Military Expenditure and Economic Development

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Abstract

This working paper evaluates the effect of military expenditure on development in 77 countries from different regions and income groups. In this endeavour, we use a baseline fixed-effects panel data model, the Poisson pseudo-maximum likelihood (PPML) methodology and an instrumental variable (IV) estimation in order to control for endogeneity. The paper also runs robustness checks through several model extensions and spinoffs, and uses a gravity model augmented with the number of bilateral conflict casualties to verify the IV exclusion condition through the channel of trade. Initially, the results show a negative correlation between the military burden and development. This downward influence is most robust in low-income countries; it gradually dissipates as the income level of the country increases. Our findings suggest that when military spending is merely linked to conflicts and counterproductive imports of weapons, its macroeconomic influence spirals further downward. There is also evidence of a potential offsetting combination of positive economic spill-overs (e.g. stable political situation, defence offset contracts, productivity-improving military research programmes) and negative crowding out effects (e.g. less civilian public investment, non-productive military imports) among middle- and high-income countries.

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THE CONTENT

I. INTRODUCTION

Conventional wisdom states that warfare is the opposite of prosperity and growth. However, this axiomatic statement should not remain beyond doubt or examination, especially that the amount dedicated to military spending worldwide has been constantly increasing and its proportion has been kept significantly high within most government budgets[1]. The question of the defence-growth nexus is particularly urgent for countries that suffer from significant infrastructure and human development shortages, and are therefore believed to be constantly facing a trade-off between security and growth/development whenever it comes to military spending.

This paradigm was first challenged by Benoit (1973, 1978), who examined the case of 44 LDCs using a cross-section data. The main finding, known as the *Benoit Hypothesis*, was that defence expenditure does actually have an upward influence on GDP growth. Since then, the literature have been divided, and several studies that followed gave different results depending on the analysed countries, the time periods and the econometric approaches. Subsequently, literature shows an absence of consensus whether in terms of impact on GDP growth or development [Dunne *et al*. (2005)]. Theoretically, this could be explained by the existence of different transmission channels for the interrelation between defence spending and income dynamics. These channels often have conflicting effects. The latter can be grouped into three main categories: demand effects, supply effects and security provision effects. Depending on which effects are considered, the outcome is likely to be different across studies.

This lack of consensus was exacerbated by sporadic choices of countries. Most previous papers either use a single-country time-series study or a panel data model that includes all countries as one entity. In the first case, the power of estimation is questionable, especially when using short data; a weak external validity is quasi-inevitable, considering that each country or group of countries supposedly has different idiosyncrasies. In the second case, treating all countries as one unit leads back to ignoring the aforementioned idiosyncrasies, thereby not enabling cross-country comparison.

[1] From 1988 to 2018, the world military expenditure went from 1.5 to 1.82 trillion USD in constant terms [Stockholm International Peace Research Institute (2018)]

In light of the examples presented in the literature review below, a sound comparison between countries seems improbable and examining different single countries or panels could yield different implications, particularly if the periods or the methodologies are unalike. Even within the same country, results differ depending on the adopted methodology. These issues are taken into consideration in our research to a fair extent, mainly by classifying countries based on income and geographic location, and by treating each group separately.

Another shortcoming of the current literature is linked to endogeneity and reverse causality. However, a few recent studies tried to cover this aspect, like Chen *et al.* (2014) who use for causality assessment purposes the two-step GMM techniques developed by Arellano and Bond (1991) with a bivariate panel VAR system. However, the control for endogeneity is confined to the use of country fixed-effects, which cannot effectively account for whether a country is in conflict. Rather, the conflict-related variable might actually hold a significant explanatory power. Febermayr *et al*. (2014) provide further insight on this methodological issue in even different areas, such as trade agreements. They argue in favour of the instrumental variable approach as a sound alternative that can also reduce reverse causality risks.

This study fits in this framework. It examines the relationship between military spending and development (which we proxy with GDP per capita) in 77 countries from different regions and income groups, and controls for endogeneity through an instrumental variable approach. In the latter, we use the variable *battle-related deaths*, which implicitly enables to control for the existence of a deadly conflict as well.

In our endeavour to explore the aforementioned nexus, we motivate two main hypotheses. The first hypothesis states that in low-income countries, where development shortages are the most severe and defence spending is merely linked to counterproductive expenses and imports of military equipment, the influence of military spending is supposed to be negative. Acting as the observe of hypothesis 1, the second hypothesis indicates that when defence expenditure is linked to some extent to technology transfer, R&D, production and investment in infrastructure, the industrial and commercial spillovers are likely to boost income development and income growth.

In order to examine this question and test these hypotheses, we initially use a baseline fixed-effects panel data model. Then, the abovementioned instrumental variable is introduced to reduce endogeneity and to provide robustness verification. In order to explore the validity of the nexus depending on the countries, we break the panel into different subpanels based on economic characteristics and category of each group of countries, namely income and geography. As an additional robustness exercise, we pool the overall panel and include income-based dummy variables. By the end of this research, different extensions are presented, where key variables like GFCF and the military burden are replaced respectively by private investment and proportion of military personnel. The objective of the extensions is to offer further insights on crowding out effects depending on both the source (military investment versus staffing budget) and the target (overall investment versus private capital spending).

The interest of this study first comes from the use of subpanels based on income and geography to provide a deeper insight into the relationship between the variables of interest. Additionally, while most studies do not deepen the analysis to deliver a narrative of the factors explaining the different results, one of this paper's fortes is providing historical background and geopolitical analysis, in an attempt to illustrate what appears to be purely statistical results.

Another novelty is the use of a gravity model that is augmented with interstate conflict-related deaths to detect the impact of the latter on trade flows, and by extension on GDP. Furthermore, the gravity model is estimated using the Poisson pseudo-maximum likelihood, which answers the criticism addressed by Santos-Silva & Tenreyro (2006) and Liu (2009) to most gravity models as regards to inconsistent results because of heteroscedasticity, truncation of panels and failure to capture the extensive margin.

Our findings challenge the seminal *Benoit hypothesis*, initially inducted based on LDC data. The negative correlation between the military burden and development in low-income countries is strongly robust through all different model estimates. Moreover, the choice of battle-related deaths as an instrumental variable showed to be best suitable for low-income countries, where the exogeneity condition is robust.

One of the extensions also provide hints on an interesting fact, i.e. staffing does not crowd out growth and development, as opposed to equipment expenditure.

In terms of policy, one major recommendation would be the improvement of the productivity of low-income countries' military investments, in light of their robust negative macroeconomic through all model varieties and spinoffs. One way of doing so could be by introducing industrial offset contracts in defence procurement in order to insure a channel of technology transfer and investment, like middle- and high-income countries. This aspect is important considering that none of the low-income countries examined in this study adopts such measures.

This research work initiates the analysis with a literature discussion in section II, followed by a detailed explanation of the methodology and the data in section III. The results of the different models and their extensions are analysed in section IV. Section V concludes and states the limits of this research exercise and potential topics to cover in future research.

II. LITERATURE REVIEW

The study of the nexus between defence and growth or development is considered as a niche area of research compared to other disciplines in economics. However, several studies have contributed to the debate on the impact of defence expenditure in different countries using various econometric methodologies.

The interest towards this topic rose after the seminal work of Benoit (1973, 1978), who found a positive influence of defence expenditure on GDP growth in the case of 44 least developing countries (LDC) from 1950 to 1965. This finding, known as the *Benoit Hypothesis*, raised several questions and eyebrows, and compelled several economists to dig into this subject. Whereas, in light of the absence of a unanimous theoretical or econometric framework, the literature still shows no consensus [Dunne *et al*. (2005)].

From the outset, the absence of consensus could be tributary to the existence of different transmission channels for the interrelation between defence spending and income dynamics. These channels often have conflicting effects. Dunne (1996) and Smith (2000) group them into three broad categories: demand effects, supply effects and security provision effects. The first category is based, on one hand, on the Keynesian multiplier effect where an increase in military expenditure raises demand and, in the case of underemployment, improves the use of resources. On the other hand, the government faces a trade-off when wielding military spending because any excess could generate crowding-out effects. The second category of channels is tightly linked to competition between technology and the factors of production. In other words, military-driven positive technological spillover effects (if they happen to exist) are competing with the crowding-out due to shifting factors of production towards military use; the latter are likely to increase amidst conscription and ideological fervour, especially during times of geopolitical tension[2]. The third category hinges on providing a propitious and secure environment for markets to operate, as the protection of the population and their properties provides strong incentives to invest and produce, thereby improving the level of development and income. In this vein, insecurity risk can

[2] Dunne *et al*. (2005), P. 451. The authors argue that even though resources used by the military are evidently not available for civilian use, there still could be externalities such as potential industrial and private spin-offs of military research outputs or relative productivity improvements among workers who were trained by the army. This idea is backed-up by authors like Deger (1986), who argues that the military could create growth-conducive infrastructures. We provide further examples of potential externalities when interpreting the results of the different models in the next sections.

be considered as an additional cost for investment, production and trade, and military spending can help reduce said cost if it is associated with security needs. However, an increasing military expenditure that is associated with other objectives such as arms race could deteriorate security and generate downward pressure on economic development.

Logically, the outcome of the abovementioned channels (and their combination) will depend on the proportion of each ingredient, how the military budget is funded, the extent to which military research produces exploitable technology, etc. This implies that the results are bound to differ across countries and depending on the period. Ergo, the emphasis should be laid on the idiosyncrasies of each country or category of countries during each period, for a comprehensive analysis.

This last point indicates another reason for the absence of consensus in the military economics literature. Several studies either opt for time-series modelling to analyse one single country, or a panel data methodology that includes all countries as one entity. Smith (1977, 1980) explores the case of OECD countries using time series and cross-section data. In both papers, he ascertains the existence of crowding-out effects driven by military spending on investment, which implies a negative effect on GDP growth and development through the demand effects channel as defined by Dunne (1996), and explained above. A different channel is explored by Daddi *et al.* (2018), who estimate a nonlinear growth model using data from Italy. Their model suggests that peacekeeping expenditure is the main component (of defence budget) that drives a positive macroeconomic effect since it supposedly reduces insecurity at home, which fits in the third category of channels we presented above in this section. In the case of a middle-income country, Üçler (2016) finds a positive relationship in Turkey for the 1975-2014 period, but no significant causality from defence expenditure based on the Hacker-Hatemi-J bootstrap causality test.

Gold (1997) uses the same econometric framework as Smith's (*ibid.*) for the case of USA in the 1949-1988 period. His results confirm military expenditure's crowding-out effects, but through private consumption rather than investment. This is supported by a more recent study by Pieroni (2009) specifically for US private consumption addressed to services and medical care. Lorusso and Pieroni (2017) also detect a negative correlation between output (through private consumption) and military spending using both a vector autoregressive estimation (VAR) and a new Keynesian dynamic stochastic general equilibrium model (DSGE) for the 1960-2013 period in the US. However, for the same country, different results are put forward by Atesoglu (2004) using a different methodology; for the 1947-2001 period, no evidence of crowding-out is detected. Another example of contradiction is from Israel, where Cohen *et al*. (1996) discover using time series, that defence spending has an upward influence on output growth through private investment. Contrariwise, a study by Derouen (2000) using a non-linear production model shows that when military expenditure is raised by 1%, the economic activity in Israel actually decreases (-0.037%).

In light of the examples shown so far, a sound comparison between countries seems improbable and examining different single countries or panels could yield different implications, particularly if the period or the methodology is unalike. Even within the same country, results differ depending on the adopted methodology.

As hinted above, the methodologies also seem to play a substantial role in influencing the outcomes of research in the literature. The absence of theoretical unanimity on how to model the military burden and growth/development nexus contributes to this diversity[3]. Econometric approaches used to explore this nexus include cross-section regressions [Galvin (2003)], fixed-effects panel data [Kollias et al. (2007)], Stroup and Heckelman (2001)], Granger causality test Joerding (1986)], panel VAR system [Chen *et al*. (2014), Lorusso and Pieroni (2017)], time-series models [Malizard (2015), Klein (2004)], among a few others.

In order to overcome some of these challenges, some economists tried to cover larger number of countries and to group them into different panels based on similarity in terms of characteristics, mainly based on income and geography. In this framework, Chen *et al*. (2014) cover 137 countries for the period 1988-2005. The authors criticise methodological limitations that characterised previous research work, namely the low explanatory power of estimations based on relatively short periods in single country studies and the risks of endogeneity related to static panel model. Instead, they suggest an alternative approach using the dynamic panel GMM model introduced by Wooldridge (2001) combined with a two-step estimator, which is argued to account for potential endogeneity and, importantly, the *interrelationship* defence-growth. The causality is measured within different sub-panels based on income and geographic location, instead of treating different countries as one entity.

[3] This point is further explained in the first part of Section III below.

Despite the continuous progress in research in defence economics, there are still substantial methodological shortcomings and risks. For instance, the bulk of literature does not control for whether a country is at war or undergoes a risk of conflict due to regional tensions with neighbouring countries for instance. Here, when a negative correlation (notwithstanding the causality direction) is detected, it could be tributary to this omitted variable. A conflict can actually be at the origin of both the increase in military spending and the decrease in GDP per capita (asset destruction, economic uncertainty…).

This risk of endogeneity and omitted variable bias is quite significant, especially when considering, for instance, that in the low-income countries sample chosen by Chen *et al*. (*ibid*.) (where a negative causality between income and defence spending was found), 14 countries had been in conflict (*low/very low* state of peace) and 16 were at *medium* risk of conflict[4]. On the other hand, among the 33 high-income countries in the same study –where the sign of causality is positive-, 23 (i.e. 69.7%) are highly ranked in terms of state of peace. It is worth mentioning that this source of endogeneity cannot simply be treated by only using country fixed-effects as Chen *et al*. (*ibid*.) had insinuated, because the conflict-related variable might actually hold a significant explanatory power. Febermayr *et al*. (2014) provide further insight on this methodological argument in even different areas, such as trade agreements. The latter authors argue in favour of the instrumental variable approach as a sound alternative in this context that can also reduce reverse causality risks, apart from the lag-based IVs that are systematically used within the GMM model.

Our research work fits in this particular framework. We suggest the number of battle-related deaths as an instrumental variable for the military burden. The Combat-related deaths instrument axiomatically enables to control for the existence of conflict, and offers more information than a conflict dummy variable would. In order to verify the IV exclusion condition, we use an augmented gravity model that includes bilateral combat-related deaths, in order to evaluate whether the latter affects trade flows –and by ricochet GDP per capita as a proxy for development.

[4] Own calculations, based on the Global Peace Index (GPI) by The Institute of Economics and Peace, for the period from 2012 to 2019.

The next section provides insight on this methodology and further explains the choice of variables and data.

III. ECONOMETRIC METHODOLOGY AND DATA

Studies use several different variables depending on the objective and prism through which the nexus of military expenditure and economic growth/development is considered. A few studies took inspiration from the growth model developed by Barro (1990), which enables to capture, via a production function, the potential influence of various tax-funded public expenditure on GDP. However, said growth model usually generates non-significant coefficients for military expenditure, and government spending in general, which is explained by the omission of explanatory variables and the existence of non-linearity [Aizenman and Glick (2003), Barro and Sala-i-Martin (1995)].

Thereupon, economists have been adding different supplementary exogenous variables. In this frame, Aizenman and Glick (2003) include hostile external threats, which are proxied by a weighted average of the number of wars and adversaries against whom a country has been involved in conflict[5]. For the case of Turkey and Greece, Manamperi (2016) uses a modified "Barro style" model, which includes education (secondary school enrolment), population growth and GFCF alongside the military expenditure.

Other studies used even fewer variables in a panel VAR framework. Here, Chen *et al.* (2014) use, for causality assessment purposes, the two-step GMM techniques developed by Arellano and Bond (1991) with a bivariate panel VAR system. The latter merely includes GDP per capita and the military burden, with focus on their interrelation.

Through the overview of the aforementioned studies among other papers, it is possible to conclude that there is no consensus on which control variables to use. This insinuates a margin of manoeuvre as long as the methodology shows the required awareness regarding the potential influence of other geopolitical and conflict-related factors.

3.1. The baseline model (Fixed effects regression)

For the economic development equation, we use real GDP per capita as a proxy for development, since it is so far the most agreed upon measure despite its limits, e.g. the significant variance. We follow in our choice of GDP the argument advocated for by seminal work such as Lucas's (1988), where income growth is seen as the main instrument to reach a higher level of

[5] Aizenman and Glick (2003), P. 3

wellbeing. Our rationale for avoiding the use of the human development index (HDI) is twofold: firstly, the data is not sufficiently available in some of the countries we examine below. Secondly, we adopt the criticism in the literature according to which the proxies used within the HDI to measure health (life expectancy), education (average number of years of study) and the standard of living (per capita GNI) relatively generate the same trends when plotted together with real GDP per capita.

$$Y_{it}^{d} = \alpha_0 + \alpha_1.MB_{it} + \alpha_2.X_{it}^{d} + \alpha_3.I_{it}^{d} + \alpha_4.U_{it} + \eta_i^{Y} + \phi_t^{Y} + \varepsilon_{it}^{Y} \quad (1)$$

Y_{it}^{d} is the real GDP per capita expressed in log; MB_{it} is defence expenditure as a proportion of GDP (in log); X_{it}^{d} represents the log of exports; I_{it}^{d} is the overall investment in log, proxied by GFCF; U_{it} is the unemployment rate. η_i^{Y} embodies country-specific effects, while ϕ_t^{Y} represents a time-specific effect. The error terms ε_{it}^{Y} are assumed to follow a distribution similar to normality. Level variables are expressed in first difference, in order to treat the unit root and to avoid spurious relationships, hence the *d* term at the end of each.

The objective is to explore the influence of military spending on economic development and other variables of interest and to discuss potential policy implications, depending on the characteristics of the country in terms of income, among others.

The inclusion of country-fixed effects aims to control for time-invariant unobservable characteristics such as the existence of natural resources, ethnic and religious diversity, and historical idiosyncrasies such as whether or not the country was a former colony, etc. As for the year-fixed effects, they enable to control for the potential unobservable influence of more global phenomena in the 1989-2017 period, such as the early 1990s recession, the international repercussions of the Asian financial crisis, the late 2000s recession, as well as temporary political alterations.

The choice of fixed-effects is based on the Hausman test's results (shown in Appendix I). The test rejects the null hypothesis of the random effect model being appropriate for the GDP per capita equation with a chi2 equal to 24.90.

In order to explore the validity of the relationship between military spending and development depending on the countries, we break the panel into different subpanels based on economic characteristics and category of each group of countries. The different classifications are based on the most recent update by the World Bank. The different countries and their income groups are listed in **Table 3.1.**

Table 3.1: List of the examined countries

LIC [Low-income]	LMC [Lower-mid income]	UMC [Upper-mid income]	HIC [High-income]	
Burkina Faso	Angola	Algeria	Argentina	Ireland
Chad	Bangladesh	Armenia	Australia	Israel
Eritrea	Cambodia	Botswana	Austria	Italy
Ethiopia	Cameroon	Bulgaria	Bahrain	Japan
Liberia	Egypt	Colombia	Belgium	Kuwait
Malawi	Ghana	Guatemala	Canada	Lithuania
Mali	Indonesia	Iran	Chile	Panama
Mozambique	Kenya	Iraq	Croatia	Saudi Arabia
Niger	Mauritania	Jordan	Cyprus	Singapore
Rwanda	Morocco	Lebanon	Czech Republic	Spain
Senegal	Nicaragua	Malaysia	Denmark	Switzerland
Sierra Leone	Nigeria	Mexico	Finland	UAE
Syria	Pakistan	Namibia	France	United Kingdom
Yemen, Rep.	Sudan	Peru	Germany	United States
Zimbabwe	Ukraine	Russian Federation	Hungary	Uruguay
		South Africa		
		Turkey		

3.2. Gravity model, IV approach and Poisson maximum likelihood

Pursuant to the criticism addressed in the previous section with regards to the risk of endogeneity, omitted variable bias and reverse causality, we estimate equation (1) using an instrument variable for military expenditure.

The first assumption here is that there is a significant first-stage correlation between conflict-related deaths and military spending. Secondly, the exclusion restriction should be satisfied, i.e. no correlation should exist between conflict-related deaths and GDP per capita.

In our case, the first-stage equation can be written as follows:

$$\widehat{MB}_{it} = \mu_0 + \mu_1.deaths_{it} + \eta_i^{deaths} + \phi_t^{deaths} + \varepsilon_{i,t}^{deaths} \quad (2)$$

The history of wars and conflicts provides substance for the exogeneity of our chosen IV. During most wars in the 19th century, military budgets increased substantially. The data is conclusive in this regards, and several examples confirm this hypothesis. On the aftermath of a failed presidential election in post-communist Angola by the end of 1992, the escalated number of battle-related casualties in 1993 (a 419% increase, i.e. 12,054 civilians and fighters) due to U.S.-backed rebel organisation UNITA's offensive on the government, generated a tremendous increase in military spending (+2264%). Subsequently, the military burden jumped from 5.68% of GDP to 17.52%[6]. During the Algerian Civil War, the alarmingly deadly attacks by different Islamist groups -GIA- against government forces and civilians went together with a continuous increase in the military burden, rising from 1.21% of GDP in 1991 to 3.7% in 2002[7]. The same logic applies to interstate conflicts such as the Eritrean-Ethiopian war in 1998-2000, or even in small clashes, e.g. sporadic ISIS attacks and border clashes targeting Jordan in 2016 and 2017, which were accompanied with an increase in the military burden from 4.30% in 2015 to 4.84% by the end of 2017.

As for the verification of the IV exclusion condition, we use an augmented gravity model that includes bilateral conflict-related deaths, in order to evaluate whether the latter affects trade flows, and by extension GDP per capita. This approach takes underpinning in the assumption that the main channel through which conflict deaths could affect GDP, would be through trade. War casualties –no matter how few they could be, are a signal of tension between at least the directly involved countries. If said tensions are translated into trade restrictions, this could affect GDP [Equation (1)], as the foreign component of the aggregate demand would be affected. In addition, trade flows could simply tumble amidst mere security risks related to the existence of a deadly conflict.

The outcome of the gravity model estimation should also hint on whether or not the exclusion restriction applies to investment, if the latter is considered as a dependent variable, since trade goes hand in hand with foreign direct investments (FDI) according to an overwhelming number of empirical studies [e.g. Büthe and Milner (2008), Fukao *et al*. (2003)]. In this study, however, we do not use investment as a dependent variable.

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[6] Author's calculations based on the Stockholm International Peace Research Institute (SIPRI) data.

[7] *Ibid*. 1991 is when a military coup cancelled the Islamist electoral victory in the first multi-party parliamentary elections since Algeria's independence. The GIA (Armed Islamic Group) was incapacitated by the year 2002. For more details about the conflict, see Hagelstein (2008).

Initially, gravity models are inspired from Isaac Newton's Law of Gravitation. Their canonical form can be expressed like this:

$$X_{ij} = G.\frac{Y_i^{\zeta_1}.Y_j^{\zeta_2}}{d_{ij}^{\zeta_3}}.\omega_{ij} \tag{3}$$

Where X_{ij} is the exports movement from country of origin i to country of destination j. Y_i and Y_j respectively represent the mass of the two economies, measured by GDP. d_{ij} accounts for the distance between each pair of origin-destination countries. G is a gravitational constant, and is supposed to account for other potential factors in this canonical version of gravity models. As for ω_{ij}, it is the error term, which is assumed to be log-normally distributed.

In case of log-linearization, Equation (3) becomes:

$$LogX_{ij} = \zeta_0 + \zeta_1.Log(Y_i) + \zeta_2.Log(Y_j) + \zeta_3.Log(d_{ij}) + \varepsilon_{ij} \tag{4}$$

With: $\zeta_0 = Log(G)$; $\varepsilon_{ij} = Log(\omega_{ij})$; $\zeta_3 \leq 0$

In the present research, we estimate a dynamic version of this model (including time *t*) that is augmented with the number of conflict-related deaths. We also add a number of control variables Ω_{ij} based on various extensions of the model in the literature [e.g. Rose (2000)]:

$$LogX_{ijt} = \zeta_0 + \zeta_1.Log(Y_{it}) + \zeta_2.Log(Y_{jt}) + \zeta_3.Log(d_{ij}) + \alpha.Log(\mathrm{Z}_{ijt}) + \beta.\Omega_{ij} + \varepsilon_{ij} \tag{5}$$

Here, Z_{ijt} is the number of (interstate) battle-related casualties. The controls Ω_{ij} include variables that are related to (i) cultural and geographic proximity, via dummy variables for contiguity, common colonisers, post-1945 colonial relationship, common religion, and common (official) language. The controls also encompass (ii) dummy variables related to free trade agreements, common currency and GATT/WTO membership.

If the correlation between the number of conflict-driven deaths and exports is found to be significant, introducing exports as an explanatory variable in the GDP per capita equation (Equation (1)) should enable to isolate and control for the potential effects driven by the number of casualties on GDP per capita through trade.

It is worth emphasising that in the potential presence of heteroscedasticity in the gravity model, the nonlinear transformation (e.g. via logarithm) of the variables expressed in equations (4) or (5) would most likely generate unreliable results. This econometric problem was first pointed out by Santos-Silva and Tenreyro (2006) who argue that a heteroscedastic error term in gravity models (ω_{ij} in this case) leads to a linear correlation between its logarithmic form (ε_{ij}) and the covariates, which would lead to inconsistent estimates of the coefficients[8]. Even in other non-gravity models, it is only when there is no linear relationship between the two that an OLS estimation of the log-linearized equation can generate the best possible linear approximation[9].

Log-linearization is also blamable for another significant statistical problem in gravity modelling, i.e. the exclusion of the zero observations, thereby failing to capture for example the extensive margin of trade [Liu (2009)]. And like in our case, this issue is more probable when small countries are considered[10]. It is even more severe when considering that the number of bilateral conflict-related casualties is zero in most cases, and non-zero numbers of deaths are usually registered only during a short period of one to three year, e.g. the early 1990s Gulf War and several very brief skirmishes between a few Sub-Saharan African countries. Thus, the elimination of zero-casualties pairs and zero-trade pairs would lead to the loss of much of the model's expected explanatory power.

In order to avoid these problems, we opt for the Poisson pseudo-maximum likelihood (PPML) approach with fixed effects, which is robust and properly addresses heteroscedasticity. The PPML also effectively handles zeros without any truncation of the panel, as it solves the model multiplicatively without any nonlinear transformation. Ergo, it even allows interpreting the coefficients as elasticity when combining variables in levels and in logarithms.

However, Since it is less suitable in the case of an IV approach, we do not use PPML when treating the zero-deaths in the first stage regression in equation (2). Instead, we set the model so that the 0 observations in the instrumental variable *battle-related deaths* can be treated separately. As an alternative, we also artificially replace the 0s with 1s to end up with 0s after applying the natural logarithm. We opt for the latter approach because of the importance of ultimately keeping

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[8] Santos-Silva and Tenreyro (2006), P. 653
[9] Goldberger (1991), P. 53
[10] Santos-Silva and Tenreyro (*ibid.*), P. 643

the zeros, since they incarnate information on the non-existence of a casualties-generating conflict in the panel.

In order to explore the nexus of interest further, we experiment a few spinoffs and extensions of both the baseline model and the IV robustness check. Further explanation is given for each in section IV below.

3.3. Variables and data sources

In order to estimate equation (1) with fixed-effects and then with the chosen instrumental variable [with equation (2)], we make use of data for the aforementioned 77 countries from 1989 to 2017. Most data comes from the World Development Indicators. For the main regression (fixed-effects and IV), the variables are detailed in the following list:

- The real gross domestic product per capita: we use the constant 2010 USD GDP divided by midyear population. As commonly used in the literature, the aggregate is computed without deducing the potential depreciation of assets nor the impact on natural resources. The data come from the World Bank national accounts data, and OECD National Accounts data files.
- The military burden: it represents the military expenditure as a share of GDP. The data encompass current and investment spending on armed forces, defence administrations/ministries and government agencies. Military research and space programmes are also taken into account. The data are provided by the Stockholm International Peace Research Institute (SIPRI). Here, we opt for *share* data (as opposed to *level* data) in order to insure comparability across countries of military budgets and to avoid exchange rate conversion problems. This definition is also present in previous studies, e.g. Kollias *et al*. (2004), and Dunne & Perlo-Freeman (2005).
- Exports: we use the figures in constant 2010 USD of the exports of goods and services to the rest of the world. Investment income and transfer payments are excluded. Here also, we use World Bank national accounts data, and OECD National Accounts data files.
- Investment: as a proxy of overall investment, we use GFCF in constant 2010 USD terms, which includes equipment purchases, the construction of different infrastructures and buildings. The data for investment is driven from the World Bank national accounts data.

- The unemployment rate: for this variable, we use estimates provided by the International Labour Organization (ILOSTAT database).
- Real interest rate: we use the lending interest rate provided by the International Monetary Fund, adjusted for inflation using the GDP deflator taken from the World Bank dataset. A caveat here would be the fact that countries could have different terms and conditions attached to said rate, which could limit its cross-country comparability. However, since this variable is used merely as a control, this risk is deemed marginal.
- Private investment: the proxy for this variable is the private sector's contribution to GFCF (in % of GDP), as defined by the World Bank and the OECD.
- Battle-related deaths (the IV): driven from the Uppsala Conflict Data Programme, this variable represents the number of human civilian and military casualties in conflicts. This includes warfare with the participation of conventional armed forces, guerrilla, and air strikes hitting both civilian and military areas/installations.

The use of international institutions' data when it comes to military expenditure, despite being convenient, should always be considered with caution. The caveat here is that countries tend to either overstate or understate military budgets for security or mere political reasons. In several developing countries undergoing constant conflict threat, a part of some development-focused concessional loans or donations provided by international institutions is secretly diverted towards purchasing military equipment, which provides a rationale for said countries to understate when communicating statistics. Also, overstating military expenditure has a dissuasive effect, especially in bipolar regions (e.g. Algeria and Morocco, India and Pakistan, Iran and Saudi Arabia…). However, since we use military spending as a share of GDP, this margin of risk is minimalised and the data can still provide significant comparative insights.

In the gravity model used to explore the exclusion restriction, the focus is shifted towards the bilateral level. However, we maintain the same sample of countries for the period between 1989 and 2014. We exclude the short period between 2014 and 2017 because of missing bilateral data for several country-pairs, which would have generated an unbalanced panel. We use data based on the CEPII square gravity model, while the bilateral trade flows are collected from the UN

COMTRADE[11]. The number of bilateral battle-related deaths were taken from the Uppsala Conflict Data Programme.

In this framework, it is worth observing that the gravity model is confined to *interstate* battle-related casualties, because even though there is a few deadly civil wars/insurgencies that were *allegedly* supported by foreign countries, we could not establish the direct link to the supporting countries in most cases. Hence, for the sake of research objectivity, we chose to consider only the casualties that happened in conflicts directly/officially involving the states of the 77 countries we study. The variable includes the number of casualties among civilians and military/paramilitary forces, whether the origin country suffered said casualties or dealt them to the other side of the conflict (country of destination of the trade flow).

Using the methodology and data explained so far, the next section discusses the different results, provides different robustness verifications and provides policy implications.

[11] The different dummy variables used were constructed by CEPII based on the World Trade Organisation information, Baier & Bergstrand (2007), Frankel (1997) and Glick & Rose (2002).

IV- RESULTS AND POLICY IMPLICATIONS

4.1 The baseline model

Column 1 of Table 4.1 presents the results of the fixed-effects regression for the overall panel with all countries. The model suggests that the military burden is negatively correlated with development, with a -0.011 coefficient. The R-squared is fairly significant, i.e. 0.42. Moreover, the relationship between GDP per capita and the remaining variables of the equation seem to abide by the economic intuition; exports and investment have significantly positive correlation coefficients, equal to 0.09 and 0.10 respectively, while the unemployment rate is negatively linked to income dynamics, with a small coefficient however.

From the outset, this result seems to refute the *Benoit hypothesis* discussed in the literature review above [Benoit (1973, 1978)]. However, deepening the investigation using different methods and subpanels should yield further analysis elements. **Table 4.2** shows the results obtained using the same approach, but with four different income-based groups of countries. The relationship between military spending and development appears to be different across income subpanels; it is only significant in low-income countries, with a -0.036 coefficient. The non-significance of the relationship between the two variables in lower middle-, upper middle- and high-income countries could be due to the existence of an offsetting combination of positive economic spill-overs (e.g. stable political situation, military infrastructure for public use) and negative crowding out effects (e.g. less *civilian* public investment, non-productive military equipment imports). When running the regressions with only country-fixed effects for robustness (See Appendix 2), the results converge slightly to the main hypotheses of our research, as military expenditure shows a decreasing negative influence on GDP per capita when moving from lower to higher income level countries. The correlation coefficients are -0.039, -0.019 and -0.010 in low-income, lower middle-income and upper middle-income economies, respectively. The coefficient in high-income countries remains insignificant however, with a positive value of 0.0018.

Another interesting point in **Table 4.2** would be related to investment (GFCF), if one assumes that its economic effectiveness can be assessed through its correlation coefficient. The latter in upper middle-income and high-income countries (respectively 0.177 and 0.152) is the double of that in low-income and lower middle-income countries (0.078 and 0.082). This suggests that the former group needs larger investments in order to generate income improvement and development in the short run, while the latter need much less. This could be linked to the level of infrastructure stock, especially when considering that less developed countries mostly invest in infrastructure, which does not generate economic returns in the very short term. Another factor could be the inefficiencies linked to the level of corruption[12]. On overall, this comparison suggests a gradually decreasing incremental capital output ratio (ICOR) as countries become more developed.

The income-based estimates corroborate the positive relationship between investment and exports found earlier in the overall panel, except in the lower middle-income group where the coefficient is not statistically significant in both **Table 4.2** and Appendix 2. Whereas, the unemployment's correlation coefficients lose significance, with the exception of high-income countries, where it keeps its negative sign. These aspects are confirmed in the country-fixed effects estimates (without controlling for time-fixed effects) as shown in Appendix 2.

[12] For instance, the average of the corruption perception index (CPI) in the group of low-income countries in 2017 was 30, while it reached 65 among the countries we had chosen for the high-income group.

TABLE 4.1: Estimates for all countries using FE and IV [Dependent variable: log GDP per capita]

VARIABLES	(1) FE approach	(2) Pooled sample with income dummy v.	(3) IV approach
MB_{it}	-0.0109***	-0.0364***	-0.0801***
	(0.00366)	(0.00681)	(0.0256)
$MB_{it} * LMCdummy_i$		0.0211**	
		(0.00922)	
$MB_{it} * UMCdummy_i$		0.0316***	
		(0.00951)	
$MB_{it} * HICdummy_i$		0.0483***	
		(0.00888)	
X_{it}^d	0.0905***	0.0873***	0.0993***
	(0.00803)	(0.00799)	(0.00892)
I_{it}^d	0.106***	0.106***	0.110***
	(0.00543)	(0.00538)	(0.00611)
U_{it}	-0.000893**	-0.000935**	-0.000728*
	(0.000386)	(0.000383)	(0.000443)
Constant	0.0240***	0.0196***	0.0655***
	(0.00410)	(0.00416)	(0.0157)
Observations	1,715	1,715	1,715
R-squared	0.418	0.428	
Number of countryid			71
The IV First-Stage Regression [endogenous variable: the military burden]			
$deaths_{it}$			0.0259***
			(0.0045)
I_{it}^d			-0.0229
			(0.0413)
U_{it}			0.0029
			(0.00291)
X_{it}^d			-0.0341
			(0.05984)
Constant			0.5811***
			(0.0249)
Observations			1,715

We approach the separation between income groups differently in **column 2 of Table 4.1**, by pooling all countries back together and using dummy variables to make allowance for each income category. This approach allows assessing the extent to which the correlation coefficient found in the low-income group between the military burden and GDP per capita is independent. It also enables further exploration of the relationship between the two variables. The coefficients linked to the dummy variables are all significant, which suggests that the effect of the military burden on GDP per capita is different across income groups.

TABLE 4.2: Panel fixed-effects estimates in different income groups [Dependent variable: log GDP per capita]

VARIABLES	(1) Low income	(2) Lower-mid income	(3) Upper-mid income	(4) High income
MB_{it}	-0.0366***	-0.00278	-0.00529	0.00336
	(0.0133)	(0.00826)	(0.00594)	(0.00405)
X_{it}^{d}	0.105***	-0.0122	0.113***	0.185***
	(0.0209)	(0.0191)	(0.0149)	(0.0141)
I_{it}^{d}	0.0779***	0.0820***	0.177***	0.152***
	(0.0135)	(0.0135)	(0.0111)	(0.00869)
U_{it}	-0.000604	0.000803	-0.000577	-0.00176***
	(0.00420)	(0.00171)	(0.000524)	(0.000301)
Constant	0.0275	0.0127	0.0210**	0.0144***
	(0.0180)	(0.0131)	(0.00835)	(0.00362)
Observations	221	349	427	718
R-squared	0.464	0.348	0.623	0.702

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results of the pooled panel in column 2 can also be interpreted in terms of impact. Apart from that of the low-income countries, the (combined) coefficient linking defence spending to GDP per capita in lower-income countries is negative (-0.0364 + 0.0211). It is negative and converging toward zero in upper middle-income economies (-0.0364 + 0.0316) and positive for high-income ones (-0.0364 + 0.0483). When considering that the more developed is a country the more likely its defence expenditure is linked to production, investment in technology and infrastructure, then this finding could support our second hypothesis to a mild extent. The gradual improvement of the negative correlation coefficient could be explained by the fact that the proportion of productive military expenditure, which yields economic spillovers, varies across the four subpanels[13].

In the low-income economies, the so-far robust negative influence of the military burden could be interpreted as the economic consequence of deviating funds that could be used to curb development shortages, towards weaponry imports and the purchase of other non-productive military equipment and constructions. Whereas, the bulk of (lower and upper) middle-income countries do not have productivity-enhancing research/industry either and face development challenges as well; this would suggest different results that those generated so far. However, it is worth observing that these countries use defence offset contracts as an alternative in order to insure technology transfer and foreign investment. The most common form of said offset contracts is industrial participation (also called industrial compensation), which is imposed as one of the conditions for foreign tenders to be awarded important military procurement contracts. This "opportunity cost" involves investment in national non-military industrial sectors, with the exception of countertrade for the case of Cuba and Burma –which are not covered by our present study. This partly justifies the better coefficients of correlation (insignificant or only slightly negative) found in both subcategories of middle-income countries, especially that none of the low-income countries (listed in **Table 3.1**) make use of offset clauses[14].

In order to test the robustness of the results so far, we examine the results of the instrumental variable approach explained in section III above, which should enable to reduce the risk of endogeneity.

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[13] Several examples of defence-related research programmes support this assumption. Among high-income countries, several military-sponsored innovation projects have benefited the economy in different fields such as cyber security, civil aviation, telecommunications, space exploration and chemical/biological engineering. Military research investment takes different forms, ranging from sponsorship of specific university research programmes, to direct involvement through agencies such as DARPA in the United States, the Defence Science and Technology Laboratory (DSTL) in the United Kingdom, and the VVU in the Czech Republic, etc. Such programmes are extremely scarce when examining low-, lower middle-income countries and even a few countries in the upper middle-income group studied in this paper.

[14] International Chamber of Commerce (2019), Annex I, PP. 37-43

4.2 The gravity model

Before analysing the results of the IV model and verifying the instrument's exogeneity, we first discuss the exclusion condition by examining the gravity model estimates. **Table 4.3** reports the latter, with four different variations. For all four, we use the Poisson pseudo-maximum likelihood pursuant to the previous discussion in **section III**. Since the model covers all possible combination among the 77 countries, the number of observations used in the regression is considerable, i.e. 143,354 observations.

In **column 1** of the table, we estimate the correlation between interstate battle-related casualties and trade flows in a canonical gravity model that includes respective gross domestic products (size of the economies) and the weighted distance between countries in each pair. The results suggest a very weak negative coefficient of correlation of -0.00009, which is statistically significant at the 10% threshold. The coefficient becomes slightly more significant in **column 2** (-0.00016 at 5%) where dummy variables are introduced to control for a number of bilateral cultural and geographical aspects, such as the existence of a colonial relationship, a common coloniser (post-1945 period), a common religion, a common official language or contiguity. However, the deaths coefficient shows no significant impact when including currency and trade dummy variables instead (**column 3**), i.e. common currency, regional/free trade agreements, GATT/WTO membership among the countries of origin and destination of the trade flow.

In **column 4**, where all the factors controlled for by dummy variables are included, the relationship between battle-related deaths and exports retrieves its statistically significant negative sign, yet with a small coefficient of -0.00014.

On the other hand, it is worth observing that the main variables of the gravity model (distance and GDPs) show a robust stance that is strongly consistent with theory. As regards to the dummy variables, it is possible to observe that countries are less likely to trade with others with which they shared the same coloniser (largely negative coefficient of correlation between -1.48 and -1.57), but more likely to trade with their former coloniser (0.234 ; 0.512). Having the same official language is not a binding condition; it is the only factor that holds no significant effect on trade. Having a common religion seems have a negative effect on trade in our panel, while the rest of the dummy variables show patterns that follow economic intuition. Like the distance and GDPs, all the dummy variables maintain similar coefficients with large statistical significance regardless of the model's specification, hence the robustness of the cultural, geographical and trade-related factors in determining trade flows dynamics.

To sum up, the gravity model estimates suggest that in most cases the existence of bilateral conflict casualties could affect trade flows between pairs of countries in a downward course, however in a very marginal proportion. This means that there is a risk that battle-related deaths could affect GDP per capita if we consider the overwhelming literature on the latter's positive relationship with trade. Therefore, we add the exports variable as an exogenous variable in the GDP per capita equation in order to control for this risk that the exclusion restriction could come up against otherwise.

TABLE 4.3: PPML estimation of the gravity model with battle-related deaths [Dependent variable: X_{ijt}]

VARIABLES	(1) Baseline	(2) Cultural DV	(3) Trade DV	(4) All
Battle-related casualties Z_{ijt}	-0.000092*	-0.000161**	-0.000018	-0.000141***
	(5.04e-05)	(6.83e-05)	(3.79e-05)	(3.01e-05)
Weighted distance d_{ij}	-0.000311***	-0.000176***	-0.000160***	-0.0000938***
	(7.12e-06)	(6.09e-06)	(5.08e-06)	(4.52e-06)
GDP of exporter Y_{it}	3.19e-13***	2.73e-13***	2.75e-13***	2.45e-13***
	(3.26e-15)	(3.71e-15)	(3.94e-15)	(3.47e-15)
GDP of importer Y_{jt}	3.34e-13***	2.89e-13***	2.90e-13***	2.61e-13***
	(3.44e-15)	(3.80e-15)	(4.25e-15)	(3.70e-15)
Colonial relationship		0.234***		0.512***
		(0.0415)		(0.0406)
Common colonizer (post 1945)		-1.485***		-1.573***
		(0.0868)		(0.0802)
Common religion		-0.120**		-0.546***
		(0.0483)		(0.0457)
Common official or primary language		-0.0549		-0.0490
		(0.0449)		(0.0353)
Contiguity		1.843***		1.472***
		(0.0486)		(0.0460)
Common currency			0.972***	1.100***
			(0.0738)	(0.0499)
RTA			1.294***	1.095***
			(0.0338)	(0.0325)
Exporter is GATT/WTO member			0.853***	0.833***
			(0.0435)	(0.0423)
Importer is GATT/WTO member			1.169***	1.152***
			(0.0402)	(0.0386)
Constant	20.74***	20.08***	17.81***	17.64***
	(0.0320)	(0.0368)	(0.0592)	(0.0582)
Observations	143,354	143,354	143,354	143,354

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

4.3 The instrumental variable approach: robustness analysis

After discussing the results of the baseline fixed-effects regression and the gravity model's implications, we turn to estimating Equation (2) which motivates *battle-related deaths* as an instrumental variable for the military burden.

Column 3 of Table 4.1 reports the results for the overall panel. With comparison to **column 1**, it seems that introducing the effect of the number of conflict casualties through military burden reveals a slightly more negative impact of the latter on development in the short run. The MB_{it} coefficient of correlation goes from -0.011 (Fixed-effects) to -0.08. The remaining exogenous variables of the equation maintain similar coefficients, at 0.0993, 0.11 and -0.00073 for X_{it}^{d}, I_{it}^{d} and U_{it} respectively.

In the first-stage regression results reported in the second part of **Table 4.1**, the exogeneity condition is established. The instrumental variable *battle-related deaths* is significantly correlated with the endogenous variable at the 1% threshold according to the t test, with a positive coefficient of 0.0259.

This logic is confirmed when subdividing the panel into income-based groups. The instrumental variable approach ascertains the robustness of the previous results, as in **Table 4.4** the military burden's coefficient is only significantly negative in low-income countries, at -0.0965. Again, this coefficient is merely slightly larger than the one estimated in the baseline fixed-effects model. Said coefficient loses its statistical significance in lower middle-, upper middle- and high-income economies, in a similar pattern to that reported in **Table 4.2** above. The robustness of the model is also supported when examining the coefficients of the other exogenous variables. Across columns **1 to 4 in Table 4.4**, the different coefficients related to export, investment and unemployment show similar values and t test results compared to those generated by the basic fixed-effects model above.

An important observation, when examining the first-stage regression, is the statistically non-significant correlation between battle-related deaths and the military burden in high-income countries, reported in the first-stage regression part of **column 4**. This suggests that the instrumental variable's exogeneity condition is not respected, hence a weak predictor of the endogenous variable for that category of countries. This outcome is plausible, particularly when bearing in mind that in several conflicts during the 1989-2017 period, most rich countries that took part in global combats have not suffered human casualties among their personnel or in their sovereign territory. This is partly because these countries have been mostly engaged through intelligence and air strikes in foreign warfare theatres. In other words, on one hand, military spending was increasing but, on the other, the number of deaths (among said rich countries) were not affected due to the reduced-risk nature of their interventions, made possible by their military superiority. Historical data-based facts provide support for this explanation, e.g. several battles in the early 1990s Persian Gulf War where the US-led international coalition massively used (costly) aviation and armoured ground forces to swiftly defeat the Iraqi army. Consequently, Canada, France and the US had zero registered deaths while Britain suffered 67 human casualties between 1990 and 1991[15]. On the other hand, the death toll on the Iraqi side (upper middle-income country) reached 23,038 people in 1991 alone. Similar dynamics are also observed in recent conflicts such as the ongoing Operation Decisive Storm in Yemen, launched in 2015 by a nine-country coalition led by Saudi Arabia (high-income country).

However, the exogeneity condition is respected in all the other income subpanels. The strongest correlation between the instrument and the endogenous variable is found among low-income countries, at +0.0684. The coefficient is at +0.0377 in the upper middle-income group. Both coefficients are significant at the 1% threshold, according to their respective t test results. In the case of lower middle-income countries, as shown in the first-stage regression part of **column 2**, the coefficient is largely significant yet negative (-0.051). While there is no certain explanation of this puzzling correlation sign, one cannot discard the possibility that it might be linked to one of the limits of the data as discussed in section III above (subsection 3.3). Some developing countries undergoing constant conflict threat supposedly have the tendency to understate their military expenditure statistics because of partial deviations of development-oriented concessional loans or donations towards purchasing military equipment, or simply for tactical reasons. This explanation is more likely in light of the results we found when lagging the variables to check for whether military spending increases as a post-hostility reaction or pre-conflict preparation in lower middle-income countries. These last two scenarios are refuted, as even after running the same regression with different combinations of lagged variables, the negative coefficient remains very robust.

[15] The statistics are based on the Uppsala Conflict Data Program.

TABLE 4.4: IV estimates and first stage regression results by income groups [Dependent var.: GDP per capita]

VARIABLES	(1) Low income	(2) Lower-mid income	(3) Upper-mid income	(4) High income
MB_{it}	-0.0965***	0.0864	0.00528	0.0641
	(0.0283)	(0.0634)	(0.0269)	(0.0792)
X_{it}^{d}	0.0968***	0.00809	0.129***	0.187***
	(0.0219)	(0.0229)	(0.0147)	(0.0322)
I_{it}^{d}	0.0751***	0.0965***	0.184***	0.166***
	(0.0135)	(0.0167)	(0.0111)	(0.0152)
U_{it}	-0.00293	-0.000624	-0.000759	-0.00193***
	(0.00349)	(0.00215)	(0.000521)	(0.000570)
Constant	0.0682***	-0.0253	0.0131	-0.0210
	(0.0240)	(0.0334)	(0.0227)	(0.0426)
Observations	221	349	427	718
Number of countries	12	14	16	29

First Stage Regression [endogenous variable: the military burden]

$deaths_{it}$	0.06839***	-0.0514***	0.03772***	0.0183
	(0.01045)	(0.0181)	(0.00862)	(0.0144)
I_{it}^{d}	0.002926	0.0297	-0.08138	-0.135
	(0.0730)	(0.0925)	(0.0948)	(0.105)
U_{it}	-0.0295	0.0131	0.00013	0.0052
	(0.0181)	(0.01199)	(0.0044)	(0.00367)
X_{it}^{d}	-0.09495	-0.0409	-0.0543	0.3653**
	(0.1148)	(0.1275)	(0.12512)	(0.1480)
Constant	0.5422***	0.6956***	0.0377***	0.5351***
	(0.0819)	(0.1234)	(0.0532)	(0.0302)
Observations	221	349	427	718
Number of countries	12	14	16	29

In order to verify if the IV model is soundly identified, we use a group of tests. The results of the latter are reported in **Table 4.5** for both the overall panel and the income-based subdivided analysis.

To test for under- or weak identification of the instrumental variable, we use the Anderson canonical correlation LM statistic, the Cragg-Donald Wald test and the Sanderson-Windmeijer F test. The null hypothesis for all three tests is weak/under-identification, but they test for it through different indicators, e.g. concentration matrix, the minimum canonical correlation. We also test the significance of the endogenous variable in the main equation, using the Anderson-Rubin Wald test and the Stock-Wright LM S statistic. Here, the null hypothesis is that the endogenous variable's coefficient is equal to zero and that orthogonality condition apply. We also include the Hansen J statistic as an over-identification test, mostly for *pedagogical purposes*. However, it is worth mentioning that the Hansen J statistic is not quite relevant to this study, because it only effectively analyses over-identification after the introduction of a second instrumental variable or more; yet we only use one instrument. Ergo, its outcome in our case is interpreted as "equation exactly identified" for all panels. Following this logic, we also skip the Angrist-Pischke test, since we only have one instrument/regressor anyway, hence no need for further individual investigation through AP first-stage F statistics.

TABLE 4.5: IV identification tests for the overall panel and income-based groups

TESTS	Low income	Lower-mid income	Upper-mid income	High income	All countries
Anderson canonical corr. LM stat	36.11	7.96	18.45	1.63	32.48
P-value	(0.0000)	(0.0187)	(0.0000)	(0.2019)	(0.0000)
Interpretation	[Identified]	[Identified]	[Identified]	[Under-identified]	[Identified]
Cragg-Donald Wald F statistic	42.82	4.02	19.13	1.62	33.05
Interpretation	[Identified]	[Under-identified]	[Identified]	[Under-identified]	[Identified]
Anderson-Rubin Wald test (Chi-sq)	13.41	4.28	0.04	1.07	12.22
P-value	(0.0003)	(0.1179)	(0.8429)	(0.3015)	(0.0005)
Interpretation	[Significant]	[Non-significant]	[Non-significant]	[Non-significant]	[Significant]
Stock-Wright LM S statistic (Chi-sq)	12.60	4.22	0.04	1.07	12.13
P-value	(0.0004)	(0.1211)	(0.8429)	(0.3019)	(0.0005)
Interpretation	[Significant]	[Non-significant]	[Non-significant]	[Non-significant]	[Significant]
Hansen J statistic *P-value*	0.0000	0.0000	0.0000	0.0000	0.0000
Sanderson-Windmeijer F test	42.82	4.02	19.13	1.62	33.05
P-value	0.0000	0.0189	0.0000	0.2032	0.0000
Observations	221	349	427	718	1715

The aforementioned tests confirm that the instrument was soundly selected for the overall panel with all countries (**column 5 of Table 4.5**), as the null hypotheses of the Anderson canonical correlation LM test, the Sanderson-Windmeijer F test and the Cragg-Donald Wald F test are rejected at the 1% threshold, which implies proper identification. Moreover, the results of the Anderson-Rubin Wald test and the Stock-Wright LM S statistic suggest that the military burden's coefficient is significant in the GDP per capita equation (i.e. second-stage regression). The last two tests are in line with the results in **column 3 of Table 4.1** discussed above.

The identification tests corroborate the IV approach results for the case of high-income countries. The variable *battle-related deaths* is evidently not a suitable instrument for the military burden in this category of countries, as the null hypotheses related to both under-identification and statistical non-significance were accepted in all the different tests. In the low- and upper middle-income subpanels, the identification tests suggest that the instrumental variable is not weak. In lower middle-income countries, the Anderson canonical correlation LM test, the Sanderson-Windmeijer F test and the Cragg-Donald Wald F test send contrasted signals. The former and the second reject the null hypothesis of under-specification at the 5% threshold while the latter accepts it when confronting its F statistic (4.02) with the Stock-Yogo weak ID test critical values on all possible maximal IV size thresholds (10%, 15%, 20% and 25%). This finding gives further rationale for the scepticism expressed above after finding a negative correlation between the number of battle-related deaths and the military burden (**column 2 of Table 4.4**). It compels to take with larger caution the results found for this category of countries and, again, the abovementioned risks regarding military data reporting in this subpanel should not be discarded.

Across all four income-based subpanels, the Anderson-Rubin and Stock-Wright tests suggest that the coefficient of the endogenous variable in the main equation is only significant in low-income countries. This could be interpreted as further robustness to the baseline model, which yields similar results. These findings confirm to some extent the first hypothesis developed in this paper, i.e. it is in the low-income countries that the influence on output and development is supposed to be negative, as those countries development shortages are the most severe and military spending is merely linked to counterproductive expenses and imports of weapons. The identification tests confirm that the military burden is tightly connected to deaths-generating conflicts in this category of countries, while the second-stage regression results insinuate the existence of a crowding out effect on development (as proxied by GDP per capita).

4.4 Further robustness and potential extensions

Applicability with regional subpanels: In Appendix 3, we disaggregate the panel differently. We classify countries by geographical locations and apply the instrumental variable methodology. We shed light on six regions, i.e. Sub-Saharan Africa, Middle East and North Africa (MENA), Europe and Russia (Europe), South-East Asia and Australia (SE Asia), Latin America (Latin Am.) and North America (North Am.). The latter only includes Canada and the USA, as Mexico is included in Latin America. The results confirm to a large extent the robustness of the negative correlation between the military burden and development in low-income countries, since they make the most of Sub-Saharan Africa[16].

The exogeneity of the instrument *battle-related deaths* is also confirmed for this region, alongside Latin America and Europe. The instrument seems not to be valid for North America, South-East Asia and MENA. The last two regions are very heterogeneous, made of low- (Syria and Yemen), middle- and high-income, which could explain why the instrument's coefficient is indecisive in the first-stage regression. As for North America, the same explanation given for high-income countries in **Table 4.4** would apply.

We also try different varieties and extensions of the model developed so far, to further test its robustness and to potentially uncover additional analysis elements. In Appendix 4, we replace overall investment (GFCF) with private investment as a robustness check, which could also reduce any risks of unobservable interconnections within government budgets that could influence the public contribution of GFCF (collinearity). Here, we notice that the coefficient of private investment loses its significance when estimating the equation with the instrumental variable approach, as opposed to that of GFCF in Table 4.1 above, where the value stays consistent in the [0.106;0.110] range. Most importantly, the correlation between the military burden and GDP per capita keeps its negative sign in both the baseline and IV models under this configuration, thereby corroborating the robustness of the findings for the overall panel.

[16] A part from Syria and Yemen, all low-income countries examined in this study are in Sub-Saharan Africa (see **Table 3.1**).

Another possible extension would be to reason in terms of military personnel instead of military burden. This spin-off should provide insights on whether it is only military capital spending that influences per capita GDP growth or does staffing also play a role. In order to enable comparability, we opt for *share* values as argued by several economists [e.g. Kollias *et al*. (2004), Dunne & Perlo-Freeman (2005)]. Thus, the variable used in this alternative variety of our model is military personnel as a proportion of the labour force. The table in Appendix 5 reports the results using the baseline fixed-effects model for the overall panel and income-based subpanels. From the outset, a striking difference emerges, i.e. the absence of a significant relationship between the army personnel and GDP per capita in the inclusive panel, unlike the robust negative coefficient linked to the military burden. This supports to some extent that, when considering all countries, staffing does not crowd out growth and development. Rather, equipment expenditure seem to have a larger influence on that front. The second interesting outcome is the negative coefficient associated with military personnel in low-income countries. The large proportion of soldiers (and potentially other non-fighting military staff) in LDCs hints atypically low costs. The latter are considered by Collier and Hoeffler (2004) as a determinant of the likelihood of conflict, because when the income foregone by enlisting a military staff member is unusually low, the opportunities of a conflict appear much higher[17]. This logic applies to both civil and interstate conflicts. Here, there is a risk of omitted variable bias, since it could be the expectation or existence of (interstate or civil) conflict combined with low cost of fighters that would simultaneously drive an upward impact on the military personnel proportions and a downward influence on development through asset destruction and economic instability. When using the instrument *battle-related deaths* to control for this risk, the negative correlation disappears. However, the exogeneity condition is not established for the military personnel in all panels, which means that the results are actually not reliable and that no claim should be motivated based on the IV approach in this very case. This spinoff emphasises the adequacy of our initial model (both baseline and IV robustness check) where endogeneity risks are minimised.

In light of the robustness of the negative macroeconomic of military variables in low-income countries through all model varieties and spinoffs, one major policy recommendation would be the improvement of the productivity of their military investment. One way of doing so could be by introducing industrial offset contracts in defence procurement in order to insure a channel of

[17] Collier and Hoeffler (2004), P. 569

technology transfer and investment, like middle- and high-income countries. This aspect is important considering that none of the low-income countries examined in this study adopts such measures.

V. CONCLUSION AND LIMITS

This research paper evaluated the effect of military expenditure on development (GDP per capita) in a panel encompassing countries from different regions and income groups. In this endeavour, we initially used a baseline fixed-effects panel data model. Following this approach, a few robustness exercises followed, mainly through an instrumental variable estimation and by pooling the data with the use of dummy variables. And in order to explore the validity of that relationship depending on the countries, we break the panel into different subpanels based on economic characteristics and category of each group of countries, namely income and geography.

The baseline fixed-effects model estimates show a negative correlation between the military burden and development. When breaking down the panel into income subpanels, the downward influence of military expenditure is observable in low-income countries only. When dividing the panel into regional groups, the results still extensively confirm the robustness of the negative correlation between the military burden and development in low-income countries, since they make the most of Sub-Saharan Africa –i.e. the only group where a negative coefficient is reported. The same evidence is corroborated when using the IV approach for the inclusive panel and the income-based subpanels.

These findings challenge the *Benoit hypothesis*, initially inducted based on LDC data. However, the idiosyncrasies of each era should be taken into account, considering that the characteristics of LDCs and the prerequisites of development are unlikely to be identical in the 1950-1965 [Benoit (1973, 1978)] and the 1989-2017 [present study] periods. In fact, the countries that are still in the LDC pool up to today are the least efficient institutionally and economically, and home to conflicts and instability [Collier (2007)].

The empirical evidence harvested through this research work provides robust support for our first hypothesis, which states that in the low-income countries, where development shortages are the most severe and military spending is merely linked to counterproductive expenses and imports of weapons, the influence of military spending is supposed to be negative. Conversely, only a few hints were drawn in support of the second hypothesis regarding the potential technology spill-overs (e.g. the fixed-effects pooled panel with income-based dummy variables) while most of the results do not show any significant positive correlation for that matter. The non-significance of the relationship between the two variables in lower middle-, upper middle- and high-income countries could be seen as the existence of a potential offsetting combination of positive economic spill-overs (e.g. stable political situation, military infrastructure for public use) and negative crowding out effects (e.g. less *civilian* public investment, non-productive military equipment imports). But as far as statistics go, this interpretation remains hypothetical.

The choice of battle-related deaths as an instrumental variable showed to be best suitable for low-income countries, where the exogeneity condition is robust. It also fits upper middle-income countries. On the other hand, lower middle-income countries show a counter-intuitive relationship between the number of deaths and military spending, and the instrumental variable choice is not robust, as the two under-specification tests (Anderson and Cragg-Donald) show contrasted results. This suggests a relatively weak instrument in this category of countries as well. As for high-income countries, the exogeneity condition is consistently not established, which is possibly tributary to the fact that in several conflicts during the 1989-2017 period, most rich countries that took part in global combats have not suffered human casualties among their personnel or in their sovereign territory. This is partly because these countries have been mostly engaged through intelligence and air strikes in foreign warfare theatres.

In terms of policy, one major recommendation would be the improvement of the productivity of low-income countries' military investments, in light of their robust negative macroeconomic effect through all model varieties and spinoffs. One way of doing so could be by introducing industrial offset contracts in defence procurement in order to insure a channel of technology transfer and investment, like middle- and high-income countries. This aspect is important considering that none of the low-income countries examined in this study adopts such measures.

Like any study examining multidimensional phenomena such the war-economy nexus, this study has several limits, including the possibility of endogeneity. Despite the arguments regarding the lack of military expenditure's productivity among low-income countries compared to better performing economies (e.g. absence of research programmes, offsets-driven technology transfers or industrial compensation…), one cannot either deny that a large number of the deadly conflicts that took place from 1989 to 2017 occurred *geographically* in LDCs. When considering the conflict theatre (location), it is possible to argue for other factors influencing GDP per capita. Such factors could include the deterioration of infrastructure due to airstrikes, the high political and economic instability or the drastic movements of the population and their direct impact on production. Sending troops or sponsoring militia in a different country certainly does not have the same economic impact as being on the receiving end. These factors are at least as much influent and plausible as the ones presented in this study, hence the risk of endogeneity. Therefore, future research work should shed light on this particular matter.

Another significant limit would be the short-term perspective of this research paper. A further analysis should consider long-term impact on development, especially that the latter supposedly requires longer periods of time to reveal its full extent. Future studies are also encouraged to investigate the potentially non-linear relationship between development and private investment on one hand, and military spending on the other. Emphasis should be laid on testing the existence of a threshold (in GDP proportion) beyond which the effect becomes negative.

Seen their allegedly important role through the discussion, a formal study of the impact of defence offset contracts on FDI and productivity would be a sound alternative route for research. The challenging part here would be gathering data for several countries. However, a quantitative analysis of this relationship is decidedly novel and should provide further insights in terms of policy implications, especially among middle-income countries where the trade-off between military and development expenditures is constantly present.

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APPENDIX 1: The Hausman test results

	Coefficients (b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
lMB	-.0145849	-.0053912	-.0091938	.0025729
lexports				
D1.	.1030769	.1009356	.0021413	.0011687
lgfcf				
D1.	.1114773	.1120032	-.000526	.000548
unemployment	-.0010234	-.0000688	-.0009546	.0002916

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

```
chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
        =       24.90
Prob>chi2 =     0.0001
```

APPENDIX 2: Income subpanels regressions with only country-fixed effects [Y: log GDP per capita]

VARIABLES	(1) Low income	(2) Lower-mid income	(3) Upper-mid income	(4) High income
MB_{it}	-0.0395***	-0.0194**	-0.0104*	0.00181
	(0.0111)	(0.00786)	(0.00565)	(0.00303)
X_{it}^{d}	0.110***	0.00621	0.129***	0.210***
	(0.0198)	(0.0184)	(0.0145)	(0.0118)
I_{it}^{d}	0.0751***	0.0988***	0.184***	0.157***
	(0.0127)	(0.0134)	(0.0110)	(0.00840)
U_{it}	-0.000933	9.21e-05	-0.000706	-0.00159***
	(0.00318)	(0.00169)	(0.000509)	(0.000291)
Constant	0.0302*	0.0244*	0.0259***	0.0125***
	(0.0157)	(0.0127)	(0.00767)	(0.00290)
Observations	221	349	427	718
R-squared	0.378	0.216	0.565	0.676

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

APPENDIX 3: IV model estimates in regional subpanels [Y: log GDP per capita]

VARIABLES	(1) Sub-Saharan Africa	(2) MENA	(3) Europe	(4) SE Asia	(5) Latin Am.	(6) North Am.
MB_{it}	-0.119***	0.0736	0.00114	-1.604	-0.0211	-0.0453
	(0.0427)	(0.168)	(0.0380)	(5.266)	(0.0146)	(0.0870)
X_{it}^{d}	0.0868***	0.126***	0.123***	0.628	0.102***	0.169**
	(0.0176)	(0.0295)	(0.0137)	(2.293)	(0.0216)	(0.0678)
I_{it}^{d}	0.0618***	0.129***	0.228***	0.109	0.189***	0.151*
	(0.0101)	(0.0251)	(0.00935)	(0.598)	(0.0113)	(0.0881)
U_{it}	-0.00167	1.53e-05	-0.0008**	-0.0140	-0.00162**	0.00123
	(0.00180)	(0.000935)	(0.000377)	(0.0494)	(0.000814)	(0.00690)
Constant	0.0862***	-0.106	0.0150	0.989	0.0238***	0.0286
	(0.0305)	(0.246)	(0.0199)	(3.182)	(0.00416)	(0.0197)
Observations	440	236	547	213	225	54
Number of countryid	21	10	21	8	9	2

First Stage Regression [endogenous variable: the military burden]

$deaths_{it}$	0.0323***	0.00897	0.031**	0.0027	0.0645***	-0.0171
	(0.000)	(0.337)	(0.020)	(0.765)	(0.000)	(0.309)
I_{it}^{d}	0.0868***	0.0551	-0.024	-0.095	0.2106	-0.9568***
	(0.0176)	(0.693)	(0.820)	(0.623)	(0.190)	(0.002)
U_{it}	-0.0076	-0.004	0.0002	-0.0093	0.0341***	0.0783***
	(0.458)	(0.430)	(0.950)	(0.522)	(0.000)	(0.000)
X_{it}^{d}	-0.1486	0.0879	0.0958	0.432***	-0.5608*	0.651**
	(0.100)	(0.578)	(0.519)	(0.009)	(0.068)	(0.029)
Constant	0.5571***	1.461***	0.4991***	0.604***	-0.0588	0.2257***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.355)	(0.001)
Observations	440	236	547	213	225	54
Number of countryid	21	10	21	8	9	2

APPENDIX 4: Baseline and IV estimates with private investment [Y: log GDP per capita]

VARIABLES	(1) IV	(2) FE
MB_{it}	-0.0905**	-0.0125**
	(0.0383)	(0.00635)
X_{it}^{d}	0.124***	0.123***
	(0.0142)	(0.0125)
$Private\ I_{it}$	0.00894	0.0177***
	(0.00866)	(0.00633)
U_{it}	0.00235*	0.00140
	(0.00136)	(0.00111)
Constant	0.0341	-0.0387*
	(0.0436)	(0.0208)
Observations	820	820
R-squared		0.270

The IV First-Stage Regression [endogenous variable: the military burden]

$deaths_{it}$	0.02993***
	(0.0000)
$Private\ I_{it}$	-0.12038***
	(0.001)
U_{it}	0.015**
	(0.024)
X_{it}^{d}	-0.104
	(0.164)
Constant	0.8974***
	(0.0000)
Observations	820

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

APPENDIX 5: FE model estimates with military personnel [Y: log GDP per capita]

VARIABLES	(1) All	(2) Low-income	(3) Lower-mid income	(4) Upper-mid income	(5) High-income
$Personnel_{it}$	-0.00486	-0.0219**	0.00793	-0.00583	-0.00148
	(0.00299)	(0.00939)	(0.0102)	(0.00528)	(0.00247)
X_{it}^{d}	0.111***	0.135***	0.00639	0.130***	0.206***
	(0.00789)	(0.0198)	(0.0179)	(0.0146)	(0.0117)
I_{it}^{d}	0.0934***	0.0566***	0.0927***	0.185***	0.154***
	(0.00509)	(0.0112)	(0.0135)	(0.0110)	(0.00829)
U_{it}	-0.00118***	-0.00122	0.000187	-0.000689	-0.00159***
	(0.000400)	(0.00333)	(0.00170)	(0.000512)	(0.000299)
$Constant$	0.0191***	-0.00863	0.0148	0.0204***	0.0142***
	(0.00337)	(0.0153)	(0.0126)	(0.00671)	(0.00242)
Observations	1,751	234	355	427	735
R-squared	0.357	0.348	0.197	0.563	0.664

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1