objectives, this research organizes the following sections. The second section will explore pertinent concepts concerning public goods, taxation, and the results of some previous studies. Section 3 will outline the research methodology employed in this study. Subsequently, the analysis results, discussions, and policy implications will be presented.

1. Literature Reviews

This section explores the concepts and the multifaceted impacts of public goods provision and taxation policies on the economy.

Public goods are non-excludable and jointly consumed, meaning one person's use does not diminish the availability for others, and individuals cannot be effectively excluded from using them. Examples include national defence, public education, clean air, and law enforcement. Governments typically provide these goods, funded through taxation, distinguishing them from private goods, which are paid for individually (Deneulin and Townsend, 2007). The unique nature of public goods often results in market failures, as traditional market mechanisms struggle to supply these goods adequately. This necessitates intervention through governmental or quasi-governmental organizations to manage their provision and consumption (Ostrom *et al.*, 2013). A significant challenge in providing public goods is the "free-rider" problem, where individuals benefit from the good without contributing to its provision, posing sustainability issues (Holcombe, 1997; Besley and Ghatak, 2006). Public goods significantly influence the economy, impacting household consumption and Subjective Well-Being (SWB). By offering economies of scale, they reduce household expenditures on public goods, allowing increased private goods consumption and enhancing SWB (Li *et al.* 2020). The provision of public goods also shapes individual preferences and consumption patterns, generating positive externalities that benefit society. Transportation networks, for example, improve accessibility and quality of life, directly affecting private consumption patterns. Also, environmental protection influences consumption decisions as a public good, thereby affecting demand in specific sectors (Reiss, 2021). Public spaces, another form of public good, are crucial for enhancing social capital and income growth, essential for economic development (Su *et al.* 2024). However, providing public goods can create conflicts between equity and efficiency, potentially benefiting one group while disadvantaging another (Buchholz *et al.* 2018). Additionally, excessive public sector intervention can lead to market distortions, affecting competition and investment decisions (Baird, 2004). Another challenge in public goods provision is the misperceptions of public goods costs, which can result in voter error and resource misallocation (Lipi *et al.* 2024; Lang *et al.* 2022).

Taxation, a fiscal policy instrument, allows governments to collect revenue from individuals and businesses to fund public expenditures and services. Taxation serves as a crucial source of revenue for the government to finance public expenditures and services, and it can be used to influence economic behaviour, redistribute wealth, and address market failures like externalities (Hindriks and Myles, 2013). The implementation of taxation can affect the economy, e.g., economic growth, labour supply, productivity, and fiscal policy effects. Although there are different forms of taxation, a study identified that consumption taxes, personal income taxes, and property taxes have been more supportive of economic growth than other forms of taxation (Stoilova, 2017). However, excessive tax burdens can negatively impact businesses and economic strength (Buliková *et al.* 2021). Therefore, the optimal taxation theory seeks to determine the most efficient and equitable tax structures to maximize social welfare while considering behavioural responses to taxes (Kaplow, 2008). Empirical studies have shown varying results on the effect of taxation on economic growth, highlighting the complexity and inconclusiveness of theoretical predictions. A study highlights that high tax rates can discourage savings and investment, limiting capital formation and long-term economic development (Stiglitz and Rosengard, 2015). In China, the tax cuts and fee reduction policies have significantly impacted consumer income and expenditure, particularly benefiting younger consumers more than older ones (Wang, 2024). In South Africa, personal income tax has a growth-friendly effect in the short run. Still, in the long run, positive changes in personal income tax are detrimental to economic growth. This suggests that the current tax system, which heavily relies on personal income tax, may need restructuring to support long-term economic growth (Tala, 2024). Nigeria's economic development is influenced by various taxes, with personal income tax and value-added tax having a short-term negative impact on growth. In contrast, corporate income tax positively affects economic expansion. The study suggests that finding the optimal tax rate is crucial for maximizing revenue and economic incentives (Success *et al.* 2024). In Indonesia, income tax, value-added tax, and excise revenue positively influence both short-term and long-term economic growth, highlighting the importance of these taxes in supporting the country's GDP (Wibowo *et al.* 2024). Uganda faces high tax rates, which negatively affect unemployment and economic productivity. The study recommends reducing taxes to stimulate economic growth and widen the tax base (Mukoki *et al.* 2024). In Sierra Leone, indirect taxes negatively impact short-term economic growth, while interest rates have a positive effect. The study suggests enhancing international relations to attract foreign direct investment and promote exports (Davies and Heimoh, 2024).

Regarding the above discussion on public goods and tax, it could be stated that public goods can help improve several aspects of the economy. For instance, public good provision can support the efficient allocation of resources by providing goods and services that would be underprovided by the private sector, which leads to market failures. Also, public goods can enhance social welfare by ensuring that essential services like education, healthcare, and infrastructure are accessible to all members of society, irrespective of their ability to pay. In

addition, public goods can promote equity by reducing disparities in access to vital services, thereby fostering a more inclusive and fair society (Stiglitz and Rosengard, 2015). Furthermore, investments in public goods, such as infrastructure and education, can lead to long-term economic growth and development by creating a conducive environment for businesses and individuals to thrive (Hindriks and Myles, 2013). However, excessive public sector intervention in providing public goods can lead to market distortions and impact competition and investment decisions, implying a negative impact on the sustainable growth of the economy (Baird, 2004). Also, it can potentially reduce private consumption as individuals may rely more on public goods, diminishing their need for private alternatives (Stiglitz and Rosengard, 2015). Furthermore, the availability of high-quality public goods like public transportation may reduce the demand for private transportation services, impacting private consumption patterns (Paul and Robin, 2015). In addition, public goods can lead to a crowding-out effect where the increased provision of public goods displaces private consumption, affecting the overall economy. Therefore, it was suggested that the government has a crucial role in balancing the provision of public goods to ensure they complement rather than substitute private consumption choices (Langdana, 2016).

In the case of tax, at the optimal level, it can provide the necessary revenue to fund public services such as infrastructure development, healthcare, education, and national security. Taxation helps redistribute wealth by collecting funds from those who can afford to pay more and using them to support social welfare programs for the less privileged. It can also be crucial in maintaining economic stability by regulating demand, controlling inflation, and funding government initiatives that stimulate economic growth. However, taxes can lead to welfare losses due to distortionary effects, impacting consumer welfare and economic efficiency (Langdana, 2016). Also, an increase in taxes can reduce the purchasing power of individuals, affecting their ability to afford goods and services, leading to a decrease in consumption (Paul and Robin, 2015). Higher taxes can influence consumer spending patterns and business investments, affecting economic growth. Individuals and businesses may alter their financial behaviours in response to increased taxes, leading to adjustments in savings, investments, and consumption patterns. Another negative effect of tax on growth rates is that taxation can affect labour supply and productivity (Hindriks and Myles, 2013). However, many factors, particularly in economic modelling, can influence optimal tax, such as equilibrium conditions, private-sector equilibrium, government budget constraints, and assumptions about the utility function (Chugh, 2015).

The effect of public goods provision and taxation policies on the economy is multifaceted and complex. Public goods play a crucial role in influencing household consumption, private consumption patterns, and economic growth, while taxation policies serve as a mechanism to finance public expenditures. Understanding the dynamics between public goods provision, taxation policies, and economic outcomes is essential for policymakers to formulate effective strategies for promoting sustainable growth, reducing inequality, and addressing societal challenges.

2. Methodology

This section will propose the model that the government expenditure in terms of public goods is composed of social utility, and tax is imposed in the social constraint based on the optimal control framework. These public goods are non-excludable and non-rival in nature, meaning that individuals cannot be excluded from their benefits, and one person's consumption does not diminish the availability for others (Langdana, 2016). These goods normally are not provided by the market. In this study, the component of public goods in the utility is assumed to substitute for private goods, i.e., the higher the public good, the lower the private good consumption. The model also assumes a large number of infinitely lived households and firms, that population growth is zero and that there is no entry or exit of firms. The representative firm produces a single composite good using private capital, K , and labour, N , based on Cobb-Douglas technology:

$$Y_t = A_t K_t^\alpha N_t^{1-\alpha} \quad (1)$$

where A_t is the total productivity and the constant α denotes the proportion of K in the output.

Assuming that this economy uses the after-tax output for either reinvest in the firms to increase capital stock or use for consumption, depending on the social preferences. The capital accumulation of this economy can be expressed by:

$$\dot{K}_t = (1 - \tau)Y_t - C_t - I_t \quad (2)$$

where τ denotes income tax. $I = \delta K$ and δ is capital depreciation rate.

The central planner maximizes lifetime utility U given by

$$U(C_t, G_t) = \ln(C_t) + \theta \ln(G_t), \tag{3}$$

where C and G represent private goods consumption and public goods consumption, respectively. The budget constraint of this economy is represented by:

$$\dot{B}_t = rB_t + \tau Y_t - G_t \tag{4}$$

where r is the interest rate and τ stand for tax rate.

The central planner considers (2) and (4) and solves the following problem:

$$MAX_{C_t, G_t} \int_0^{\infty} U(C_t, G_t) e^{-\rho t} dt \tag{5}$$

where the constant ρ is the rate of time preference.

The Hamiltonian function associated with problem (5) can be written by:

$$H = U(C_t, G_t) e^{-\rho t} + \lambda_1 (\dot{K}_t) + \lambda_2 (\dot{B}_t), \tag{6}$$

which implies the following:

$$\dot{C}_t = \frac{C_t}{G_t} (\alpha A_t ((1-\tau)G_t + \tau\theta C_t) K_t^{\alpha-1} N_t^{1-\alpha} - (\rho + \delta)G_t), \tag{7}$$

$$\dot{G}_t = (r - \rho)G_t, \tag{8}$$

The stability of this economy can be evaluated

$$J = \begin{bmatrix} a_1 & a_2 & a_3 & 0 \\ 0 & r - rho & 0 & 0 \\ -1 & 0 & a_4 & 0 \\ 0 & -1 & a_5 & r \end{bmatrix}, \tag{9}$$

$$a_1 = \frac{A_t (\alpha ((1-\tau)G_t + \tau\theta C_t) + C_t) K_t^{\alpha-1} N_t^{1-\alpha} \alpha \tau \theta - (\rho + \delta)G_t}{G_t}$$

$$a_2 = \frac{C_t (\alpha A_t (1-\tau) K_t^{\alpha-1} N_t^{1-\alpha} - \rho - \delta)}{G_t} - \frac{C_t (\alpha A_t ((1-\tau)G_t + \tau\theta C_t) K_t^{\alpha-1} N_t^{1-\alpha} - (\rho + \delta)G_t)}{G_t^2}$$

$$a_3 = \frac{\alpha C_t A_t ((1-\tau)G_t + \tau\theta C_t) K_t^{\alpha-1} (\alpha - 1) N_t^{1-\alpha}}{K_t G_t}$$

$$a_4 = \frac{\alpha (1-\tau) A K^\alpha N^{1-\alpha}}{K} - \delta$$

$$a_5 = \frac{\alpha A K^\alpha N^{1-\alpha} \tau}{K}$$

which provide

$$Det(J) = a_1 a_4 r^2 - a_1 a_4 r \rho + a_3 r^2 - a_3 r \rho, \tag{10}$$

$$Tr(J) = a_1 + a_4 - \rho + 2r. \tag{11}$$

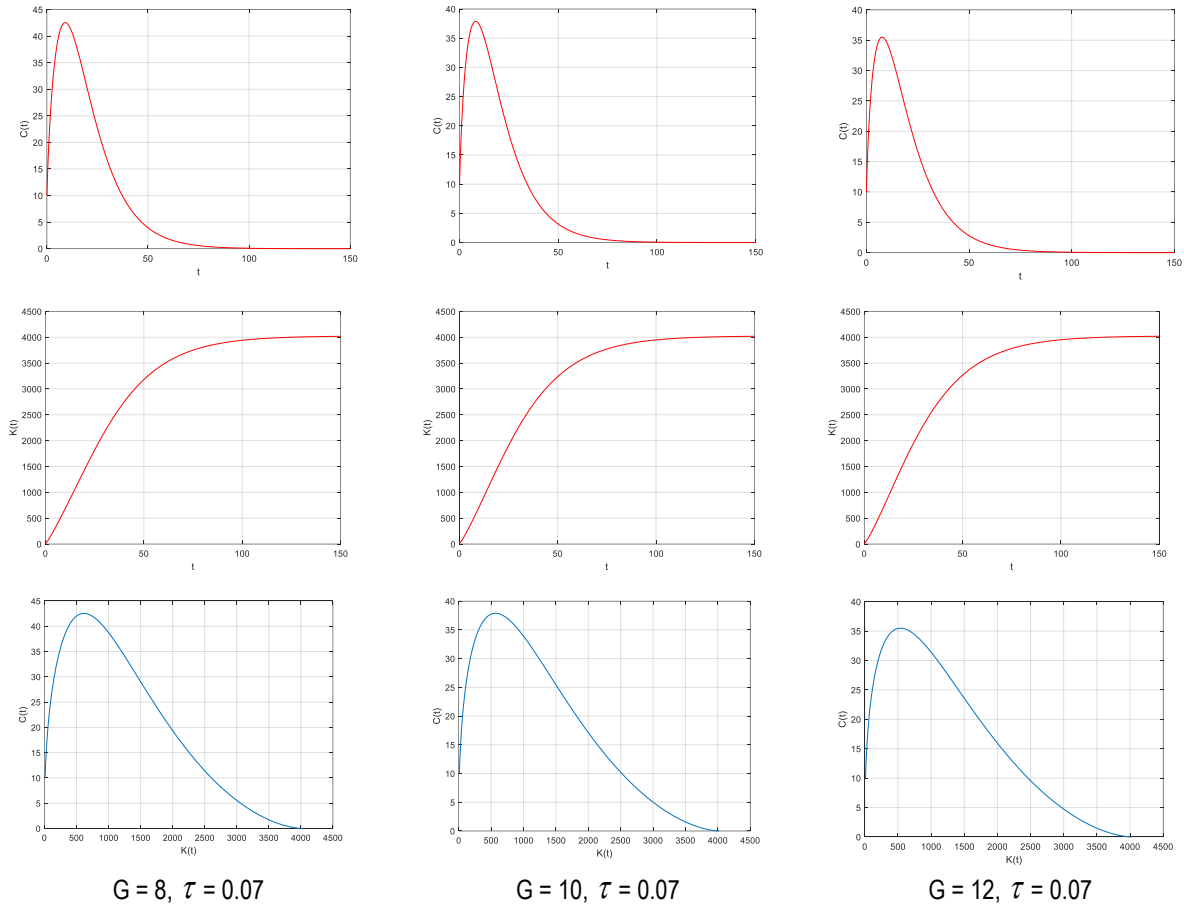
Therefore, in general, the stability of this economy is represented by $Det(J) > 0$, $Tr(J) < 0$, and $Det(J) < Tr^2/4$.

3. Results

This section will investigate the effect of the fiscal policy instruments, i.e., public goods and tax, on consumption, C, and the growth of the economy reflected by the level of capital, K. To visualize their effect, this study defines

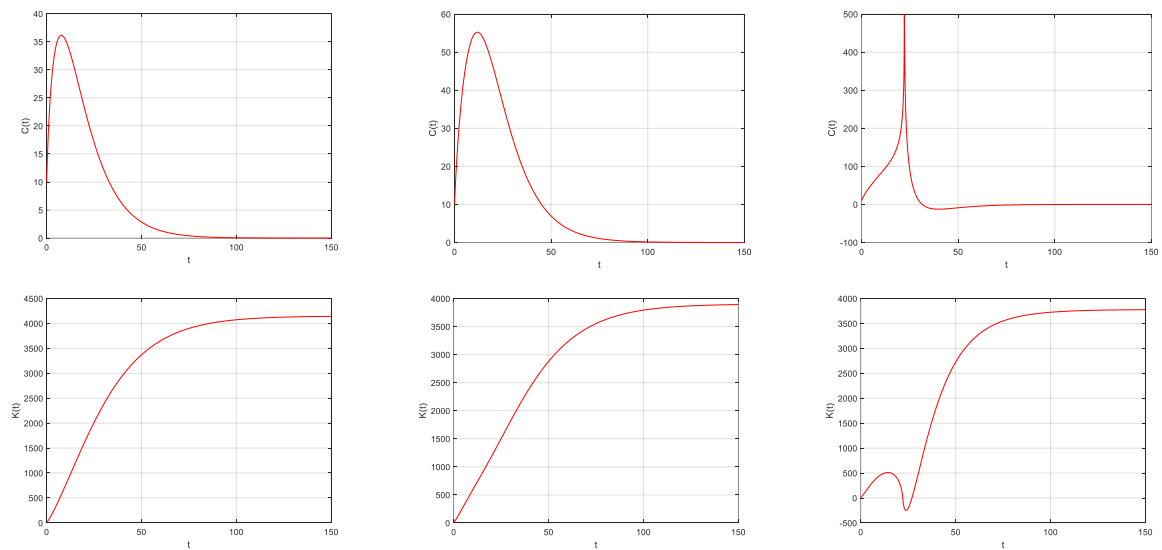
$\rho = 0.03$, $\theta = 1$, $\tau = 0.07$, $\alpha = 0.3$, $\delta = 0.07$, and $r = 0.07$. The results from the numerical analysis are presented in Figure 1 and Figure 2.

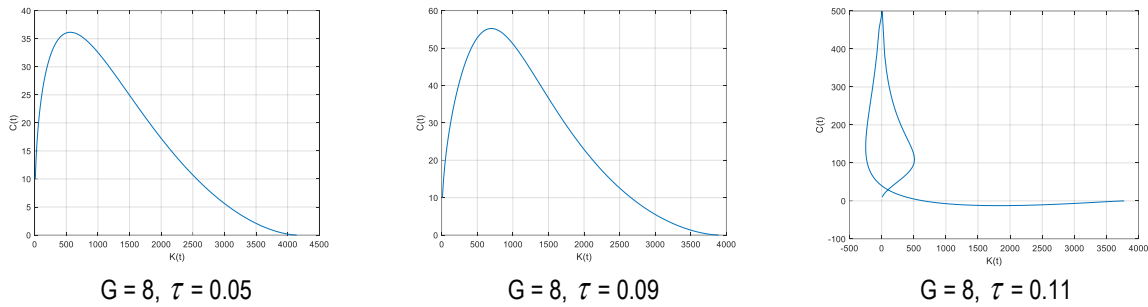
Figure 1. The effect of increased government spending on public goods on consumption and economic growth



Source: Author's presentation

Figure 2. The effect of tax on consumption and economic growth.





Source: Author's presentation

The illustration in Figure 1 shows that increasing government spending on public goods will decrease private goods consumption while keeping capital unchanged. This implies that when the economy reaches the potential level, encouraging public goods only reduces private consumption without benefit for growth. Figure 2 expresses the scenario of tax increases, which eventually lead to the collapse of private goods consumption and the economy's growth reaching the maximum at a lower level. This implies that when the economy reaches the potential level, the high tax rate will make the economy's growth rely on government action and negatively affect economic growth.

4. Discussion

The results of this study are based on the assumption that public goods can substitute for private goods. Hence, when public goods are offered, they will choose to consume them, which leads to a reduction in private consumption. However, the results may be directed in the opposite direction if the public goods are assumed to be complementary goods.

Refer to the knowledge obtained from the literature section, which implies that public goods, such as infrastructure and education, generate positive externalities that enhance productivity, human capital, and economic well-being (Li *et al.* 2020; Reiss, 2021). These goods improve individual well-being by reducing household costs and increasing access to essential services, which, in turn, influence consumption patterns. However, the results of this simulation study indicate a more complex dynamic. According to the findings, increasing government spending on public goods does not necessarily translate into economic growth; instead, it can reduce private consumption. As shown in Figure 1, higher investment in public goods decreases private consumption without significantly benefiting growth when the economy reaches its potential level. This suggests that, beyond a certain threshold, the provision of public goods may crowd out private goods, reducing overall consumption and limiting its impact on growth. This aligns with existing literature highlighting the challenges associated with public goods provision. The "free-rider" problem and potential conflicts between equity and efficiency may arise, complicating efforts to optimize public goods provision (Holcombe, 1997; Buchholz *et al.* 2018). While public goods create economies of scale and promote societal well-being, their overprovision can distort market dynamics and lower private consumption, especially when poorly managed. Thus, a balanced approach is needed to ensure public goods support rather than hinder economic growth.

Taxation is another crucial fiscal policy component with significant economic performance implications. The literature suggests that the structure and level of taxation directly influence investment decisions, labour supply, and productivity (Stoilova, 2017; Buliková *et al.* 2021). Optimal taxation theory aims to identify tax structures that maximize social welfare while minimizing negative economic impacts (Kaplow, 2008). However, the results from the simulation in this study offer mixed results on the impact of taxation, with high tax rates potentially discouraging savings and investment, thereby limiting long-term economic growth (Stiglitz and Rosengard, 2015). The results of this study reinforce the notion that high tax rates can adversely affect economic growth. As depicted in Figure 2, increased taxation eventually leads to a collapse in private consumption, constraining the economy's growth potential. This finding resonates with previous research highlighting the detrimental effects of excessive taxation on business activity, investment, and overall economic strength (Buliková *et al.* 2021). In particular, as the economy reaches its potential, reliance on government action through high taxation can stifle growth, underscoring the importance of moderate and growth-friendly tax policies. Several studies have shown that different types of taxes have varying impacts on economic growth. For instance, corporate income taxes have positively influenced growth in some contexts, while personal income taxes may have a negative long-term effect (Tala, 2024; Success *et al.* 2024). This study adds to this debate by showing that high tax rates on private goods consumption reduce economic dynamism. The results highlight the need for

tax reforms that foster innovation, entrepreneurship, and investment, aligning with recommendations for more efficient taxation policies seen in both developed and developing economies (Wang, 2024; Mukoki *et al.* 2024).

5. Policy Implications

Based on the findings that increasing government spending on public goods can lead to a decrease in private goods consumption without significant benefits for economic growth and that high tax rates could potentially hinder economic growth by overly relying on government intervention, the following policy recommendations and implementations can be suggested. 1) Rather than solely focusing on increasing government spending on public goods, policymakers should aim for a balanced approach. This involves carefully evaluating the allocation of public funds to ensure optimal investment in public goods while minimizing negative impacts on private consumption. Prioritizing essential public goods with high social returns and efficiency can be beneficial. 2) Implement measures to enhance the efficiency and effectiveness of public spending. This includes regularly evaluating public projects to ensure they deliver value for money and contribute positively to economic growth. 3) Instead of high tax rates, focus on implementing tax reforms to foster economic growth. This could involve reducing tax burdens on individuals and businesses, especially those that hinder investment, innovation, and entrepreneurship.

6. Future Research

Based on the findings of this research, there are several potential avenues for future research in the domain of the effect of public goods and taxation on economic growth. Some suggestions for future research are as follows. Future research may explore dynamic economic models that capture the interplay between public goods provision, taxation policies, and economic growth over time. This could involve incorporating technological change, demographic shifts, and policy responses into the model better to understand the long-term implications of different policy interventions. In addition, they may try to investigate the behavioural aspects of how individuals and firms respond to changes in taxation and public goods provision. This could include examining factors such as consumer preferences, saving behaviour, investment decisions, and responses to government policies to enhance the realism of economic models.

Conclusion

This study examines the effect of fiscal policy, specifically government spending on public goods and taxation policies, on economic growth. Through an economic model constructed within the optimal control framework, the research aimed to estimate the potential impacts of these fiscal policy instruments on consumption and the economy's growth while also analyzing the stability conditions of the proposed model and conducting numerical experiments to elucidate its implications further. The methodology employed in this study integrated taxation policies into the social constraint and incorporated public goods into the social utility function within the optimal control framework. This framework allowed for the examination of how changes in government spending on public goods and tax policies influence private consumption and economic growth. The numerical analysis revealed significant insights into the dynamics between fiscal policy instruments and economic outcomes. The simulation results demonstrated that increasing government spending on public goods could decrease private goods consumption without significant benefits for economic growth. Conversely, high tax rates could potentially hinder economic growth by overly relying on government intervention, leading to a collapse in private goods consumption and limiting the growth of the economy. These findings highlight the importance of a balanced approach to fiscal policy, wherein policymakers carefully evaluate the allocation of public funds to ensure optimal investment in public goods while minimizing negative impacts on private consumption. Enhancing the efficiency and effectiveness of public spending, implementing tax reforms aimed at fostering economic growth, and encouraging private sector participation are recommended strategies.

Acknowledgements

This research is supported by the School of Economics, Sukhothai Thammathirat Open University, Thailand. This research is also supported by the Computer Engineering Department, Srinakharinwirot University, Thailand.

Credit Authorship Contribution Statement

Adirek Vajrapatkul: Contributions: Conceptualization, Methodology, Investigation, Formal analysis, Writing, original draft, editing, and Supervision.

Pinmanee Vajrapatkul: Contributions: Software, Data Curation, Visualization, Writing, Review, and Editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

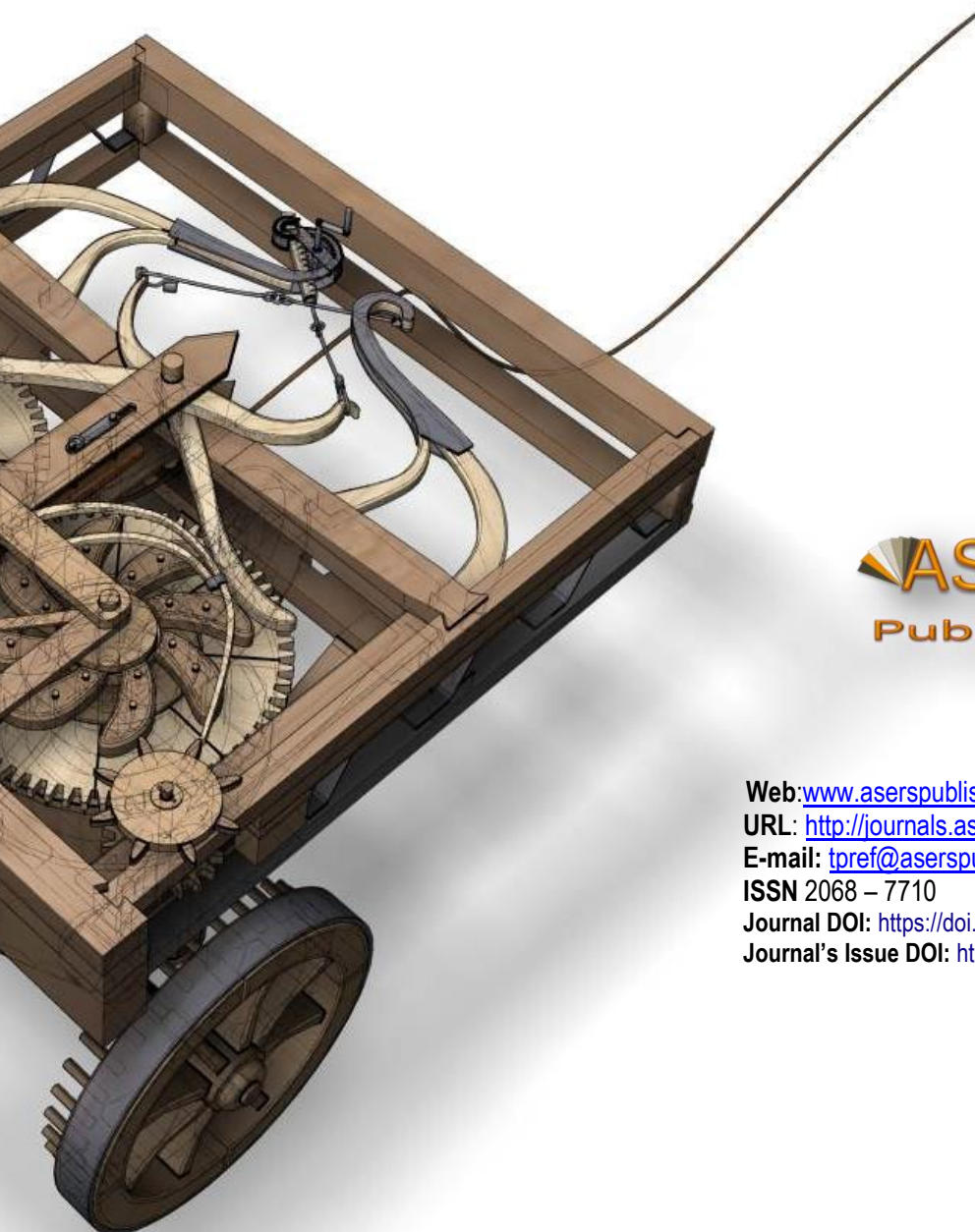
The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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ISSN 2068 – 7710

Journal DOI: <https://doi.org/10.14505/tpref>

Journal's Issue DOI: [https://doi.org/10.14505/tpref.v15.3\(31\).00](https://doi.org/10.14505/tpref.v15.3(31).00)