PUBLIC DEBT POLICY EFFECTIVENESS IN ENABLING SUSTAINABLE DEVELOPMENT IN CENTRAL ASIA

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ABSTRACT. *A steady increase in public debt, which occurs against a substantial lag in progress toward the United Nations' Agenda for Sustainable Development by 2030, brings research on the effectiveness of public debt policy to the forefront. This study thus examines the impact of public debt policy on sustainable development (SD) with a focus on Central Asian countries. Fixed effects regression with a dummy variable and moderated regression analysis are utilized to examine the nexuses between debt financing and the SD's four dimensions, drawing on panel data from 1996 to 2023. The results suggest that external public debt promotes economic, social, and institutional development, while hampering the environment. Moreover, the outcomes of debt financing change depending on the performance of public policies, leading to synergy, lost, and conflicting effects. When dealing with these policy trade-offs, it is advisable to ensure an SD-informed fiscal framework and rules, adopt strategic investment of borrowed funds, and apply SD-aligned criteria to evaluate projects financed by public debt.*

KEYWORDS: *external public debt, sustainable development, Central Asia.*

INTRODUCTION

What are the effects, if any, of public debt policy in accelerating progress towards sustainable development? This question has gained importance as rising public debt occurs against the backdrop of substantial gaps in achieving the Sustainable Development Goals (SDGs). Currently, less than one-fifth of the SDGs are on track, even though over two-thirds of the United Nations' Agenda for Sustainable Development (the 2030 Agenda) execution time has elapsed (UN, 2025). Central Asian countries are experiencing similar trends, reflecting challenges of cascading financial, environmental, social, and geopolitical shocks and addressing the funding gap of the 2030 Agenda through expansionary fiscal policy (UNCTAD, 2024; WB, 2024).

Notwithstanding existing studies that investigate the relationship between public debt and sustainable development, this nexus is scarcely studied. Specifically, Luu et al. (2024) highlight that external public debt can contribute to promoting sustainable development in emerging and low-income countries. Studies testing nexuses between debt financing and indicators that can be proxied for economic (Alsamara et al., 2024; Butkus et al., 2021; Doojav & Baatarkhuu, 2024; Martín et al., 2024; Mejia, 2024; Phuc Canh, 2018; Reinhart et al., 2012), social (Aladejare, 2023; Arshed et al., 2022; Farooq et al., 2022; Simionescu & Cifuentes-Faura, 2023; Tung, 2020), environmental (Akam

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et al., 2022; Bese et al., 2021a, 2021b; Carrera & de la Vega, 2024; Saleem et al., 2024; Stanciu & Mitu, 2024; Zhao & Liu, 2022), and governance (Ma & Qamruzzaman, 2022) dimensions of sustainable development also shed some light on the effects of public debt policy. These studies suggest that the effects of debt financing vary contingent upon country(region) specifics, debt regimes, access to natural resources, geographical heterogeneity, and institutional development.

To the best of my knowledge, there are no recent studies that provided a comprehensive view on how public debt policy affects sustainable development (SD) across its four dimensions. This study aims to fill this research gap by answering the following questions:

- Whether and, if so, how public debt financing affects the SD's economic, social, environmental, and governance dimensions?
- What are the moderating effects (if any) of public policies on the debt-SD nexus?

The study focuses on the case of Central Asian countries as a unique and suitable case for exploring the effects of public debt policy on the SD's perspectives due to their experience in transitioning from a Soviet-era planned economy to a market economy, resource dependency, arid climate, and distinct governance landscape. Moreover, this study is the first to examine the effects of public debt financing on sustainable development in Central Asian countries.

The panel data from 1996 to 2023 were analyzed using fixed effects regression with a dummy variable and moderated regression analysis, as they provide a robust framework for policy implications. The results show that external public debt benefits the SD's economic, social, and governance dimensions, while hampering environmental development. The outcomes of debt financing vary depending on the moderating effects of public policies.

The remainder of this paper is organized as follows. Section two reviews associated literature. Section three describes the model, data, and estimation methodology. Section four outlines and discusses empirical results. Section five concludes with policy implications and suggestions for future research.

LITERATURE REVIEW

The impact of public debt policy on sustainable development has been recently explored by analyzing relationships between debt financing and the SD's indicators. Luu et al. (2024) argued that external public debt improves the Sustainable Development Index; however, its impact varies across the SDGs, and excessive debt can hinder sustainable development. Similar findings are reported in studies that investigate how public debt affects individual SDGs (see, e.g., Biswal & Patra, 2024). There is also an abundance of research investigating the effects of debt financing on various economic, social, environmental, and governance indicators, which can be proxied for the SD's dimensions.

The economic dimension
Well-established indicators of economic development, such as gross domestic product (GDP) and gross national income (GNI), can serve as proxies for the SD's economic dimension. Theoretical research examines the debt-growth nexus by analyzing how the behavior of economic agents (consumption or saving) changes in response to

governments' financial decisions (whether to borrow more or cut spending). The classic economic school questions the role of debt financing as an asset productive in accelerating income growth since borrowing is associated with increasing interest rates and taxes on investors' profit, followed by decreasing consumption and crowding out of investment (Alsamara et al., 2024; Cifuentes-Faura & Simionescu, 2024; Phuc Canh, 2018). Moreover, excessive borrowing leads to a debt overhang and weakening financial discipline (Hilton, 2021). According to the Ricardian equivalence, public debt has no consequences for the economy because the effects of increasing debt financing are offset by economic agents' actions to save more, which subsequently forces governments to stimulate demand through tax cuts and other measures (Cifuentes-Faura & Simionescu, 2024; Hilton, 2021; Phuc Canh, 2018). In contrast, the Keynesians associate the debt financing with the crowding-in effects. When considering an imperfectly competitive market with unemployed resources and effects of externalities, expansionary fiscal policy stimulates demand, investment, and employment, leading to economic growth and debt repayment (Cifuentes-Faura & Simionescu, 2024; Phuc Canh, 2018). The Keynesian model, however, works for crowding-in if debt is used to overcome the recession and triggers crowding-out effects when deviating from this rule (Phuc Canh, 2018).

The recent empirical studies that have become a focal point of interest in response to economic crises indicate that the impact of debt on growth is contingent upon country(region) specifics, including the level of economic development (see, e.g., Mejia, 2024; Panizza & Presbitero, 2013), fiscal multiplier intensity (Butkus et al., 2021), access to natural resources (Ampofo et al., 2021), debt regimes (Reinhart & Rogoff, 2010), and geographical heterogeneity (Doojav & Baatarkhuu, 2024). Studies spurred by all-time high debt size indicate that economic development significantly affects the dynamics of debt accumulation, as well as interest rates, exchange rates, life expectancy, unemployment, trade openness, fiscal deficit, and institutional quality (see, e.g., Azolibe, 2021; Briceño & Perote, 2020). In turn, the institutional quality has a moderating effect on the debt-growth nexus (Shi et al., 2025; Abbas et al., 2021).

Then, many studies evidence a threshold effect, meaning the debt size beyond which debt financing becomes harmful to economic development. Interestingly, the debt threshold tends to increase as economic and financial systems advance, and it varies from 20 to 90% of GDP depending on social, environmental, and governance aspects (Alsamara et al., 2024; Martín et al., 2024; Ndoricimpa, 2020; Reinhart et al., 2012; Smyth & Hsing, 1995). Identifying an ideal debt threshold is unfeasible, given ever-evolving uncertainties. However, policy implications from these studies include preventing excessive debt, which undermines both economic and social development.

The social dimension
Unlike the debt-growth nexus, the relationship between debt financing and social development is studied fragmentarily. Moreover, using a wide range of indicators—from poverty rate to human development index—as proxies for social development makes it difficult to systematize theoretical and empirical results. Recently, scholars have examined the debt-social development nexus, grounding their analysis in theories of economic growth, distributional justice, and human development. Specifically, Arshed et al. (2022), relying on the Solow Growth Model and the Kuznets inequality curve, argued that long-term external debt exceeding 46% of GDP and short-term external debt

exceeding 97% of GDP are associated with a decline in the standard of living in highly indebted Asian countries. A debt threshold aligned with social development objectives varies depending on the institutional quality (Farooq et al., 2022).

Tung (2020) argued that public debt harms social development in the Asia-Pacific region since increasing debt financing is negatively associated with per capita GDP and domestic investment. The debt financing, therefore, can lead to an increase in poverty and, consequently, to excessive debt accumulation (Simionescu & Cifuentes-Faura, 2023). In countries with high poverty, this causality constrains governments' ability to mitigate crises through affordable debt relief (Okafor & Khalid, 2023). The distributional effects of debt financing are also confirmed when using income inequality as a proxy indicator for social development (Akram, 2016; Borissov & Kalk, 2020; Obiero & Topuz, 2022).

Studies that use social sector performance proxied by life expectancy, morbidity and mortality rates, school attendance, healthcare, and education spending also clarify the debt-social development nexus. Specifically, life expectancy can drive public debt accumulation (Abbas et al., 2020; Abd Rahman et al., 2021) and, in turn, external debt can boost life expectancy (Bese & Friday, 2021); however, unsustainable, illiquid, or insolvent external debt can reduce longevity (Aladejare, 2023). Then, debt financing may impede social development because of crowding out funds from infrastructure projects in the health, education, social care, water, and sanitation sectors (Fosu et al., 2025). Excessive or ineffective debt financing can hinder economic, human, and environmental development; these adverse effects are worse when institutional quality is weak (Sadiq et al., 2022; Wang et al., 2021).

The environmental dimension
The nexus between debt financing and the environment is explored through the lens of the Environmental Kuznets Curve (EKC) theory. In line with the EKC, as economies grow, the environment tends to degrade—the upward slope of an inverted U-curve—and, after reaching a certain threshold (peak of the curve), further economic growth improves environmental quality—the downward slope of the inverted U-curve (Grossman & Krueger, 1995). The non-linearity of the EKC results from a shift from industrialization, which prioritized economic growth over environmental protection, to the adoption of green technologies enabled by increased environmental awareness (Stern, 2017; Wang et al., 2024).

Well-tested proxies for environmental quality within the debt-environment nexus include greenhouse gas (GHG) emissions, especially carbon dioxide (CO_2) emissions, which account for the largest share of GHG emissions, and the material footprint, which tracks the raw materials extracted to meet final consumption demands. In particular, external debt is positively associated with CO_2 emissions in China, India, Malaysia, and Somalia, thereby implying that an increase in debt financing leads to environmental degradation (Bese et al., 2021a, 2021b; Shaari et al., 2024; Warsame et al., 2024) and supporting findings from the cases of heavily indebted poor countries, advanced, developing, and emerging economies (Akam et al., 2022; Carrera & de la Vega, 2024; Stanciu & Mitu, 2024). An increase in debt is associated with a decrease in CO_2 emissions in Morocco (Bachegour & Qafas, 2023), while debt is statistically insignificant in explaining environmental quality in Turkey (Bese & Friday, 2022). Then, in advanced and emerging economies,

public debt is the second-largest determinant of CO_2 emissions, following economic growth (Stanciu & Mitu, 2024; Zhao & Liu, 2022). However, advanced economies can mitigate environmental disasters with minimal risks to economic growth when they utilize debt financing, whereas developing countries are compelled to choose between financing climate mitigation measures and long-term debt sustainability due to carbon lock-in effects (Fan et al., 2024; Jalles, 2023).

The load capacity factor (LCF), green total factor productivity, renewable energy consumption (REC), and energy efficiency are also well-suited proxies for environmental development. In particular, an increase in external debt leads to a decrease in the LCF, meaning the harmful impact of debt on ecological sustainability (Saleem et al., 2024). Hashemizadeh et al. (2021) argued that public debt reduces the REC in emerging economies, confirming the findings of Onuoha et al. (2023) based on the case of countries in Sub-Saharan Africa. Abbas et al. (2024) concluded that an increase in debt financing leads to an increase in CO2 emissions; however, the interaction between REC and public debt diminishes carbon emissions. Alhassan and Kwakwa (2022) and Carratu et al. (2019) argued that there is a threshold level beyond which an increase in debt distresses the environment, supporting the EKC-related argumentations. Moreover, when governments rely on debt financing, they are at risk of making politically sensitive decisions (Boly et al., 2022; Carrera & de la Vega, 2024), thereby exacerbating governance issues.

The governance dimension

Institutions are essential to public governance, in which governments, whether elected or appointed, function and remain in governance if their performance is regarded as effective by those who elect or appoint them. When exploring associations between debt and governance, scholars rely on the institutional theory, which explains agents' decision-making and behavior shaped by rules, norms, structures, and traditions (Kaufmann & Kraay, 2024; Meyer & Rowan, 1977). In turn, Worldwide Governance Indicators are the best proxies for institutional quality, covering core aspects of the SD's governance dimension (Glass & Newig, 2019; Kaufmann & Kraay, 2024; Liu et al., 2022). The institutional quality can serve as a moderator in the debt-growth nexus (see, e.g., Abbas et al., 2021; Abduvaliev & Bustillo, 2024). Butkus and Seputiene (2018) argued that improvements in government effectiveness raise the threshold of public debt considered safe for sustaining economic growth. However, the government effectiveness is insufficient to cope with the adverse effects of debt, while the trade balance is the most influential moderating factor in the debt-growth nexus (Butkus & Seputiene, 2018). Governance indicators also have a moderating effect on the nexuses of economic institutions and public debt (Nutassey et al., 2023), external debt and investment (Ojeka et al., 2024), and trade openness and external debt (Harsono et al., 2024).

The institutional quality can prevent debt crises if a country has strong financial, economic, and trade positions and strengthens fiscal and macroeconomic policies (see, e.g., Ben Ali & Ben Abdul Aziz Al Yahya, 2019; Nguen & Luong, 2021). Political stability and control of corruption have a debt-reducing effect in EU countries and have no impact on debt size in non-EU nations with weaker institutions (Cooray & Ozmen, 2024). In Middle East and North Africa countries, poor governance, proxied by

political stability, regulatory quality, and rule of law, has a debt-increasing effect (Tarek & Ahmed, 2017). Furthermore, institutions that mitigate asymmetric information and lower transaction costs can promote a crowding-in effect when external debt remains below 40% of GNI in emerging economies (Phuc Canh, 2018). Kemoe and Lartey (2022) argued that once institutional quality surpasses a certain threshold, increased public debt can have a positive impact on growth.

The recent studies thus focused on the moderating role of governance or the effects that institutional quality has on debt accumulation. The effects of debt financing on governance remain unstudied, except for the research work of Ma and Qamruzzaman (2022) on BRICS countries. The authors concluded that government debt is negatively associated with institutional quality in the long and short run, and excessive debt may threaten institutional development (Ma & Qamruzzaman, 2022).

Reviewing theoretical and empirical research indicates that the theory of economic growth, Kuznets' hypotheses regarding the importance of quantitatively measurable factors of economic, social, and environmental development, and institutional theory collectively provide a foundation for constructing a conceptual framework to evaluate the impact of public debt policy on sustainable development (see Figure 1).

Figure 1. The conceptual framework
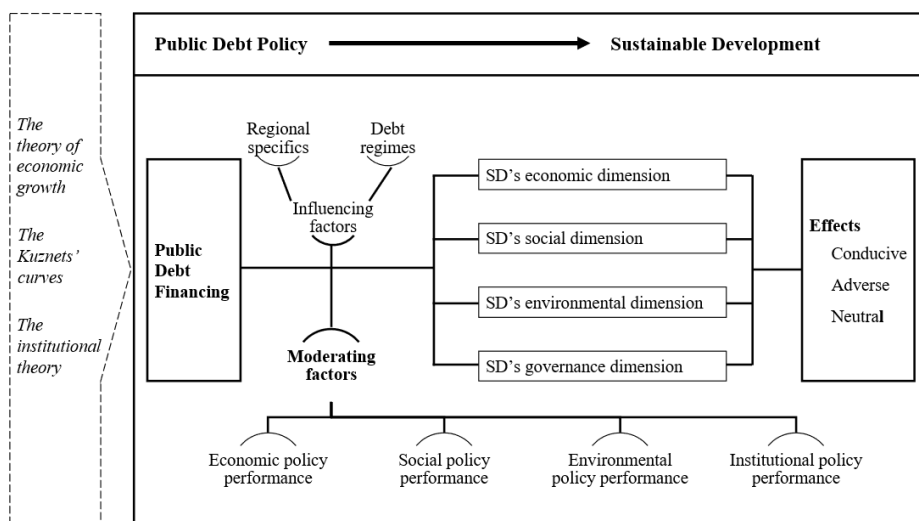
Source: The author's deliberations;

As demonstrated in Figure 1, the effects of public debt policy are identified through analyzing how public debt financing influences the SD's four dimensions. Public debt financing may have a conducive, adverse, or neutral impact on the economic, social, environmental, and governance dimensions. The debt's effects depend on both regional specifics and debt regimes. The interconnectedness and interdependence of the SD's pillars (Breuer et al., 2019; Mensah, 2019) may lead to moderating effects of corresponding public policies on the debt-SD nexus.

The literature review also suggests that there are no recent studies that comprehensively analyzed the impact of public debt policy on the SD's dimensions. The case of Central Asian countries is unexplored; only a few recent studies have examined the impacts of public debt on economic growth (see, e.g., Abduvaliev & Bustillo, 2024). Therefore, this study aims to explore the effects (if any) of public debt policy on the SD's four dimensions and examines whether public policies' performance moderates the debt-SD nexus, focusing on Central Asian Countries and utilizing econometric analysis methods.

DATA, MODEL, AND ESTIMATION METHODOLOGY

Data

This study utilized panel data from 1996 to 2023, covering five Central Asian countries—Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan—and sourced from open World Bank (WB) and United Nations (UN) databases. The external public and publicly guaranteed debt service (EPDebtS) was used as a key explanatory variable to assess the impact of public debt policy on the SD's economic, social, environmental, and governance dimensions. Proxies for these dimensions, such as gross national income (GNI), life expectancy (LifeEx), material footprint (FootPr), and government effectiveness (GovEf), are used as dependent variables (see Table 1). Assumptions about how public debt policy affects the SD's dimensions are made based on previous studies that explored the nexuses between debt financing and growth (Mejia, 2024; Panizza & Presbitero, 2013), social development (Aladejare, 2023; Bese & Friday, 2021), environmental performance (Akam et al., 2022; Carrera & de la Vega, 2024), and institutional quality (Ma & Qamruzzaman, 2022).

Table 1. Variables description

Variables	Definition (measurement; source)	Roles in modelling the impact of public debt policy on the SD's dimensions:			
		economic	social	environmental	governance
Trade	Trade (% of GDP; WB)	independent			
Unempl	Unemployment (% of total labor force; WB)	control			
FossilFu	Fossil fuel energy consumption (% of total; WB)				
ConCor	Control of corruption: Estimate (scale of − 2.5 to 2.5; WGI; WB)				
GNI	Gross national income (current US$; WB)	dependent	moderating	moderating	moderating
LifeEx	Life expectancy at birth (years; UN)	moderating	dependent	moderating	moderating
FootPr	Material footprint per capita (tones; UN)	moderating	dependent	dependent	moderating
GovEf	Government effectiveness: Estimate (scale of − 2.5 to 2.5; WGI; WB)	moderating	dependent	moderating	dependent

Source: The author's deliberations.

As demonstrated in Table 1, trade (Trade), unemployment rate (Unempl), fossil fuel consumption (FossilFu), and control of corruption (ConCor) are used as control variables in all models as they affect sustainable development. Specifically, trade is a well-tested determinant of economic growth that impacts social and environmental

development through income generation and production intensity, as well as governance through commitments to accountable engagement with international markets (Barros & Martínez-Zarzoso, 2022; Chen et al., 2025; Fankem & Feyom, 2024; Felbermayr et al., 2025; Seti et al., 2025). Being one of the key determinants of social development, unemployment impacts the economic, environmental, and governance dimensions as a labor factor of growth and an outcome indicator of institutional development (Ayad & Djedaiet, 2024; Boța-Avram et al., 2021; Feng et al., 2024; Koyuncu Çakmak et al., 2025; Uddin & Rahman, 2023).

Next, increasing the consumption of fossil fuels is associated with an expanded ecological footprint and growing CO_2 emissions, leading to environmental degradation and, consequently, adverse social and economic effects, as well as changes in institutional quality (Arora & Kaur, 2020; Ozturk et al., 2022; Somoye et al., 2024; Umair et al., 2025). The control of corruption also impacts the SD's dimensions through either hindering or facilitating economic and social development by, respectively, siphoning resources away from productive sectors and bypassing bureaucratic hurdles, and having ambiguous effects on environmental quality (Ahmad et al., 2021; Akpan & Kama, 2023; Badur et al., 2024; Fhima et al., 2023; Uddin & Rahman, 2023).

Then, to explore whether and, if so, how the performance of corresponding public policies changes the impact of public debt policy on the SD's dimensions, the dependent variables' roles were replaced with the roles of moderating variables, as detailed in Table 1.

Model and estimation methodology

This study employed a fixed effects model with a dummy variable, also known as the least squares dummy variable model (LSDV; Wooldridge, 2010). The standard LSDV model was used as follows:

$$Y_{it} = \alpha + \beta X_{it} + \gamma_i u_{it} + \varepsilon_{it}, \tag{1}$$

where Y and X denote an outcome and independent variables, which are observed for units (i) over multiple periods (t), uit is a dummy variable that equals to 1 if the observation belongs to unit i and to 0 otherwise; α is the overall intercept (or constant), β and γ are vectors of coefficients for the independent and unit i's dummy variables (the fixed effects); and εit is the error term.

To evaluate the effects of public debt policy on sustainable development, the standard model (1) was specified as follows:

$$SD_{it} = \alpha + \beta X_{it} + \delta C_{it} + \sum_{i=1}^{n} \gamma_i u_{it} + \varepsilon_{it}, \tag{2}$$

where SD denotes an associated dimension of sustainable development, X is the key explanatory variable, C denotes control variables; α is the overall intercept; β, δ, and γ are the vectors of coefficients for the independent, control, and unit i's dummy variables; i and t represent the countries (i = 1, …,5) and the periods (t = 1996, …,2023); uit is a dummy variable; n is the number of dummy variables (n=5-1); and εit is the error term.

To moderated regression analysis, the corresponding moderating variables were integrated into the model (2) as follows:

$$SD_{it} = \alpha + \beta X_{it} + \delta C_{it} + (\varphi M_{it} + \omega IC_{it}) + \sum_{i=1}^{4} \gamma_i u_{it} + \varepsilon_{it}, \qquad (3)$$

where M denotes moderating variables and IC is the interaction terms between the key explanatory variable and moderators [Xit × Mit]; φ and ω are the vectors of coefficients for the moderators and interaction terms.

The key explanatory, dependent, and control variables, except for GovEf and ConCor, which are negative, were transformed into natural logarithms to reduce potential autocorrelation and heteroscedasticity.

The empirical models for this study were thus specified as follows.

1) The economic dimension:

$$\begin{aligned} nGNI_{it} = \alpha + &\beta LnEPDebtS_{it} + \delta_1 LnTrade_{it} + \delta_2 LnUnempl_{it} + \delta_3 LnFossilFu_{it} + \\ &\delta_4 ConCor_{it} + (\varphi M_{it} + \omega IC_{it}) + \sum_{i=1}^{4} \gamma_i u_{it} + \varepsilon_{it}, \end{aligned} \qquad (3.1)$$

where moderating variables were added as follows –

(i) LifeEx, the moderator on social performance, with the interaction term IC.soc (IC.soc = EPDebtS × LifeEx);
(ii) FootPr, the moderator on environmental performance, with the interaction term IC.env (IC.env = EPDebtS × FootPr); and
(iii) GovEf, the moderator on governance performance, with the interaction term IC.gov (IC.gov = EPDebtS × GovEf).

2) The social dimension:

$$\begin{aligned} LnLifeEx_{it} = \alpha + &\beta LnEPDebtS_{it} + \delta_1 LnTrade_{it} + \delta_2 LnUnempl_{it} + \\ &+ \delta_3 LnFossilFu_{it} + \delta_4 ConCor_{it} + (\varphi M_{it} + \omega IC_{it}) + \sum_{i=1}^{4} \gamma_i u_{it} + \varepsilon_{it}, \end{aligned} \qquad (3.2)$$

where moderating variables were added as follows: (i) GNI, the moderator on economic performance, with the interaction term IC.ec (IC.ec = EPDebtS × GNI); (ii) FootPr and IC.env; and (iii) GovEf and IC.gov.

3) The environmental dimension

$$\begin{aligned} LnFootPr_{it} = \alpha + &\beta LnEPDebtS_{it} + \delta_1 LnTrade_{it} + \delta_2 LnUnempl_{it} + \\ &+ \delta_3 LnFossilFu_{it} + \delta_4 ConCor_{it} + (\varphi M_{it} + \omega IC_{it}) + \sum_{i=1}^{4} \gamma_i u_{it} + \varepsilon_{it}, \end{aligned} \qquad (3.3)$$

where moderating variables were added as follows: (i) GNI and IC.ec; (ii) LifeEx and IC.soc; and (iii) GovEf and IC.gov.

4) The governance dimension::

$$\begin{aligned} GovEf_{it} = \alpha + &\beta LnEPDebtS_{it} + \delta_1 LnTrade_{it} + \delta_2 LnUnempl_{it} + \delta_3 LnFossilFu_{it} \\ &+ \delta_4 ConCor_{it} + (\varphi M_{it} + \omega IC_{it}) + \sum_{i=1}^{4} \gamma_i u_{it} + \varepsilon_{it}, \end{aligned} \qquad (3.4)$$

where moderating variables were added as follows: (i) GNI and IC.ec; (ii) LifeEx and IC.soc; and (iii) FootPr and IC.env.

To ensure the applicability and reliability of the selected method, diagnostic tests and comparative analyses were conducted using ordinary least squares (OLS) and random effects (RE) regression methods for all generated models, including 16 models from the main estimation and 16 models from the robustness check.

Table 2 presents descriptive statistics. The correlation matrices and variance inflation factors (VIFs) are provided in Annex 1. In particular, VIFs in all models across the SD's four dimensions varied from 1.5 to 4.3, indicating moderate (acceptable) multicollinearity. The Hausman test results suggest that the selected method is more robust to endogeneity; the p-values in all models are <0.001. To address potential heteroskedasticity and/or serial correlation, diagnostics for RE models were conducted by integrating Arellano's approach to robust standard errors (see Tables 3, 4, 5, and Annex 2).

Table 2. Descriptive Statistics

Variables	Mean	Std. Dev.	Min	Max	Mean across countries: 1996-2023				
					KZ	KG	TJ	TM	UZ
EPDebtS	0.5170	0.6245	0.02	3.21	0.99	0.09	1.70	0.77	0.62
GNI	37.9585	52.5842	0.82	236.49	109.11	5.09	6.30	23.45	45.84
LifeEx	68.3276	2.8536	60.81	74.40	68.23	69.48	67.48	67.42	69.03
FootPr	7.6096	5.6208	1.39	23.76	15.46	3.13	3.48	11.67	4.31
GovEf	-0.8364	0.3854	-1.57	0.15	-0.41	-0.71	-1.04	-1.19	-0.83
Trade	83.4262	32.5727	29.19	181.59	75.69	108.79	100.44	75.60	55.62
Unemployment	6.4174	3.4670	1.53	13.46	7.50	2.86	8.11	6.52	7.10
FossilFu	82.4604	22.2401	34.61	100.00	98.42	69.58	45.59	100.00	98.71
ConCor	-1.1262	0.2470	-1.45	-0.19	-0.82	-1.14	-1.25	-1.31	-1.11

Source: The author's calculations.
*KZ – Kazakhstan, KG – the Kyrgyz Republic, TJ – Tajikistan, TM – Turkmenistan, UZ – Uzbekistan.

As demonstrated in Table 2, the external public and publicly guaranteed debt service, the key explanatory variable of this study, ranged from US$0.02 billion to US$3.21 billion, with a mean value of US$0.52 billion. Tajikistan exhibits the highest EPDebtS at US$1.70 billion, followed by Kazakhstan (US$0.99 billion), Turkmenistan (US$0.77 billion), and Uzbekistan (US$0.62 billion), while the Kyrgyz Republic had the lowest at US$0.09 billion. Gross national income, used as a proxy for the economic dimension, ranged from US$0.82 billion to US$236.49 billion, with a mean of US$37.96 billion. Kazakhstan reported the highest GNI at US$109.11 billion, while the Kyrgyz Republic reported the lowest at US$5.09 billion. Life expectancy, serving as a proxy indicator for the social dimension, varied from 60.8 to 74.4 years, with a mean of 68.3 years. Comparing the average indicators among Central Asian countries, the Kyrgyz Republic demonstrated the highest LifeEx at 69.5 years, whereas Turkmenistan had the lowest at 67.4 years. Material footprint, used as a proxy for the environmental dimension, ranged from 1.39 to 23.76 tons (per capita), with a mean value of 7.61 tons (per capita). Kazakhstan recorded the highest value at 15.46 tons per capita, and the Kyrgyz Republic

reported the lowest value at 3.13 tons per capita. Government effectiveness, serving as a proxy indicator for the governance dimension, extended from -1.57 to 0.15, with a mean value of -0.84. Kazakhstan had the highest score at -0.41, while Turkmenistan reported the lowest at -1.19.

RESULTS AND DISCUSSIONS

Effects of public debt policy

The results of this study indicate that, in Central Asian countries, external public debt financing has a positive and statistically significant impact on all the SD's dimensions, thereby confirming that external debt affects sustainable development prospects (Luu et al., 2024). As demonstrated in Table 3, a one percent increase in EPDebtS is associated with a 0.57% increase in GNI, 0.02% increase in LifeEx and 0.12% increase in FootPr at the $p < 0.01$ level, and 0.06% increase in GovEf at the $p < 0.05$ level.

Table 3. Public debt policy effects on the sustainable development dimensions

Dependent Variables/ Models	The sustainable development dimensions:			
	economic	social	environmental	governance
	LnGNI Model1-ec	LnLifeEx Model1-s	LnFootPr Model1-en	GovEf Model1-g
LnEPDebtS	0.568***	0.021***	0.121***	0.057**
	(0.091)	(0.004)	(0.033)	(0.028)
LnTrade	-0.820***	-0.041***	-0.265***	-0.176***
	(0.197)	(0.008)	(0.073)	(0.061)
LnUnempl	-0.816***	-0.034***	0.114**	-0.201***
	(0.144)	(0.006)	(0.053)	(0.045)
LnFossilFu	1.908**	0.089***	0.703**	0.455**
	(0.733)	(0.031)	(0.270)	(0.227)
ConCor	-0.722**	0.028*	0.434***	0.734***
	(0.339)	(0.014)	(0.125)	(0.105)
Constant	0.304	4.088***	0.802	-0.741
	(3.508)	(0.149)	(1.293)	(1.087)
Observations	139	139	139	139
R2	0.820	0.592	0.902	0.711
Adjust. R2	0.808	0.563	0.895	0.691
F-value	65.875***	20.935***	132.935***	35.610***
t-Hausman:				
Chi-square test value	14529.4	142.225	3837.74	1174.02
p-value	<0.001	<0.001	<0.001	<0.001

Notes: Robust standard errors are in parentheses.
***, **, and * denote significance at 1, 5, and 10 percent levels, respectively.

Rising external public debt service financing, which leads to an increase in GNI (Model1-ec; Table 3), suggests that the public debt policy in Central Asian countries is, to a certain degree, effective in income accumulation and associated with the crowding-in effects, confirming the Keynesian theory. This finding contradicts studies that highlight adverse consequences of external debt due to (i) crowding-out effects (Mejia, 2024; Panizza & Presbitero, 2013) aggravated by excessive debt size (Martın et al., 2024; Ndoricimpa, 2020); (ii) using the debt financing to address the current funding gap instead of long-term investing in labour productivity and well-being (Alsamara et al., 2024); and (iii) low institutional quality (Abduvaliev & Bustillo, 2024). In the case of Central Asian countries, the positive association between debt financing and national

income can be explained by regional characteristics and external influences, such as public sector domination, limited liquidity in national financial markets, and cascading financial crises, which justify the use of expansionary fiscal policies (Butkus et al., 2021; Phuc Canh, 2018; Van Twillert & Halleck Vega, 2023).

The revealed positive association between EPDebtS and LifeEx (Model1-s; Table 3) is similar to that reported by Bese and Friday (2021). Thus, as Central Asian countries increase external public debt service, life expectancy tends to increase, meaning that public debt policy is relatively effective in translating borrowed financial resources into social benefits. The debt's favorable effect on the social dimension can be explained by comparably low debt burden coupled with a historical context of social sector developments (WB, 2024). However, the argument on the beneficial impact of increased debt financing on the social dimension can be either supported or contested due to variations in nexuses between debt financing and proxy indicators for social development. For instance, public debt can have detrimental effects on longevity when its size is excessive (Aladejare, 2023) or on human development when borrowed funds are used to pay more in interest instead of spending more on education and healthcare (Sadiq et al., 2022; Wang et al., 2021). Therefore, further research is needed to provide more evidence on the debt-social development nexus.

The adverse effect that external public debt service has on the environmental dimension (Model1-en; Table 3) indicates the ineffectiveness of the public debt policies of Central Asian countries in promoting better environmental performance, supporting the findings of studies that highlight the hampering effects of debt on environmental development (see, e.g., Akam et al., 2021; Carrera & de la Vega, 2024). However, these findings contradict studies that proved the contributions of debt financing to enhanced environmental quality in Morocco (over the study period spanning from 1984 to 2018; Bachegour & Qafas, 2023), BRICS countries (1990-2019; Sadiq et al., 2022), 22 emerging economies (1990-2020; Zeraibi et al., 2023), and the high-income panel of the Organization of Islamic Cooperation countries (1996-2018; Farooq et al., 2023). Specifically, Sadiq et al. (2023) explained the favorable impacts of external debt on environmental quality by the fact that "the economic and environmental authorities of BRICS countries utilize external debt funds efficiently by financing environmental protection and other alternative energy projects" (pp. 3304-3305). In Central Asian countries, the detrimental effect of debt on the environment can be attributed to the lack of alignment between borrowing policies and environmental development priorities, resulting in weak regulation and gaps in the adoption of green technologies (Filipović et al., 2024; Pobedinsky & Shestak, 2020).

The positive association between EPDebtS and GovEf (Model1-g; Table 3) is a novelty, as governance has been previously analyzed as a dependent variable in the debt-governance nexus only by Ma and Qamruzzaman (2022), who have indicated the harmful impact of debt financing on government effectiveness. Mixed results may stem from examining the relationship between debt financing and governance through different case studies, specifically, Central Asian countries, in contrast to the BRICS countries. The positive impact of external public debt financing on the governance dimension can be explained by the debt sustainability-related requirements of external creditors for gaining access to new financial resources. All five countries in the region are working closely with

international financial organizations and foreign governments to expand the lists of used debt instruments and loan (credit) portfolios (Nikonov et al., 2023).

Then, trade hampers the economic, social, and governance dimensions; however, as Central Asian countries expand their trading operations, the material footprint tends to decrease, meaning a beneficial impact of trade openness on the environmental dimension. These findings are consistent with studies that report negative and positive effects of trade on the SD's dimensions (Barros & Martínez-Zarzoso, 2022; Chen et al., 2025). Unemployment adversely affects all the SD's dimensions. The identified negative relationships between unemployment and GNI, LifeEx, and GovEf are mainly consistent with studies that explored determinants of economic, social, and institutional development (Bota-Avram et al., 2021; Uddin & Rahman, 2023). An unexpected finding on the hampering effect that unemployment has on the environmental dimension contradicts the studies that highlight an advantageous impact of increased unemployment on environmental quality (Koyuncu Çakmak et al., 2025) and calls for further research on the unemployment-environment nexus.

Next, fossil fuel consumption has positive effects across the economic, social, and governance dimensions while adversely affecting the environmental dimension. These results are consistent with studies that identify beneficial contributions of fossil fuel consumption to socio-economic and institutional development, as well as test its role in environmental deterioration (see, e.g., Arora & Kaur, 2020; Ozturk et al., 2022). The findings on relationships between the control of corruption and the SD's dimensions are similar to those reported in studies that suggest variations in the effects of corruption. Specifically, strengthening anti-corruption measures, which entails adverse consequences for the economic dimension, suggests that the Central Asian case confirms the "grease the wheels" hypothesis (Lui, 1985), as in other cases of developing countries (Fhima et al., 2023). In turn, a positive association between ConCor and GovEf and government effectiveness is consistent with the arguments of Kaufmann et al. (2011) on the interdependence of governance indicators.

Moderating effects of public policies
The performance of social (LifeEx), environmental (FootPr), and institutional (GovEf) policies is associated with a positive and statistically significant relationship with GNI, proxied for the SD's economic dimension. A one percent increase in EPDebtS coupled with a one percent rise in FootPr, i.e., the interaction term (IC.env = EPDebtS × FootPr), leads to a 0.03% decrease in GNI at the $p < 0.05$ level, and coupled with a one percent increase in GovEf (IC.gov = EPDebtS × GovEf) results in a 0.99% increase in GNI at the $p < 0.01$ level (Model3-ec, Model4-ec; Table 4).

Table 4. Public debt policy effects on the economic and social dimensions

Dependent	Economic dimension			Social dimension		
	LnGNI			LnLifeEx		
	Model2-ec	Model3-ec	Model4-ec	Model2-s	Model3-ec	Model4-ec
LnEPDebtS	0.230**	0.682***	0.811***	0.018***	0.021***	0.035***
	(0.093)	(0.116)	(0.102)	(0.003)	(0.005)	(0.004)
LnTrade	-0.049	-0.678***	-0.780***	-0.012*	-0.030***	-0.041***
	(0.121)	(0.204)	(0.183)	(0.007)	(0.008)	(0.007)
LnUnempl	-0.209**	-0.917***	-0.804***	0.001	-0.034***	-0.035***
	(0.104)	(0.154)	(0.142)	(0.006)	(0.006)	(0.006)

LnFossilFu	0.057 (0.424)	1.237* (0.717)	0.696 (0.686)		0.041* (0.024)	0.062** (0.030)	0.028 (0.028)
ConCor	-1.192*** (0.219)	-0.942** (0.406)	-2.136*** (0.389)		-0.022 (0.015)	0.002 (0.017)	-0.040** (0.016)
LifeEx	0.289*** (0.017)			GNI	0.001*** (0.000)		
IC.soc	-0.002 (0.002)			IC.ec	-2.253E-5 (0.000)		
FootPr		0.112*** (0.029)		FootPr		0.006*** (0.001)	
IC.env		-0.026** (0.012)		IC.env		-0.001 (0.000)	
GovEf			0.542** (0.261)	GovEf			0.018* (0.010)
IC.gov			0.997*** (0.206)	IC.gov			0.054*** (0.008)
Constant	-15.796*** (2.407)	1.539 (3.589)	4.992 (3.244)		3.986*** (0.116)	4.059*** (0.149)	4.335*** (0.130)
Observ.	139	139	139		139	139	139
R^2	0.947	0.841	0.859		0.767	0.656	0.716
Adjust. R^2	0.942	0.828	0.847		0.748	0.627	0.691
F-value	206.302***	61.700***	70.907***		38.412***	22.203***	29.313***
t-Hausman:							
Chi-square test value	445.855	965052	37.6032		6045.52	3348.23	73355.5
p-value	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001

Source: The author's calculations.
Notes: Robust standard errors are in parentheses.
***, **, and * denote significance at 1, 5, and 10 percent levels, respectively

The revealed negative moderating effect of environmental performance suggests that public debt and environmental policies have conflicting effects on the economic dimension because increasing debt financing with deterioration in environmental quality adversely affects gross national income. The positive moderating effect of governance performance demonstrates that public debt and institutional policies effectively interact to improve the economic dimension (synergy effects). In contrast, the absence of a statistically significant moderating effect of social performance indicates that potential benefits from the interaction between public debt and social policies are not realized (lost effects). The data on net effects also suggest that the public debt and corresponding policies have synergy and lost effects; the net effect of environmental performance is 0.48 = −0.026 × 7.6096 + 0.682, i.e., the interaction coefficient × the mean of the moderator + the coefficient of the unconditional effect; the net effect of governance performance is −0.02.

The performance of economic (GNI), environmental, and institutional policies has a positive and statistically significant impact on LifeEx, proxied for the *SD's social dimension*. Only the governance performance has a moderating effect; the interaction of EPDebtS and GovEf (IC.gov) is 0.05% at the p <0.01 level (Model4-s; Table 4), meaning that public debt and institutional policies have synergy effects on the social dimension. In contrast, the public debt, economic, and environmental policies are associated with the lost effects because the corresponding interaction terms are statistically insignificant (Model2-s, Model3-s; Table 4).

The performances of economic, social, and institutional policies are associated with a positive and statistically significant impact on FootPr, proxied for *the SD's environmental dimension*. All these indicators have a moderating effect on the nexus between EPDebtS and FootPr. A one percent increase in EPDebtS coupled with a one percent increase in GNI (IC.ec = EPDebtS × GNI) and LifeEx (IC.soc = EPDebtS × LifeEx) decreases FootPr by 0.001% at the $p < 0.01$ level and 0.002% at the $p < 0.05$ level, respectively (Model2-en and Model3-en; Table 5). In turn, the interaction of external debt service and government effectiveness (IC.gov) is 0.201% at the $p < 0.05$ level (Model4-en; Table 5). Thus, public debt, economic, and social policies have synergy effects on the environmental dimension because better environmental quality is achieved through increased debt financing and improved economic and social performances. In contrast, public debt and institutional policies have conflicting effects because increased debt financing and improved governance performance hamper the environmental dimension. The net effects of economic, social, and governance performances are 0.106, -0.041, and -0.004, respectively.

Government effectiveness, proxied for the *SD's governance dimension*, is positively and significantly influenced by the performance indicators of economic and social policies, while the performance indicator of environmental policy is insignificant in explaining changes in governance. Only the social performance has a moderating effect; the interaction of EPDebtS and LifeEx (IC.soc) is 0.002% at the $p < 0.05$ level (Model3-g; Table 5), meaning that public debt and social policies have synergy effects on the governance dimension. Interestingly, the effect of public debt policy on the governance dimension becomes insignificant when performance indicators of all corresponding policies are embedded (Model2-g, Model3-g, and Model 4-g in Table 5 versus Model1-g in Table 1). Thus, the public debt and corresponding policies have lost effects, meaning that the benefits from their interaction are not realized.

Table 5. Public debt policy effects on the environmental and governance dimensions

Dependent	Economic dimension				Governance dimension		
	LnFootPr				GovEf		
	Model2-ec	Model3-ec	Model4-ec		Model2-s	Model3-ec	Model4-ec
LnEPDebtS	0.144***	0.096**	0.164***		0.047	-0.074	0.030
	(0.031)	(0.048)	(0.040)		(0.030)	(0.050)	(0.038)
LnTrade	-0.086	-0.078	-0.237***		-0.074	-0.063	-0.127*
	(0.067)	(0.062)	(0.072)		(0.065)	(0.065)	(0.066)
LnUnempl	0.322***	0.231***	0.140**		-0.078	-0.068	-0.175***
	(0.056)	(0.054)	(0.056)		(0.054)	(0.056)	(0.050)
LnFossilFu	0.323	0.110	0.406		0.286	0.391*	0.436*
	(0.230)	(0.218)	(0.270)		(0.222)	(0.228)	(0.233)
ConCor	0.337**	0.405***	0.064		0.558***	0.544***	0.592***
	(0.138)	(0.113)	(0.153)		(0.133)	(0.118)	(0.132)
GNI	0.006***			GNI	0.003***		
	(0.001)				(0.001)		
IC.ec	-0.001***			IC.ec	-9.273E-5		
	(0.000)				(0.000)		
LifeEx		0.078***		LifeEx		0.031***	
		(0.009)				(0.009)	
IC.soc		-0.002**		IC.soc		0.002**	
		(0.001)				(0.001)	
GovEf			0.224**	FootPr			0.014
			(0.103)				(0.009)

IC.gov			0.201** (0.081)	IC.env		0.003 (0.004)
Constant	0.815 (1.100)	-2.688** (1.239)	1.834 (1.279)	-1.092 (1.064)	-3.690*** (1.295)	-1.316 (1.168)
Observ.	139	139	139	139	139	139
R^2	0.933	0.943	0.912	0.741	0.742	0.719
Adjust. R^2	0.928	0.938	0.904	0.718	0.719	0.695
F-value	163.081***	193.265***	120.662***	33.229***	33.398***	29.808***
t-Hausman:						
Chi-square test value	10173.5	61222.4	15499.1	636.178	40116.0	9857.83
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

In sum, as demonstrated in Figure 1, by the economic dimension, the increased external debt service leads to a positive impact when embedded:

(i) the social policy performance (outcome), wherein the interaction coefficient is statistically insignificant, meaning the likelihood of a lack of consistency between public debt and social policies that results in lost effects;

(ii) the environmental policy performance; the interaction coefficient is negative and significant, meaning the likelihood of an inconsistency between public debt and environmental policies that results in conflicting effects; and

(iii) the governance policy performance; the interaction coefficient is positive and statistically significant, meaning the likelihood of consistency between public debt and institutional policies that result in synergy effects.

Figure 2. Public debt policy effects on the SD's dimensions
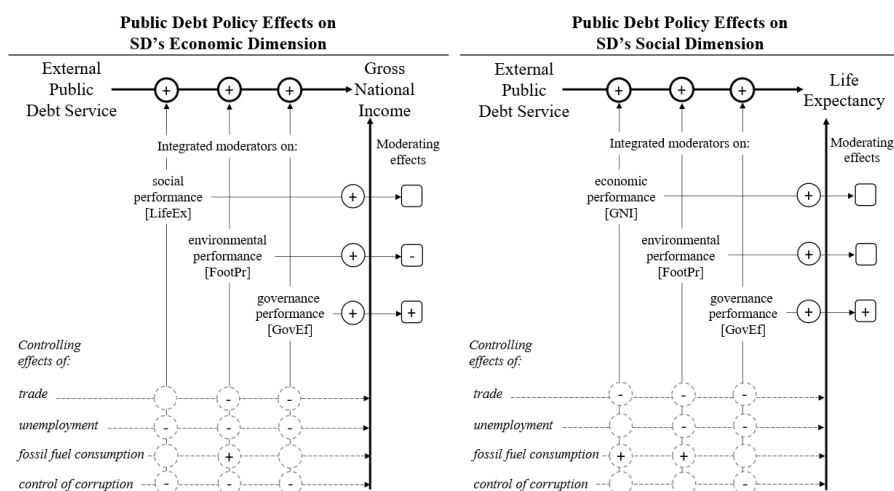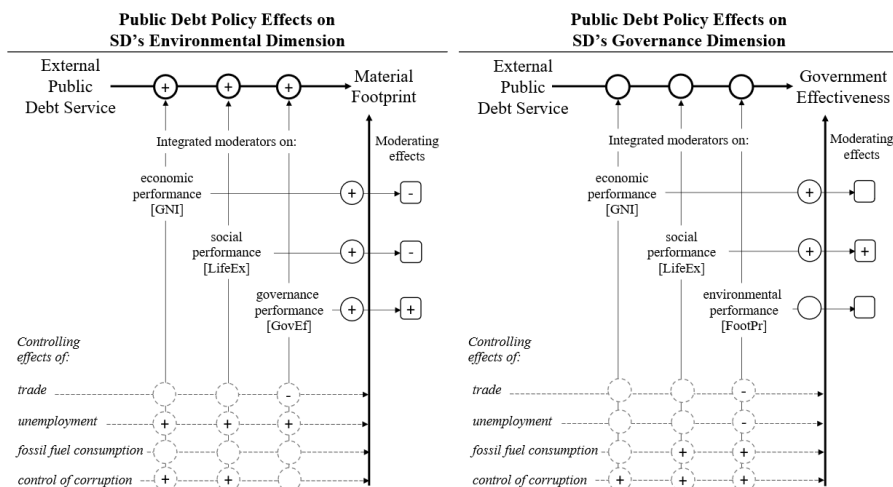
Source: The author's deliberations.
Notes: The figure illustrates the moderating effects of public policies—economic, social, environmental, and governance performances—on the debt-SD nexus across four dimensions. ⊕,⊖,◯ -denote positive, negative, and not significant coefficients, respectively; and ⊞,⊟,☐ -denote positive, negative, and not significant interaction coefficients.

By the social dimension, the increased external debt service leads to a positive impact when integrating the economic and environmental performances [lost effects by the interaction terms] and the governance performance [synergy effects; i.e., *increased debt financing alongside the better performance of institutional policy leads to better changes by the social dimension*]. By the environmental dimension, the increased external debt service leads to a positive impact when embedding the economic and social performances [synergy effects; i.e., *increased debt financing alongside the better performance of economic and social policies leads to the better changes by the environmental dimension*] and the governance performance [conflicting effects; i.e., *increased debt financing alongside the better performance of institutional policy leads to the worsened outcomes by the environmental dimension*]. By the governance dimension, while the effects of external debt service become insignificant due to embedded moderators of economic, social, and environmental performances, the corresponding policies are associated with lost effects.

These findings are relatively new, since this study is the first attempt to simultaneously evaluate the moderating roles of the performance of economic, social, governance, and environmental policies on the nexus between public debt policy and the SD's dimensions. In the categorical context, however, these results are consistent with studies that highlight challenges in achieving progress toward sustainable development caused by trade-offs across the SD's four pillars and goals (Breuer et al., 2019; Mensah, 2019; Bali Swain & Yang-Wallentin, 2020).

The findings on conducive effects of corresponding public policies on the SD's dimensions are generally consistent with theoretical considerations of the economic, social, environmental, and institutional development factors. Regarding the moderating

role of corresponding public policies, it is likely that governments still prefer to use public debt to finance projects that are detrimental to the environment and have low social returns while implementing public administration reforms. Although debt financing, in combination with improvements in economic and social policies, somewhat reduces the negative environmental effects of debt, these measures do not fully counteract the resulting environmental harm. This suggests that Central Asian countries remain heavily dependent on fossil fuel-based industries and, according to the EKC theory, are situated on the upward slope of the Kuznets curve. The missed opportunities for better changes in the institutional dimension, through debt financing, indicate a lack of coherence between institutional and corresponding policies. Therefore, Central Asian countries are in a position similar to that of most emerging economies, where economic growth is the main task that, due to both external and internal circumstances, continues to be accomplished at the expense of other aspects of sustainable development.

Robustness check

The robustness check corroborates the key findings of the main estimation, thereby meaning that the main results of this study can be relied upon (see Annex 2). In particular, a one percent increase in the external public and publicly guaranteed debt results in a 0.78% increase in GNI, 0.03% increase in LifeEx, 0.19% increase in FootPr, and 0.13% increase in GovEf at the $p < 0.01$ level. The findings confirm that public debt policy in Central Asian countries is relatively effective in promoting improvements in economic, social, and governance dimensions, but it impedes progress in the environmental dimension. The relationships between control and dependent variables are identical. While moderation analysis results are generally consistent, a few variations in the environmental dimension require further investigation.

CONCLUSION

The persistent rise in external public debt financing, coupled with limited progress toward the SDGs after more than two-thirds of the 2030 Agenda timeline, underscores the necessity of examining the impact of public debt policy on sustainable development. Since earlier studies investigated the impacts of debt on a few development indicators, there is a lack of a comprehensive analysis of the debt's effects on the SD across its economic, social, environmental, and governance dimensions. This study addresses that gap and is the first to explore the relationship between external public debt financing and all four dimensions of the SD through econometric analysis of panel data from five Central Asian countries spanning 1996 to 2023.

The case of Central Asian countries demonstrates that external public debt financing plays a significant role in fostering sustainable development. In these countries, the increase of debt financing is associated with rising gross national income and life expectancy, as well as enhanced government effectiveness, thereby suggesting that public debt policy leads to better changes across the SD's economic, social, and governance dimensions. However, an increase in external public debt financing leads to a rise in the material footprint. This indicates that public debt policy is unlikely to be effective in promoting environmental improvements. These findings partially align with the arguments of Luu et al. (2024), such as (a) external debt can benefit healthy lives, inclusive education, gender equality, economic growth, and innovation; and (b) external debt has harmful

effects on cities' resilience, safe human settlements, and land biodiversity. When making public debt-related decisions, governments in Central Asian countries should therefore apply effective strategies to translate debt financing into environmental gains. Simultaneously, employing public debt to finance environmentally friendly initiatives should be guided by policies that explicitly tie borrowing to measurable improvements across the SD's economic, social, and governance dimensions.

Next, the debt-SD nexus can change due to moderating effects that economic, social, environmental, and institutional policies have. More specifically, debt financing fosters the economic and social dimensions as governance performance becomes better, and the environmental and governance dimensions as social performance improves. However, when debt financing increases, it tends to hinder the economic dimension as environmental performance improves. Conversely, as economic and social performance improves, increased debt financing appears to foster the environmental dimension. The effects of public debt policy on the governance dimension become statistically insignificant when embedding the performance indicators of economic, social, and environmental policies. Thus, public debt and corresponding public policies may have conflicting, lost, and synergy effects. These results support earlier considerations related to challenges of the 2030 Agenda caused by synergies and trade-offs within and between the SD's dimensions and individual SDGs (Breuer et al., 2019; Mensah, 2019), thereby calling for well-balanced public policy decisions (Elder, 2024).

In particular, integrating an evaluation of the effects of debt policy on the SD's dimensions and the moderating effects of corresponding public policies on the debt-SD nexus into public debt management is advisable for fulfilling the 2030 Agenda. Increasing external debt financing appears to be a justified tactic due to its contribution to economic goals, improvement of social well-being, and strengthening of institutional quality, but it is questionable from an environmental development perspective. Addressing this trade-off necessitates moving beyond a traditional fiscal framework through, inter alia, upgrading budgetary rules and ensuring financial discipline. Specifically, it is recommended to use a debt threshold that aligns not only with economic growth objectives (as is the case) but also with social, environmental, and institutional development goals, i.e., a holistic debt threshold in the context of sustainable development. Adverse consequences of debt policy, which may arise from conflicting or lost effects of corresponding public policies, can be mitigated through the strategic investment of borrowed funds. This approach requires making SD-informed decisions regarding the prioritization and spending of borrowed funds. Applying SD-aligned criteria to evaluate the effectiveness of projects financed by public debt can enhance oversight and improve the implementation of public debt policy.

Last, but not least, the following limitations of this study should be acknowledged. The external public debt service and external public debt, used as key explanatory variables in the main estimation and robustness check, and gross national income, life expectancy, material footprint, and government effectiveness, that represent proxies for the SD's economic, social, environmental, and governance dimensions, are well-suited, but not sufficient, to fully clarify the impact of public debt policy on sustainable development. This study focuses solely on Central Asian countries, whereas both

regional and country-specific factors can significantly influence the debt-SD nexus. Therefore, future research that examines other regions or countries, incorporates a broader set of explanatory, control, outcome, moderating, and mediating variables, and explores a non-linearity of the debt-SD nexus may provide deeper insights into the effectiveness of debt policy, thereby informing and contributing to public policy decisions aligned with the 2030 Agenda.

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CONFLICTS OF INTEREST

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AUTHORS' CONTRIBUTIONS

AM: conceptualization, methodology, data curation, formal analysis, investigation, validation, visualization, writing – original draft, writing – review & editing.

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Annex 1. Correlation matrixes

The economic dimension									
	GNI	EPDebtS	Trade	Unempl	FossilFu	ConCor	LifeEx	FootPr	GovEf	VIF
GNI	1									
EPDebtS	0.631**	1								2.244
Trade	-0.392**	-0.433**	1							2.415
Unempl	-0.154	-0.080	-0.321**	1						1.718
FossilFu	0.458**	0.508**	-0.518**	0.094	1					2.042
ConCor	0.658**	0.510**	-0.068	-0.079	0.227*	1				2.586
LifeEx	0.497**	0.372**	-0.376**	-0.351**	0.100	0.262**	1			2.087
FootPr	0.701**	0.615**	-0.338**	0.107	0.589**	0.472**	0.155	1		2.148
GovEf	0.696**	0.464**	-0.167	-0.252**	0.170	0.716**	0.559**	0.374**	1	2.723

The social dimension									
	LifeEx	EPDebtS	Trade	Unempl	FossilFu	ConCor	GNI	FootPr	GovEf	VIF
LifeEx	1									
EPDebtS	0.372**	1								2.226
Trade	-0.376**	-0.433**	1							2.111
Unempl	-0.351**	-0.080	-0.321**	1						1.540
FossilFu	0.100	0.508**	-0.518**	0.094	1					1.942
ConCor	0.262**	0.510**	-0.068	-0.079	0.227*	1				2.732
GNI	0.497**	0.631**	-0.392**	-0.154	0.458**	0.658**	1			4.321
FootPr	0.155	0.615**	-0.338**	0.107	0.589**	0.472**	0.701**	1		2.979
GovEf	0.559**	0.464**	-0.167	-0.252**	0.170	0.716**	0.696**	0.374**	1	2.769

The environmental dimension									
	FootPr	EPDebtS	Trade	Unempl	FossilFu	ConCor	GNI	LifeEx	GovEf	VIF
FootPr	1									
EPDebtS	0.615**	1								2.053
Trade	-0.338**	-0.433**	1							2.454
Unempl	0.107	-0.080	-0.321**	1						1.684
FossilFu	0.589**	0.508**	-0.518**	0.094	1					1.833
ConCor	0.472**	0.510**	-0.068	-0.079	0.227*	1				2.798
GNI	0.701**	0.631**	-0.392**	-0.154	0.458**	0.658**	1			3.225
LifeEx	0.155	0.372**	-0.376**	-0.351**	0.100	0.262**	0.497**	1		2.160
GovEf	0.374**	0.464**	-0.167	-0.252**	0.170	0.716**	0.696**	0.559**	1	2.940

The governance dimension									
	GovEf	EPDebtS	Trade	Unempl	FossilFu	ConCor	GNI	LifeEx	FootPr	VIF
GovEf	1									
EPDebtS	0.464**	1								2.244
Trade	-0.167	-0.433**	1							2.545
Unempl	-0.252**	-0.080	-0.321**	1						1.804
FossilFu	0.170	0.508**	-0.518**	0.094	1					2.038
ConCor	0.716**	0.510**	-0.068	-0.079	0.227*	1				2.077
GNI	0.696**	0.631**	-0.392**	-0.154	0.458**	0.658**	1			4.147
LifeEx	0.559**	0.372**	-0.376**	-0.351**	0.100	0.262**	0.497**	1		2.037
FootPr	0.374**	0.615**	-0.338**	0.107	0.589**	0.472**	0.701**	0.155	1	2.983

Source: the author's calculations.
Notes:
**. Correlation is significant at the 0.01 level (2-tailed);
*. Correlation is significant at the 0.05 level (2-tailed).

Annex 2. The robustness check

Dependent	The economic dimension: LnGNI					The social dimension: LnLifeEx			
Models	Model1r-ec	Model2r-ec	Model3r-ec	Model4r-ec		Model1r-s	Model2r-s	Model3r-s	Model4r-s
LnEPDebtS	0.782*** (0.074)	0.291*** (0.097)	0.882*** (0.090)	0.958*** (0.104)		0.033*** (0.003)	0.025*** (0.003)	0.031*** (0.004)	0.044*** (0.004)
LnTrade	-0.617*** (0.166)	-0.064 (0.117)	-0.551*** (0.169)	-0.487*** (0.169)		-0.030*** (0.007)	-0.016** (0.006)	-0.022*** (0.007)	-0.024*** (0.007)
LnUnempl	-0.546*** (0.123)	-0.208** (0.094)	-0.681*** (0.129)	-0.551*** (0.127)		-0.022*** (0.005)	-0.002 (0.005)	-0.022*** (0.005)	-0.023*** (0.005)
LnFossilFu	1.552** (0.601)	0.346 (0.406)	1.299** (0.580)	1.390** (0.592)		0.064*** (0.024)	0.048** (0.021)	0.052** (0.023)	0.056** (0.023)
ConCor	-1.264*** (0.291)	-0.922*** (0.265)	-1.003*** (0.371)	-1.866*** (0.367)		0.001 (0.012)	-0.020 (0.015)	-0.018 (0.015)	-0.029** (0.014)
GNI		0.281*** (0.021)			GNI		0.001*** (0.000)		
IC.ec		0.000** (0.000)			IC.ec		-2.111E-6 (0.000)		
LifeEx			0.091*** (0.027)		FootPr			0.004*** (0.001)	
IC.soc			-0.003*** (0.001)		IC.env			-1.174E-5 (0.000)	
GovEf				-0.035 (0.257)	GovEf				-0.007 (0.010)
IC.gov				0.096*** (0.033)	IC.gov				0.005*** (0.001)
Constant	-1.600 (2.855)	-16.737*** (2.227)	-1.224 (2.791)	-2.116 (2.799)		4.040*** (0.114)	3.954*** (0.102)	3.988*** (0.112)	4.008*** (0.109)
Observ.	139	139	139	139		139	139	139	139
R^2	0.875	0.947	0.887	0.883		0.748	0.811	0.775	0.776
Adjust. R^2	0.866	0.942	0.878	0.873		0.731	0.794	0.755	0.757
F-value	101.012***	206.950***	91.610***	87.583***		42.978***	49.825***	40.003***	40.388***
t-Hausman:									
Chi-square test value	291.915	238.332	278.643	3612.96		956.271	91938.2	12759.6	4.89145e+07
p-value	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001

Source: The author's calculations.
Notes: EPDebt denotes the external debt stocks, public and publicly guaranteed in current bln.US$.
*Robust standard errors are in parentheses. ***, **, and * denote significance at 1, 5, and 10 percent levels, respectively.*

Annex 3. The robustness check (cont.)

Dependent	The environmental dimension: LnFootPr					The governance dimension: GovEf			
Models	Model1r-en	Model2r-en	Model3r-en	Model4r-en		Model1r-g	Model2r-g	Model3r-g	Model4r-g
LnEPDebt	0.185*** (0.030)	0.158*** (0.034)	-0.010 (0.051)	0.163*** (0.044)		0.132*** (0.025)	0.114*** (0.032)	0.085* (0.051)	0.127*** (0.032)
LnTrade	-0.208*** (0.068)	-0.112* (0.066)	-0.044 (0.062)	-0.196*** (0.071)		-0.115** (0.057)	-0.075 (0.061)	-0.108* (0.061)	-0.101 (0.061)
LnUnempl	0.179*** (0.050)	0.314*** (0.057)	0.305*** (0.050)	0.199*** (0.053)		-0.154*** (0.042)	-0.098* (0.052)	-0.128** (0.049)	-0.153*** (0.047)
LnFossilFu	0.581** (0.245)	0.460** (0.224)	0.225 (0.214)	0.549** (0.248)		0.283 (0.206)	0.237 (0.206)	0.270 (0.212)	0.263 (0.209)
ConCor	0.288** (0.119)	0.421** (0.163)	0.252* (0.140)	0.227 (0.154)		0.591*** (0.100)	0.582*** (0.150)	0.482*** (0.139)	0.557*** (0.134)
GNI		0.005*** (0.001)			GNI		0.002** (0.001)		
IC.ec		0.000*** (0.000)			IC.ec		-2.768E-5 (0.000)		
LifeEx			0.081*** (0.011)		LifeEx			0.002 (0.011)	
IC.soc			2.834E-5 (0.000)		IC.soc			0.000 (0.000)	
GovEf				0.130 (0.108)	FootPr				0.007 (0.010)
IC.gov				-0.002 (0.014)	IC.env				-2.528E-5 (0.000)
Constant	0.475 (1.165)	0.175 (1.077)	-4.085*** (1.172)	0.578 (1.173)		-0.699 (0.980)	-0.887 (0.990)	-0.938 (1.165)	-0.791 (1.006)
Observations	139	139	139	139		139	139	139	139
R²	0.916	0.932	0.941	0.917		0.754	0.762	0.756	0.755
Adjust. R²	0.911	0.926	0.936	0.910		0.737	0.741	0.735	0.734
F-value	158.415***	160.035***	184.857***	129.209***		44.219***	37.164***	36.113***	35.845***
t-Hausman:									
Chi-square test value	277829	1528.61	39101.9	3391.83		1168.55	2290.94	2650.4	1008.51
p-value	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001

Source: The author's calculations.
Notes: EPDebt denotes the external debt stocks, public and publicly guaranteed in current bln.US$.
*Robust standard errors are in parentheses. ***, **, and * denote significance at 1, 5, and 10 percent levels, respectively.*