Journal of Economic Integration

Vol. 40, No. 1, March 2025, 205-235
https://doi.org/10.11130/jei.2024039

pISSN: 1225-651X eISSN: 1976-5525

Examining the Effect of Economic Sophistication on Public Health Expenditure? Evidence from a Global Sample

Ronald Djeunankan[1+], Joseph Keneck-Massil[2,3], Henri Njangang[4], and Youssouf Nvuh-Njoya[2]

[1]*The Dschang School of Economics and Management, University of Dschang, Dschang, Cameroon*
[2]*CEREG, University of Yaounde II, Yaounde, Cameroon*
[3]*University of Versailles Saint-Quentin-en-Yvelines, France*
[4]*Faculty of Economics and Management, University of Dschang, Dschang, Cameroon*

Abstract Do sophisticated countries spend more on health? This paper endeavors to analyze, for the first time, the extent to which the mix of products a country produces and exports, measured by the economic complexity index, determines public health expenditure. Empirical analyses based on an Instrumental Variable approach from a sample of 116 countries over the period 2002-2019 consistently show that countries exporting complex products on average spend more on health than their counterparts with economic structures mainly based on simple products with low productivity. Complementary analyses show that the effect of economic complexity on public health spending is a function of income level, political regime, and type of democracy. Specifically, results show that although the effect of economic complexity on public health expenditure on average is positive in all subsamples, the effect is greater in high-income countries, democratic countries, and countries with parliamentary democracies. Furthermore, there exist evidence that some key channels via which economic complexity improves public health expenditure are the so-called *resource curse* and economic growth. It flows from these results that government health expenditure may be increased by diversifying the productive structure toward the production and export of highly sophisticated products.

Keywords: Economic Complexity, Government Health Expenditure, Developed Countries, Developing Countries

JEL Classifications: O11, O14, O57, I15, H51

Received 20 February 2024, Revised 13 August 2024, Accepted 19 August 2024

+Corresponding Author: Ronald Djeunankan
Ph.D. Student, The Dschang School of Economics and Management, University of Dschang, Dschang, Cameroon.
E-mail: nouganronald@yahoo.com
Co-Author: Joseph Keneck-Massil
Associate Professor, CEREG, University of Yaounde II, Yaounde, Cameroon.
Associate Professor, University of Versailles Saint-Quentin-en-Yvelines, France. E-mail: joseph.keneck-massil@uvsq.fr
Co-Author: Henri Njangang
Ph.D. Scholar, Faculty of Economics and Management, University of Dschang, Dschang, Cameroon.
E-mail: ndieupahenri@gmail.com
Co-Author: Youssouf Nvuh-Njoya
Associate Professor, CEREG, University of Yaounde II, Yaounde, Cameroon. E-mail: youssouf.nvuh@univ-yaounde2.org
Acknowledgement: We are very grateful to the journal's editor and to the reviewer for their very pertinent comments, which helped us to considerably improve the quality of this paper. Any remaining errors are our responsibility.

I. Introduction

Health expenditure is a key factor in monitoring a country's health and development outcomes, which are preconditions for the achievement of other sustainable development goals (Stubbs et al., 2017). Indeed, several authors have shown that health spending improves health outcomes such as infant mortality rates, life expectancy at birth, and other health outcome measures (Bokhari et al., 2007). This has encouraged countries to increase public spending on healthcare, which has almost tripled over the past two decades on a global scale, from 3200 billion euros in 2000 to about 9500 billion euros in 2020, which represented 4 and 6%, respectively, of world GDP (WHO, 2020). Although this evolution seems interesting, the uneven distribution of public health expenditures remains a major concern. In 2018, for example, East Asia and the Pacific topped the list with 6.7% of GDP invested in healthcare spending, followed by Latin America and the Caribbean (4.07%), the Middle East and North Africa (3.4%), and finally Sub-Saharan Africa with just 1.87% (World Bank, 2023). The main factors explaining this uneven distribution of public healthcare expenditure across countries primarily relate to economic growth (Di Matteo and Di Matteo, 1998).

The economic literature has mainly relied on the use of basic aggregate measures, such as GDP per capita, to quantify economic performance. The fact that this strategy ignores innovation in manufactured (and exported) goods is one of its primary flaws. According to recent studies, various items have diverse effects on the economy (Hidalgo and Hausmann, 2009; Hartmann et al., 2017). This begs the issue of whether the sophistication of a nation's economic structure influences its level of health expenditure, which is the study's major focus. As a result, one of the key points of this study is to show that, all else being equal, nations that produce (and export) a wide range of highly sophisticated products tend to spend more on health. Economic sophistication is measured by the economic complexity index proposed by Hidalgo and Hausmann (2009). According to Hidalgo and Hausmann (2009), economic complexity specifically refers to the nation's degree of technological advancement and expertise from the manufacturing to the export phase. In parallel, the World Health Organization defines government health expenditure as the share of current domestic general government resources used to fund health expenditures as a share of GDP.

From these definitions, the level of economic complexity and the level of public health spending may be linked with income levels. We hypothesize that a higher level of economic complexity can increase government health expenditures. This argument is consistent with the product-space theory developed by Hidalgo et al. (2007). This theory states that complex nations are located at the densely connected core of the product space, producing and exporting a wide range of highly related, sophisticated products, while less complex nations are located at the less dense periphery, producing (and exporting) simple, unrelated products. Thus, rich countries producing (and exporting) highly sophisticated products may find it easier to diversify into new sectors with higher productivity levels, because their products typically occupy a densely connected core (Hidalgo et al., 2007). Intuitively, producing highly sophisticated products with high and increasing returns may endow the government with enough resources to spend a proportion on health.

Given the importance of health expenditure in determining cross-country variation in health outcomes, a branch of the health economics literature has sought into its drivers. From an institutional perspective, existing studies have analyzed the role of women in parliament or cabinet, share of female legislators, IMF conditionality, accountability and democracy (Stubbs et al., 2017; Datta, 2020; Tadadjeu et al., 2021a). Moreover, demographic determinants of public health expenditure have examined the role of population aging and obesity (Murthy and Okunade, 2016). Macroeconomic determinants of public health expenditure appear to be more numerous examining the role of per capita income (Khan and Husnain, 2019), financial development (Rana et al., 2020), technological progress and health insurance (Nghiem and Connelly, 2017), and natural resources (Cockx and Francken, 2014; Tadadjeu et al., 2021b). Despite this fast-rising literature on the macroeconomic determinants of public health expenditure, the potential role of economic complexity is yet to be investigated.

This article offers a new perspective on understanding the determinants of public health expenditure by examining the role of economic complexity. Hidalgo and Hausmann (2009) associate the factors of economic complexity with the factors of accumulation capacity and productive capacity. These factors result either from the improvement of existing capacities (infrastructure, human capital accumulation, investment in research and development, etc.) or from the import of new capacities. These have encouraged a new but fast-growing branch of the economic literature that has examined the effect of economic complexity on a set of factors including economic growth, energy efficiency, income inequality, resource rents, environmental quality, health outcomes, and recently, energy efficiency and obesity (Poncet and Waldemar, 2013; Hartmann et al., 2017; Vu, 2020; Canh et al., 2020; Adam et al., 2023; Djeunankan et al., 2023a; b; Djeunankan et al., 2024a, Djeunankan et al., 2024b). To date, no paper has empirically investigated the effect of economic complexity on public health expenditure.

This work contributes to the literature on at least four fronts. First, to the best of our knowledge, this is the first study to investigate the effect of economic complexity on public health expenditures. This study fills the knowledge gap and provides a new lever via which governments might act to increase their health-care spending. Second, the IV-2SLS technique is primarily used in this study to limit endogeneity. Identifying an external tool for economic complexity is the difficulty of IV-2SLS. We refer to Stojkoski et al (2023) and use the average economic complexity of three countries that have the most similar patterns of specialization to the given country but do not have a land or sea border with it to instrument a country's economic complexity. This goes beyond previous research, which used an average of the economic complexity of surrounding countries to measure the level of complexity (Vu, 2020). Third, we run a series of heterogeneous analyses by distinguishing high-income from low- and middle-income countries, democratic from non-democratic countries, and presidential democracies from parliamentary democracies. This enables us to suggest more precise policy recommendations. Finally, beyond analysing the direct effect of economic complexity on government health expenditures, this research further identifies some channels through which economic complexity could improve government health expenditure. This mediation analysis enabled us to identify the contribution of each channel, and to draw up economic policy recommendations.

To summarise, empirical findings consistently show that sophisticated countries spend more on health. Moreover, there is some evidence that the effect of economic complexity on government health expenditure is more important in high-income countries than in low-income ones, higher in democratic countries than in their non-democratic counterparts, and greater in parliamentary democracies than in presidential democracies. Furthermore, this study presents empirical evidence that income and natural resource rents are some of the transmission pathways via which economic complexity increases government health expenditure. The remainder of the research is structured as follows: The following section digs into the theoretical background and potential transmission channels. Section 3 describes the data and empirical methodology. Empirical findings are presented in Section 4. Section 5 empirically investigates the transmission pathways, and a summary conclusion completes the study.

II. Economic Complexity and Public Health Expenditure: Theoretical Background and Potential Transmission Channels

The main hypothesis of this study is that a country's ability to produce and export a wide range of sophisticated products increases the share of public health expenditure in GDP. The commodity space theory of Hidalgo et al. (2007) underpins this argument. According to this theory, nations become more complex by moving from the less dense peripheral zone of the commodity space to the dense central zone. Highly-developed countries at the heart of the product space, where connections are dense, have the capacity to easily produce a greater variety of connected products than their less-developed counterparts on the periphery, who can only produce a handful of simple, unconnected products, with low productivity (Hidalgo et al., 2007). Economic complexity can help to increase public spending on health, insofar as a country with a relatively high level of economic complexity can easily make improvements in the medical sector. These improvements in the medical sector may encourage leaders to increase the share of public spending in their budgets. Moreover, a country with a relatively high level of economic complexity is more resilient and can therefore invest more in social areas such as healthcare. It flows from these arguments that economic complexity may have a direct positive effect on government health expenditure.

Regarding indirect effects, we find two possible ways that economic complexity could affect how much the government spends on health care.

A. Increased economic complexity improves the level of income, thereby increasing government health expenditure.

Several studies have shown that an increase in economic complexity is associated with a higher level of income (Hidalgo and Hausmann, 2009; Hartmann et al., 2017; Morales et al., 2018). For example, Hidalgo and Hausmann (2009) show that countries tend to converge on the level of income determined by the complexity of their productive systems, implying that development efforts should concentrate on creating the conditions that allow complexity to emerge in order to achieve long-term growth and prosperity. Moreover, Hartmann et al. (2017) also point out that economic complexity is highly predictive of future economic growth.

Similarly, many studies suggest that the level of income is the most important determinant of public health expenditure (Barros, 1998; Herwartz and Theilen, 2003; Murthy and Okunade, 2009; Younsi et al., 2016; Nghiem and Connelly, 2017). For example, Khan et al. (2016) point out income as a main factor (with an income elasticity of health expenditure of 0.99), responsible for explaining variation in the level and growth of health care expenditure in Malaysia, which is the most rapidly growing economy in Southeast Asian countries. In 2012, it spent 4,49% of GDP on its total health expenditure, in contrast to the 2,94% spent in 1997. Younsi et al. (2016) also find that the trend in health expenditure growth is strongly correlated with the country's economic growth and development level. Higher income countries spend more than 15% of GDP on health, while lower income countries spend less than 5.5% on health.

In short, a higher level of economic complexity leads to more income, thereby improving future economic growth and development levels. The literature shows that economic complexity, which causes the economy to grow quickly, tends to increase the amount of money spent on public health.

B. Economic complexity may also lower resource curses and improve the quality of institutions, which could help pay for public health

Many papers argue that countries specializing in a range of sophisticated products tend to enjoy good institutional quality (Hidalgo and Hausmann, 2009; Khan, 2010, 2013; Hartmann et al., 2017). For example, according to Khan (2010, 2013), countries that specialize in a small number of basic products are more likely to have poor institutional quality because the benefits of maintaining the rule of law and property rights are insufficient to pay the costs of enforcement. Hartmann et al. (2017) argue that economic complexity grows in tandem with institutional changes because a firm's capacity to build institutions that function well in the sector in which it operates is critical to its survival. Moreover, producing complex products is detrimental to the resource curse. It leads to less dependence on natural resources. For example, Canh et al. (2020) show that economic complexity has a significant negative impact on natural resource rents. In other words, structural changes lead to improvement in quality and diversification of production, which reduce the raw natural resource dependence of the economy and lower the resource curse.

In the same way, several studies show that the quality of institutions affects the budget of public health expenditure or impacts its efficiency (Mauro, 1998; Besley and Kudamatsu, 2006; Dyer, 2006; Wigley and Akkoyunlu, 2011; Kotera and Okada, 2017; Swaleheen et al., 2019; Sommer, 2020; Yan and Lin, 2020; Blum et al., 2021). As an illustration, according to Wigley and Akkoyunlu (2011), several studies find that democratic regimes improve population health by allocating more resources to health expenditure than autocratic regimes. Although some authors (Yan and Lin, 2019, 2020) have shown that some autocratic regimes promote health expenditure, this expenditure is lower compared to democratic regimes. Blum et al. (2021) confirm this result by estimating that public expenditure on health as a percentage of GDP is 20-30% higher than in autocratic regimes. It has also been shown that corruption reduces the amount of budget spent on health. In fact, many millions of dollars of the health budget intended for the construction of hospitals, the procurement of drugs, and the pay of health personnel can be misappropriated by budget officials. For example, the Global Corruption Report (2006) shows that in Cambodia, between 5% and 10% of the health budget disappears before it is even paid by the Ministry of Finance to the Ministry of Health. According to Public Expenditure Tracking Surveys (PETS) in countries like Ghana, Uganda, or Peru, it was also found that more than 70% of non-wage funds or leakage of specific drugs and supplies failed to reach health facility services (Global Corruption Report, 2006). Furthermore, although resource-rich countries have the capacity to invest and spend more on health to increase human capital, many empirical studies point out that, due to the resource curse hypothesis, the abundance and dependence of natural resources are correlated with lower public health expenditure (Cockx and Francken, 2014; El Anshasy and Katsaiti, 2015; Erdoðan et al., 2020). This result can be evidence of an indirect effect of dependence and abundance through a deterioration of the quality of institutions (Mehlum et al., 2006; Bhattacharyya and Hodler, 2010; Henri, 2019) or political regime type (Ajide et al., 2020), as previous studies have pointed out. Thus, El Anshasy and Katsaiti (2015) condition the efficiency of the abundance of natural resources on health outcomes by geographical, historical, and institutional traits.

Therefore, economic complexity may enhance public health spending by improving institutional quality and reducing resource curses.

III. Data and Methodology

A. Data

This study aims to analyze the effect of economic complexity on public health expenditure. For this purpose, we use data from 116 countries over the period 2002-2019. The period and sample under study were conditioned by data availability and reliability.

1. Endogenous variable

The main dependent variable in this study is public health expenditure measured by government health expenditure as a percentage of GDP (GHE%GDP) from the World Bank. Public expenditure on health includes recurrent and capital expenditure from public budgets, external borrowing, grants, and social insurance funds. It therefore includes development assistance for health from the public accounts as well as public expenditure on health from domestic resources. This indicator has been extensively used in the empirical literature, notably in the work of Cockx and Francken (2014) and Rana et al. (2021). For robustness purposes, we use public expenditure on health as a percentage of total public expenditure (GHE%GE).

2. Exogenous variable

The Economic Complexity Index (ECI), obtained from the Atlas of Economic Complexity published by the Observatory of Economic Complexity, is the main variable of interest. The ECI shows the depth of knowledge about a country's productive structure. More precisely, this indicator assesses the availability of production capacities that enable nations to produce complex goods. Country's diversity and product's ubiquity are the two dimensions that make up this index. The earlier measures the number of distinct products that a country can produce and export with reveal comparative advantage, while the later reflects the number of countries that can export a given product competitively (Hidalgo and Hausmann, 2009). Consequently, an economy is considered complex when it is able to produce and export a variety of goods that are only sold by a limited number of countries. Sophisticated products, reflected by low ubiquity, are only exported by a few economies because they require many hard-to-find capabilities (Vu, 2022)[1]. For robustness purposes, we use an alternative measure of economic complexity,

1) According to Felipe et al (2012), the most sophisticated products are machinery, chemicals and metals, while

technology ECI developed by Stojkoski et al. (2023)[2]. The Technological ECI is calculated using data from the World Intellectual Property Organization's International Patent System. The unconditional correlation between public health spending and economic complexity is illustrated in Figure 1. ECI and public health spending are positively correlated. Specifically, nations with relatively higher economic complexity spend more on health. The ECI (or the technological ECI) is calculated using a technique that operates on a binary country-product (or patents) matrix M with components Mcp, where c and p are the indices for countries and products (or patents), respectively (Stojkoski et al., 2023).

$$M_{cp} = \begin{cases} 1 \text{ if } country\ c\ has\ a\ revealed\ comparative\ advantage \\ \quad (RCA) \geq 1\ in\ activity\ p \\ 0 \text{ if } country\ c\ has\ a\ revealed\ comparative\ advantage \\ \quad (RCA) < 1\ in\ activity\ p \end{cases}$$

The RCA is computed using the Balassa index, which is provided by

$$RCA_{cp} = \frac{x_{cp} / \sum_p x_{cp}}{\sum_c x_{cp} / \sum c \sum_p x_{cp}} \tag{1}$$

where x_{cp} denotes the value of exports of patents of country c in activity p. The diversity and ubiquity of the country's products are produced by adding the elements across the rows and columns of M and are defined as follows:

$$Country's\ \div ersity = k_c^{(0)} = \sum_p M_{cp} \tag{2}$$

$$\text{Pr}oduct's\ ubiquity = k_p^{(0)} = \sum_c M_{cp} \tag{3}$$

Hidalgo and Hausmann (2009) employ a "method of reflection" in which each product is weighted according to its market ubiquity and each country is weighted proportionally to the variety of its basket. They define the ECI (technological ECI) as an eigenvector K_c on the matrix $\widetilde{M}_{cc'}$ corresponding to the second biggest eigenvalue.

$$\widetilde{M}_{cc'} = \sum_p \frac{M_{cp} M_{c'p}}{k_c^{(0)} k_p^{(0)}} \tag{4}$$

the simplest products are agricultural products, raw materials, wood and textiles.

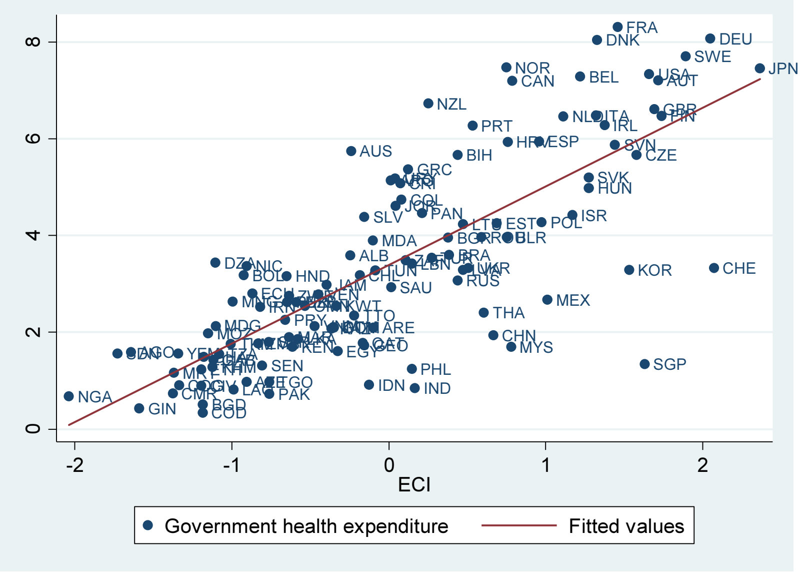
2) See Stojkoski et al. (2023) for more explanation of these measures.

The economic complexity index (ECI) or the technological ECI is then calculated according to the following formula:

$$ECI\ (Technological\ \ ECI) = \frac{K_c - \widetilde{K}_c}{\sigma(K_c)} \tag{5}$$

where $\widetilde{K}_c$ and $\sigma(K_c)$ is respectively the average and standard deviation of K_c.

Figure 1. Relationship between economic complexity and government health expenditure



(Source) Authors

3. Other exogenous variables

In line with the literature on the determinants of health expenditure (Cockx and Francken, 2014), we consider a set of control variables, including financial development, remittances and education. A well-developed financial system should ease budget constraints and increase the funds available for health care (Rana et al., 2020). Accordingly, we expect financial development to increase government health expenditure. Remittances represent an additional source of income for recipient households enabling the government to raise some income from tax collection to spend on health (Amuedo-Dorantes and Pozo, 2011). From this argument, we expect remittances to positively affect government health expenditure. Intuitively, a well-educated population has the ability to raise more income from well-paid jobs in order to spend on health expenses. Thus, we expect education to have a positive effect on government health expenditure.

For robustness purposes, we also use four additional control variables, including urban population, women in parliaments, access to the internet and control of corruption. Indeed, rising number of women in parliaments reduces corruption and increases democracy which favors a better allocation of resources (Bhalotra and Clots-Figueras, 2014). Consistent with this argument, we expect a positive effect of female parliamentarians on health spending. Moreover, the empirical literature provides argument in support that access to the internet increases economic growth (Meijers, 2014). Consistent with this argument, we posit that access to the internet by increasing economic growth provide governments with enough income to spend on health. However, the effects of urbanization are mixed (Gerdtham et al., 1992). Consistent with Shi et al. (2021) who argue that urbanisation leads to an increase in the demand for health care services, we posit that urbanisation may positively affect public health expenditure. More so, Delavallade (2006) argues that public corruption distorts the structure of public spending by reducing the share of social spending (education, health, and welfare). Consistent with this argument, we assume that controlling corruption can increase public health expenditure. Finally, older people consume more health services thus ageing population is associated with increased health spending (Di Matteo and Di Matteo, 1998; Murthy and Okunade, 2016). Accordingly, we expect a positive effect of population aged 65 and above on public health expenditure. Table 1 provides descriptive statistics, while variable description and data sources are provided in Table A1 in the online appendix.

Table 1. *Descriptive Statistics*

Variables	Obs	Mean	Std. Dev.	Min	Max
GHE (%GDP)	2,049	3.410	2.164	0.062	9.278
GHE (%GE)	2,049	10.407	4.836	1.263	33.099
ECI	2,047	0.031	1.005	-2.791	2.612
ECI (Technology)	1,562	0.084	0.974	-3.092	1.569
Financial development	1,755	58.410	46.871	0.186	233.211
Remittances	1,950	3.336	5.007	0.000	34.499
Education	1,545	86.351	28.183	8.624	163.935
Urban population	2,088	61.972	20.490	14.740	100.00
Women in parliaments	1,995	18.460	10.793	0.00	53.077
Internet	2,068	34.122	29.292	0.006	97.999
Control of corruption	1,963	0.013	1.057	-1.664	2.470
Pop. > 65 years	2,088	13.907	1.549	9.212	18.781
Natural rents	2,075	8.562	12.317	0.001	86.252
GDP per cap. (ln)	2,067	8.752	1.433	5.272	11.425
IV	2,059	-0.027	0.984	-2.241	2.176

In order to isolate any exogenous source of variation in economic complexity, we instrument a given country's economic complexity with the average of 3 countries with the most similar specialization patterns to the given country, but that do not share a sea or land boundary with the given country (IV).

C. Model specification and identification strategy

1. Model specification

This paper endeavours to examine the effect of economic complexity on government health expenditure. For this purpose, we draw on Vu (2020) and specify the following empirical model:

$$GHEGDP_{i,t} = \alpha + \beta_1 ECI_{i,t} + \beta_2 X_{i,t} + \mu_i + V_t + \epsilon_{it} \quad (1)$$

where $GHEGDP_{i,t}$ is government health expenditure in country i for year t. $ECI_{i,t}$ represents the Economic Complexity Index. $X_{i,t}$ is the vector of control variables including financial development, remittances, and education. μ_i and V_t are unobserved country-specific and time-specific effects, respectively. ϵ_{it} is the error term.

2. Identification strategy

The purpose of this study is to analyse the effect of economic complexity on government health expenditure. Although the OLS method is easy to implement and provides interesting insights because it corrects correlation within the cluster, it ignores heterogeneity, endogeneity and some unobserved differences that could skew parameter estimation (Burns et al., 2017). The study's endogeneity may potentially stem from biases related to measurement error, omission variables, or reverse causality.

First, bias due to missing variables may be the source of endogeneity in our study. Indeed, it is rather challenging to include every factor influencing government health spending in a single empirical definition. Furthermore, if some local characteristics, like location and culture, have an impact on a right-side variable and government health spending at the same time, omitted variable bias may result. In line with the empirical literature, we incorporate some critical control factors into the baseline model and do a robustness check where we incorporate some additional control variables in order to reduce this bias and increase the consistency of our results. Additionally, each model includes year and country dummies to constrain any potential unobserved year and nation-fixed effects, respectively. Even with a large number of variables included in the model that are thought to be drivers of government health spending, it is challenging to determine whether or not ECI is orthogonal to the error term. This concern prompts us to use Oster (2019)'s coefficient stability test, which is described in section 4.1.

Measurement mistakes may be the second cause of endogeneity in this investigation. This bias, in instance, might arise from inadequate measurement of a key model variable- in this example, the economic complexity index. In fact, trade geography acts as a stand-in for the economic complexity index, excluding information on innovation-related activities such as research papers and patent filings (Stojkoski et al., 2023). Additionally, the productive knowledge included into the goods that a nation exports is measured by the economic complexity index, which is based on trade statistics. If a nation develops sophisticated items but does not export them, its complexity level may be underestimated (Arif, 2021). Above all, Stojkoski et al. (2023) correctly point out that the economic complexity index predicated on trade geography may systematically underestimate the economic complexity of nations that are geographically removed from the global economy. This is why the economic complexity index has been based on employment, patents, and research papers in recent studies (Balland and Rigby, 2017; Balland and Boschma, 2022). As a result, we use an alternative measure of economic complexity-technology ECI- developed by Stojkoski et al. (2023) in order to offset the measurement error bias.

The reverse causality bias in this study might be the third cause of endogeneity. Indeed, reverse causality may exist if public spending on healthcare can finance research and development in this field, thereby boosting economic complexity. We suggest an identification method based on the Instrumental Variable Two-Stage Least Squares (IV-2SLS) to reduce this worry. But in order to be useful, the IV-2SLS has to be paired with a reliable and valid instrument for the variable of interest. Finding a robust, and exogenous instrument is especially difficult for practical research (in this instance for economic complexity). In fact, this instrument should only be connected to the dependent variable (government expenditure) through economic complexity, and it should have a strong relationship with economic complexity but not with the error term. Otherwise, if an inadequate instrument is employed, the "cure" of endogeneity may be worse than the "disease" itself (Rossi, 2014). However, a number of studies have used the jack-knifed average of economic complexity levels in neighboring countries to instrument a country's ECI in a given year (Bahar et al., 2014; Vu, 2020; Djeunankan et al., 2024b). The dispersion of information over geography and time may limit this identification strategy, notwithstanding its potential. In reality, when nations are separated by land or water, local and cultural characteristics may spread across borders and influence macroeconomic results in neighboring countries, undermining the effectiveness of this tool.

To mitigate this concern, we leverage the findings of a recent study by Stojkoski et al. (2023) and instrument the economic complexity of a given nation c using the average of three countries that, while not sharing a land or sea border, have the most similar specialization patterns with country c. This identification approach is based on the idea that economies with similar levels of complexity are more likely to exhibit comparable specialization patterns (Stojkoski et al., 2023; Djeunankan et al., 2024a). In fact, actual data from Stojkoski et al. (2023) supports the idea that countries with similar patterns of specialization have a higher likelihood of producing and exporting similar items. Specifically, neighboring countries are left out because it is well established that local conditions and information may propagate regionally and change the socioeconomic landscape in surrounding nations (Bahar et al., 2014). This identification approach's exclusion constraint is that the kinds of goods that a nation produces and exports are probably similar to those produced by nations that have similar patterns of specialization but do not share a land or maritime border. Importantly, there is very little chance that the goods produced in these nations will affect the macroeconomic circumstances of the target nation because they do not share a land or sea border. We do admit, however, that the unobserved character of the error element precludes an empirical examination of this identification limitation condition. It's interesting to note that this study uses the System Generalized Method of Moments (SGMM) as an alternative identification strategy. The empirical literature is increasingly using this strategy to reduce endogeneity concerns. In fact, this approach uses the technique of moment to concurrently estimate a difference and a level equation, which restricts reverse causality. The lag explanatory variable serves as the instrument for the level equation, while the lagged difference of the explanatory variable serves as the instrument for the difference equation (see paragraph 4.3.4 for further information).

IV. Empirical Results

A. Baseline results

Table 2 presents the benchmark results from OLS. From column (1) to (4), we include control variables cumulatively. Column (1) presents the bivariate model where we analyse the effect of economic complexity on government health expenditure without controls. We find that the coefficient associated with the economic complexity index is positive and statistically significant at the one percent threshold. The efficient associated with economic complexity has an amplitude suggesting that a one standard deviation increase in economic complexity (1.005) on average is associated with about 0.734 standard deviation increase in public health expenditure[3]. A plausible explanation to this result is that technical innovation that comes about with economic complexity enables countries to transfer resources from low productivity sectors to those with relatively high productivity thereby boosting economic growth (Hartmann et al., 2017). Rising economic growth partly induced by the production and export of complex products generates enough income to increase public health expenditure (Younsi et al., 2016). In addition, the ability of a country to produce sophisticated products provides the required technology to reduce the dependence on natural resources (Canh et al., 2020). Interestingly, studies converge

3) The standardized coefficients are calculated according to the following: $\beta_x = \alpha_x \frac{\lambda_x}{\lambda_y}$ with β_x, α_x λ_x, λ_y, corresponding to the standardized coefficient, the estimated initial coefficient, the standard deviation of ECI (1.005), and the standard deviation of public health expenditure (2.164), respectively.

to support that reduced dependence on natural resources increases public health spending (Cockx and Francken, 2014).

In column (2) we control for financial development and observe that the coefficient associated with economic complexity remains positive and statistically significant at a 1% threshold. Interestingly, the coefficient associated with financial development is positive and statistically significant suggesting that a well-developed financial development provides the government with enough income to spend on health. This result is in line with that of Rana et al. (2021) who find that financial development is a positive predictor of government health expenditure. In column (3) we control for remittances and the effect of economic complexity remains positive. Regarding remittances, it corresponding coefficient is positive and statistically significant suggesting that rising inflow of remittances increases government health expenditure. Indeed, an increased inflow of remittances provides households with enough additional income and the government with supplementary income from tax collection to spend on health. This result contradicts that of Hubert (2012) who argues that in the context of poor governance, remittances reduces government health expenditure through a phenomenon of «public moral hazard problem». Finally, we control for education in the last column and the coefficient associated with economic complexity remains positive and statistically significant at a conventionally accepted threshold. Consistent with our expectations, the coefficient associated with education is positive and statistically significant suggesting that higher levels of education provide a favourable environment for investment in health. Intuitively, higher levels of education enable people to enjoy higher income from well paid jobs which can be spend on health.

Although OLS provides interesting results confirming our hypothesis, these results suffer from a major limitation in that they do not account for endogeneity concerns. As presented earlier, possible endogeneity in this study may come from omission variable bias and we limit this concern by running the Oster coefficient stability test. The result of the Oster coefficient stability test is presented in column (4) of table 2. The Oster's (2019) coefficient stability test has been increasingly used in the empirical literature to ensure that results are not mainly driven by unobserved controls (for example, see Vu, 2020). The seminal work of Altonji et al. (2005) provides the theoretical foundation for this stability test by arguing that the degree of selection bias due to unobserved factors may be estimated by comparing the amount of bias reduction caused by the addition of observable confounders in the baseline model. Specifically, it is argued that the degree of selection bias caused by unobserved confounding factors can be gauged by the variation of the coefficients attached to variables and the value of the adjustment coefficients (R-square) in the bivariate model and the complete model (Oster, 2019). The following procedure was provided by Oster (2019) to assess the resilience of the initial result to the influence of omitted characteristics.

Table 2. *Baseline OLS*

Variables	Dependent variable: GHE(%GDP)			
	(1)	(2)	(3)	(4)
ECI	1.580*** (0.0315)	1.187*** (0.0442)	1.188*** (0.0453)	0.760*** (0.0529)
Financial development		0.0124*** (0.0010)	0.0125*** (0.0010)	0.0101*** (0.0010)
Remittances			0.0147* (0.0077)	0.0155* (0.0092)
Education				0.0287*** (0.0019)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Constant	3.698*** (0.0354)	3.065*** (0.0663)	3.034*** (0.0718)	0.801*** (0.161)
Observations	1,764	1,474	1,423	1,128
R-squared	0.602	0.644	0.639	0.714
Delta (δ) statistic for β = 0				2.57>1
Oster bounds (β^ ; β* (Rmax = 1, δ = 1))				[0.717, 0.760]

Note. *, **, *** denote statistical significance at the 10%, 5% and 1% levels respectively. Standard errors are reported in parenthesis.

Oster (2019) suggests recording the coefficient of proportionality, otherwise known as the delta (δ) and the bias-adjusted β* statistics. Firstly, the delta (δ) statistic is equal to the level of selection bias on unobserved confounding factors, relative to that caused by observed confounding factors required to explain away the significant coefficient of economic complexity (β = 0). Furthermore, Oster (2019) provides some evidence to support the idea that when the coefficient of proportionality (δ) is greater than unity, the results are highly unlikely to be mainly driven by unobserved confounding factors. The value of the delta (δ) statistic presented in Table 2 is greater than the unity conventional threshold with an amplitude suggesting that the degree of selection induce by unobserved confounding factors need to be at least twice as important as the degree of selection caused by observed confounding to drag the coefficient of economic complexity down to zero. Second, the two hypotheses under which the β* statistic is recorded are that the level of selection on observed confounding is equal to that on unobserved confounding and that the maximum adjustment coefficient value (R-square) equals one. Oster (2019) provides evidence to support the conclusion that if an interval bounded by the estimated coefficient of economic complexity (β) in the complete model and the β* statistic clearly excludes zero, we can conclude that the baseline result is not mainly driven by unobserved confounding factors. The result of these statistics presented in column (4) of Table 2 safely excludes zero, thus providing supplementary evidence in support of the baseline OLS results.

In summary, results from the Oster's (2019) coefficient stability test show that the estimated effect of economic complexity on government health expenditure is not likely to be mainly driven by unobserved confounding factors.

B. Endogeneity concern: Baseline IV-2SLS

Previous results from OLS suggest that sophisticated countries spend more on health. More importantly, we provide empirical evidence from Oster's (2019) coefficient stability test supporting that this result is unlikely to be mainly driven by omitted variables. Even though this provides interesting insides in support of our hypotheses, this result may still suffer from the well-known bias of reverse causality. In order to limit this bias, the empirical literature proposes the internal instrumentation approach and the external instrumentation approach. The internal instrument approach based on the SGMM is applied for a robustness check but the external instrument (IV-2SLS) is our preferred method. The results of the IV-2SLS estimates are displayed in Table 3. From the first stage estimation results in Panel B, one can see that the instrument (IV) has a positive and statistically significant effect on ECI, suggesting a strong relationship between our instrument and ECI. This result is supported by the findings of Stojkoski et al. (2023), who argue that countries with similar patterns of specialisation are more likely to have comparable levels of economic complexity. Since empirically testing the exclusion restriction condition is impossible due to the unobserved nature of the error term, we rely on partial tests to provide some evidence in support of this instrumental strategy. The empirical literature posits that the Kleibergen-Paap Wald rk F statistic is generally informative about instrument validity (Kleibergen and Paap, 2006). For weak identification not to be considered a concern, the Kleibergen-Paap Wald rk F statistic must be at least 10 in each case. The statistics depicted in Table 3 are greater than the ten-point rule of thumb, indicating that it is unlikely to have an issue with weak identification. In addition, the Kleibergen-Paap rk LM test statistic is statistically significant at the one percent threshold. Judging from the post estimation tests, the estimated models and corresponding instruments are valid. Looking at panel A of Table 3, results show that economic complexity has positive and statistically significant coefficients which are in line with our hypotheses and are consistent with the OLS-FE results. Globally, the empirical results from IV-2SLS are quite satisfactory. Regarding the control variables, they all have the expected signs and statistical significance. Thus, we can conclude that our results remain robust to the use of the IV-2SLS.

Table 3. *Baseline IV-2SLS*

Variable	Dependent variable: GHE (%GDP)			
	(1)	(2)	(3)	(4)
Panel A. Second-stage estimates. Dependent variable is GHE (%GDP)				
ECI	1.722*** (0.0369)	1.320*** (0.0460)	1.322*** (0.0469)	0.841*** (0.0622)
Panel B. First-stage estimates. Dependent variable is ECI				
IV	0.9156*** (0.0104)	0.8768*** (0.0151)	0.8747*** (0.0156)	0.8088*** (0.0210)
Panel C: Supplementary information				
Financial development		0.0105*** (0.0012)	0.0107*** (0.0012)	0.0096*** (0.0012)
Remittances			0.0179*** (0.0057)	0.0182*** (0.0069)
Education				0.0280*** (0.0022)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Constant	3.668*** (0.0354)	3.143*** (0.0636)	3.098*** (0.0663)	0.852*** (0.178)
Observations	1,739	1,449	1,398	1,106
R-squared	0.597	0.639	0.633	0.710
Kleibergen-Paap rk LM P_val	0.000	0.000	0.000	0.000
Kleibergen-Paap rk LM wald	7772.745	3364.631	3148.889	1482.092
Stock-Yogo critical values: 10% max IV size	16.38	16.38	16.38	16.38

Note. *, **, *** denote statistical significance at the 10%, 5% and 1% levels respectively. Corrected standard errors reported in parenthesis. In order to isolate any exogenous source of variation in economic complexity, we instrument a given country's economic complexity with the average of the level of economic complexity of 3 countries with the most similar specialization patterns to the given country, but that do not share a sea or land boundary with the given country (IV).

C. Mediation analyses

Previous findings, subject to a series of robustness assessments have clearly shown that sophisticated nations spend more on healthcare. This section aims to highlight important channels through which economic complexity affects public health spending. We estimate the following system of simultaneous equations using the theory of Baron and Kenny (1986), which has been used in recent research (Djeunankan et al., 2024a);

$$Model\ 1: M_{it} = \tau_0 + \tau_1\ ECI_{it} + \tau_2\ X_{it} + \mu_i + V_t + \epsilon_{it} \quad (2)$$

$$Model\ 2: GHE_{it} = \omega_0 + \omega_1 M_{it} + \omega_2\ ECI_{it} + \omega_3 X_{it} + \mu_i + V_t + \epsilon_{it} \quad (3)$$

where, M_{it} is either income or natural resources channel. ω_2 is the indirect effect of economic complexity on public health expenditure. All the other terms have the same meaning like in equation (1). The advantage of the system of simultaneous equations is that it specifies causal relations between variables and describes their direct and indirect effects.

We also use the Sobel (1982) test to provide additional evidence to support this mediation analysis. This test examines whether the addition of a channel significantly reduces the indirect effect of economic complexity on public health expenditure. The following formula is used to calculate the statistic for this test:

$$t = \frac{\omega_1{}^* \ \tau_1}{\sqrt{\left(\omega_1^{2*}\sigma_{\tau_1}^2 + \ \tau_1^{2*}\sigma_{\omega_1}^2\right)}} \tag{4}$$

where σ is the standard deviation of the corresponding estimated coefficients. If the Sobel statistic is statistically significant and the coefficients ω_1 and τ_1 are all significant, then the mediating role of the transmission channel is verified.

The results of the mediation analysis are reported in Table 4. Column (1) presents the total effect of economic complexity on government health expenditure. The positive and statistically significant coefficient attached to economic complexity confirms previous results that sophisticated countries spend more on health. Columns (2) and (3) represent the results of equations (2) and (3), respectively. The result in column (2) shows that economic complexity has a positive and statistically significant effect on income. Indeed, economic complexity is the process by which economies move from low-productivity sectors to those with higher productivity thereby increasing income (Hausmann et al., 2007). Moreover, empirical evidence supports the idea that economic diversification, an important component of economic complexity, may promote the emergence of new sectors of activity with a higher growth-enhancing effect (Hidalgo and Hausmann, 2009; Hartmann et al., 2017). Interestingly, the Sobel test statistic obtained by applying equation (4) is 0.924 and is statistically significant at the 1% level, thus validating the mediating role of income.

Moreover, in column (3), the estimated coefficient of income is 0.9574 and is statistically significant at a conventionally accepted threshold. The coefficient of economic complexity in the same column is 0.2798, which is lower than the coefficient of the total effect of economic complexity in column (1). A possible explanation for this decrease in the amplitude of the coefficient of economic complexity when we control for income is that part of the effect of economic complexity on government health spending is mediated by income. From these results, we can conclude that sophisticated countries spend more on health by boosting economic growth. Indeed, results show that about 77% of the effect of economic complexity on government health expenditure is mediated by income. As income increases, partly induced by rising economic complexity, the government has enough resources to spend part on health.

Table 4. *Empirical Analyses of the Transmission Channel*

Variables	Total effect	Income Channel		Natural resource Channel	
	GHE (%GDP)	Income	GHE (%GDP)	Natural resources	GHE (%GDP)
	(1)	(2)	(3)	(4)	(5)
ECI	1.2036*** (0.0462)	0.9649*** (0.0278)	0.2798*** (0.0580)	-6.1358*** (0.3747)	0.8508*** (0.0566)
Income			0.9574*** (0.0392)		
Natural resources					-0.0204*** (0.0042)
Baseline controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Constant	2.9971*** (0.0734)	8.1716*** (0.0454)	-4.8272*** (0.3282)	3.4539*** (1.0769)	0.7753*** (0.1601)
Sobel test		0.924*** (0.046)		0.125*** (0.027)	
% of total effect that is mediated		77%		13%	
Observations	1,631	1,631		1,294	

Notes: *, **, *** denote statistical significance at the 10%, 5% and 1% levels, respectively. Corrected standard errors reported in parenthesis. GHE stands for government health expenditure.

The mediating effect of natural resources is shown in columns (4) and (5). Economic complexity has a negative and statistically significant effect on natural resources, as seen in column (4). Indeed, the technological change that lays the foundations for the process of economic complexity encourages new entrepreneurs to use less natural resources in the production process in order to improve their profit (Canh et al., 2020). Furthermore, an increase in economic complexity implies a higher quality production system, which leads to increased efficiency in activities that consume less natural resources on a global scale. It has been shown in the literature that the exploitation of natural resources by rentier rulers leads to poor institutional quality (Sachs and Warner, 2001). Poor institutional quality characterized by a lack of accountability in the management of natural resources impedes public health spending (Tadadjeu et al., 2021b). While the total effect of economic complexity is accounted for by the coefficient in column (1), the indirect coefficient of economic complexity in column (5) is smaller (0.8508). According to these findings, natural resources may account for part of the effect of economic complexity on government health spending. Further, about 13% of the effect of economic complexity on government health expenditure is mediated by natural resources. The significance level of the Sobel test for this channel is 0.125, demonstrating that natural resources serve as a mediator.

D. Robustness checks

In order to confirm our previous results, we performed several robustness tests. First, we include several additional control variables representing determinants of public health expenditure in our model. Second, we use an alternative measure of public health expenditure (GHE%GE). Third, we use an alternative measure of economic complexity measure (ECI technology). Finally, we test the robustness of the results to some heterogeneities: Low versus high-income level, democratic versus non democratic countries, and presidential versus parliamentary democracy countries.

1. Additional covariates

First, we test the robustness of our result by including a set of additional control variables cumulatively and the result is presented in Table 5. We find that the coefficients associated with economic complexity are positive and statistically significant at a conventionally accepted threshold in all the columns. Regarding the additional control variables, in line with the work of Shi et al. (2021), we find that urban population increases public health expenditure. On the other hand, consistent with Tadadjeu et al. (2021a) female parliamentarians and corruption control have a positive and statistically significant effect on public health expenditure. These results are in line with those of Bhalotra and Clots-Figueras (2014) and Delavallade (2006), showing respectively that women parliamentarians and institutional quality increase public health expenditure. Moreover, we find that internet has a positive and statistically significant effect on government health expenditure. Furthermore, consistent with Tadadjeu et al. (2021a), and Tadadjeu et al. (2021b), we find that population age 65 and above has a positive effect on public health expenditure. We can then conclude that our results are resilient to the inclusion of additional control variables.

Table 5. *Robustness to Additional Control*

Variables	Dependent variable: GHE(%GDP)				
	(1)	(2)	(3)	(4)	(5)
Panel A. Second-stage estimates. Dependent variable is GHE (%GDP)					
ECI	0.843*** (0.0620)	0.828*** (0.0629)	0.768*** (0.0664)	0.524*** (0.0694)	0.323*** (0.0835)
Panel B. First-stage estimates. Dependent variable is ECI					
IV	0.8098*** (0.0212)	0.8124*** (0.0210)	0.8003*** (0.0217)	0.7614*** (0.0247)	0.7414*** (0.0286)

Table 5. *Continued*

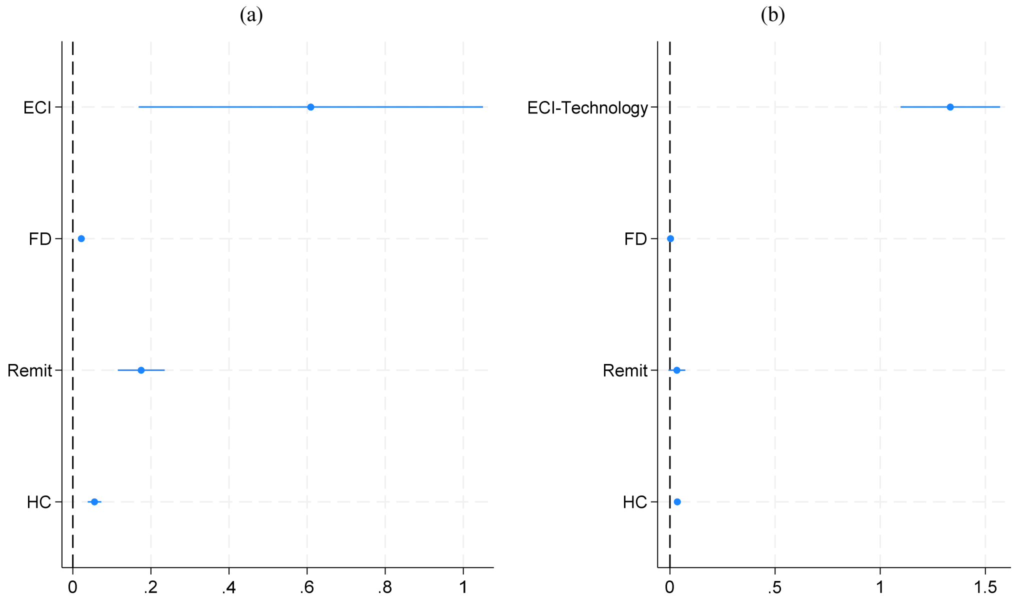
Variables	Dependent variable: GHE(%GDP)				
	(1)	(2)	(3)	(4)	(5)
Panel C: Supplementary information					
Urban population	0.0068** (0.0029)	0.0072** (0.0030)	0.0066** (0.0030)	0.0046 (0.0029)	0.0027 (0.0031)
Women in parliaments		0.0236*** (0.0038)	0.0203*** (0.0039)	0.0126*** (0.0038)	0.0121*** (0.0038)
Internet			0.0082*** (0.0022)	0.0056*** (0.0021)	0.0070*** (0.0021)
Control of corruption				0.678*** (0.0652)	0.859*** (0.0727)
Pop > 65 years					0.188*** (0.0378)
Baseline control	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Constant	0.683*** (0.196)	0.445** (0.194)	0.545*** (0.185)	1.208*** (0.179)	-1.391** (0.562)
Observations	1,106	1,081	1,076	1,020	1,020
R-squared	0.712	0.715	0.720	0.752	0.758
Kleibergen-Paap rk LM P_val	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap rk LM wald	1461.940	1484.508	1363.485	950.263	671.035
Stock-Yogo critical values: 10% max IV size	16.38	16.38	16.38	16.38	16.38

Note. *, **, *** denote statistical significance at the 10%, 5% and 1% levels respectively. Corrected standard errors reported in parenthesis.

2. Robustness to an alternative dependent and an alternative independent variable

Second, we test the robustness of our results to the use of an alternative dependent variable, namely public health expenditure as a percentage of government expenditure (GHE %GE) and results are presented in Figure 2(a). This result consistently show that economic complexity (ECI) has a positive and statistically significant effect on public health expenditure as a percentage of government expenditure. Next, we draw on the recent study by Stojkoski et al. (2023) and use an alternative metric of economic complexity, namely: technology complexity (ECI technology) and results are presented in Figure 2(a). Stojkoski et al. (2023) have used patent application from World Intellectual Property Organisation's International Patent System to construct technology complexity. We observe that ECI technology has a positive and statistically significant effect on public health expenditure. We can then conclude that our results withstand the use of an alternative dependent and an alternative independent variable.

Figure 2. Robustness to an alternative dependent variable and an alternative variable of interest



3. Dynamic panel estimate: SGMM

While the previous methodological approach is interesting, it fails to account for the inertia of public health spending. We limit this shortcoming by using a dynamic panel model specified in equation (5).

$$GHEGDP_{i,t} = \alpha + \beta_1 GHEGDP_{i,t-1} + \beta_2 ECI_{i,t} + \beta_3 X_{i,t} + \nu_t + \epsilon_{it} \tag{5}$$

where $GHEGDP_{i,t-1}$ denotes the optimal lag of public health expenditure, and v_t is time specific-effect. In order to efficiently estimate the dynamic model formulated above, we use the Generalized Method of Moments (GMM) initially proposed by Arellano and Bond (1991), and further improved by Arellano and Bover (1995), and Blundell and Bond (1998).

In the literature, GMM estimators are widely employed to address a variety of issues, including heteroscedasticity and endogeneity. Baum et al. (2003) supports that the GMMs is a more efficient method of handling heteroscedasticity than the instrumental variable estimator. Second, the GMM performs better than the IV-2SLS because it restricts the endogeneity of all the variables on the right side, as opposed to only the variable of interest, as the IV-2SLS does (Farhadi et al., 2015). The GMM is declined into two versions; the difference GMM proposed by Arellano and Bond (1991) and the System GMM proposed by Arellano and Bover (1995). One issue with the Difference-GMM is that if the series is sufficiently persistent, lag levels have been demonstrated to be poor instruments for first-differences (Arellano and Bover, 1995). In addition, by taking the first differences, we can lose information related to the long-run relationship between the explanatory variables and the dependent variable (Griliches and Hausman, 1986). To limit the effects of weak instruments and increase the efficiency of our estimates, we use the two-step System GMM of Blundell and Bond (1998)[4].

The consistency of the GMM estimator depends on whether the lagged values of the explanatory variables are valid instruments. We use the Arellano and Bond's (1991) AR (1) and AR (2) test of the serial correlation properties and the Hansen J-test of over-identifying restrictions, to test the validity of the instruments. The first difference equation should show evidence of first order residual serial correlation, but there shouldn't be any indication of second order residual serial correlation. In general, there should be fewer instruments than there are nations in the sample (Roodman, 2009). For the variance of the two-step linear system GMM, we further use Windmeijer's (2005) finite-sample correction. The outcomes are shown in Table 6.

Table 6. *Dynamic Panel Estimate: SGMM*

Variables	Dependent variable: GHE (%GDP)			
	(1)	(2)	(3)	(4)
Lagged dependent variable	0.944*** (0.0162)	0.967*** (0.0437)	0.971*** (0.0309)	0.865*** (0.0520)
ECI	0.108*** (0.0262)	0.127*** (0.0428)	0.253*** (0.0494)	0.272*** (0.0738)
Financial development		-0.0020 (0.0031)	-0.0017 (0.0024)	-0.0021 (0.0023)
Remittances			0.0058* (0.0035)	0.0129** (0.0062)
Education				0.0112*** (0.0039)
Year FE	Yes	Yes	Yes	Yes
Constant	0.224*** (0.0553)	0.271*** (0.0743)	0.232*** (0.0757)	-0.371 (0.251)
Observations	1,896	1,631	1,476	1,141
Number of countries	115	114	111	105
Number of instruments	15	15	25	29
AR (1)	0.000	0.000	0.000	0.000
AR (2)	0.160	0.198	0.295	0.750
Hansen OIR	0.118	0.114	0.237	0.328

Note. *, **, *** denote statistical significance at the 10%, 5% and 1% levels respectively. Corrected standard errors reported in parenthesis.

4) Using Monte Carlo simulations, Blundell and Bond (1998) and Bond (2002) show that the system GMM estimator is more efficient than the difference GMM estimator.

Results from the SGMM estimator consistently show that the coefficients associated with economic complexity are positive and statistically significant at a conventionally accepted threshold. This result corroborates previous findings suggesting that sophisticated countries spend more on health. Thus, we can conclude that our results remain robust to the use of a dynamic estimation technique.

E. Heterogeneity analyses

We now examine the results according to some economic and political characteristics and results are presented in Table (7). From an economic perspective, we distinguish low- and middle-income countries from high-income countries. From a political point of view, we compare democratic countries to non-democratic ones, and countries with parliamentary democratic regimes from those with presidential democratic regimes. The results in column (1) and (2) show the effect of economic complexity on public health expenditure in low and middle income countries, and high income countries, respectively. Globally, we find that economic complexity has, on average, a weakly significant effect in low and middle income countries compared to high-income countries. This result can be explained by the fact that the production and export of complex products in an economy leads to an increase in overall income, which will allow for increased investment in health. But in low- and middle-income countries, the level of economic complexity is still lower than in high-income countries.

From a political perspective, we examine the effect of economic complexity on public health expenditure by distinguishing democratic from non-democratic countries and the results are presented in column (3) and (4) of Table 7. We find that the coefficient associated with economic complexity is on average more significant in countries with democratic regimes. The relatively small effect in countries with non-democratic regimes is explained by the fact that governments are less constrained in the provision of public goods such as health in countries characterized by autocratic leaders (Datta, 2020). These results are in line with the recent studies of Njangang and Nvuh-Njoya (2023) who show that democratic countries are associated with higher level of economic complexity. Finally, we run a sensitivity analysis where we compare the effect of economic complexity on public health expenditure by distinguishing countries with presidential democracies from those with parliamentary democracies and the results are confine in columns (5) and (6) of Table 7. We find that the coefficients associated with economic complexity are of smaller amplitudes in countries with presidential democracies compared to those in the sample of parliamentary democratic countries. Indeed, the trust requirement creates strong incentives to maintain party discipline and induces the government in parliamentary democracies to pursue the common interests of its constituents (Huber, 1996). In this context, government spending is optimally directed towards broad programs serving a large and stable majority of voters (Persson et al., 2000).

Table 7. *Results of Heterogeneity*

Variables	Dependent variable : GHE (%GDP)					
	LMIC	HIC	Demo	Non Demo	Parlia Demo	Presi Demo
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Second-stage estimates. Dependent variable is GHE (%GDP)						
ECI	0.279** (0.113)	0.925*** (0.105)	0.807*** (0.0658)	0.769*** (0.154)	0.353** (0.147)	0.396*** (0.0913)
Panel B. First-stage estimates. Dependent variable is ECI						
IV	0.6873*** (0.0281)	0.8144*** (0.0366)	0.8266*** (0.0234)	0.5901*** (0.0415)	0.8415*** (0.0581)	0.7366*** (0.026)
Panel C: Supplementary information						
Financial development	0.0017 (0.0021)	0.0088*** (0.0015)	0.0110*** (0.0013)	-0.0035 (0.0028)	0.0057** (0.0025)	0.0075*** (0.0027)
Remittances	0.0288*** (0.0095)	0.0051 (0.0568)	-0.0027 (0.0084)	0.0975*** (0.0136)	-0.0108 (0.0268)	0.0181* (0.0102)
Education	0.0388*** (0.0025)	0.0377*** (0.0034)	0.0274*** (0.0024)	0.0200*** (0.0042)	0.0258*** (0.0039)	0.0265*** (0.0028)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.507** (0.214)	-0.145 (0.311)	0.966*** (0.187)	0.937** (0.383)	1.775*** (0.273)	0.518** (0.233)
Observations	712	526	915	188	448	640
R-squared	0.489	0.432	0.694	0.658	0.479	0.498
Kleibergen-Paap rk LM P_val	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap rk LM wald	597.374	495.063	1248.097	201.802	209.989	804.8
Stock-Yogo critical values: 10% max IV size	16.38	16.38	16.38	16.38	16.38	16.38

Note. *, **, *** denote statistical significance at the 10%, 5% and 1% levels respectively. Corrected standard errors reported in parenthesis. LMIC, HIC, Demo, Presi Demo and Parlia Demo stand for Low and Middle Income Countries, High Income Countries, Democracy, Presidential Democracy and Parliamentary Democracy, respectively.

V. Conclusion and Policy Implications

This paper assesses the effect of economic complexity on government health expenditure in 116 countries over the period 2002-2019. Based on various empirical approaches, we find that countries that produce and export a wide range of sophisticated products, on average, spend more on health than their counterparts who produce relatively simple products with low productivity. Empirical results survive a set of comprehensive robustness checks, including controlling for additional factors, an alternative measure of government health expenditure, an alternative measure of economic complexity, and an alternative estimation strategy. To limit the possibility that this result is not mainly driven by omitted variables, we ran the Oster's coefficient stability test. Results consistently show that the estimated effect of economic complexity on public health expenditure is very unlikely to be purely driven by unobserved confounding characteristics. To account for the heterogeneity that may exist in the sample, we also examine the results according to some economic and political characteristics of the countries. The effect of economic complexity on GHE is more significant in high-income countries than in low- and middle-income countries. We also show that the effect of economic complexity on GHE is more significant in countries with democratic regimes than in non-democratic ones. Finally, we find that economic complexity has a stronger effect on public health spending in parliamentary democratic countries than in presidential democratic ones. This paper also highlights some channels through which economic complexity could influence public health spending. Specifically, empirical results from a mediation analysis enable us to show that economic complex may foster government health expenditure through higher income levels and reduced natural resource dependence.

The results of this study have some important policy implications. First, the result that sophisticated countries spend more on health enables us to encourage decision-makers to diversify their productive structures toward the production and export of highly sophisticated products like chemicals and electronics. This can be achieved by encouraging high-tech companies to manufacture sophisticated products, by providing them with the necessary technical, financial and institutional support. Moreover, results from the heterogeneity analyses in favour of democratic countries, especially parliamentary democracies, enable us to recommend political leaders to shift their political regimes to parliamentary democracies in order to reap the higher effect of economic complexity on public health expenditure. Finally, empirical results from the mediation analyses enabled us to identify income and resource rent as some channels through which economic complexity may foster public health expenditure. From these results, we recommend that the government put more effort into strengthening the quality of institutions and thereby reduce the dependence on natural resources, since studies argue that better institutional quality alleviates the deleterious effect of natural resource dependence.

Although this study is relevant and interesting, it is not without some limitations. Firstly, a major limitation of this work is that it focuses only on public health expenditure, omitting private health expenditure. Another limitation attributable to this study is that it uses a global panel yet we account for country and year-specific factors. Moreover, this study analyzes the effect of economic complexity on public health expenditure using the instrumental variable method and the GMM. While these approaches are relevant, they are limited in that they do not allow for heterogeneity in the distribution of the dependent variable and the short- and long-term dynamics between economic complexity and public health expenditure. These limitations however, pave the way for future studies. Indeed, future studies may analyse the effect of economic complexity on private health expenditure. Moreover, future studies may analyse the effect of economic complexity on public health expenditure by using the quintile regression to account for the heterogeneity in the distribution of the dependent variable and the FMOLS and DOLS to account for the short and long term dynamics in the economic complexity-public health expenditure nexus. Furthermore, future studies may identify other channels through which economic complexity may affect public health expenditure such as income inequality for example.

References

Adam, A., Garas, A., Katsaiti, M. S., & Lapatinas, A. (2023). Economic complexity and jobs: an empirical analysis. *Economics of Innovation and New Technology, 32*(1), 25-52.

Ajide, K. B., Adenuga, J. I., & Raheem, I. D. (2020). Natural resource rents, political regimes and terrorism in Africa. *International Economics, 162*, 50-66. https://doi.org/10.1016/j.inteco.2020.04.003

Altonji, J. G., Elder, T. E., & Taber, C. R. (2005). Selection on observed and unobserved variables: Assessing the effectiveness of Catholic schools. *Journal of Political Economy, 113*(1), 151-184.

Amuedo-Dorantes, C., & Pozo, S. (2011). New evidence on the role of remittances on healthcare expenditures by Mexican households. *Review of Economics of the Household, 9*, 69-98.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies, 58*(2), 277-297.

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error components models. *Journal of Econometrics, 68*(1), 29-51.

Arif, I. (2021). Productive knowledge, economic sophistication, and labor share. *World Development, 139*, 105303.

Bahar, D., Hausmann, R., & Hidalgo, C. A. (2014). Neighbors and the evolution of the comparative advantage of nations: Evidence of international knowledge diffusion? *Journal of International Economics, 92*(1), 111-123.

Balland, P. A., & Boschma, R. (2022). Do scientific capabilities in specific domains matter for technological diversification in European regions? *Research Policy, 51*(10), 104594.

Balland, P. A., & Rigby, D. (2017). The geography of complex knowledge. *Economic Geography, 93*(1), 1-23.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173.

Barros, P. P. (1998). The black box of health care expenditure growth determinants. *Health Economics, 7*(6), 533-544.

Baum, C. F., Schaffer, M. E., & Stillman, S. (2003). Instrumental variables and GMM: Estimation and testing. *The Stata Journal, 3*(1), 1-31.

Besley, T., & Kudamatsu, M. (2006). Health and Democracy. *The American Economic Review, 96*(2), 313-318.

Bhalotra, S., & Clots-Figueras, I. (2014). Health and the political agency of women. *American Economic Journal: Economic Policy, 6*(2), 164-97.

Bhattacharyya, S., & Hodler, R. (2010). Natural resources, democracy and corruption. *European Economic Review, 54*(4), 608-621.

Blum, J., Dorn, F., & Heuer, A. (2021). Political institutions and health expenditure. *International Tax and Public Finance, 28*(2), 323-363. https://doi.org/10.1007/s10797-020-09648-9

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics, 87*(1), 115-143.

Bokhari, F. A., Gai, Y., & Gottret, P. (2007). Government health expenditures and health outcomes. *Health Economics, 16*(3), 257-273.

Bond, S. R. (2002). Dynamic panel data models: a guide to micro data methods and practice. *Portuguese Economic Journal, 1*(2), 141-162.

Burns, D. K., Jones, A. P., Goryakin, Y., & Suhrcke, M. (2017). Is foreign direct investment good for health in low and middle income countries? An instrumental variable approach. *Social Science & Medicine, 181*, 74-82.

Canh, N. P., Schinckus, C., & Thanh, S. D. (2020). The natural resources rents: is economic complexity a solution for resource curse? *Resources Policy, 69*, 101800.

Cockx, L., & Francken, N. (2014). Extending the concept of the resource curse: Natural resources and public spending on health. *Ecological Economics, 108*, 136-149.

Datta, S. (2020). Political competition and public healthcare expenditure: evidence from Indian states. *Social Science & Medicine, 244*, 112429.

Delavallade, C. (2006). Corruption and distribution of public spending in developing countries. *Journal of Economics and Finance, 30*(2), 222-239.

Di Matteo, L., & Di Matteo, R. (1998). Evidence on the determinants of Canadian provincial government health expenditures: 1965-1991. *Journal of Health Economics, 17*(2), 211-228.

Djeunankan, R., Kamguia, B., & Tadadjeu, S. (2023a). Does economic complexity enhance governance quality in Africa? *Canadian Journal of Development Studies/Revue canadienne d'études du développement, 45*(2), 306-331.

Djeunankan, R., Njangang, H., & Oumbé, H. T. (2024a). Examining the Effect of Economic Complexity on Energy Poverty in Developing Countries. *Environmental Modeling & Assessment, 29*, 735-765.

Djeunankan, R., Njangang, H., & Tékam, H. (2023b). How does economic complexity improve energy efficiency? *Mechanism discussion and empirical test. Environmental Science and Pollution Research, 30*(43), 96906-96925.

Djeunankan, R., Tadadjeu, S., Njangang, H., & Mazhar, U. (2024b). The hidden cost of sophistication: economic complexity and obesity. *The European Journal of Health Economics, 25*, 1-23.

Dyer, O. (2006). New report on corruption in health. *Bulletin of the World Health Organization, 84*(2), 84-85. https://doi.org//S0042-96862006000200004

El Anshasy, A. A., & Katsaiti, M.-S. (2015). Are natural resources bad for health? *Health & Place, 32*, 29-42. https://doi.org/10.1016/j.healthplace.2014.12.011

Erdoðan, S., Çevik, E. Ý., & Gedikli, A. (2020). Healthcare Expenditures Channel of Natural Resource Curse: The Case of Gulf Cooperation Council Countries. *International Journal of Energy Economics and Policy, 10*(2), 285-293.

Farhadi, M., Islam, M. R., & Moslehi, S. (2015). Economic freedom and productivity growth in resource-rich economies. *World Development, 72*, 109-126.

Felipe, J., Kumar, U., Abdon, A., & Bacate, M. (2012). Product complexity and economic development. *Structural Change and Economic Dynamics, 23*(1), 36-68.

Gerdtham, U. G., Søgaard, J., Andersson, F., & Jönsson, B. (1992). An econometric analysis of health care expenditure: A cross-section study of the OECD countries. *Journal of Health Economics, 11*(1), 63-84.

Global Corruption Report. (2006). Corruption and Health. Transparency International. https://images.transparencycdn.org/images/2006_GCR_HealthSector_EN.pdf

Griliches, Z., & Hausman, J. A. (1986). Errors in variables in panel data. *Journal of Econometrics, 31*(1), 93-118.

Hartmann, D., Guevara, M. R., Jara-Figueroa, C., Aristarán, M., & Hidalgo, C. A. (2017). Linking economic complexity, institutions, and income inequality. *World Development, 93*, 75-93.

Hausmann, R., Hwang, J., & Rodrik, D. (2007). What you export matters. *Journal of Economic Growth, 12*, 1-25.

Henri, P. A. O. (2019). Natural resources curse: A reality in Africa. *Resources Policy, 63*, 101406. https://doi.org/10.1016/j.resourpol.2019.101406

Herwartz, H., & Theilen, B. (2003). The determinants of health care expenditure: Testing pooling restrictions in small samples. *Health Economics, 12*(2), 113-124. https://doi.org/10.1002/hec.700

Hidalgo, C. A., & Hausmann, R. (2009). The building blocks of economic complexity. *Proceedings of the National Academy of Sciences, 106*(26), 10570-10575.

Hidalgo, C. A., Klinger, B., Barabási, A. L., & Hausmann, R. (2007). The product space conditions the development of nations. *Science, 317*(5837), 482-487.

Huber, J. D. (1996). The vote of confidence in parliamentary democracies. *American Political Science Review, 90*(2), 269-282.

Hubert Ebeke, C. (2012). Do remittances lead to a public moral hazard in developing countries? An empirical investigation. *Journal of Development Studies, 48*(8), 1009-1025.

Khan, H. N., Razali, R. B., & Shafie, A. B. (2016). Modeling Determinants of Health Expenditures in Malaysia: Evidence from Time Series Analysis. *Frontiers in Pharmacology, 7*. https://doi.org/10.3389/fphar.2016.00069

Khan, M. A., & Husnain, M. I. U. (2019). Is health care a luxury or necessity good? Evidence from Asian countries. *International Journal of Health Economics and Management, 19*(2), 213-233.

Khan, M. H. (2010). *Political Settlements and the Governance of Growth-Enhancing Institutions.* London: SOAS, University of London.

Khan, M. H. (2013). Political Settlements and the Design of Technology Policy. In J. E. Stiglitz, J.

L. Yifu, & E. Patel (Eds.), *The Industrial Policy Revolution II: Africa in the 21st Century* (pp. 243-280). Palgrave Macmillan UK. https://doi.org/10.1057/9781137335234_10

Kleibergen, F., & Paap, R. (2006). Generalized reduced rank tests using the singular value decomposition. *Journal of Econometrics, 133*(1), 97-126.

Kotera, G., & Okada, K. (2017). How does democratization affect the composition of government expenditure? *Journal of Economic Behavior & Organization, 137*, 145-159. https://doi.org/10.1016/j.jebo.2017.03.004

Mauro, P. (1998). Corruption and the composition of government expenditure. *Journal of Public Economics, 69*(2), 263-279. https://doi.org/10.1016/S0047-2727(98)00025-5

Mehlum, H., Moene, K., & Torvik, R. (2006). Institutions and the Resource Curse*. *The Economic Journal, 116*(508), 1-20. https://doi.org/10.1111/j.1468-0297.2006.01045.x

Meijers, H. (2014). Does the internet generate economic growth, international trade, or both? *International Economics and Economic Policy, 11*, 137-163.

Morales, A. J., Gershenson, C., Braha, D., Minai, A. A., & Bar-Yam, Y. (Eds.). (2018). *Unifying Themes in Complex Systems IX: Proceedings of the Ninth International Conference on Complex Systems*. Springer International Publishing. https://doi.org/10.1007/978-3-319-96661-8

Murthy, V. N. R., & Okunade, A. A. (2009). The core determinants of health expenditure in the African context: Some econometric evidence for policy. *Health Policy, 91*(1), 57-62. https://doi.org/10.1016/j.healthpol.2008.10.001

Murthy, V. N., & Okunade, A. A. (2016). Determinants of US health expenditure: Evidence from autoregressive distributed lag (ARDL) approach to cointegration. *Economic Modelling, 59*, 67-73.

Nghiem, S. H., & Connelly, L. B. (2017). Convergence and determinants of health expenditures in OECD countries. *Health Economics Review, 7*, 1-11.

Njangang, H., & Nvuh-Njoya, Y. (2023). Unravelling the link between democracy and economic complexity: Fresh evidence from the Varieties of Democracy data. *SN Business & Economics, 3*(3), 77.

Oster, E. (2019). Unobservable selection and coefficient stability: Theory and evidence. *Journal of Business & Economic Statistics, 37*(2), 187-204.

Persson, T., Roland, G., & Tabellini, G. (2000). Comparative politics and public finance. *Journal of Political Economy, 108*(6), 1121-1141.

Poncet, S., & de Waldemar, F. S. (2013). Economic complexity and growth. *Revue Economique, 64*(3), 495-503.

Rana, R. H., Alam, K., & Gow, J. (2020). Health expenditure and gross domestic product: Causality analysis by income level. *International Journal of Health Economics and Management, 20*(1), 55-77.

Rana, R. H., Alam, K., & Gow, J. (2021). Financial development and health expenditure nexus: A global perspective. *International Journal of Finance & Economics, 26*(1), 1050-1063.

Roodman, D. (2009). A note on the theme of too many instruments. *Oxford Bulletin of Economics and Statistics, 71*(1), 135-158.

Rossi, P. E. (2014). Even the rich can make themselves poor: A critical examination of IV methods in marketing applications. *Marketing Science, 33*(5), 655-672.

Sachs, J. D., & Warner, A. M. (2001). The curse of natural resources. *European Economic Review, 45*(4-6), 827-838.

Shi, L., Smit, E., & Luck, J. (2021). Panel Survey Estimation of the Impact of Urbanization in China: Does Level of Urbanization Affect Healthcare Expenditure, Utilization or Healthcare Seeking Behavior? *The Chinese Economy, 54*(3), 145-156.

Sobel, M. (1982). The Mediating Roles of Disgust Sensitivity and Danger Expectancy in Relation to Hand Washing Behaviour. *Sociological Methodology, 13*, 290-312.

Sommer, J. M. (2020). Corruption and Health expenditure: A Cross-National Analysis on Infant and Child Mortality. *The European Journal of Development Research, 32*(3), 690-717. https://doi.org/10.1057/s41287-019-00235-1

Stojkoski, V., Koch, P., & Hidalgo, C. A. (2023). Multidimensional economic complexity and inclusive green growth. *Communications Earth & Environment, 4*(1), 130.

Stubbs, T., Kentikelenis, A., Stuckler, D., McKee, M., & King, L. (2017). The impact of IMF conditionality on government health expenditure: A cross-national analysis of 16 West African nations. *Social Science & Medicine, 174*, 220-227.

Swaleheen, M., Ali, M. S. B., & Temimi, A. (2019). Corruption and public spending on education and health. *Applied Economics Letters, 26*(4), 321-325. https://doi.org/10.1080/13504851.2018.1468549

Tadadjeu, S., Belek, A., Njangang, H., Belomo, M. L., & Kamguia, B. (2021a). Does women's political empowerment promote public health expenditure in Africa. *Economics Bulletin, 41*(3), 1959-1969.

Tadadjeu, S., Njangang, H., & Kamguia, B. (2021b). Ressources naturelles et dépenses publiques de santé en Afrique: l'Initiative pour la Transparence des Industries Extractives rompt-elle la malédiction? *Revue d'économie du développement, 35*(4), 83-125.

Vu, T. V. (2020). Economic complexity and health outcomes: A global perspective. *Social Science & Medicine, 265*, 113480.

Vu, T. V. (2022). Does institutional quality foster economic complexity? The fundamental drivers of productive capabilities. *Empirical Economics, 63*(3), 1571-1604.

Wigley, S., & Akkoyunlu, A. (2011). The Impact of Regime Type on Health: Does Redistribution Explain Everything? *World Politics, 63*, 647-677. https://doi.org/10.1017/S0043887111000177

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics, 126*(1), 25-51.

World Bank. (2023). World development indicators. Available at https://databank.worldbank.org/source/world-development-indicators.

World Health Organization. (2020). *Global spending on health: Weathering the storm* (p. 84). WHO. https://www.who.int/publications/i/item/9789240017788

Yan, H.-T., & Lin, Y.-C. (2019). A Dictator's Gift: Dominant party regimes and health expenditures. *European Journal of Public Health, 29*(6), 1172-1177. https://doi.org/10.1093/eurpub/ckz070

Yan, H.-T., & Lin, Y.-C. (2020). How time horizons of autocrats impact health expenditure: A mixed methods research. *BMC Public Health, 20*(1), 649. https://doi.org/10.1186/s12889-020-08821-3

Younsi, M., Chakroun, M., & Nafla, A. (2016). Robust analysis of the determinants of healthcare expenditure growth: evidence from panel data for low-, middle-and high-income countries. *The International Journal of Health Planning and Management, 31*(4), 580-601.