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Does military spending increase public debt in G-5 Sahel states? evidence from a panel data analysis

Les dépenses militaires augmentent-elles la dette publique dans les pays de G-5 Sahel ? une analyse en données de panel

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Abstract

This paper analyzes the public debt effects of military spending using data from G-5 Sahel states over the period 1990-2020. We first test for the cross-sectional dependence among units in order to adopt an appropriate panel data tool. We then employ the panel granger causality approaches and compute the impulse response functions (IRF) and forecast error variance decompositions (FEVD) from our empirical panel vector autoregressive model (PVAR). The results indicate that granger-causality firmly runs from military spending to public debt. Moreover, findings from IRF show that military spending positively affects public debt in the short run whereas its long run effect on public debt is negatively negligible. The results from FEVD also reveal that military spending explains by about 1.62% the overall variation in public debt. A policy implication derived from our findings is that G-5 Sahel states can reduce their debt burden by optimally allocating ressources to military sector, and promoting economic growth and globalization.

Keywords: Military spending; public debt; cross-section dependence; Granger-causality; panel-VAR; G-5 Sahel states.

Résumé

Ce papier utilise les données allant de 1990 à 2020, pour examiner les effets des dépenses militaires sur la dette publique des pays de G-5 Sahel. Nous testons d'abord la dependence inter-individuelle pour choisir les outils méthodologiques les plus adaptés. Nous employons ensuite les tests de causalité de granger en panel et calculons la fonction de reponse impulsionnelle (FRI) ainsi que la décomposition de variance des erreurs (DVE) à partir de notre modèle empirique vectoriel autorégressif (VAR) en panel. Il ressort de résultats que la causalité va solidement des dépenses militaires vers la dette publique. Par ailleurs, les résultats de la FRI indiquent que les dépenses militaires ont un effet positif sur la dette publique sur le court terme alors qu'il est négatif et négligeable sur le long terme. De plus, les résultats de la DVE montrent que les dépenses militaires expliquent pour 1,62% les fluctuations de la dette publique. Enfin, nous recommandons aux pays de G-5 Sahel d'allouer optimalement les ressources destinées au secteur militaire, tout en promettant la croissance économique et la mondialisation afin de réduire leur dette publique.

Mots clés : Dépenses militaires ; dette publique ; dépendance individuelle ; VAR-panel ; G-5 Sahel.

Introduction

In recent decades, several studies have been given a particular attention to the military spending and public debt relationship in developing countries (Smith and Kumar Narayan,2009; Ahmed,2012; Dunne, Nikolaidou and Chiminya,2019; Khan, Arif and Waqar, 2020; Okwoche and Nikolaidou,2022). The major motivation of these studies is to verify whether the military spending increases public debt which is suspected to be an impediment to economic growth revival. This is in accordance with G-5 Sahel states preoccupations about their public debt burden sustainability. Indeed, these countries are experiencing in the two recent decades a higher public debt burden surrounding 50.46% of their gross domestic product (see Table N°2). For this reason, it is crucial for these countries to curtail their public debt burden incurred through military spending in order to set free resources for development spending, such as education, health, agriculture, infrastructure spending etc.

Furthermore, it is important to stress that under the Heavily Indebted Poor Countries (HIPC) initiative launched by the Breton Woods institutions in the early of 2000s many developing countries benefited from debt relief. As shown Figure A3 (see Appendix), under this initiative, the G-5 Sahel states that are Burkina Faso, Chad, Mali, Mauritania and Niger have experienced a significant drop in their average public debt, which goes down from 82% to 24% of GDP during the 2001-2008 period. Meanwhile, it shows up that their defense burden fell from 1.63% to 1.14% of GDP during the 2001-2006 period while indicating a positive correlation between military spending and public debt for the last decade.

Many economic theories support the idea according to which military spending and public debt are linked. For instance, Keynesians support that military spending may contribute to reduce public debt through its effects on aggregate demand and employment. This may improve economic growth that generates tax revenue for countries. The same argument holds for the theoreticians of endogenous growth that argue military spending via its spill-over effects on civilian economy promotes long run growth that in turn generate tax revenue to be used to undertake public investment (Barro,1990; Huang and Mintz, 1991; Mankiw, Romer and Weil,1992). However, some economists think that military spending increases public debt by impeding growth. Indeed, when countries get into debt on financial markets the interest rates rise. This crowds out private investment that is a determinant of long run growth (see Keynes, 1936, Barro 1974).

Empirically previous studies have analyzed the military spending-public debt nexus. Earlier studies by Looney (1987), Dunne, Perlo-Freeman and Soydan (2004), Smyth and Kumar

Narayan (2009), Paleologou (2012) and Azam and Yi-Feng (2015) have investigated the effect of military spending on external debt of developing countries using several econometric techniques during different spans of time. They proved unanimously the positive effect of military spending on public debt. Specially, Wolde-Rufael (2009), Ahmed (2012), Dunne, Nikolaidou and Chiminya (2019) and Okwoche and Nikolaidou (2022) are interested in examining the effect of public debt of military spending in African countries context. The authors used econometric techniques and found military spending positively affect the public debt of African countries.

In view of the above exposed arguments, this paper asks the following research question: **does military spending increase the level of public debt in G-5 Sahel countries?** To answer this question, we use annual data spanning the period 1900-2020 and adopt two methodological approaches. First, we employ the panel granger causality approaches by Dumitrescu and Hurlin (2012) and Juodis *et* al. (2021) in order to determine the causal links between military spending and public debt. Second, we calculate the impulse response function and the forecast error variance decomposition of military spending and public debt from the estimated panel vector autoregressive (PVAR). The findings indicate that military spending granger causes public debt. They also support that military spending increases the level of public debt in these countries in the short run.

This paper contributes to the existing literature in several aspects. Its first contribution consists to take into account cross-section dependence in its empirical strategies including unit root, cointegration, and causality tests. Its second contribution is to use two granger causality approaches developed by Dumitrescu and Hurlin (2012) and Juodis *et* al. (2021), unlike previous studies. These tests perform better than other causality tests because it accounts for heterogeneity coefficients, cross-section dependence, heteroskedasticity and Nickell bias (Juodis *et* al.,2021; Xiao *et* al.,2022). Its third contribution is to adopt a panel VAR that combines simultaneously classical VAR and panel data advantages as it treats all variables as endogenous in the dynamic framework where individual heterogeneity is allowed. Its fourth contribution is related to investigation area. To the best of our knowledge, no previous study has specifically analyzed the effect of military spending on public debt in the context of G-5 Sahel states.

The rest of this paper is organized as follows. Section 1 reviews previous studies while Section 2 describes methodology and data. Section 3 presents and discusses the empirical results. Finally, Section 4 concludes the paper.

1. Literature review

Theoretically, public spending including military spending are mainly financed through either tax revenue or borrowing. Depending on these two funding sources, this paper mobilizes several economic theories to support the link between military spending and public debt. Firstly, keynesian theory suggests that military spending reduces public debt through the tax revenue channel (see Keynes,1936). This theory argues that the increase in public spending including military spending in times of economic downturns stimulates aggregate demand and employment, which in return promote economic growth that generates tax revenue. The latter may be used, instead of public borrowing way, to finance the future military spending and other development spending as well as debt servicing. In this instance, one can expect to overall reduction in public debt level at least in the long run. Moreover, the endogenous growth theory supports that military spending may reduce public debt in the long run. According to this theory, military spending contributes to improve the stock and productivity of human capital and yields positive externalities for civilian economy (Barro,1990; Huang and Mintz, 1991; Mankiw, Romer and Weil,1992). Indeed, the military sector provides both education and health services and technological spillover effect that improve long-run economic growth. The latter, in return, generates enough tax revenue that substitutes public borrowing for financing military spending and other development spending.

Although, the crowding-out theory supports that military spending increases public debt level (Keynes,1936; Barro, 1974). It explains that when countries get into debt on financial markets, interest rate rises. This rise in interest rate hampers the ability of private sector to borrow so that to finance its investment projects. The consequence of such reduction in private investment is to slowed down long-run economic growth which is not henceforth able to generate enough tax revenue. In this instance, public debt level may increase because countries use the public borrowing as alternative way to finance their future public spending. Also, the Ricardo-Barro equivalence theory stresses that military spending increases public debt level (see Barro,1974). According to this theory if military spending is financed through debt, households will anticipate to face higher tax in the future. In fact, households react by reducing their current consumptions and increasing their savings in order to offset the future tax increasing. The reduction in current consumptions may weaken economic growth that leads to diminishing in tax revenue and increasing in public debt.

Finally, this paper calls up political economy theorical views to explain the defence-debt nexus. According to these theorical views military spending increases public debt, depending on political factors. Indeed, in real world, there are situations where governments face military-lobbies and political pressures, and interest groups who claim to increase military spending for specific reasons. In most cases, governments approve claims by increasing their military spending through running into debt, even if it is economically inefficient, in order to prevent political unrest and secure their electorate.

Several studies have investigated the public debt effect of military spending in developed and developing countries. In this way, Brzoska (1983) investigates the impact of military spending on external debt in third world, over the period 1970-1979. Using an opportunity cost assessment approach, he shows that military spending occurred through arms imports influences positively the public debt burden in these countries. Looney (1987) analyzes the military spending-external public debt nexus in third world countries for the period 1970-1982. Using some econometric procedures, he finds that military spending increases external public debt mainly in resource constrained countries. Then, Dunne, Perlo-Freeman and Soydan (2004) study the impact of military spending on public debt in 11 small industrializing countries over the 1960-2000 period. Using a various of panel data techniques, authors show that military spending increases debt. Smyth and Kumar Narayan (2009) investigate the military spending-external debt relationship in Middle East countries over the period 1988-2002. Utilizing panel data techniques, the authors show that military spending positively affects external debt. Also, Wolde-Rufael (2009) examines the impact of defence spending on external debt in Ethiopia from 1970 to 2005. Using Granger causality and cointegration approaches, he finds that defence spending positively impacts external debt. Paleologou (2012) investigates the relationship between military expenditure and general government debt in 25 European Union countries over the period 1996-2009. Using a dynamic panel data approach, the author finds that military spending has a positive effect on general government debt. Ahmed (2012) studies the relationship among debt, military spending and growth in 25 Sub-Saharan African countries for the period 1988-2007. Using panel data techniques, he shows that military spending has a positive effect on external debt. Azam and Yi-Feng (2015) study the effect of military spending on external debt for 10 Asian countries from 1990 to 2011. They use panel data techniques to find that military spending positively affects external debt. Dunne, Nikolaidou and Chiminya (2019) analyze the impact of military spending on external debt in 47 Sub-Saharan African countries from 1960 to 2016. Employing dynamic panel data techniques, they find that military spending has a positive effect on external debt, but this effect varies across countries. Recently, Khan *et* al. (2020) investigate the relationship between military spending and external debt in

35 arms importing countries, over the period 1995-2016. Employing a pooled mean group approach, they find that military spending increases external debt, mainly in countries with weak management debt systems. Finally, Okwoche and Nikolaidou (2022) examine the relationship among military spending, external, domestic and total public debt in Nigeria over the period 1970-2020. Using an ARDL approach, authors find that military spending positively affects external public debt.

2. Methodology and data

2.1. Panel Granger-causality approaches

Preliminarily, we use the granger causality approaches developed by Dumitrescu and Hurlin (2012) to check the direction of causality between military spending and public debt in G5-Sahel countries. Indeed, this test outperform existing Holtz-Eakin *et* al. (1988) test which does not account for individual-heterogeneity and heteroskedasticity. Furthermore, we make use of the test by Juodis *et* al. (2021) to check robustness of the baseline test by Dumitrescu and Hurlin (2012). One of the advantages of this test is to complement the tests by Holtz-Eakin *et* al. (1988) and Dumitrescu and Hurlin (2012) by accounting for cross-sectional dependence and Nickell bias, even in case where time-series dimension is moderate (Juodis *et* al.,2021; Xiao *et* al.,2022). We therefore consider a linear dynamic panel data framework to model panel granger causality between military spending and public debt in two ways as follows:

$$pubdebt_{it} = \mu_i + \sum_{k=1}^{p} \alpha_{k,i} pubdebt_{it-k} + \sum_{k=1}^{p} \beta_{k,i} milspen_{it-k} + \varepsilon_{1it} \quad (1)$$

$$milspen_{it} = \lambda_i + \sum_{k=1}^{q} \eta_{k,i} milspen_{it-k} + \sum_{k=1}^{q} \gamma_{k,i} pubdebt_{it-k} + \varepsilon_{2it} \quad (2)$$

Where $i = 1, 2, 3, 4, and\ 5$ and $T = 1,\ 2,\ ....,30$ denote countries and time period, respectively; p and q are the optimal lag length ; μ_i and λ_i stand for the country-specific fixed effect in each model ; $\alpha_{k,i}$ and $\eta_{k,i}$ are the heterogenous autoregressive parameters ; $\beta_{k,i}$ and $\gamma_{k,i}$ denote the granger causality parameters ; ε_{1it} and ε_{2it} are error terms that can be serially correlated and cross-sectionally dependent.

The model (1) above tests panel granger causality under the null hypothesis that military spending does not Granger-cause public debt, as follows:

$H_0 : \beta_{k,i} = 0$ for all *i* and *k* ***versus*** $H_1 : \beta_{k,i} \neq 0$ for some *i* and *k*.

Likewise, the model (2) above tests panel granger causality under the null hypothesis that public debt does not Granger-cause military spending, as follows:

$H_0 : \gamma_{k,i} = 0$ for all *i* and *k* ***versus*** $H_1 : \gamma_{k,i} \neq 0$ for some *i* and *k*.

In both models (1) and (2), the alternative hypothesis will be accepted if the p-values are lower than either 1% or 5% level of significance, meaning that military spending granger causes public debt and vice-versa.

2.2. Empirical model and estimation strategy

As an alternative approach to panel granger causality, we use a panel vector autoregressive model. The latter allows for examining the dynamic relationship between military spending and public debt to G-5 Sahel countries, controlling other factors such as economic growth, population growth, exchange rate etc. Drawing from the empirical literature presented in previous section, we specify our empirical PVAR in a reduced-form below:

$$Y_{it} = \alpha_i + \phi_{1i}.Y_{it-1} + \phi_{2i}.Y_{it-2} + \ldots.. + \phi_{pi}Y_{it-p} + \mu_{it} \quad (3)$$

Where *i* and *t* are respectively countries and time period; The vector of endogenous variables is given by $Y_{it} = (milspen_{it}, pubdebt_{it}, ecogro_{it}, popgro_{it}, glob_{it}, exchrat_{it})'$; $Y_{it-1}, Y_{it-2}, \ldots\ldots, Y_{it-p}$ are the vectors of lagged endogenous variables; α_i denotes country-specific fixed effect; $\phi_{1i,}\phi_{2i,\ldots\ldots,}\phi_{pi}$ are parameters to be estimated; μ_{it} is a vector of error terms that can to be serially correlated and cross-sectionally dependent.

Estimating model (3) require to follow several econometric procedures. At first, we check the presence of cross-sectional dependence in variables using tests by Baltagi et al. (2012) and Pesaran (2021). The results from these tests enable us to discriminate between the first-generation and second-generation panel tests (Hurlin and Mignon, 2007). Given our variables exhibit CD evidence (see Table 3), we explore the integration order of the variables through Pesaran (2007) unit root test because it outperforms the first-generation test. After testing for unit root in variables, we examine the long-run relationship among them utilizing the bounds test to cointegration proposed by Pesaran et al. (2001). This test is appealing than cointegration test by Westerlund (2007) that requires all variables to be integrated of order one (I(1)). The results from this test indicate our variables are not cointegrated (see Table A2), constraining us to apply an unrestricted PVAR model as our empirical model to be estimated. Moreover, we implement the Juodis *et* al. (2021)[1] Granger causality test so that to rank variables in PVAR from the most exogenous to the least exogenous. This is crucial for the computing of impulse

[1] The Juodis *et* al. (2021) test performs better than other panel causality tests by taking into account simultaneously heterogeneity, heteroskedasticity, cross-sectional dependence and Nickell bias.

response functions and variance decompositions based on the Cholesky decomposition. We then make use of the standard information criteria by Akaike (1979) to derive the optimal lag length to be used in our empirical model. After undertaking all the procedures above, we employ the least squares dummy variable (LSDV) method to estimate the model (3). Indeed, LSDV-PVAR method is more appropriate than GMM-PVAR method for this paper that employ panel data with moderate time-series dimension and relatively small cross-section dimension (Bundell and Bond, 1998; Bun and Kiviet, 2006).

Finally, we carry out some post-estimation tests in order to check the robustness of the PVAR results that enable computing of the impulse response functions and forecast error variance decompositions. To do this, we test for autocorrelation, heteroskedasticity, and stability conditions of the estimated PVAR model.

2.3. Impulse responses functions and forecast error variance decompositions

We make use of the above estimated PVAR results to compute the impulse response functions and forecast error variance decompositions. The used estimated PVAR may be stable and invertible meaning that it has an infinite order vector mean average (VMA) representation. We rely on this VMA representation to write the IRF to be computed below:

$$\Phi_i = \begin{cases} I_k & i = 0 \\ \sum_{j=1}^{i} \Phi_{i-j} \mathrm{A}_j & i = 1, 2, 3, 4... \end{cases}$$

Where Φ_i is the VMA parameters and A_j is an element of the companion matrix.

Furthermore, we can use the above result to write our *h*-step ahead forecast error variance decomposition to be computed as follows:

$$Y_{it+h} - \mathrm{E}(Y_{it+h}) = \sum_{i=0}^{h-1} e_{i(t+h-i)} \Phi_i$$

We also calculate the confidence intervals analytically using the asymptotic distribution of the PVAR coefficients and the cross-section equation error variance-covariance.

2.4. Data and variables description

In this paper, we use annual data from G-5 Sahel states that are Burkina Faso, Chad, Mali, Mauritania and Niger. The data spans the period from 1990 to 2020. Choice of this time period is motivated by the availability of data on interest variables mainly military spending and public debt. Although, there are some missing data in military spending variable that we may impute. To do this, we make use of the linear interpolation and extrapolation method that is widely used in economic literature due to its simplicity and reliability to generate missing data (Gygli *et* al.,2019). Further, it is crucial to impute missing data in order to get a balanced panel data. The latter is a requisite for implementing the both granger causality tests to be used (Juodis et al.,2021; Xiao et al.,2022). The Table N°1 below reports the variables description and data sources. It emerges from this table that variables come from several sources and are differently measured. Some of variables are measured as GDP ratio and other in terms of percentage.

Table N°1. variables description and data sources

Variables	Description and measure	Sources
milspen	military spending (% PIB)	SIPRI
pubdebt	public debt (% PIB)	Global Database Debt
ecogro	real gross domestic product growth (%)	World Development Indicator
popgro	population growth rate (%)	World Development Indicator
glob	economic globalization index	KOF Swiss Economic Institute
exchrat	exchange rate(1dollar per domestique currency)	World Development Indicator

Source: Author; Note: SIPRI means Stockholm International Peace Research

Table N°2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
milspen	155	1.972	1.116	.72	7.96
pubdebt	155	50.469	26.045	14.135	125.237
ecogro	155	4.368	4.991	-15.71	33.629
popgro	155	3.081	.537	1.929	4.436
glob	155	39.076	7.404	23.069	52.001
exchrat	155	420.083	223.914	8.061	732.398

Source : Author

Moreover, the above Table N°2 presents the summary statistic of variables. It shows that military spending and public debt in G-5 Sahel states account for 1.97% and 50.46% of their GDP on average. The maximum and minimum indicators reveal that military spending and public debt are so dispersed, indicating that the amounts of these variables are heterogenous across countries. The same argument holds when analyzing the remainder variables including economic growth, globalization, exchange rate etc.

3. Empirical results

3.1. Econometric test results

In this section, we present and discuss some relevant test results. The results from tests by Baltagi et al. (2012) and Pesaran (2021) are reported in Table 3. It merges from the latter variables exhibit cross-sectional dependence at 1% significance level, as all corresponding p-values are below usual significance levels. Given CD matters in variables, we conduct Pesaran (2007) unit root test to check the order of integration of the variables. We report the test results in Table 4 that indicates all variables are difference stationary at 1% level, except *ecogro* variable which is level stationary at 1% level of significance. Regarding Table A2, it reports the results of cointegration test by Pesaran et al. (2001). According to these results there is no long-run relationship among variables at 5% level since the corresponding F-statistic is above the upper bond for non-stationary variables. We also present in Table A1 (see Appendix) results for Dumitrescu and Hurlin (2012) panel granger causality test. The latter suggests to arrange the variables as follows: *exchrat-ecogro-pop-glob-milspend-pubdebt*. This classification is important when it comes to apply the Cholesky decomposition. Then, we make use of the Akaike information criteria (AIC) to select the optimal lag length to be used in regression model. The results for optimal lag length selection are reported in Table A3(see Appendix). It emerges from results that AIC suggests to use 2 lags when estimating the above PVAR model. Furthermore, we check robustness of our estimated PVAR by conducting some tests for VAR residuals. This way, we consider the VAR residuals serial correlation and heteroskedasticity test results reported in Tables A4 and A5 respectively (see Appendix). The results indicate respectively that VAR residuals are no serially correlated at lag 3 at 1% level, but heteroskedastic at 1% level. At last, Figure A1 shows that the estimated PVAR satisfies the stability condition because all inversed roots of autoregressive characteristic polynomial lie inside the unit circle. These results indicate that our estimated PVAR findings are robust and therefore, they can be used to calculate the IRF and FEVD.

Table N°3. Cross-section dependence test results

Variables	BCSLM-stat	P-value	CD-stat	P-value(CD)
milspen	7.997***	0.000	1.773*	0.076
pubdebt	37.054***	0.000	13.153***	0.000
ecogro	3.870***	0.000	4.308***	0.000
popgro	15.902***	0.000	1.844*	0.065
glob	59.781***	0.000	16.659***	0.000
exchrat	47.710***	0.000	14.449***	0.000

Source: Author; Note: *** p<0.01, ** p<0.05, * p<0.1; BCSLM stands for Bais-Corrected Scaled Lagrange Multiplier.

Table N°4. Results for unit root test by Pesaran (2007)

Variables	Level Intercept CIPS-stat	Level Intercept&trend CIPS-stat	First diff. Intercept CIPS-stat	First diff. Intercept&trend CIPS-stat
milspend	-1.763	-1.588	-4.766***	-5.365***
pubdebt	-1.539	-2.358	-4.809***	-4.747***
ecogro	-5.453***	-5.991***	-	-
popgro	-1.675	-1.012	-3.004***	-3.333***
glob	-2.806	-2.863	-5.665***	-5.820***
exchrat	-1.557	-3.292***	-4.626***	-4.559***

Source: Author; Notes: *** p<0.01.

3.2. Granger causality analysis of the military spending-public debt nexus

We discuss the results of the panel granger causality tests by Dumitrescu and Hurlin (2012) and Juodis *et* al. (2021) presented in Table N°5. It emerges from this table that the null hypothesis testing military spending does not Granger-cause public debt in the model (1) is rejected at the 1% and 5% significance levels by the two tests, regardless of lags length. This means that military spending firmly granger causes public debt. Moreover, we consider the model (2) that tests the null that public debt does not Granger-cause military spending. The findings from our baseline test accept the null hypothesis at the 5% level of significance for the lags 2, 3 and 4. These results are supported by those of test by Juodis *et* al. (2021) at the same level of significance. So, the both results do not support the unidirectional causation running from public debt to military spending. Our findings firmly indicate that military spending contains information that assists to predict public debt. Therefore, any change in military spending will affect public debt level in G-5 Sahel states in the short run. This prediction is in accordance with the crowding-out theory and Ricardo-Barro equivalence theorem that supporting the positive effect of military spending on public debt. Our findings are then in line with those of Wolde-Rufael (2009) who found that military spending granger causes public debt in Ethiopia.

Tableau N°5. Results for panel causality test between military spending and public debt

Juodis et al.(2021) test			Dumitrescu and Hurlin (2012) test			**Direction of causality**	**Nature of causality**
Test-statistics			**Test-statistics**				
Lag length	W-stat (HPJ)	P-value (HPJ)	W-stat	Zbar-stat	P-value		
1	3.437*	0.063	4.161***	4.243***	0.000	milspen → pubdebt	bidirectional
1	7.166**	0.007	3.483***	3.310***	0.000	pubdebt → milspen	
2	7.782**	0.020	5.491**	3.096**	0.002	milspen → pubdebt	unidirectional
2	40.319***	0.000	4.016*	1.716*	0.086	pubdebt → milspen	
3	7.582*	0.055	8.829***	4.002***	0.000	milspen → pubdebt	unidirectional
3	68.698***	0.000	4.867	1.126	0.259	pubdebt → milspen	
4	34.708***	0.000	13.77***	5.455***	0.000	milspen → pubdebt	unidirectional
4	44.700***	0.000	5.113	0.360	0.7185	pubdebt → milspen	

Source: Author; Note: *** p<0.01, ** p<0.05, * p<0.1; milspen → pubdebt and pubdebt → milspen denote causality running from milspen to pubdebt and inversely.

3.3. Dynamic military spending effects on public debt in G-5 Sahel states

This section presents and discusses the impulse response function and forecast error variance decomposition of public debt in Table N°6 and N°7 respectively. We start with Table N°6 that presents the response[2] of public debt to one standard deviation shock to military spending over 10 periods. It shows that the public debt instantaneously and positively reacts to one standard deviation shock to military spending. During the first five periods, a positive one standard deviation shock to military spending positively affects the public debt except in the third period where the shock effect turns negative. For the remainder of periods the effect becomes blurred by turning to its long-run path. These results mean that any increase in military spending leads to rise in public debt amount for the G-5 Sahel countries, in the short run. Furthermore, these results are also confirmed by those of the variance decomposition reported in Table N°7. It emerges from this Table N°7 that public debt is sensitive to military spending change; its forecast error variance decomposition is due to 1.62% to military spending innovations. This implies that military spending explains the fluctuations of the level of public debt by about

[2] The graphical outputs for IRF are also available in the appendix.

1.62%. Our results are line with the crowding-out theory and Ricardo-Barro equivalence theorem that support the positive effect of military spending on public debt. Our results are consistent with those found by Smyth and Kumar Narayan (2009), Dunne *et* al. (2018) and Okwoche and Nikolaidou (2022).

Tableau N° 6. Response of public debt to military spending innovation

	Response variable	Impulse variable	
Forecast horizon	**D(PUBDEBT)**	D(MILSPEN)	D(PUBDEBT)
1		0.763	9.182
2		0.654	1.283
3		-0.690	0.286
4		0.005	-0.141
5		0.162	0.072
6		-0.025	0.027
7		-0.036	-0.000
8		0.037	-0.028
9		0.029	-0.004
10		-0.016	0.011

Source: Author

Table 7. Forecast error variance decomposition of public debt

Period	D(Milspen)	D(Pubdebt)	D(exchrat)	Ecogro	D(POP)	D(KOFGI)
1	0.690	99.309	0.000	0.000	0.000	0.000
2	1.114	94.103	2.107	2.112	0.471	0.090
3	1.598	91.763	2.834	2.454	0.506	0.841
4	1.596	91.647	2.831	2.452	0.629	0.843
5	1.623	91.582	2.854	2.464	0.631	0.843
6	1.623	91.538	2.855	2.476	0.661	0.844
7	1.624	91.528	2.855	2.480	0.666	0.844
8	1.625	91.516	2.855	2.482	0.675	0.844
9	1.626	91.512	2.855	2.482	0.678	0.844
10	1.626	91.507	2.855	2.483	0.680	0.844

Source: Author

Conclusion and policy recommendations

The main objective of this paper was to analyze the effects of military spending on public debt in G-5 Sahel states, over the period 1990-2020. To achieve this objective, we proceeded in two manners. First, we conducted two panel Granger causality approaches developed by Dumitrescu and Hurlin (2012) and Juodis *et* al. (2021). Second, we computed impulse response function and variance decomposition based on a panel VAR that is estimated by the Least Squares Dummy Variable method. Above all, we performed several preliminary econometric tests including the cross-section dependence, unit root, cointegration, causality and optimal lag choice tests. The test results indicated the existence of cross-sectional dependence in variables that are in the most cases integrated of order 1 and are not cointegrated. The study found three conclusive results. Results from Granger causality tests showed that causality was unidirectional and ran one way from military spending to public debt. Then, result from impulse response function revealed that military spending positively affected public debt in the short run. Finally, like previous findings, the variance decomposition result showed that public debt was sensitive to military spending change in G5-Sahel countries.

We draw lessons from our empirical results to make recommendation allowing the G5-Sahel states to reduce their debt burden. So, these countries can reduce their public debt burden by optimally allocating ressources to military sector, without neglecting to promote globalization and economic growth. The latter are recognized in the literature to be able to generate tax revenue that will be used, as alternative way to foreign borrowing, to finance public spending such as military spending.

APPENDIX

Tableau A1. Pairwise panel granger causality test results for all variables

	Dumitrescu and Hurlin (2012) test				
	Test-statistics				
Optimal lag length	W-stat	Zbar-stat	P-value	Direction of causality	Nature of causality
2	5.491**	3.096**	0.002	milspen → pubdebt	**unidirectional**
2	4.016*	1.716*	0.086	pubdebt → milspen	
2	4.597**	2.260**	0.023	milspen → ecogro	**unidirectional**
2	2.586	0.378	0.704	ecogro → milspen	
2	1.400	-0.731	0.464	milspen → popgro	none
2	4.327**	2.007**	0.044	popgro → milspen	
2	1.075	-1.034	0.300	milspen → glob	**unidirectional**
2	5.645**	3.240**	0.001	glob → milspen	
2	0.842	-1.253	0.210	milspen → exchrat	none
2	0.587	-1.492	0.135	exchrat → milspen	
2	2.307	0.118	0.9061	pubdebt → ecogro	none

2	1.674	-0.474	0.635	ecogro → pubdebt	
2	1.427	-0.705	0.480	pubdebt → popgro	**unidirectional**
2	5.410**	3.020**	0.002	popgro → pubdebt	
2	3.572	1.300	0.193	pubdebt → glob	none
2	2.713	0.497	0.618	glob → pubdebt	
2	3.652	1.375	0.168	pubdebt → exchrat	none
2	3.683	1.404	0.160	exchrat → pubdebt	
2	3.131	0.888	0.374	ecogro → popgro	**unidirectional**
2	6.679***	4.208***	0.000	popgro → ecogro	
2	5.695**	3.287**	0.001	ecogro → glob	**unidirectional**
2	3.409	1.148	0.250	glob → ecogro	
2	3.797	1.511	0.130	ecogro → exchrat	**unidirectional**
2	4.629**	2.289**	0.022	exchrat → ecogro	
2	6.035***	3.605***	0.000	popgro → glo	**unidirectional**
2	2.529	0.325	0.744	glob → popgro	
2	3.481	1.215	0.224	popgro → exchrat	none
2	3.173	0.927	0.353	exchrat → popgro	
2	1.186	-0.930	0.352	glob → exchrat	none
2	2.481	0.280	0.779	exchrat → glob	
Cholesky causal ordering : **exchrat → ecogro → popgro → glob → milspen → pubdebt**					

Note: *** p<0.01, ** p<0.05, * p<0.1, → indicates the direction of causality between variables

Table A2. Bounds tests approach to cointegration

Cross-Section	Obs.	F-Stat.
1	30	3.091
2	30	1.677
3	30	5.752
4	30	3.857
5	30	3.026

Note: the null is no level relationship; I(0)=4.134 and I(1)= 5.761 are respectively stationary and non-stationary bounds at 1% level of significance.

Table A3 Optimal lag length selection results

Lag	LR	FPE	AIC	SC	HQ
0	NA	205142.2	29.258	29.387*	29.311
1	96.517	164605.1	29.0380	29.941	29.405
2	122.110*	103442.1*	28.570*	30.249	29.252*
3	48.907	116561.6	28.682	31.135	29.679

Note: * denotes minimal value of the corresponding criteria

Table A4. VAR residual serial correlation LM-test results

Lag	LRE*stat	df	**Prob**	Rao F-stat	df	**Prob**
1	62.109	36	**0.004**	1.771	(36,512.2)	**0.004**
2	70.360	36	**0.005**	2.023	(36,512.2)	**0.005**
3	29.506	36	**0.769**	0.815	(36,512.2)	**0.769**

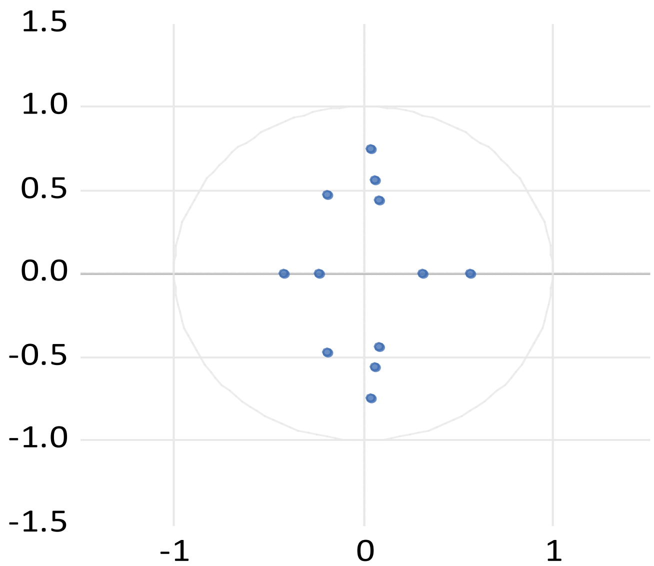
Note: the null hypothesis is no serial correlation at lag 3.

Table A5. VAR residual heteroskedasticity White test result

Join test	Chi-square	df	Prob
No cross terms	712.177	504	0.000
With cross terms	2224.737	1890	0.000

Source: Author; Note: the null hypothesis is residuals are homoscedastic

Figure A1. Inverse roots of AR characteristic polynomial



Source : Author

Figure A2. Impulse responses of military spending and public debt

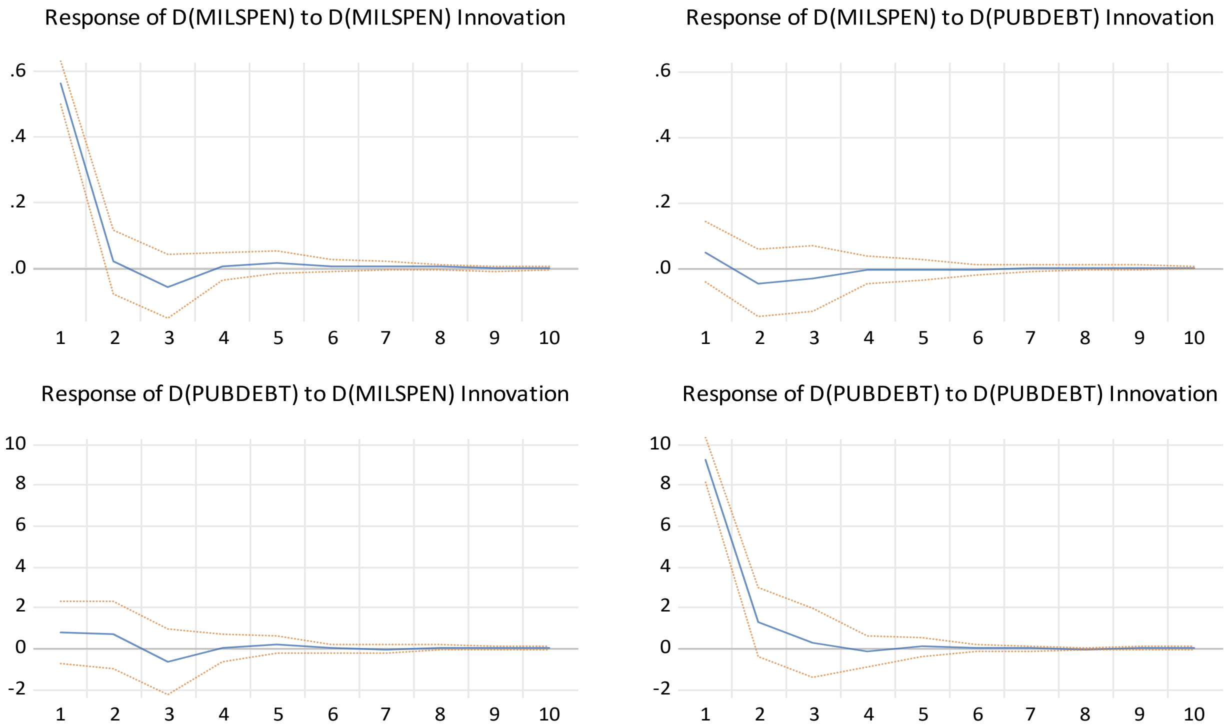
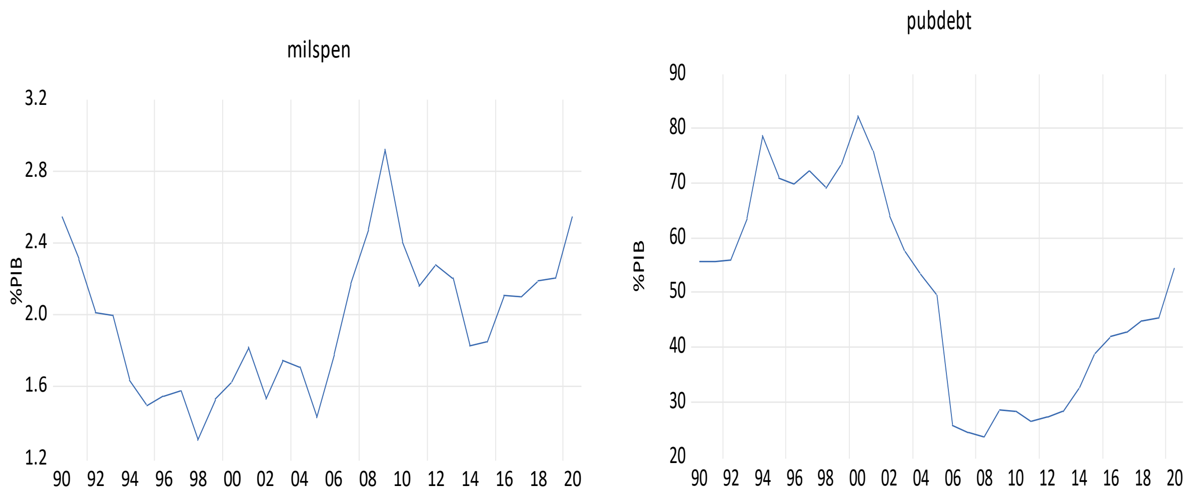


Figure A3: Trends of military spending and public debt in average values



Source: Author

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