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U.S. border militarization and foreign policy: A symbiotic relationship

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Abstract

U.S. government security along the U.S.–Mexican border has been increasingly militarized. This domestic militarization has been influenced by U.S. government military intervention abroad. Preparing for and executing foreign interventions involves investing in physical and human capital to effectively coerce and control the target population. The U.S. government's "war on drugs" and "war on terror" created the conditions for this capital to be repurposed for domestic use in border-security efforts. While foreign policy created the conditions for border militarization, border militarization has also influenced foreign interventions. This article explores the symbiotic relationship between U.S. border militarization and foreign policy.

In recent decades, the United States Border Patrol has increasingly used military hardware and methods to enforce immigration restrictions and drug laws, as well as to surveil the U.S.–Mexico border. This has included the use of unmanned aerial vehicles (UAVs) or drones to monitor the border, surveillance towers purchased from major defense contractors, and the use of tear gas grenades and tactical riot gear. Border Patrol personnel, particularly those associated with SWAT-style teams like the Border Patrol Tactical Unit (BORTAC), receive training that is directly modeled on military training. In addition, Border Patrol personnel collaborate with military personnel on joint operations.

Our core argument is that the militarization of domestic security efforts along the U.S.–Mexico border is linked to U.S. military interventions abroad. During these interventions, officials experiment with new ways to subdue, monitor, coerce, and control populations abroad. In the process, they invest in and develop both physical capital and human capital that is useful for social control. This capital does not remain abroad. Instead, it is brought home, where its availability lowers the relative price of engaging in militarized domestic social control. Border security officials must choose among different law enforcement strategies. When the relative price of militarized strategies falls, officials will (all else being equal) choose more militarized tactics. However, the price that government officials face when they decide which strategy to embrace rarely reflects the social costs of the tactics selected. Militarized strategies externalize costs onto various third parties, so the fact that government officials choose these tactics need not mean that they are worth the cost.

Once created and integrated into the border security apparatus, officials and contractors face incentives to maintain and expand militarized programs. This includes the expansion of operations beyond U.S. borders. For instance, BORTAC has traveled to numerous countries to train police and military forces to secure, monitor, and police borders. Sometimes, this has meant traveling to Central American countries during peacetime. In other cases, it has meant aiding the U.S. military's nation-building efforts in Afghanistan and Iraq. While these are foreign intervention militarized U.S. border security efforts, border militarization has created a bureaucratic apparatus that now directly engages in U.S. government interventions abroad.

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U.S.–Mexico border militarization shows a symbiotic relationship between government foreign policy and border security. Foreign military interventions result in investments in physical and human capital that are brought back home for militarized forms of social control. Conversely, border security personnel have been sent abroad thereby exporting this militarized social control as part of foreign policy. As such, foreign policy has real effects on the fabric of domestic life; and domestic life, in turn, has real effects on foreign affairs. This fostering of a culture of militarism which is self-extending and self-perpetuating has costs which are understated.

This article's main contribution is the exploration of the symbiotic relationship between U.S. border militarization and the foreign policy of the U.S. government. Border militarization matters for four reasons. First, border militarization raises issues pertaining to the rights and liberties of both non-U.S. and U.S. persons. Tools of violent social control grant power to those who wield them over others. The exercise of this power can be direct (e.g., direct violence against others), or indirect (e.g., violations of privacy through surveillance). Second, the militarization of the border contributes to threat inflation related to the supposed "immigration threat," consisting of economic and criminal harms from immigrants, despite evidence to the contrary.[1] Stakeholders in the border security apparatus have an incentive to fan the flames of fear associated with this threat to entrench and extend their resources and power. Third, the militarization of the border diverts migrants towards more dangerous routes, increases the reliance on coyotes (smugglers) to navigate the more dangerous routes, results in increased migrant deaths, and raises the cost of migrants returning to Mexico once in the United States due to increased border security.[2] Finally, the militarization of the border fosters a broader culture of militarization whereby force becomes the primary instrument for social and foreign relations. This elevates violence and zero-sum conflict over alternative, non-violent and potentially positive-sum means of resolving collective action challenges.

Our analysis is best understood in the context of two categories of scholarship. The first is the growing literature on border militarization.[3] The second is scholarship on how military intervention abroad influences domestic politics and the growth of government.[4]

The next section offers a theory of foreign intervention's domestic consequences, emphasizing the role of physical and human capital in this process. We then apply this theory to explain how foreign interventions contributed to the militarization of U.S. security activities along the U.S.–Mexico border. The subsequent section explains how militarized U.S. border security bureaucracies became involved in foreign interventions abroad. We conclude with a discussion of the implications of our analysis.

Foreign intervention and the capital structure

At the foundation of any foreign intervention is the desire by interveners to alter the actions of those being intervened upon. If actions abroad already matched the desires of the interveners, then intervention would be unnecessary. To alter foreigners' actions and ensure compliance, interveners may use a variety of forms of social control, including surveillance, intimidation, imprisonment, occupation, policing, and physical violence.

To effectively engage in this type of social control, the interveners must first invest in capital that is particularly suited to the task. This includes physical capital, such as surveillance equipment, aircraft, armored vehicles, and weaponry. It also includes human capital, skills and knowledge that make soldiers, intelligence officers, and other interveners more effective at producing social control. Capital is heterogeneous and multi-specific.[5] Capital

1 Dunn (2021, p. 36).
2 Cornelius (2001); Massey, Pren and Durand (2016); Massey (2017); Chambers et al. (2021).
3 Dunn (1996, 2009, 2021); Parenti (1999); Palafox (2000); Cornelius (2001); Nevins (2002); Huspek (2001); Andreas (2009); Cornelius and Lewis (2007); Michalowski (2007); Slack et al. (2016); Miller (2019a, b); Chambers et al. 2021).
4 Higgs (1987, 2004, 2007, 2012); Porter (1994); Coyne and Hall (2014, 2018).
5 Lachmann (1956).

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heterogeneity means that once capital is created, it can only be used for some types of projects, but not others. For instance, a Blackhawk helicopter cannot be used to bake bread. However, capital is also multi-specific, meaning it can be used for multiple types of projects. A Blackhawk helicopter is useful for foreign wars *and* for patrolling the U.S.–Mexico border.

Prior to engaging in foreign military interventions, government officials invest in physical capital that is particularly useful for militarized social control. While some of this capital will be destroyed or rendered useless due to combat, much of it remains operational after the intervention. As it is brought home, this equipment increases the supply of physical capital available for militarized domestic social control. For public officials as well as private contractors, this lowers the relative price of choosing militarized means to achieve their domestic goals.

All else being equal, an official is therefore more likely to choose the militarized approach because of the availability of physical capital allowing for more effective social control. An official within an immigration enforcement bureaucracy can choose among multiple strategies for enforcing immigration laws. One method might be auditing employers to identify and fine those who hire undocumented immigrants. Another might consist of surveilling the border using drones, night vision goggles, and Blackhawk helicopters.

Similar logic applies to human capital. Prior to engaging in foreign intervention, interveners develop skills, knowledge, habits, and expertise related to surveilling, intimidating, and controlling other people. These skills are refined and honed through on-the-ground experiences with interventions abroad. While this human capital may atrophy with disuse, it does not simply go away once interveners return home. Once they return home, they integrate into domestic life. Some pursue opportunities to advance their careers using what they learned abroad, which can mean deploying social control techniques domestically.

Existing scholarship documents a variety of cases in which physical and human capital developed through foreign intervention return home.[6] For example, veterans of the Vietnam and Korean wars used human capital they acquired during those operations to develop one of the first domestic Special Weapons and Tactics (SWAT) teams in Los Angeles, California, in the 1960s. These militarized police units then proliferated around the country, using weaponry and other military hardware provided by the U.S. Department of Defense (DoD). In other words, both human capital and physical capital developed for use abroad were later deployed in domestic policing in the United States. The same type of process has occurred in the realm of border security. Physical and human capital developed abroad has been brought home and repurposed by federal officials for border security efforts.

Militarizing the American border

Border security efforts have been repurposing capital from the military for decades.[7] In 1945, military officials transferred several Stinson L-5 aircraft to the Border Patrol. These airplanes were used for aerial surveillance and sent radio transmissions to Border Patrol agents on the ground when they observed unauthorized migrants.[8] Physical capital used in World War II was thereby repurposed to monitor the U.S.–Mexico border.

Officials escalated their militarization of the border in the late 1960s with the beginnings of President Richard Nixon's "war on drugs". In June 1969, Nixon created a "new working group to devise and implement a 'frontal attack' on border narcotics traffic."[9] This task force featured "members from the Bureau of Customs, Defense Department, Bureau of Narcotics and Dangerous Drugs, Criminal Division of the Justice Department, Federal Bureau

6 Coyne and Hall (2014, 2018).
7 Dunn (1996, 2021).
8 Hernández (2010, p. 105).
9 Craig (1980, p. 560).

of Investigation, Immigration and Naturalization Service, and Transportation Department."[10] This task force designed and launched "Operation Intercept", which intensified searches and surveillance along the U.S.–Mexico border for purposes of drug interdiction.

Throughout the 1970s the Border Patrol acquired additional physical capital. For instance, in 1973 and 1974, Border Patrol agents placed various electronic intrusion ground sensors along the border with Mexico. By the late 1970s the Border Patrol used small fixed-wing aircraft for surveillance in all sectors of the U.S.–Mexico border.[11] This buildup further accelerated in the next decade.

In the 1980s, several policy changes expanded transfers of physical and human capital from the military to domestic law enforcement, including border security. The Defense Authorization Act of 1982 introduced "a new chapter to U.S. law regarding the use of the military, entitled 'Military Cooperation with Civilian Law Enforcement Officials'."[12] As a result, "military personnel were now explicitly allowed to *assist* (not just support) civilian law enforcement agencies in newly specified ways—by operating and maintaining military equipment loaned to federal law enforcement agencies."[13] The law also authorized the Secretary of Defense to give law enforcement officers access to military facilities and empowered military officials to share information with law enforcement.[14] Notably, however, these powers were "limited to agencies with the jurisdiction to enforce *drug, customs, and immigration laws*."[15]

Using these new powers, President Ronald Reagan's administration created task forces that brought border security officials together with military leaders. For instance, in 1982 the South Florida Task Force on Organized Crime brought leaders from numerous agencies together to work on drug interdiction under the direction of Vice President George H.W. Bush. Law enforcement officers used the task force to access physical capital from the military, including "E-2B, E-2C, and P-3 radar and surveillance aircraft and UH-1N helicopters, as well as hydrofoil, frigate, and destroyer sea vessels, for the Navy; AWACS (or E-3) radar aircraft and aerostat radar aircraft and radar balloons for the Air Force; and UH-1H, Cobra, and Blackhawk helicopters, as well as OV-1 Mohawk tracker aircraft, for the Army."[16]

In 1983, the "South Florida Task Force model was extended to the borderlands…when President Reagan created the National Narcotics Border Interdiction System (NNBIS)."[17] Vice President Bush directed this effort as well. The task force brought agents from the Immigration and Naturalization Service (INS) and the Customs Service together with officials from the Central Intelligence Agency (CIA), the Federal Bureau of Investigation (FBI), the Drug Enforcement Agency (DEA), and such military branches as the Army, Air Force, and Navy. The military transferred hardware to various domestic law enforcement agencies through the NNBIS.

In addition to lending and transferring physical capital, the military also used their soldiers' human capital to police the border. From 1983 to 1985 "the U.S. Army Intelligence School at Fort Huachaca, Arizona, initiated two frequently conducted border surveillance operations."[18] One of these programs, Operation Groundhog, "reported 1,083 targets which resulted in the apprehension of 372 illegal aliens by the Border Patrol" within a single year.[19]

10 Craig (1980: 560).
11 Dunn (1996: 38).
12 Dunn (1996, p. 106).
13 Dunn (1996, p. 106, emphasis in original).
14 Dunn (1996, p. 107).
15 Dunn (1996, p. 107, emphasis in original).
16 Dunn (1996, p. 108).
17 Dunn (1996, p. 109).
18 Dunn (1996, p. 110).
19 Quoted in Dunn (1996, p. 110).

The other, Operation Hawkeye, "consisted of ongoing OV-1 Mohawk aerial surveillance training flights along the border between Douglas and Nogales, Arizona."[20]

Building on the NNBIS model, Vice President Bush and Attorney General Edwin Meese spearheaded Operation Alliance, "an ongoing effort to interdict drugs along the border, based on the coordination of local, state, and federal law enforcement agencies, with the military playing a support role."[21] The INS, Border Patrol, and Customs Service played a key role in Operation Alliance, and they were joined by other federal law enforcement agencies such as the FBI and DEA. In addition to these federal participants, Operation Alliance featured "representatives from various law enforcement agencies of each of the four border states."[22] As part of Operation Alliance, the Department of Defense provided physical capital through "aerial surveillance and extensive loans of such resources as night-vision equipment and portable on the ground radar" and human capital through "joint training exercises with civilian law enforcement agencies."[23]

Given these increasing partnerships with the armed forces, it is no surprise that the INS's access to military hardware increased throughout the Reagan administration. For example, they went from having 28 fixed-wing aircraft to 46 fixed-wing aircraft and they acquired 20 new helicopters. They also purchased 278 new night-vision scopes.[24] Some equipment that the Reagan administration deployed at the border had been directly used in prior foreign wars. For instance, "some of the ground sensors being set out along that border were leftovers from Vietnam."[25]

In 1984, officials formed the Border Patrol Tactical Unit (BORTAC) "to serve a civil disturbance function in response to rioting at legacy Immigration and Naturalization Service detention facilities."[26] BORTAC agents "received special training in riot control, counterterrorism, and other paramilitary activities similar to the training provided to U.S. marshals and the FBI Special Weapons and Training [sic] (SWAT) teams."[27] Such training replicates human capital initially developed through foreign interventions. To understand why, consider the history of SWAT teams.

In Los Angeles, John Nelson and Daryl Gates of the Los Angeles Police Department (LAPD) created one of the country's first SWAT teams in 1967. As a Marine, Nelson "served in an elite Force Recon unit" in Vietnam.[28] Such units were significantly more lethal and aggressive than other Marine units as "Force Recon teams were trained to engage and kill, and they did so efficiently."[29] To address riots in Los Angeles, Nelson proposed creating a new unit modeled after the Force Recon unit he served in abroad. Inspector Daryl Gates, who had served in the Navy during World War II, supported the idea and worked with Nelson to bring it to fruition. Each team member they recruited "for the original SWAT team had specialized experience and prior military service."[30] Together they used the human capital they cultivated abroad to militarize policing in Los Angeles. Those innovations in militarization quickly spread beyond Los Angeles. SWAT teams are now used by police departments and law enforcement agencies all around the country.

The creation of BORTAC in 1984 meant bringing SWAT tactics to border policing. But SWAT teams were not

20 Dunn (1996: 110).
21 Dunn (1996, p. 113).
22 Dunn (1996: 113).
23 Dunn (1996, p. 113).
24 Dunn (1996, pp. 43-44).
25 Grandin (2019).
26 Customs and Border Protection (2014).
27 Dunn (1996, p. 52).
28 Coyne and Hall (2018, p. 105).
29 Coyne and Hall (2018, p. 105).
30 Coyne and Hall (2018, p. 107).

the only route by which the U.S. military influenced BORTAC's human capital. BORTAC also deliberately emulated the military, specifically special forces. Border Patrol agents understood BORTAC as "much like a *special forces team* for us."[31] More recent official materials note that "BORTAC's Selection and Training Course (BSTC) was designed to mirror aspects of the U.S. Special Operations Forces' selection courses."[32] So BORTAC agents are trained to emulate the practices and skills used by U.S. Special Forces teams.

While BORTAC was initially created to address riots, their role expanded over time, empowering them to address additional issues. "By 1987 BORTAC was taking part in drug enforcement and crop eradication efforts in the United States."[33] BORTAC agents collaborated with the National Guard on "clandestine reconnaissance patrolling operations (dubbed Operation Unity)…in Big Bend National Park in the fall of 1988 and spring of 1989 for one week and two weeks, respectively, as a pilot project to assess the feasibility of such operations."[34] In 1990, BORTAC collaborated with the New Mexico National Guard on an anti-narcotics operation. Any given bureaucratic organization seeks to maintain and expand its budget[35], which in this case meant that their specialized military training was used to enforce drug prohibition.

Border militarization continued throughout the 1990s and into the 21st century. In 1990, President George H.W. Bush established the 1280 program which authorized the Department of Defense to transfer surplus military equipment to federal and state agencies involved in counternarcotics. In 1997, President Bill Clinton expanded this program by authorizing The Law Enforcement Support Office (LESO) to implement the 1033 Program to transfer military hardware from the Department of Defense to police departments. Under the Clinton Administration, the Border Patrol acquired "infrared night scopes, thermal-imaging devices, motion detectors, in-ground sensors, and software that allowed biometric scanning of all apprehended migrants."[36]

To date, empirical studies of the effects of transfers under the 1033 program are mixed. Some studies find that 1033 Program transfers are associated with increased deaths of suspects at the hands of police.[37] There is evidence that police militarization harms police reputation, as well as evidence that SWAT teams are deployed more often in communities of color.[38] The impacts of SWAT teams and 1033 Program transfers on crime and officer safety are disputed. At least one study finds no evidence that militarization improves officer safety,[39] while other studies find that some types of military equipment (e.g., armor and clothing) reduce assaults.[40] Some studies find evidence that police militarization is associated with reductions in crime,[41] while others fail to find evidence of this effect.[42] Recent research suggests that military hardware transfers contribute to reductions in crime rates, but they find that some of this is achieved by displacing crime into neighboring jurisdictions, thereby causing negative spillovers.[43] Despite the lack of consensus on the effects, both physical capital and human capital continue to flow from the Department of Defense to law enforcement, including border security agencies such as Customs and Border Protection (CBP).[44]

31 Quoted in Dunn (1996, p. 52).
32 Customs and Border Protection (2014).
33 Dunn (1996, p. 52).
34 Dunn (1996, p. 129).
35 Niskanen (1968, 1971).
36 Grandin (2019).
37 Delehanty et al. (2017); Lawson (2019).
38 Mummolo (2018).
39 Mummolo (2018).
40 Carriere and Encinosa (2017); Harris et al. (2017).
41 Bove and Gavrilova (2017); Harris et al. (2017); Masera (2021).
42 Gunderson et al. (2021); Mummolo (2018).
43 Masera (2021).
44 Davenport et al. (2018).

Nation building and border building

On September 11, 2001, terrorists hijacked multiple aircraft within American borders and used them to target buildings such as the World Trade Center and the Pentagon. These high-profile terrorist attacks killed over 2,900 people.[45] In response, U.S. government officials began implementing a range of new programs and policies in the name of counterterrorism, including the reorganization of domestic law enforcement bureaucracies and border policing. The United States Immigration and Naturalization Service (INS) disbanded, with its core functions split between U.S. Customs and Border Protection (CBP) and U.S. Immigration and Customs Enforcement (ICE), both of which were housed under the newly created Department of Homeland Security (DHS). The Border Patrol, including its militarized units, such as BORTAC, was placed within CBP.

In addition to these domestic reorganizations, the 9/11 attacks were used to justify multiple U.S. foreign interventions, most notably in Afghanistan and Iraq. While most analysis of these interventions focuses on the role of the U.S. military, the Border Patrol also played a significant role in these foreign occupations. To understand why, consider how U.S. officials reconceived the role of border security after 9/11.

Border security became heavily tied to "homeland security," a concept that took on an expansive meaning. As the 9/11 Commission Report concluded, "9/11 has taught us that terrorism against Americans 'over there' should be regarded just as we regard terrorism against Americans 'over here'. In this same sense the American homeland is the planet."[46] This broad view of threats and security shaped U.S. government counter-terrorism policies, including border security, across multiple federal bureaucracies. As one Border Patrol agent put it:

> *"It is now understood by the U.S. government and its citizens that the U.S. must 'take the fight' to the people who are attempting to do the U.S. harm. Although on a smaller scale, CBP has a direct parallel to the Department of Defense and the 'War on Terror' in order to prevent attacks on the homeland. CBP is expanding into foreign countries to be more effective and keep the bad actors away from U.S. soil".*[47]

Former U.S. CBP commissioner Alan Bersin described this shift towards an expansive, global approach to border security as a "massive paradigm change."[48]

As CBP turned their attention abroad, BORTAC played a crucial role. They already had some experience internationally. For instance, they had provided "international airport security details during Operation Desert Storm."[49] They also participated in international counter-narcotics efforts, such as an intervention in Latin America called Operation Snowcap, which began in 1987.[50] However, after the 9/11 attacks, international efforts became a larger part of BORTAC's mission. For example, now one of BORTAC's signature features is "that it conducts training and operations both in the United States and in other countries in furtherance of the U.S. Border Patrol's mission."[51] Their tactics and training, which imitate the training given to the military's Special Operations forces, were adapted for domestic use and then redeployed abroad.

BORTAC's participation in Operation Iraqi Freedom and its aftermath illustrates how border security officials became involved in foreign intervention and nation building. In 2003, the United States invaded Iraq and overthrew

45 CNN (2021).
46 Quoted in Miller (2019a, p. 6).
47 Seiler (2017, p. 5).
48 Quoted in Miller (2019a, p. 6).
49 Jacobellis (2014).
50 Jacobellis (2014).
51 Customs and Border Protection (2014).

Saddam Hussein. By overthrowing Saddam Hussein's government, U.S. and coalition forces eliminated Iraq's previous border security arrangements. To fill this gap, the U.S. government sent "thousands of soldiers, Marines, military police, special operations forces and aviation units" to patrol Iraq's border with Syria and train Iraqi border patrol under Operation Phantom Linebacker.[52] However, officials eventually concluded that CBP agents could bring expertise that soldiers lacked, and, in 2005, the Department of Defense requested that CBP agents come to Iraq.[53]

CBP agents in Iraq were organized into Border Support Teams (BSTs). Members of each BST worked alongside the U.S. military, training both Iraqi personnel and U.S. military personnel in a range of border policing tactics. For CBP agents in the early years of the Iraq War, "[f]irefights with insurgents were a regular occurrence…".[54] Over the years CBP officers in Iraq shifted their emphasis "from training individuals to the work of advising the leaders in the Iraqi Ministry of Interior on how they can create and sustain modern training and management techniques."[55] This move also involved shifting away from working closely with the U.S. military and towards working more with the U.S. embassy. Despite this shift, CBP's work in Iraq was consistently oriented towards nation building, with the aim of developing a strong border security bureaucracy in Iraq that reflected many of the border security practices used within the United States.

In 2011, U.S. troops withdrew from Iraq, as the Status of Forces Agreement expired.[56] However, CBP personnel remained in Iraq even when the occupation formally ended. Their continued presence was "part of an effort known as the Police Development Program, or PDP, managed by the Department of State's Bureau of International Narcotics and Law Enforcement, or INL."[57] This program ended in 2013.[58]

BORTAC's operations abroad extend beyond the Middle East and the global war on terror. For instance, BORTAC also actively trains police in Central America, largely to support the U.S. government's ongoing war on drugs. Border security training in countries like Guatemala has largely been funded through the State Department's Central American Regional Security Initiative (CARSI) program.[59] In Africa, BORTAC and CBP have "trained new patrol and homeland security units for Kenyan, Tanzanian, and Ugandan borders."[60] Likewise, on the Indian subcontinent, "CBP has an attaché office in New Delhi."[61] Meanwhile, in Eastern Europe, "U.S. Border Patrol and Drug Enforcement Administration officials trained the Ukrainian 'Sokil' rapid-reaction unit."[62]

Operations abroad continue to be a key part of American border security strategies. For example, the Department of Homeland Security's fiscal year 2020 budget request stated that "The 'home game' has merged with the 'away game' and DHS actions abroad are just as important as our security operations here at home."[63] In their communications with Congress, DHS officials make it clear that they see homeland security and border security policies as closely intertwined with U.S. foreign policy. CBP, which has been militarized using capital from U.S. government foreign military interventions, is now being used in numerous countries to advance U.S. foreign policy objectives and enhance allied nation states' border security capabilities.[64]

52 Mazzetti (2004).
53 Mayfield (2012).
54 Mayfield (2012, p. 9).
55 Mayfield (2012, p. 9).
56 Sky (2017).
57 Mayfield (2012, p. 12).
58 Ackerman (2013).
59 Miller (2019a, p. 37).
60 Miller (2019a, p. 32).
61 Miller (2019a, p. 33).
62 Miller (2019a, p. 32).
63 Department of Homeland Security (2019, p. 2).
64 Ibid.

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Conclusion

The history of American border militarization shows a symbiotic relationship between U.S. government foreign policy and border security. Foreign military interventions result in investments in physical and human capital that are useful for militarized forms of social control. As these forms of capital are brought back home, the relative price of choosing militarized forms of domestic social control falls. Physical and human capital used abroad are repurposed for use at home. This influence is bi-directional. Militarized border security personnel have been sent abroad, both to aid overt U.S. government nation building as part of military interventions and, more often, to train the border security personnel of other governments. The main implications are twofold.

First, foreign policy and domestic life cannot be neatly separated into distinct and non-interactive arenas. Foreign policy has real effects on the fabric of domestic life; and domestic life, in turn, has real effects on foreign affairs. The methods, techniques, and mentalities associated with a proactive military-driven foreign policy often return home and become integrated into domestic life. Likewise, tools of social control employed domestically are often exported, affecting other societies.

Second, the costs of war and foreign intervention are understated. A substantial literature discusses the costs of war,[65] but largely focuses on the direct opportunity costs of monetary outlays, casualties, and deaths, as well as health costs and the effects of conflict and military expenditure on economic growth. But the history of border militarization shows that the overall costs are greater in terms of fostering a culture of militarism which is self-extending and self-perpetuating. This has immediate costs on those directly affected by these policies, but also broader costs in terms of crowding out alternative, more peaceful, solutions to social interaction challenges between people irrespective of their country of origin.

We have analyzed some of the ways that foreign policy and border security policy interact. However, there are more interactions of this sort that we have not explored. For instance, hardening borders in one location may divert migrant flows; if migrants are diverted into conflict-prone countries with weak institutions, this may undermine foreign policy goals or exacerbate conflict. Migration restrictions can also trap people in conflict zones, which may force those individuals to devote their efforts to zero-sum conflict rather than productive activity. Whether in the examples we have discussed or in these other cases, policies do not operate in isolation. Instead, they alter the incentives and constraints faced by other decision-makers, causing important, often perverse, unintended consequences.

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65 See, for instance, Collier (1999); Ghobarah, Huth, and Russett (2003); Stiglitz and Bilmes (2008); Dunne and Tian (2013, 2019); Smith (2014).

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Militarization, investment, and economic growth 1995–2019

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Abstract

The economic effects of defense spending have attracted considerable attention in the literature. Invariably, the defense burden, i.e., the military spending to GDP (gross domestic product) ratio, is the variable through which these effects are empirically traced. In this article, an alternative measure that captures the burden on the economy and society from allocating resources to the defense sector is used—the Global Militarization Index (GMI), constructed by the Bonn International Centre for Conflict Studies (BICC). The empirical investigation covers a total of 116 countries and spans the period 1995–2019. The results reported herein do not reveal any systematic and statistically significant relation between a country's militarization levels and two main macroeconomic variables (growth rate of GDP and gross fixed capital formation as a share of GDP).

The literature on the economic effects of military spending has systematically grown over the years. Recent representative examples of this steadily expanding body of literature are Agostino *et al.* (2017), Desli and Gkoulgkoutsika (2021), Emmanouilidis and Karpetis (2021), Cevik and Ricco (2018), and Dunne and Tian (2015). In brief, the potential effects of such expenditures include both demand and supply side as well as security related externalities.[1] A comprehensive and in-depth critical discussion of the issues associated with the impact of defense spending on the economy can be found in Dunne and Tian (2013, 2016) and in Churchill and Yew (2018). In addition, Alptekin and Levine (2012), Yesilyurt and Yesilyurt (2019), and Emmanouilidis and Karpetis (2020) offer a comprehensive review and meta-analysis of the accumulated empirical findings and methodologies used to probe into this issue. Consequently, for reasons of brevity, we refrain from engaging in a fundamentally similar discussion and review.

Invariably, all empirical studies that address the nexus between this budgetary item and countries' economic performance employ the defense burden, i.e., military spending as a share of GDP, to examine its impact on macroeconomic variables such as GDP growth rates, investment, savings, and unemployment. This article builds on this literature and extends the empirical analysis by employing an alternative index that encapsulates the economic burden of the defense sector. The Global Militarization Index (GMI) is an annual index estimated and published by the Bonn International Centre for Conflict Studies (BICC)[2]. As pointed out by Mutschler and Bales (2020), "[it] presents the relative weight and importance of a country's military apparatus in relation to its society as a whole"[3]. Hence, it can be construed as an alternative measure of a country's defense burden. To the best of our knowledge, this is the first time that BICC's GMI has been used in this context[4]. The index is presented in more detail in the next

1 *Inter alia,* Desli *et al*. (2017); Heo and Ye (2016); Malizard (2016).
2 https://www.bicc.de/about/about-us/.
3 https://www.bicc.de/publications/publicationpage/publication/global-militarisation-index-2020-1024/.
4 The index is available at https://gmi.bicc.de/ranking-table.

section; this is followed by the presentation and discussion of the empirical methods and findings.

This article uses the Global Militarization Index constructed by BIC to examine the effects that the allocation of resources to defense sector exerts on two key macroeconomic variables. The results do not show any systematic and significant effect of the levels of militarization on growth and investment. This rather surprising result may suggest that this more general measure of military burden reflects a more complex set of interactions that are not captured in the existing literature

The data: a bird's eye view

BICC's militarization index, GMI, is a composite index of annual frequency that takes values on a scale ranging from 0 to 1,000 with higher values reflecting higher militarization[5]. It is constructed using data grouped in three broad categories: expenditures, personnel and weapons. The first category comprises two indicators: military expenditure as percentage of GDP and military expenditure relative to health spending. The second group includes three indices: First military and paramilitary personnel as a share of the total population, second military reserves as a share of population and of the core military, and third paramilitary personnel relative to the number of physicians. The third category is the number of heavy weapons in relation to population, including all types of armored vehicles, artillery, fighter aircrafts, and naval assets (such as submarines and surface vessels above corvette size). In calculating the annual value of the final composite index, all the indicators are normalized and assigned different weights with which they contribute towards the estimation of the GMI[6] (Mutschler and Bales, 2020). While data is available from 1990 onwards, missing values meant that 1995 was taken as the starting year.

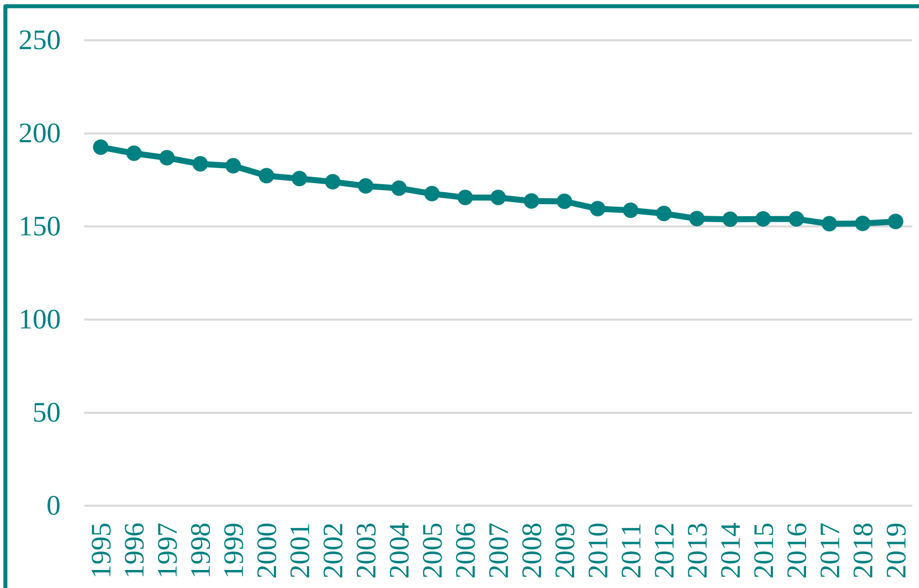

Figure 1: Sample's annual average GMI 1995–2019

In line with Dunne and Smith (2020) and Kollias and Paleologou (2016, 2019) the two macroeconomic variables used to probe the issue are the growth rate of GDP and gross fixed capital formation as a share of GDP—drawn from the IMF and the World Bank's World Development Indicators databases[7]. The rate of economic growth is used by the vast majority of empirical studies[8] and a strong positive relationship between investment and the long-run growth performance of an economy is a robust and well-established finding (Bond *et al.* 2010). The allocation of resources to the defense sector can crowd-out investment since, as it has been shown in the extant literature, they compete for financing from the same sources (Dunne *et al*. 2005; Dunne and Smith, 2020; Kollias and Paleologou, 2010; 2019).

5 Apart from BICC's own data, other sources of data are the Stockholm Peace Research Institute (SIPRI), the International Monetary Fund (IMF), the World Health Organization (WHO), and the International Institute for Strategic Studies (IISS).
6 A detailed presentation of the methodology used to estimate the GMI and the sources of the data used can be found here: https://gmi.bicc.de/.
7 https://data.imf.org/regular.aspx?key=63122827 and https://databank.worldbank.org/reports.aspx?source=world-development-indicators.
8 *Inter alia,* Chen *et al*. (2014); Malizard (2016); Desli *et al*. (2017); Desli and Gkoulgkoutsika (2021).

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Drawing on the sample of 116 countries, four summary variables were key: GMI, GDP, INV (the gross fixed capital formation as a share of GDP), and MILEX (the military burden).[9]

Figure 1 shows the average value of GMI for the entire period (i.e., 1995–2019[10]). As can be seen, it follows a mild downward trend. From an average value of 192.6 in 1995 to 152.6 in 2019. However, as one would expect, the countries in our sample exhibit great heterogeneity in terms of their respective GMI scores (as well as GDP and INV). A summary snapshot picture of GMI and GDP is offered in Tables 1 and 2.

Table 1 presents the sample's top and bottom ten average GMI scores. Israel emerges as the country with the highest GMI average score of 417.5, followed by Singapore (388.9) and Bahrain (354). Iceland, Costa Rica and Panama have the lowest average GMI scores (3.2, 15.9 and 38.2 respectively).

In Table 2, the best growth performers are China with an average annual rate of 9% followed by Rwanda (8.7%) and Cambodia (7.5%). The three lowest average annual GDP growth rates are Jamaica (0.6%), Italy (0.7%) and Zimbabwe (0.7%).

Both tables illustrate that there is no apparent consistent pattern between the two variables.

Table 1: Sample's top ten average GMI scores and ten lowest 1995–2019

Ten highest GMI			*Ten lowest GMI*		
	GMI	*GDP Growth %*		*GMI*	*GDP Growth %*
Israel	417.5	4.2	Nigeria	70.0	5.3
Singapore	388.9	5.2	Mexico	62.5	2.3
Bahrain	354.0	6.0	Gambia	61.8	3.4
Oman	349.6	3.3	Ghana	60.9	5.8
Saudi Arabia	331.9	2.9	Jamaica	59.8	0.6
Jordan	323.3	4.3	Malta	55.0	4.0
Brunei	318.2	0.9	Mauritius	53.1	4.2
Russia	314.6	2.8	Panama	38.2	5.8
Armenia	299.5	6.4	Costa Rica	15.9	4.1
Lebanon	298.8	3.4	Iceland	3.2	3.4

Table 2: Sample's ten highest and ten lowest GDP growth rates (%) 1995–2019

Ten highest GDP growth rates			*Ten lowest GDP growth rates*		
	GMI	*GDP Growth %*		*GMI*	*GDP Growth %*
China	134.5	9.0	France	171.5	1.7
Rwanda	162.6	8.7	Portugal	177.8	1.5
Cambodia	216.0	7.5	Germany	137.4	1.4
Azerbaijan	247.0	7.3	Ukraine	214.2	1.0
Mozambique	116.3	7.1	Greece	285.7	0.9
India	137.6	6.9	Japan	95.8	0.9
Uganda	135.6	6.6	Brunei	318.2	0.9
Armenia	299.5	6.4	Zimbabwe	183.2	0.7
Mongolia	235.0	6.1	Italy	155.4	0.7
Tanzania	121.4	6.1	Jamaica	59.8	0.6

9 Descriptive statistics for the GDP, GMI and INV series of the complete sample can be found at https://mycloud.econ.uth.gr/s/o9bFo5ci5BKaSC7.
10 Downloaded in November 2021

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Method and findings

For the empirical analysis an extended version of the Panel VAR model with fixed effects from Sigmund and Ferstl (2021) is used:

$$(1)\quad \pi_{i,t} = \left(T_\zeta - \sum_{l=1}^{\zeta} K_l\right)\delta_i + \sum_{l=1}^{\zeta} K_l \pi_{i,t-1} + B\pi_{i,t} + M\rho_{i,t} + \omega_{i,t}$$

where $\pi_{i,t}$ are the endogenous covariates, t is the period, and $\pi_{i,t-1}$ the lagged of endogenous covariates. An identity matrix $(\delta * \delta)$ is displayed by T_ζ , while the homogeneity parameters are $K, B\ and\ M$. Sigmund and Ferstl (2021) follow Binder *et al*. (2005) to determine the GMM conditions and establish the first difference GMM estimator:

$$(2)\quad \Delta\pi_{i,t} = \sum_{l=1}^{\zeta} K_l \Delta\pi_{i,t-1} + B\Delta\pi_{i,t} + M\Delta\rho_{i,t} + \Delta\omega_{i,t}$$

where Δ is the first difference or the forward orthogonal transformation, π the lagged endogenous variables, in our case military burden (MILEX), GMI, GDP, and investment (INV). We use the moment selection criteria-Hannan-Quinn information criterion (MMSC-HQIC) and one proposed by Andrews and Lu (2001), based on the Bayesian information criterion (MMSC-BIC). We also use the orthogonal impulse response function (OIRF) introduced by Luetkepohl (2005) to check the response between the three endogenous covariates. The OIRF model can be obtained as follows:

$$(3)\quad OIRF(\zeta,\theta) = \frac{\partial\pi_{i,t+\zeta}}{\partial\left(\omega_{i,t}\right)_\theta}$$

Turning to the empirical investigation, before the estimation of the panel VAR we begin by applying preliminary tests. Panel unit root tests are applied using the Im *et al.* (2003) and Pesaran (2007) tests. The results reported in Table 3 indicate that all four variables (GMI, GDP, INV and MILEX) are stationary in levels, that is $I(0)$.

Before proceeding with the estimation of the GMM-PVAR model, we probe into the associations governing the four variables using two standard techniques that produce reliable and comparable results—the Pooled OLS and Fixed Effects (FE) estimators[11]. The results of the panel data estimations are reported in Table 4. Three different models were

Table 3: Panel unit root tests

Level		*GMI*	*GDP*	*INV*	*MILEX*
Pesaran (2007)	t-bar	-1.736	-2.19	-1.709	-2.160
	p-value	0.00	0.00	0.00	0.00
Im *et al.* (2003)	t-bar	-2.895	-3.539	-2.763	-3.451
	p-value	0.00	0.00	0.00	0.00
First difference					
Pesaran (2007)	t-bar	-8.643	-4.843	-4.065	-5.260
	p-value	0.00	0.00	0.00	0.00
Im *et al.* (2003)	t-bar	-11.913	-12.446	-12.334	11.656
	p-value	0.00	0.00	0.00	0.00

11 To decide between Fixed or Random effects we implemented a Hausman test.

estimated[12]. Model 1 shows the association of MILEX with the militarization index (GMI), while Models 2 and 3 show the effect of MILEX and GMI on growth (GDP) and gross fixed capital formation (INV), respectively.

Given the construction of the composite militarization index, the results of both the Pooled OLS and Fixed effects in the case of Model 1 are as expected—since they reveal a strong positive association between the two variables. The results of Models 2 and 3 in Table 4 show that MILEX has a significant negative influence on growth, but only for the fixed effects estimates, while investment is positively influenced by GMI but only for the pooled OLS estimation results. It is likely that these results reflect the potential endogeneity problem that is a common characteristic among the variables, such as bidirectional causality.

Table 4: Results of Pooled OLS and Fixed Effects

	Model 1 - GMI		*Model 2 - GDP*		*Model 3 - INV*	
Dependent variables	*Pooled OLS*	*Fixed effects*	*Pooled OLS*	*Fixed effects*	*Pooled OLS*	*Fixed effects*
MILEX	0.249*** (0.058)	0.113*** (0.041)	-0.037 (0.058)	-0.179** (0.091)	-0.001 (0.049)	-0.003 (0.007)
GMI	-	-	-0.064 (0.146)	0.252 (0.261)	0.046*** (0.122)	-0.004 (0.025)
Constant	4.480*** (0.147)	4.745*** (0.457)	4.115*** (0.665)	2.817** (1.220)	2.834*** (0.556)	3.089*** (0.122)
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	116	116	116	116	116	116
R^2	0.386	0.203	0.153	0.205	0.264	0.229

Notes: ***, **, and * depict significance at a 1%, 5% and 10% level, respectively. Robust standard errors are depicted in parentheses.

Using the GMM-PVAR method ought to overcome this potential endogeneity, so two models are constructed. The first model includes the variables GMI, growth and investment while the second model encompasses the variables GMI, MILEX, growth and investment. The results of Model 1 are presented in Table 5 and point to a statistically significant relationship only in the case of the GDP growth rates and gross fixed capital formation as a share of GDP (INV) with a positive effect from GDP to INV. No statistically significant nexus is established between the militarization index (GMI) and the other two macroeconomic variables. These findings are in line with those reported by Dunne and Smith (2020), as their findings do not suggest any strong relations between military expenditure and either investment or growth. Nonetheless, it should be pointed out that the results reported here constitute initial evidence. More robust inferences can be drawn through a formal modelling procedure.

12 We thank the two anonymous reviewers for this suggestion.

Similarly, the results of the extended Model 2 in Table 6 show that GMI has a significantly positive effect on growth but not on the other variables. Figures 2 and 3 illustrates the stability condition of the models, as all variables (the dots in Figures 2 and 3) are inside the unit circle.

The orthogonalized impulse response functions, in Figures 4 and 5, show the response of one variable to shocks of the other covariates. These shocks have short-run dynamics, eight quarters (two years) with the blue areas illustrating the confidence bands. A positive shock in GDP leads to an increase in INV and GMI, but this shock is very small and short-lived. Moreover, a positive shock in GMI leads to a stable response on GDP and INV. A positive shock in the gross fixed capital formation variable (INV) yields a stable response of GDP but a negative response of GMI (albeit

Table 5: Results for the GMM-PVAR Model 1

Variables	*GMI(t)*	*GDP(t)*	*INV(t)*
GMI(t-1)	0.890 (0.00)	0.007 (0.198)	0.005 (0.263)
GDP(t-1)	0.180 (0.143)	0.326 (0.00)	0.095 (0.01)
INV(t-1)	-0.159 (0.174)	0.035 (0.301)	0.781 (0.00)

Notes: p values in parenthesis

Table 6: Results for the GMM-PVAR Model 2

Variables	*GMI(t)*	*GDP(t)*	*INV(t)*	*MILEX(t)*
GMI(t-1)	0.874(0.00)	0.014(0.01)	0.004(0.321)	0.002(0.457)
GDP(t-1)	0.199(0.114)	0.308(0.00)	0.089(0.01)	0.010(0.207)
INV(t-1)	-0.112(0.142)	0.020(0.718)	0.774(0.00)	0.003(0.279)
MILEX(t-1)	0.135(0.565)	-0.545(0.475)	-0.339(0.360)	0.678(0.00)

Notes: p values in parenthesis

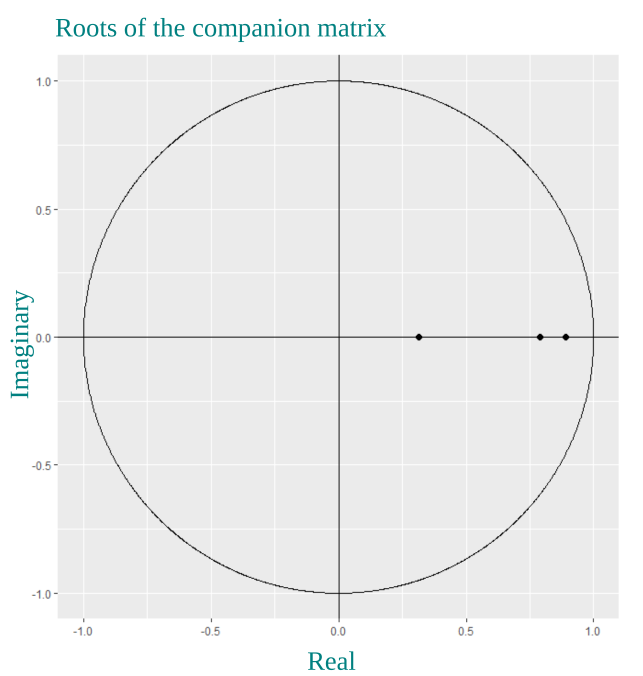

Figure 2: Stability test for Model 1

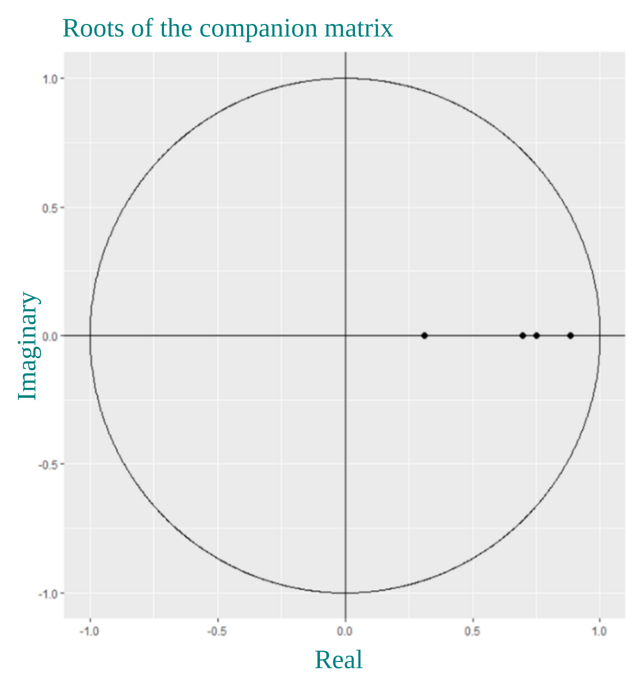

Figure 3: Stability test for Model 2

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very small). Finally, Tables 7 and 8 report the forecast error variance decompositions (FEVD), the percent of the fluctuation in one variable that is brought about by the shock to other covariates for the two models. Since, the FEVD calculation stems from the OIRF the outcomes are the intuitively expected ones. None of the variables can be explained by the dependent variables since the percentage response is very small (less than one percent).

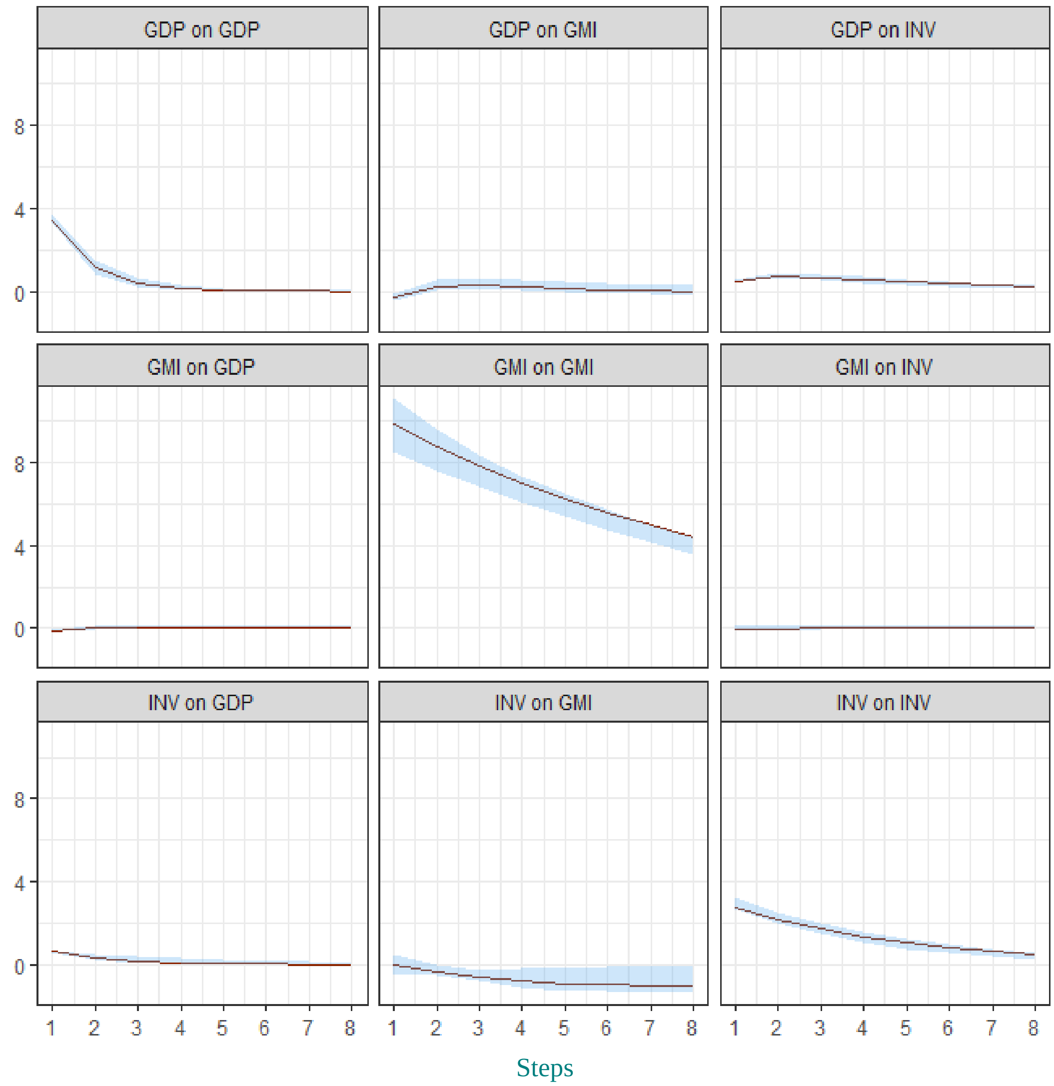

Figure 4: OIRF for model 1 — Generalized impulse response function.
Notes: GIRF and 95% confidence bands.

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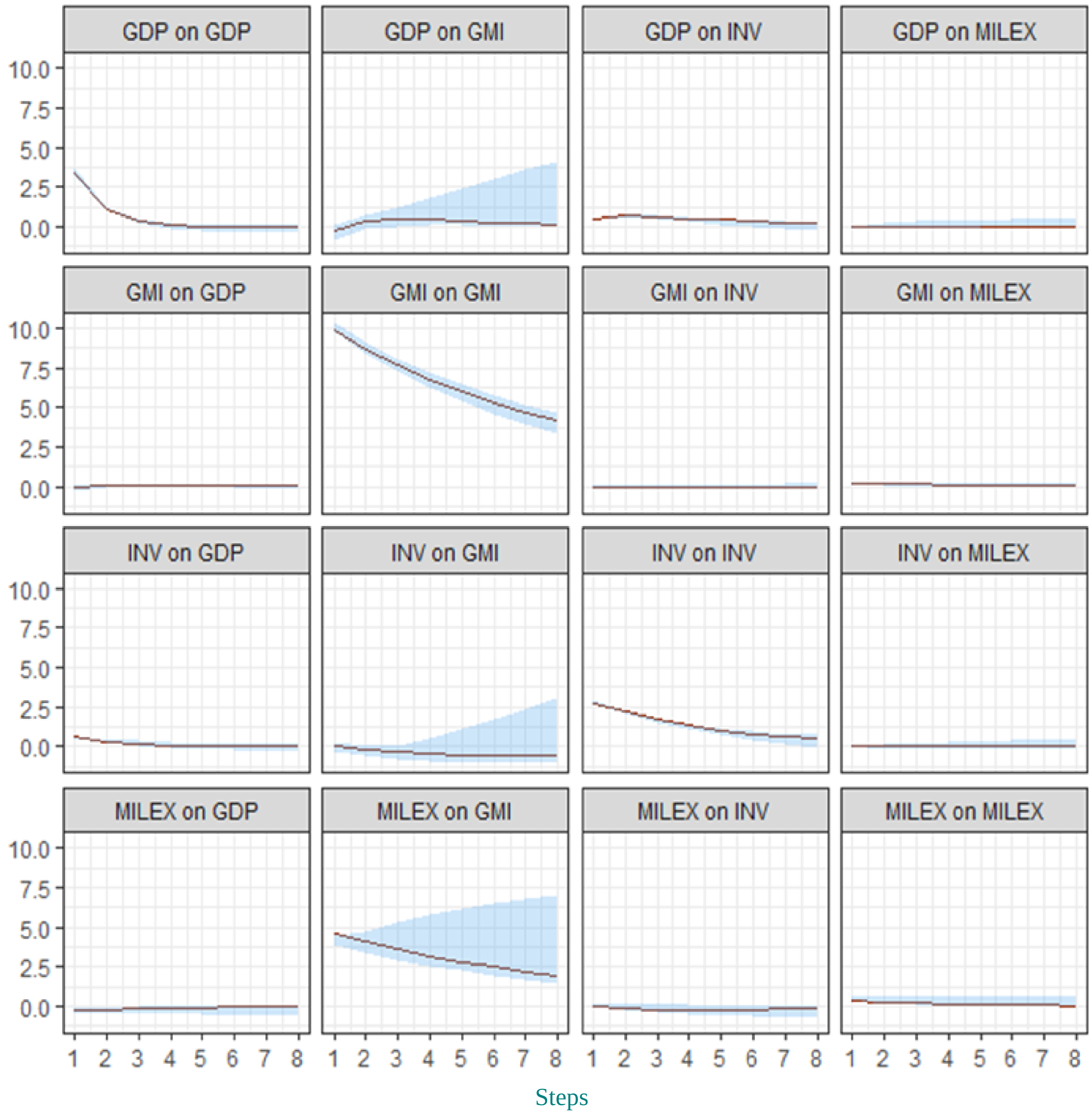

Figure 5: OIRF for model 2 — Generalized impulse response function.
Notes: GIRF and 95% confidence bands.

Table 7: Results for forecast error variance decomposition for Model 1

Dependent variable GMI

Period	*GMI*	*GDP*	*INV*
1	1.000	0.000	0.000
3	0.994	0.002	0.002
5	0.989	0.002	0.007
10	0.980	0.002	0.016

Dependent variable GDP

Period	*GMI*	*GDP*	*INV*
1	0.000	0.999	0.000
3	0.001	0.997	0.001
5	0.002	0.995	0.002
10	0.003	0.993	0.002

Dependent variable INV

Period	*GMI*	*GDP*	*INV*
1	0.000	0.999	0.000
3	0.001	0.997	0.001
5	0.002	0.995	0.002
10	0.003	0.993	0.002

Table 8: Results for forecast error variance decomposition for Model 2

Dependent variable GMI

Period	*GMI*	*GDP*	*INV*	*MILEX*
1	1.000	0.000	0.000	0.000
3	0.994	0.003	0.001	0.000
5	0.991	0.004	0.003	0.000
10	0.987	0.004	0.007	0.000

Dependent variable GDP

Period	*GMI*	*GDP*	*INV*	*MILEX*
1	0.000	0.999	0.000	0.000
3	0.000	0.992	0.000	0.006
5	0.001	0.989	0.000	0.009
10	0.001	0.987	0.000	0.009

Dependent variable INV

Period	*GMI*	*GDP*	*INV*	*MILEX*
1	0.000	0.034	0.965	0.000
3	0.000	0.076	0.919	0.003
5	0.000	0.087	0.903	0.008
10	0.000	0.091	0.893	0.014

Dependent variable MILEX

Period	*GMI*	*GDP*	*INV*	*MILEX*
1	0.219	0.002	0.000	0.777
3	0.257	0.006	0.002	0.734
5	0.284	0.009	0.003	0.703
10	0.314	0.010	0.003	0.670

Conclusion

The economic effects of military spending have attracted considerable attention in the literature in both single and multi-country empirical studies (*inter alia*: Emmanouilidis and Karpetis, 2021; Agostino *et al.* 2017; Desli and Gkoulgkoutsika, 2021; Dunne and Tian, 2015). Invariably, defense burden (military spending as a share of GDP) is the variable used to probe into the potential economic effects of allocating resources to defense. Building on this literature, this article considered an alternative measure that better captures the burden on the economy and society—the Global Militarization Index (GMI). To the best of our knowledge, BICC's GMI has never been used before in an empirical investigation. Considering 116 countries for the period 1995–2019, the results did not reveal any systematic and statistically significant relation between the militarization index (GMI) and two main macroeconomic variables—namely the growth rate of GDP and gross fixed capital formation as a share of GDP. Given the common finding that military burden has a significant impact on growth, this is a rather surprising result. It may suggest that this more general measure of military burden reflects a more complex set of interactions that are not captured in the existing literature. The findings should be treated with caution as a more formal modelling procedure is probably required in order to draw more robust inferences. It certainly suggests that further research using the GMI measure would be of value.

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Augustine, costs and defense industries

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Abstract

Augustine weapons systems are presented as a new class of economic good. Their distinguishing characteristics are identified in the form of advanced technology, inter-generational cost escalation and small quantities. A distinction is made between cost increases between generations of weapons and falling unit costs within a generation of equipment. The impact of Augustine weapons on learning curves is assessed and the article concludes with an evaluation of Augustine systems for the future defense industrial base.

Norman Augustine pioneered work on cost escalation (Augustine, 1987). This article starts by reviewing the evidence on Augustine cost escalation and presents these weapons systems as a new and distinctive class of economic good with clearly defined characteristics. Augustine cost escalation refers to real unit cost increases *between* generations of weapons systems. This article distinguishes between such cost escalation and cost decreases *within* a weapons system reflecting scale and learning economies. Aircraft are presented as a case study of a Decreasing Cost Industry and the impact of Augustine technological change on aircraft industry learning curves is assessed. Finally, consideration is given to the implications of Augustine weapons systems for the future of the defense industrial base.

Cost escalation

Norman Augustine famously forecast continuously rising unit costs of certain military hardware—rising at an exponential rate with time. For modern high performance fighter aircraft, he forecast unit costs rising by a factor of four every ten years. This rate of growth appeared to be an inherent characteristic of these systems with rising unit costs closely correlated with time rather than with the technical performance features of the aircraft (e.g., speed, weight, etc.). The same trend, but at a lower rate, applies to civil aircraft, helicopters, ships, and tanks—the latter two having a 10 year growth rate (Augustine 1987, p. 140). The results of the predicted rising unit costs led to a second and more famous prediction (Augustine Law XVI), namely, that by the year 2054, the entire U.S. defense budget would purchase just one aircraft. Similar predictions were made for other nations but with earlier dates, e.g., a single aircraft for the United Kingdom by 2052 (Augustine, 1987, p. 144). More widely, there were forecasts of a future comprising a single ship navy, a single tank army, and a Starship Enterprise for the air force (Kirkpatrick and Pugh, 1983).

Cost escalation: Some evidence

Table 1 presents evidence on the rising real unit prices of U.K. combat aircraft over the period 1940 to 1959. Successive generations of combat aircraft are shown. The table has two notable features. First, the magnitude of the rising unit costs in real terms. Between the World War II propeller-powered Spitfire and the jet-powered Meteor, real unit costs rose nearly five-fold. Similarly, between the Meteor and the next generation Hunter, real unit costs rose by a much smaller 1.2-fold; but between the Hunter and the next generation Lightning, unit costs rose by almost 3-fold.

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Bomber aircraft showed similar cost trends. The Mosquito and Canberra were light bombers and unit costs rose by almost 5-fold from one to the other. From the propeller-powered Lancaster to the jet-powered Vulcan real unit costs rose by a substantial amount, over 13-fold (although this example covers more than 10 years). The context for these cost trends was the original Augustine forecast of unit costs for fighter aircraft rising by a factor of four every ten years.

Augustine weapons systems represent a new class of economic good, identifiable as having advanced technology, inter-generational cost escalation, and small quantities. These factors mean difficult choices for the United Kingdom and similar states, such as whether to reduce defense capability, import costly equipment, increase collaboration, and/or fund real-term defense budget growth.

The second notable feature of Table 1 shows falling output for each type of aircraft. Part of this fall reflects the end of the war, but after 1945 the declining output reflects the rising real unit costs of combat aircraft. For example, in 1955, the U.K.'s RAF deployed about 1,000 Hunter fighter aircraft; by 2021, the corresponding number of U.K. RAF fighter aircraft had declined to 160 Typhoons. Hard budget constraints lead to a downward sloping demand curve, meaning that less is bought at a higher price.

Various explanations have been offered for intergenerational cost escalation. These include defense equipment viewed as a tournament good, monopoly pricing by defense industries, optimistic forecasting and changes in operational requirements (Hartley, 2020). Public choice analysis offers a further explanation focusing on the behavior of agents in the military-industrial-political complex. On the demand side of procurement markets, there are procurement officials in defense departments and the armed forces acting as budget maximisers. On the supply side, there are scientists, technologists, and industrialists in the defense industrial base pursuing objectives ranging from maximizing technology (e.g., enjoying shifting the frontiers of technology) to profit maximization. Whilst public choice analysis appears an attractive explanation, it needs much more theoretical modelling and empirical testing.

Defining Augustine weapons systems

While Augustine's Laws outline the features of certain high technology hardware, this article goes further and proposes Augustine weapons systems as a new class of economic good.[1] The key features of these systems comprise high or advanced technology, rising real unit costs, and small and declining quantities. The classic example of rising real unit costs is military fighter aircraft, with unit costs rising by a factor of four every ten years. This suggests that by 2054, rising unit costs could lead to the purchase of one aircraft, known as Battlestar Galactica or Starship Enterprise. Rising unit costs reflect the greater use of complex electronics, computer software and stealth technology—these industries will become more important in the defense industrial base. New technology leads to "vast new capability vistas" being crammed into each new generation of equipment (Augustine, 1987, p. 140). Critics have used this example to claim that modern weapons systems are laden with technological "bells and whistles" which add much to cost but little to military effectiveness (Franck, 1992). Cost escalation is explained by the "engineering mindset" of decision-makers in the military-industrial–political complex (Hartley, 2017). Public choice analysis views engineering staff and military personnel as budget-maximisers seeking to buy weapons systems which provide them with the greatest satisfaction (rather than the most cost-effective defense equipment). Their mindset values technology for technology's sake, creating cost growth that is unsustainable over time.

Radical frame-breaking technologies open vast new capability vistas, with real options analysis providing a useful way of thinking about Augustine weapons systems. For example, frame-breaking technologies might open new capability options within the weapon system as well as in completely different fields (spin-offs) as with a new fighter aircraft being adapted to perform strike missions and its technologies being used on civil aircraft (e.g., jet engines)

1 Further details are in Brauer, et al, (2021) and Markowski, et al, (2022).

and in other civil fields (e.g., health and motor cars). As real options, Augustine weapons, can be viewed as the "bundling together" partly-developed technologies, which are "stored" as development options for use when events require an all-out military commitment; otherwise, they are allowed to lapse and are not pursued.

Augustine weapon systems result from an increasing emphasis on smaller volumes of costlier technologically complex weapons—with, for example, one fourth-generation fighter jet costing the same as five first-generation aircraft. In addition, the existence of disruptive technologies is likely to make cost forecasting even more difficult.

Table 1: Rising unit prices of U.K. combat aircraft, 1940–1959

Aircraft	*Date of Contract*	*Unit Prices*	*Aircraft*
Fighters			
Spitfire	June 1940	9,700	20,351
Meteor	March 1946	47,137	3,947
Hunter	Jan 1955	55,626	1,972
Lightning	April 1959	160,000	337
Bombers			
Mosquito	Aug 1943	15,700	7,781
Lancaster	June 1943	31,700	7,377
Canberra	June 1951	73,482	949
Vulcan	Dec 1954	422,991	136

Notes: U.K. combat aircraft are a sample of fighter and bomber aircraft from World War II, and the subsequent peace to 1959, based on airframe unit costs only. Both fighters and bombers comprise propeller-powered aircraft: Spitfire, Mosquito and Lancaster; and jet powered aircraft: Meteor; Hunter; Lightning; Canberra; Vulcan. Data based on details of the contract for the date shown. Other contracts were available, but their data are not shown in Table 1. Total output comprises output for the United Kingdom and exports.

Source**:** DSTL (2010)

Comedy or reality?

From the outset, Norman Augustine recognized that his book might be classified as comedy or tragedy or even science fiction.[2] His assertions have been viewed as both frivolous and thoughtful insights into the impact of unit cost escalation of complex military equipment on the procurement of successive generations of major weapons systems. The essence of the Augustine crowding-out argument is that the introduction of increasingly sophisticated, complex, and costly warfighting equipment, together with stagnant procurement budgets, results in the acquisition of ever-smaller volumes of equipment. The eventual result is that technology leads to "backdoor" disarmament.

Recent developments have cast doubts on the original Augustine claims, finding that unit prices of military fighter aircraft have *not* increased by a factor of four every ten years, with fifth-generation fighter aircraft costing almost ten times their first-generation predecessors. Unit costs of fighter aircraft will *not* overtake the defense budget, but fighter aircraft will become more expensive over time and quantities will continue to fall. Rising unit costs *are* correlated with aircraft technical performance characteristics reflected in aircraft empty weight and the generation of the aircraft (Johnstone, 2020). It must also be remembered that trends are not causation. This is illustrated the limerick:

2 He presents an amusing anecdote. Long queues of bus passengers were being passed by drivers in half-empty buses. A bus company official responded to the public's objections to this annoying practice by stating that it is impossible for drivers to keep to their timetables if they have to stop for passengers.

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A trend is a trend is a trend
But the question is, will it bend?
Will it alter its course
Through some unforeseen force
And come to a premature end?[3]

Rising costs reflect greater capability. Today's fourth and fifth generation fighter aircraft could easily defeat their first generation equivalents operating at subsonic speeds and without radar or missiles. So, a focus on aircraft costs fails to recognize the *output* implications of new technology weapons systems. Here, there is a major gap in our knowledge since there are no measures of the money value of defense output. Instead, references are made to peace, protection, and security with defense output measures often based on *input* measures.

Table 2: Examples of U.K. aircraft as a Decreasing Cost Industry

Aircraft	*Start Date Index=100*	*Quantity*	*UPC Index at end of contract*	*ULC Index at end of contract*
Hurricane Mk1	Sept 1938	1,046	57	37
Spitfire	Dec 1939	10,341	74	83
Mosquito	Aug 1943	3,420	66	68
Meteor	March 1946	2,538	24	34
Javelin	July 1954	200	53	64
Hunter	Jan 1955	585	83	71
Canberra	June 1951	692	79	59

Notes: All are U.K. combat aircraft for periods of war and peace (1938–1955). Hurricane data for Mark 1 version only. Most are fighter aircraft except for Mosquito and Canberra which are light bombers. See also Notes to Table 1. Quantity refers to numbers ordered for a specific contract or from a specific supplier. UPC is unit production cost index based on constant prices. ULC is unit labor cost index in constant prices based on end date for the contract

Source**:** DSTL (2010)

Aircraft as a decreasing cost industry

Augustine's focus was on inter-generational cost escalation showing cost increases *between* generations of aircraft. However, there are cost curves *within* each generation of aircraft showing declining unit costs with larger outputs of a given type of aircraft. In other words, whilst cumulative volumes of equipment usually decrease for each new generation of equipment (the Augustine volume effect), there are scale and experience-related efficiencies that lead to lower unit costs as batch size increases and production experience accumulates through learning-by-doing. These intra-generational efficiencies may decline over time as declining equipment volumes (inter-generational effects) restrict opportunities for scale, scope and learning economies with the procurement of new generations of equipment.

Table 2 presents original evidence of U.K. aircraft as a Decreasing Cost Industry. Decreasing costs apply to both war and peace-time, and to propeller-powered and jet-powered U.K. combat aircraft. Decreasing costs reflected both economies of scale and learning. Falling unit labor costs reflected learning economies and there was evidence of substantial learning for the Hurricane and Meteor aircraft. However, it has to be stressed that unit labor costs are used as a proxy for learning curves: true learning curves are defined with respect to a doubling of cumulative output.[4]

3 Cairncross, (1969, p. 797).
4 The data did not allow curves to be defined with respect to a doubling of cumulative output. Instead, data were only available showing unit labor costs for various quantities which were specified by each contract.

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There was also evidence of major reductions in unit production costs for the Hurricane, Meteor and Javelin aircraft (Hartley, 2022).

Learning curves

The original Wright model for aircraft industry learning curves was (Wright, 1936):

$$Y = aX^{-b}$$

where Y = average direct man hours
a = man hours at unit number one
X = cumulative output
b = slope of learning curve

Traditionally, labor learning curves for the aircraft industry were estimated at 80%, meaning that direct labor inputs declined by 20% for each doubling of *cumulative* output. For example, the first aircraft produced might require 1,000 man hours; doubling from one to two units would require 800 man hours for unit two; and a further doubling to four units would require 640 man hours for the fourth unit. Learning economies mainly reflected productivity gains from worker repetition and experience. More recent developments have identified "forgetting" curves where knowledge is not retained by workers. Forgetting arises from production breaks, labor turnover, aircraft modifications and new production technology.

Modern examples of learning are available. The learning rate for the U.S. F-15 combat aircraft was 88%; for the U.S. F-18E/F fighter aircraft it was 86%; and for the F-22 Raptor it was 85.4%[5] (Hartley, 2022). The U.S. evidence on learning curves shows the possible impact on learning of Augustine technical progress. Despite the technological differences between the fourth-generation F-18 and the fifth-generation F-22, their learning curves are similar; but for the current generation U.S. F-35 Lightning II combat aircraft, the learning curve was substantially different at 91%.

Modern learning rates differ from the traditional Wright 80% curve. These differences might reflect smaller quantities for new generations of jet fighters and the greater use of automated rather than labor-intensive production methods. Over time, it might be expected that smaller equipment quantities will lead to both scale and experience related (learning) efficiencies becoming weaker, resulting in changes in Wright's traditional scale and experience coefficients. There is tentative support for the possibility that Augustine weapons systems might have affected learning curves and rates, but more data are required to reach a definitive conclusion. Future learning curves will depend on new technology in the production process and the extent to which it offers new opportunities for learning-by-doing. Possible future limitations on the opportunities for achieving scale and learning economies might increase the opportunities for firms to achieve economies of scope.

Augustine and the future defense industrial base

As a new class of economic goods, Augustine weapons have implications for the future defense industrial base. They are likely to mean a more technology-intensive and a smaller defense industrial base, with fewer opportunities for scale and learning economies but perhaps more opportunities for scope economies. These economic impacts will affect capital and labor inputs for defense industries. Capital inputs will become more R&D intensive and lower

5 There is limited evidence of learning curves for U.K. aircraft. For the 1946 Vampire fighter jet, the median learning rate was 63% (Hartley 2022).

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volumes will lead to smaller requirements for production inputs. For labor inputs there will be a shift from production to technology requirements reflected in greater demands for scientific and technical labor.

Augustine weapons systems are likely to lead to a smaller defense industry as measured by numbers of employees and numbers of production plants, but higher unit labor costs and a higher value of unit real sales. Industry structure is also likely to change, with a long-run trend to a smaller number of larger arms companies reflecting more mergers and exits. Some mergers will be international between U.S. and European firms, as firms seek to obtain entry into established defense markets (with prospects for orders).

International mergers, larger firms and increased market concentration will affect industry conduct leading to a decline in competitive tendering with potential adverse effects on industry performance (greater monopoly power). A greater emphasis on arms export markets is likely, with larger arms firms seeking new arms markets. Buying nations might respond to monopoly suppliers by creating international buying consortia. Finally, there will be ownership issues. Privately-owned monopoly suppliers are likely to be subject to greater state regulation; but regulation raises more problems to be solved (e.g., whether to regulate prices, profits, or aspects of conduct).

Augustine weapons systems can lead to battle-field substitution effects. For example, drones are possible substitutes for the increasingly expensive fighter aircraft and could have major economic impacts on the armed forces and defense industries. Their military use means that weapons systems become more capital/technology intensive with less military personnel required for traditional front-line roles (e.g., fewer combat aircraft pilots and personnel for servicing manned equipment). Drones are likely to be acquired in larger quantities and they are accessible to small terrorist groups. However, by the time drones are able to replace modern combat aircraft they might be as costly. A future of Starship Enterprise weapons will lead to Space Forces replacing traditional Air Forces. But the future is uncertain, and no one can predict it accurately: the most likely outcome is that future predictions are likely to be wrong!

Conclusion

Augustine weapons systems represent a new class of economic good**.** Whilst these goods have some distinctive features, further research work is needed to provide a clear unambiguous definition of their key features. Definitions are needed of *high* technology, *high* unit costs and *small* volumes. In the meantime, Augustine weapons systems are distinguished by cost escalation reflected in continuously rising real unit costs and by higher technology, greater complexity, and smaller volumes—with impacts on the future armed forces and defense industries. All of which means that nations such as the United Kingdom, and similar European states, will face the need for difficult defense choices. Something will have to be sacrificed and the options include abandoning a major defense capability (e.g., no more manned combat aircraft as in New Zealand), importing costly equipment, greater and more efficient international collaboration, or higher real terms defense budgets (Kirkpatrick, 1995).

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Should education and military expenditures be combined for government economic policy?

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Abstract

This article examines the impact of EDUMILEX, namely the ratio between investment in education and military expenditure, on economic performance. It uses panel data estimation methods for 60 countries over the period 2000–2018. The findings suggest the existence of a non-linear, cubic relationship between EDUMILEX and economic performance. In particular, EDUMILEX is positively associated with both GDP per capita and labor productivity. The results also show that the effect of EDUMILEX is heterogeneous across countries, with lower values of EDUMILEX required to increase economic performance in developed countries than developing ones.

This article considers the appropriate economic policies to build peace in the long run—taking the conceptual insights of Caruso (2017) as point of departure, in which a workable definition of peace took inspiration from the balance between productive and destructive activities as envisioned in Baumol (1990). Defining peace as "an integrative institutional setting that favors productive at the expense of unproductive activities due to democratic governance, balanced economic interdependence, and long-lasting productivity growth in the long-run", the ratio of public education investment to military expenditure (hereafter EDUMILEX) is considered a relevant variable for a peaceful economic policy. The choice of this ratio appears to be reasonable in the light of the existing literature. On the one hand, almost all economists agree on the positive impact of education on economic growth in the long run[1]. On the other hand, prevailing literature shows the negative impact of military expenditures on growth[2]. Thus, it seems reasonable to consider military expenditures and investment in education as countervailing forces for economic growth. Keller *et al*. (2009) investigated the relationship between the military draft and economic growth in OECD countries, finding that countries with military draft exhibited poorer economic performance compared to countries with an all-volunteer recruitment of military personnel. Military conscription seems to have a negative impact on human capital accumulation because it diverts younger people from studying. Indirect confirmation of this is found in the study of the earthquake that hit Southern Italy in 1980, by Cipollone and Rosolia (2007). Young men were exempted from compulsory military service after the earthquake, and this eventually led to high-school-graduation rates of boys increasing by more than 2 percentage points. Moreover, due to peer-effect, graduation rates of young women also increased. In addition, there is more recent empirical evidence of a negative relationship between conscription and labor market outcomes[3].

This article considers the impact of EDUMILEX on economic performance. It takes GDP per capita and labor productivity as dependent variables and regresses them against the EDUMILEX ratio for a panel of countries over the period 2000 to 2018. In the next section, the relevant variables are presented, and the data sources given. Long-

1 See among others: Hanushek and Woessmann (2020); Marconi (2018); Benos and Zotou (2014); Krueger and Lindhal (2001).
2 See among others: Dunne and Tian (2020, 2016), D'Agostino *et al.* (2019), Awaworyi Churchill and Yew (2018).
3 See among others: Bingley *et al.* (2020); Torun (2019), Jaworski (2014), and Bauer *et al.* (2012).

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run correlations have been considered by means of several plots and cross-section analyses. This article then presents panel data estimation results and draws some conclusions.

Given that education and military expenditures are countervailing factors in securing long-run growth, the ratio between public investment in education and military expenditure (EDUMILEX) is proposed as a target variable for a peaceful economic policy. EDUMILEX has a non-linear, cubic relationship with economic performance, being positively associated with both GDP per capita and labor productivity. Lower income countries are found to need higher levels of EDUMILEX to improve economic performance.

Data and variables

The analysis focuses on the impact of the EDUMILEX ratio on per capita GDP and labor productivity. The main explanatory variable, EDUMILEX, is defined as the ratio of public investment in education over military expenditure.

$$EDUMILEX = \frac{Public\ investment\ in\ education\ (constant\ dollars)}{Military\ expenditures\ (constant\ dollars)}$$

Public investment in education is from the UNESCO[4] dataset. Unfortunately, data for some relevant countries, such as China, France and the Republic of Korea are not available. Data on military expenditure are provided by the Stockholm International Peace Research Institute (SIPRI). We compute labor productivity as the ratio between GDP (gathered from UNCTAD) and the number of employed persons in line with the definition provided by the International Labor Organization[5]. The number of employed persons has been computed by using the employment rate of 15+ populations and working age populations (15–64) and total population figures from the World Bank. GDP per capita is computed as the ratio of GDP to total population. All data sources quoted in current dollars are converted to constant dollars (base year 2015) using the Consumer Price Index from the Bureau of Labor Statistics.

Table 1 shows the EDUMILEX ratio for some selected countries. At first glance, two stylized facts emerge. First, it seems that the EDUMILEX ratio has grown over time for most countries. Second, it appears that countries with the lowest EDUMILEX ratio (Colombia, Israel, the Russian Federation, the United States, and Iran) are frequently involved in armed conflicts. This suggests a hypothesis that the greater the EDUMILEX ratio is at a certain point in time, the greater the level of GDP per capita and labor productivity will be in the long run. Put differently, the aim is to test whether the EDUMILEX ratio at time *t* can be expected to have a positive impact on growth measures at *t+n*.

The plots in Figure 1 depict a long-run relationship between the EDUMILEX ratio and the development measures used (GDP per capita and Labor Productivity). Data for 60 countries[6] are used for the period 2000–2018, including 28 current high-income countries and 32 current middle- and low-income countries, according to the World Bank classification. The first graph in Figure 1 shows the relationship between GDP per capita in 2018 and the EDUMILEX ratio in 2000; the second illustrates the relationship between labor productivity in 2018 and the EDUMILEX ratio in 2000. It would appear that a positive correlation does exist.

4 Germany data are from OECD. (Accessed: 10 January 2022).
5 https://ilostat.ilo.org/resources/concepts-and-definitions/description-labour-productivity/ .
6 Countries included in the panel are: Argentina, Armenia, Australia, Austria, Azerbaijan, Benin, Brazil, Cameroon, Chile, Colombia, Côte d'Ivoire, Cyprus, Czech Republic, Denmark, El Salvador, Estonia, Finland, The Gambia, Georgia, Germany, Ghana, Guyana, Hungary, Iran, Ireland, Israel, Italy, Jamaica, Japan, Kenya, Kyrgyz Republic, Latvia, Lithuania, Madagascar, Malaysia, Mali, Mauritius, Mexico, Moldova, Nepal, Netherlands, New Zealand, Norway, Pakistan, Peru, Poland, Portugal, Romania, Russian Federation, Senegal, Sierra Leone, Slovakia, South Africa, Spain, Sweden, Switzerland, United Kingdom, Ukraine, United States.

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This positive relationship between the EDUMILEX ratio and GDP per capita or labor productivity is supported by the results of the cross-section regression analysis. Estimating:

$$y_{i,2018} = \beta_0 + \beta_1 \, EDUMILEX_{i,2000} + \epsilon$$

$$y_{i,2018} = \beta_0 + \beta_1 \, EDUCATION_{i,2000} + \beta_2 \, MILEX_{i,2000} + \epsilon$$

gave the results in Table 2, with the coefficients on EDUMILEX all positive and significant at 10%.

Both the plots and the cross-section analysis suggest the higher the current value of EDUMILEX, the higher will be GDP per capita and labor productivity in the long run. In addition, Table 2 columns (2) and (4) confirm a hypothesis drawn from previous literature—that in the long run investment in education is positively associated both to GDP per capita and labor productivity, while a negative association exists between military expenditure and GDP per capita and labor productivity in the long run. There is, however, also the possibility that this pattern represents an underlying non-linear relationship, as suggested by the recent empirical works by Tiwari and Shahbaz (2013) and Dunne and Tian (2015) for military expenditure, and Krueger and Lindhal (2001) and Marquez-Ramos and Mourelle (2019) for education. Figures 2 and 3 show the relationship between the EDUMILEX ratio and GDP per capita and labor productivity respectively at t-5 and t-8, distinguishing high-, middle- and low-income countries and showing clear differences. We choose 5-year time lags as they have been already used in previous empirical works on education and growth[7]. Furthermore, an 8-year lag is also used, inspired by the recurring political cycle of the US (being the main spender regarding military expenditures). The heterogeneity is also apparent in the cross-section results in columns (3) and (6) of Table 2. High Income_{2000} is a dummy variable which is equal to 1 if, in 2000, the World Bank classified the country as high-income and 0 otherwise and is positive and significant. These cross-section results reveal that, all other things being equal, countries that were classified as high-income countries in 2000 show higher GDP per capita and labor productivity in 2018.

Table 1: EDUMILEX ratio for some selected countries

Country	*2000*	*2010*	*2018*
United States	1.93	1.36	-
United Kingdom	1.72	2.15	2.50
Russian Federation	0.83	-	1.26
France	-	-	2.93
China	-	-	-
Argentina	3.98	6.12	6.66
Brazil	2.28	3.67	4.14
Colombia	1.16	1.33	1.47
Germany	2.98	3.45	-
Ireland	5.94	10.52	11.79
Israel	0.97	0.93	1.15
Italy	2.47	2.88	3.13
Iran	0.55	1.14	1.57
Japan	3.52	3.48	3.25
Kenya	4.04	3.27	3.76
Mexico	9.32	11.39	8.90
New Zealand	-	4.40	4.96
Spain	2.42	3.50	3.33

7 See among others: Barro (2013); Marconi (2018).

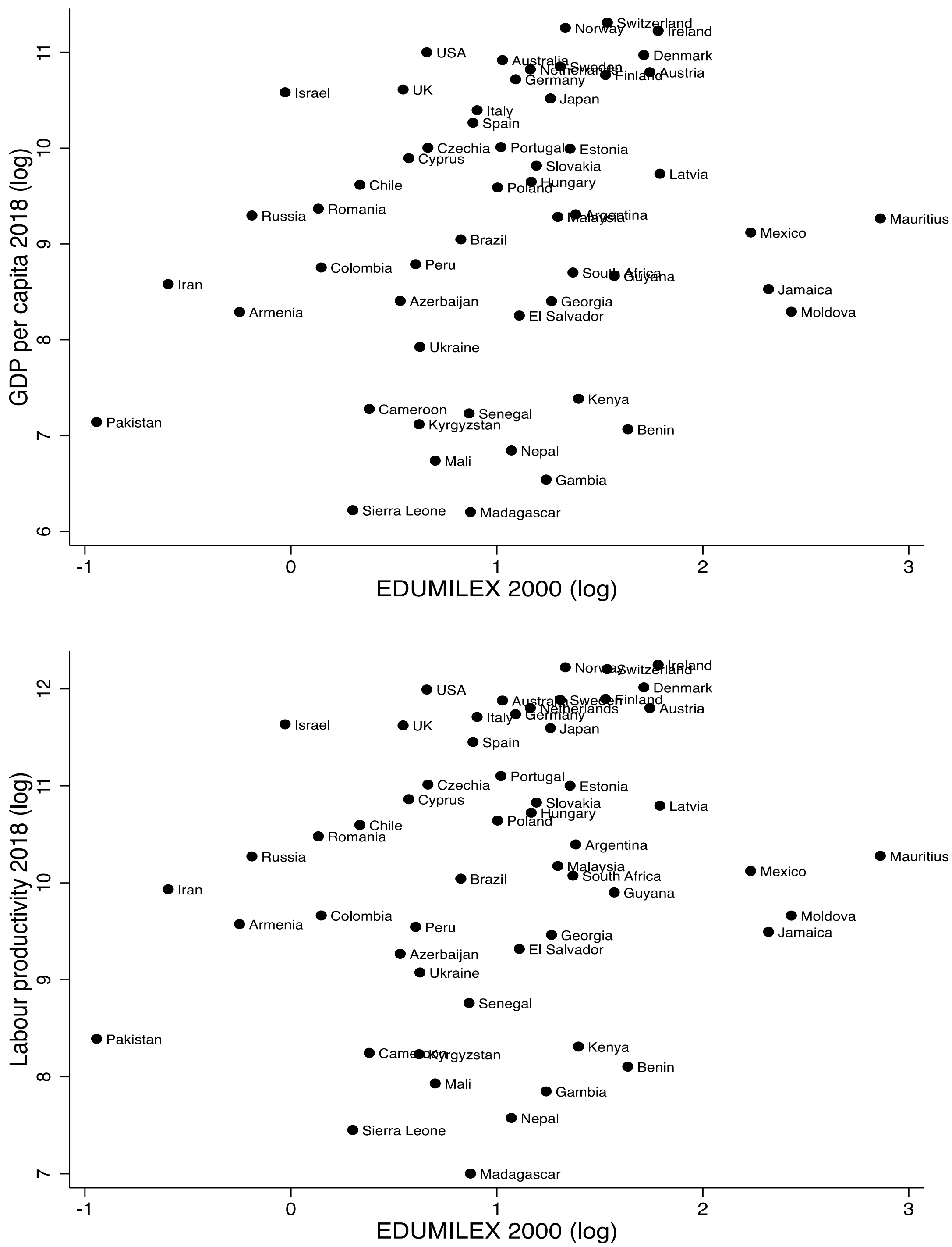

Figure 1: Productivity 2018 and GDP per capita 2018 against the EDUMILEX ratio

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Table 2: Cross-section analysis

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Dependent variables	*GDP per capita 2018 (log)*	*GDP per capita 2018 (log)*	*GDP per capita 2018 (log)*	*Labor Productivity 2018 (log)*	*Labor Productivity 2018 (log)*	*Labor Productivity 2018 (log)*
$EDUMILEX_{2000}$ (log)	**0.430*** (0.218)		**0.274*** (0.140)	**0.406*** (0.208)		**0.252*** (0.069)
$EDUEX_{2000}$ (log)		**0.920***** (0.185)			**0.883***** (0.185)	
$MILEX_{2000}$ (log)		**-0.464***** (0.165)			**-0.440***** (0.164)	
High $Income_{2000}$			**2.282***** (0.201)			**2.255***** (0.196)
Constant	**8.719***** (0.287)	**5.117***** (0.456)	**8.129***** (0.246)	**9.807***** (0.278)	**6.297***** (0.468)	**9.224***** (0.240)
Obs.	55	55	55	55	55	55
R-squared	0.046	0.654	0.592	0.042	0.638	0.592
F statistic	**3.88***	**52.36*****	**65.92*****	**3.82***	**47.42*****	**67.57*****

Notes: Robust standard error in parentheses. *** significant at 1%, **significant at 5%, *significant at 10%. For sake of readability statistically significant coefficients are in bold.

We hypothesize that the relationship between EDUMILEX and economic growth is N-shaped. The poorest countries usually exhibit very low literacy rates and higher levels of military expenditure compared to investment in education. In such countries, when government policies divert resources from the military sector to education, slight increases in literacy rates result in higher levels of productivity and GDP per capita in the short run. In addition, military expenditure might cause an increase of GDP per capita in the short run through the government spending multiplier. In the medium term, as long as a country's level of development increases, investment in education switches from primary to secondary and tertiary education. Later investment might cause a drop in GDP per capita and labor productivity for two reasons. First, returns on these investments need time to take shape. A second explanation relies on the concept of firms' absorptive capacity expounded by Cohen and Levinthal (1990), which is the ability of firms to internalize and exploit external knowledge. In the developmental path there might be a time in which workers' level of education is too high compared to the absorptive capacity of firms. As a result, since firms are not able to exploit workers' high skills, public investment in education does not result in higher GDP per capita and labor productivity. On the other hand, as Tiwari and Shahbaz (2013) show, any positive effect of military expenditure on economic growth rapidly vanishes. In the long run, as long as a country keeps following a developmental path, the economic framework will adapt to highly skilled workers. Public investment in education is increasingly devoted to tertiary education, which eventually results in higher economic performance in the long run. The next section provides an empirical analysis of this assumption by using longitudinal data for 60 countries over the period 2000–2018.

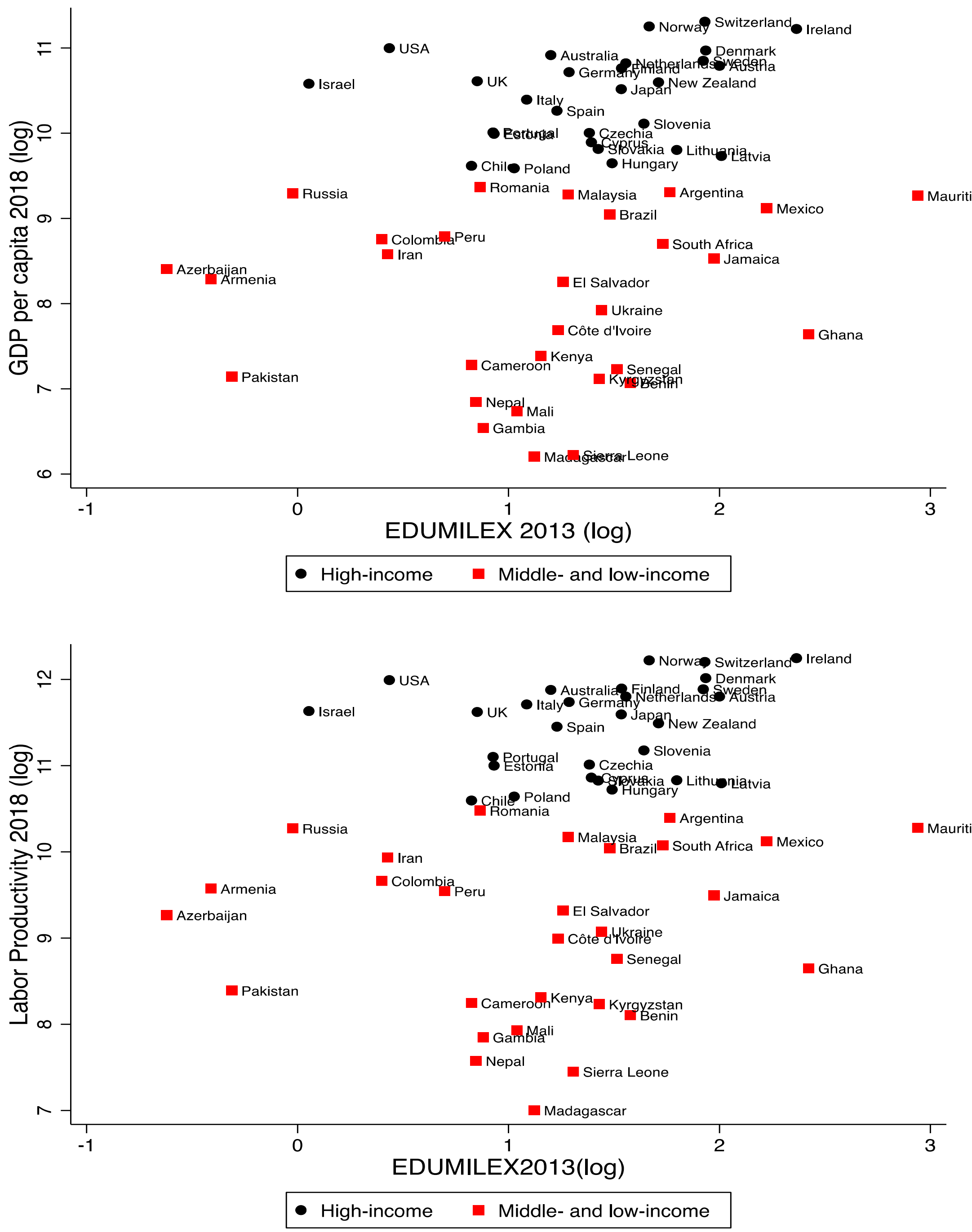

Figure 2: the relationship between EDUMILEX ratio and GDP per capita and labor productivity at t-5

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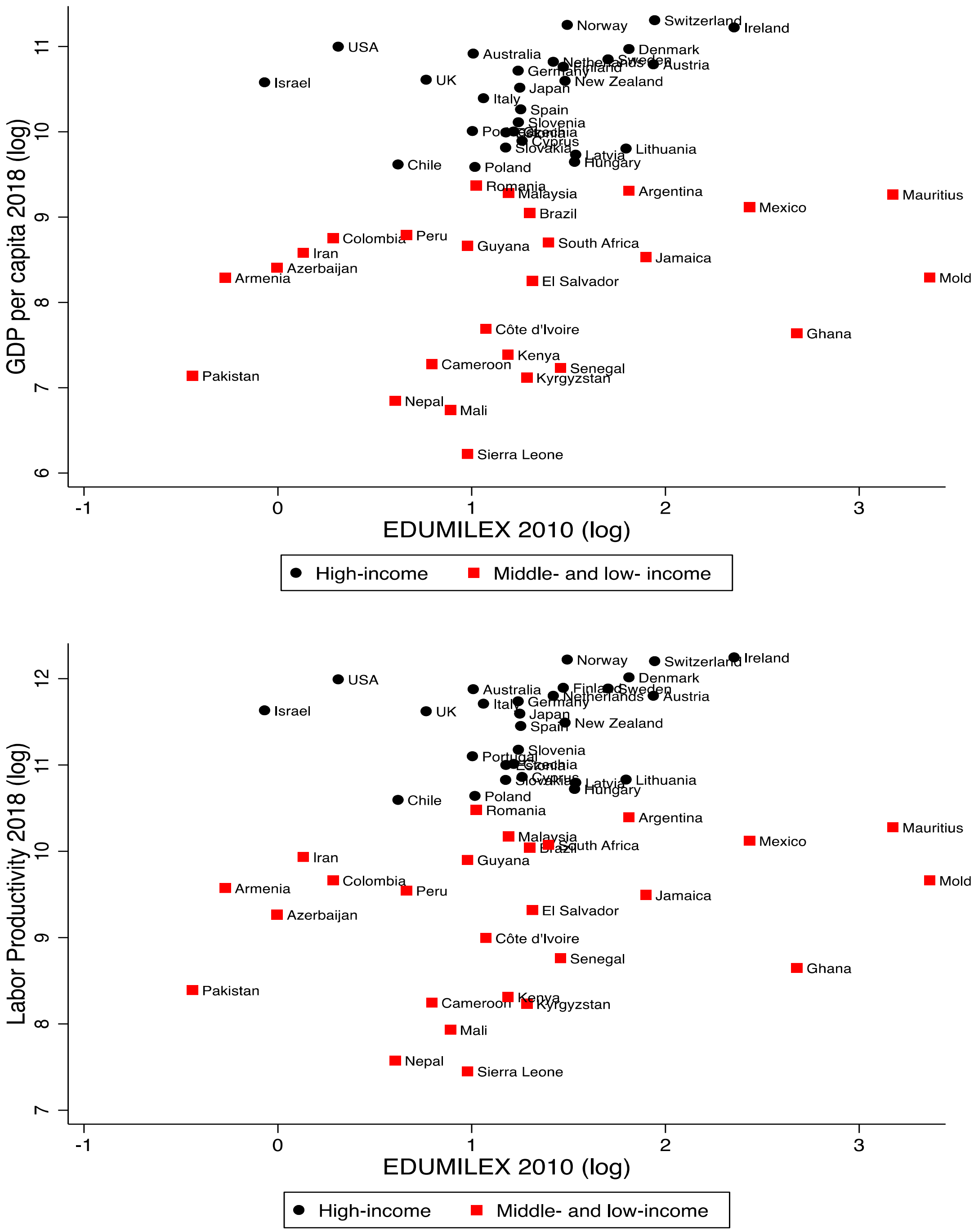

Figure 3: the relationship between EDUMILEX ratio and GDP per capita and labor productivity at t-8

The panel data analysis

To take the analysis further, a parsimonious panel data analysis is applied using the simple econometric model:

$$y_{i,t} = \beta_0 + \beta_1 y_{i,t-1} + \beta_2 EDUMILEX_{i,t-n} + \beta_3 EDUMILEX^2_{i,t-n} + \beta_4 EDUMILEX^3_{i,t-n} + X_{it} + \epsilon_{i,t}$$

Where y denotes alternatively the GDP per capita and the labor productivity. The number of lags n is equal to 5 and 8 alternatively[8]. X_{it} is the vector of the control variables. Control variables are military conscription and the Electoral Democracy Index (EDI)[9]. The first is a dummy which is equal to 1 if military draft is in force in country *i* at time *t*. Information are drawn from the CIA World Factbook[10]. Most countries (75% of the sample) show no change in their military recruitment policies during the relevant period. The US enduringly relies on all-volunteer recruitment of military personnel, while the Russian Federation, conversely, has the military draft as a permanent recruitment strategy. In Europe, there have been changes in the military recruitment strategy. Countries such as Italy, Portugal, and Spain abolished conscription in the early 2000s, while Sweden and Ukraine abolished conscription respectively in 2010 and 2012 and then reinstated it in 2018 and 2014 (to counter deteriorating security situations). The Electoral Democracy Index (EDI) provided by V-Dem measures to what extent country *i* at time *t* accomplish electoral democracy features of polyarchies as defined by Dahl (1971). It ranges from 0 (low) to high (1). The quality of political and economic institutions (Acemoglu and Robinson, 2012; Monteforte and Temple, 2020) has a clear-cut impact on developmental paths. In particular, Acemoglu *et al*. (2019) highlighted that democracy is pivotal for economic growth because democracies tend to invest more in human capital compared to autocratic regimes. Moreover, several studies show that democracies tend to exhibit lower levels of military expenditure compared to autocratic regimes (Mulligan, Gil and Sala-i-Martin, 2004; Albalate, Bel and Elias, 2012). Table 3 summarizes the descriptive statistics of the data used in the panel regression.

The estimation results of the model using OLS fixed effect is presented in Table 4 and Table 5[11]. Random effects are also reported as a robustness check, though the Hausman test suggests that the fixed-effect model is appropriate.

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8 The time lags also allow to mitigate the endogeneity concerns.

9 Coppedge *et al*. (2022). "VDem [Country–Year/Country–Date] Dataset v12" Varieties of Democracy (V-Dem) Project. https://doi.org/10.23696/vdemds22 . (Accessed: 10 January 2022).

10 Central Intelligence Agency (2022). "The World Factbook" Available at: https://www.cia.gov/the-world-factbook (Accessed 10 January 2022).

11 The use of ratio implies that the effect of increasing investment in education or cutting military expenditure are symmetric. Since our estimation employs logs it takes the form:

$$Eq.1)\ y_{i,t} = \beta_0 + \beta_1 y_{i,t-1} + \beta_2 (e-m)_{i,t-n} + \beta_3 (e-m)^2_{i,t-n} + \beta_4 (e-m)^3_{i,t-n} + \beta_5 X_{i,t} + \varepsilon_{i,t}$$

Where e is the investment in education and m is the military expenditure. We also consider the two variables independently as follows:

$$(Eq.2)\ y_{i,t} = \gamma_0 + \gamma_1 y_{i,t-1} + \gamma_2 e_{i,t-n} + \gamma_3 m_{i,t-n} + \gamma_4 e^2_{i,t-n} + \gamma_5 m^2_{i,t-n} + \gamma_6 e^3_{i,t-n} + \gamma_7 m^3_{i,t-n} + \gamma_8 e^2_{i,t-n} m_{i,t-n} + \gamma_9 m^2_{i,t-n} e_{i,t-n} + \gamma_{10} m_{i,t-n} e_{i,t-n} + \gamma_{11} X_{i,t} + \varepsilon_{i,t}$$

With the aim of corroborating our hypothesis we compute the F-stat of Eq.(2) against Eq. (1). F-statistic critical value is 3.10 at a significance level of 1% in all models. F-statistic values are 16.5 when GDP per capita is the dependent variable and independent ones are 8 years lagged; 7.91 when GDP per capita is the dependent variable and independent ones are 5 years lagged; 8.25 when labor productivity is the dependent variable and independent ones are 8 years lagged; 3.6 when labor productivity is the dependent variable and independent ones are 5 years lagged. These results confirm the hypothesis that the ratio matters. We thank one referee for suggesting this.

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Table 3: Cross-section analysis

Variable	*Source*	*Obs.*	*Mean*	*Std. dev.*	*Min*	*Max*
EDUMILEX	UNESCO/ SIPRI	1,068	4.25	3.95	0.29	33.44
GDP per capita	UNCTAD/ World Bank	1,200	18,964.71	21,640.79	258.41	106,721.5
Labor productivity	UNCTAD/ World Bank	1,200	46,129.91	51,383.07	511.35	248480.6
Military Conscription	CIA The World Factbook	1,200	0.45	0.50	0	1
Electoral Democracy Index	V-Dem	1,200	0.69	0.22	0.16	0.919

When considering GDP per capita as a dependent variable, the findings show the expected non-linearity, suggesting a cubic relation between GDP per capita and EDUMILEX. This means that for very low levels of EDUMILEX, an increase in EDUMILEX will result in increase in GDP per capita until a turning point is reached—after which GDP per capita starts to decrease. After reaching the minimum level of GDP per capita, any additional increase of EDUMILEX generates further GDP per capita growth. As EDUMILEX goes beyond a certain level, a lasting increase in GDP per capita can be observed. The result holds when the EDUMILEX is five-year lagged and eight-year lagged. The same relationship is suggested for labor productivity and EDUMILEX, even though it is statistically significant only when the EDUMILEX is eight-years lagged.

To infer a policy prescription, the turning points of such non-linearities are computed—when the value of EDUMILEX beyond which the relationship between EDUMILEX and dependent variables turns unambiguously positive. The turning point of EDUMILEX might thus be considered a target variable for economic policy.

The minimum turning point is computed when the first derivative of the function is zero and the second derivative is positive at that point. When GDP per capita is the dependent variable and EDUMILEX is eight-years lagged, the function derived from the regression is $y = 3.17 + 0.023\,x - 0.081\,x^2 + 0.025\,x^3$. Then the minimum turning point is 2 and, taking the natural antilog, the value of EDUMILEX is 7.39. If control variables are included, the turning point of EDUMILEX rises to 7.46. When labor productivity is the dependent variable, the coefficient associated with the EDUMILEX ratio at *t-8* is 1.49 and, taking the natural antilog, the turning point of EDUMILEX is 4.44. If the control variables are included the turning point of EDUMILEX increases slightly to 4.53 (see Table 6).

In sum, the regression results indicate that if GDP per capita is considered as the dependent variable, a higher value of EDUMILEX is required to enable long-lasting growth than when labor productivity is the dependent variable. When the model is augmented with control variables, the turning point of EDUMILEX slightly increases for both dependent variables. The hypothesis that higher EDUMILEX is associated to better economic performance in the future is thus confirmed.

Table 4: GDP per capita and the EDUMILEX ratio

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Dependent variable	*GDP per capita (log)*	*GDP per capita (log)*	*GDP per capita (log)*	*GDP per capita (log)*	*GDP per capita (log)*	*GDP per capita (log)*
GDP per $capita_{t-1}$ (log)	**0.732***** (0.019)	**0.732***** (0.018)	**0.727***** (0.018)	**0.680***** (0.024)	**0.660***** (0.026)	**0.651***** (0.027)
$EDUMILEX_{t-5}$ (log)	-0.022 (0.018)	-0.001 (0.034)	0.002 (0.034)			
$EDUMILEX_{t-5}$ (log) squared		**-0.036**** (0.023)	-0.035 (0.023)			
$EDUMILEX_{t-5}$ (log) cubic		**0.009*** (0.005)	**0.009*** (0.005)			
$EDUMILEX_{t-8}$ (log)				0.004 (0.024)	0.023 (0.029)	0.031 (0.028)
$EDUMILEX_{t-8}$ (log) squared					**-0.081***** (0.019)	**-0.086***** (0.020)
$EDUMILEX_{t-8}$ (log) cubic					**0.025***** (0.004)	**0.026***** (0.005)
Military conscription			0.002 (0.013)			-0.034 (0.030)
Electoral Democracy Index	**0.732***** (0.019)	**0.732***** (0.018)	**0.727***** (0.018)	**0.680***** (0.024)	**0.660***** (0.026)	**0.651***** (0.027)
Constant	**2.493***** (0.175)	**2.510***** (0.171)	**2.454***** (0.173)	**2.943***** (0.229)	**3.168***** (0.246)	**3.149***** (0.257)
Groups	60	60	60	60	60	60
Obs.	846	846	846	673	673	673
R-squared within	0.7333	0.7349	0.7366	0.4937	0.5094	0.5141
R-squared between	0.9996	0.9995	0.9992	0.9998	0.9994	0.9986
R-squared overall	0.9951	0.9949	0.9949	0.9954	0.9949	0.9942
F-Stat	**841.94*****	**518.77*****	**414.99*****	**412.61*****	**228.13*****	**146.38*****

Notes: Robust standard error in parentheses. *** significant at 1%, **significant at 5%, *significant at 10%. For sake of readability statistically significant coefficients are in bold.

Table 5: Productivity and the EDUMILEX ratio

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Dependent variable	*Labor productivity (log)*	*Labor productivity (log)*	*Labor productivity (log)*	*Labor productivity (log)*	*Labor productivity (log)*	*Labor productivity (log)*
Labor productivity$_{-1}$ (log)	**0.759***** (0.017)	**0.760***** (0.017)	**0.752***** (0.016)	**0.660***** (0.028)	**0.639***** (0.031)	**0.627***** (0.032)
EDUMILEX$_{t-5}$ (log)	0.005 (0.018)	0.010 (0.033)	0.014 (0.033)			
EDUMILEX$_{t-5}$ (log) squared		-0.015 (0.020)	-0.012 (0.020)			
EDUMILEX$_{t-5}$ (log) cubic		0.004 (0.005)	0.004 (0.005)			
EDUMILEX$_{t-8}$ (log)				0.033 (0.021)	0.033 (0.028)	**0.044*** (0.025)
EDUMILEX$_{t-8}$ (log) squared					**-0.069***** (0.017)	**-0.075***** (0.017)
EDUMILEX$_{t-8}$ (log) cubic					**0.026***** (0.004)	**0.027***** (0.004)
Military conscription			-0.017 (0.106)			**-0.048*** (0.026)
Electoral Democracy Index			**0.161**** (0.068)			**0.187**** (0.081)
Constant	**2.462***** (0.163)	**2.466***** (0.134)	**2.430***** (0.166)	**3.445***** (0.283)	**3.694***** (0.317)	**3.705***** (0.330)
Groups	60	60	60	60	60	60
Obs.	846	846	846	673	673	673
R-squared within	0.8126	0.8129	0.8145	0.5042	0.5195	0.5264
R-squared between	0.9996	0.9997	0.9987	0.9992	0.9987	0.9962
R-squared overall	0.9947	0.9947	0.9940	0.9943	0.9936	0.9913
F-Stat	**1271.12*****	**748.30*****	**635.25*****	**285.97*****	**178.06*****	**116.15*****

Notes: Robust standard error in parentheses. *** significant at 1%, **significant at 5%, *significant at 10%. For sake of readability statistically significant coefficients are in bold.

Since the existing literature finds that the impact of military expenditures may differ between developed and developing economies (e.g., Kollias and Paleologou, 2019), it is hypothesized that the turning points of EDUMILEX could differ substantially between developing and developed countries. Splitting the sample gave the results in Table 7 and 8 for high-income and for middle- and low- income countries combined. These confirm the previous findings. In the two sub-samples, the cubic coefficient of EDUMILEX, eight-years lagged, is statistically significant.

In sum, regression results suggest that in middle- and low- income countries EDUMILEX needs to be considerably higher compared to high-income countries in order to trigger economic growth. It should be almost double if the dependent variable is GDP per capita, and around 65% higher if the dependent variable is labor productivity. EDUMILEX turning points are higher when controls are included in the regression in both sub-samples.

Figure 4 illustrates the implications of the results. Plotting GDP per capita (upper plot) and labor productivity (lower plot) in 2018 against EDUMILEX in 2010 and adding the regression lines for the high-income countries and the middle- and low-income countries, show a relatively close fit, with goodness of fit higher for labor productivity.

Table 6. Turning points of 8-year lagged EDUMILEX ratios

Country Type	*Dependent variable*	*Controls*	*EDUMILEX*
All countries	GDP per capita	No	7.39
High Income	GDP per capita	No	4.48
Middle and Low Income	GDP per capita	No	8.85
All countries	GDP per capita	Yes	7.46
High Income	GDP per capita	Yes	4.66
Middle and Low Income	GDP per capita	Yes	8.76
All countries	Labor productivity	No	4.44
High Income	Labor productivity	No	3.63
Middle and Low Income	Labor productivity	No	5.99
All countries	Labor productivity	Yes	4.53
High Income	Labor productivity	Yes	3.82
Middle and Low Income	Labor productivity	Yes	6.36

Notes: In column EDUMILEX the turning points of EDUMILEX ratio are highlighted beyond which economic performance, (namely GDP per capita and labor productivity) unambiguously increase.

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Table 7: Baseline results: High income countries

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Dependent variable	*GDP per capita (log)*	*GDP per capita (log)*	*GDP per capita (log)*	*GDP per capita (log)*	*Labor productivity (log)*	*Labor productivity (log)*	*Labor productivity (log)*	*Labor productivity (log)*
GDP per capitat-1 (log)	**0.678***** (0.025)	**0.679***** (0.026)	**0.635***** (0.032)	**0.639***** (0.032)				
Labor Productivity$_{t-1}$ (log)					**0.708***** (0.021)	**0.698***** (0.023)	**0.507***** (0.046)	**0.506***** (0.045)
EDUMILEX$_{t-5}$ (log)	0.008 (0.091)	0.010 (0.095)			0.067 (0.105)	0.068 (0.107)		
EDUMILEX$_{t-5}$ (log) squared	-0.127 (0.017)	-0.137 (0.082)			**-0.151*** (0.083)	**-0.161*** (0.082)		
EDUMILEX$_{t-5}$ (log) cubic	**0.046**** (0.004)	**0.049**** (0.020)			**0.058***** (0.020)	**0.062***** (0.019)		
EDUMILEX$_{t-8}$ (log)			0.061 (0.167)	0.090 (0.157)			-0.013 (0.245)	0.026 (0.225)
EDUMILEX$_{t-8}$ (log) squared			-0.209 (0.137)	**-0.240*** (0.134)			-0.140 (0.186)	-0.184 (0.172)
EDUMILEX$_{t-8}$ (log) cubic			**0.084**** (0.032)	**0.091***** (0.032)			**0.075*** (0.043)	**0.087**** (0.039)
Military conscription		0.005 (0.014)		-0.009 (0.023)		**-0.027**** (0.013)		-0.026 (0.019)
Electoral Democracy Index		**-0.145**** (0.063)		-0.118 (0.072)		-0.143 (0.092)		-0.167 (0.113)
Constant	**3.449***** (0.266)	**3.572***** (0.254)	**3.859***** (0.351)	**3.927***** (0.334)	**3.358***** (0.223)	**3.610***** (0.242)	**5.682***** (0.534)	**5.846***** (0.518)
Groups	406	406	325	325	406	406	325	325
Obs.	28	28	28	28	28	28	28	28
R-squared within	0.5927	0.5944	0.4926	0.4943	0.7213	0.7241	0.3926	0.3993
R-squared between	0.9923	0.9905	0.9944	0.9930	0.9980	0.9957	0.9893	0.9854
R-squared overall	0.9717	0.9698	0.9750	0.9735	0.9765	0.9732	0.9664	0.9615
F-stat	**210.71*****	**168.89*****	**144.68*****	**102.88****	**473.49*****	**352.60*****	**89.90*****	**107.41*****

Notes: Robust standard error in parentheses. *** significant at 1%, **significant at 5%, *significant at 10%. For sake of readability statistically significant coefficients are in bold.

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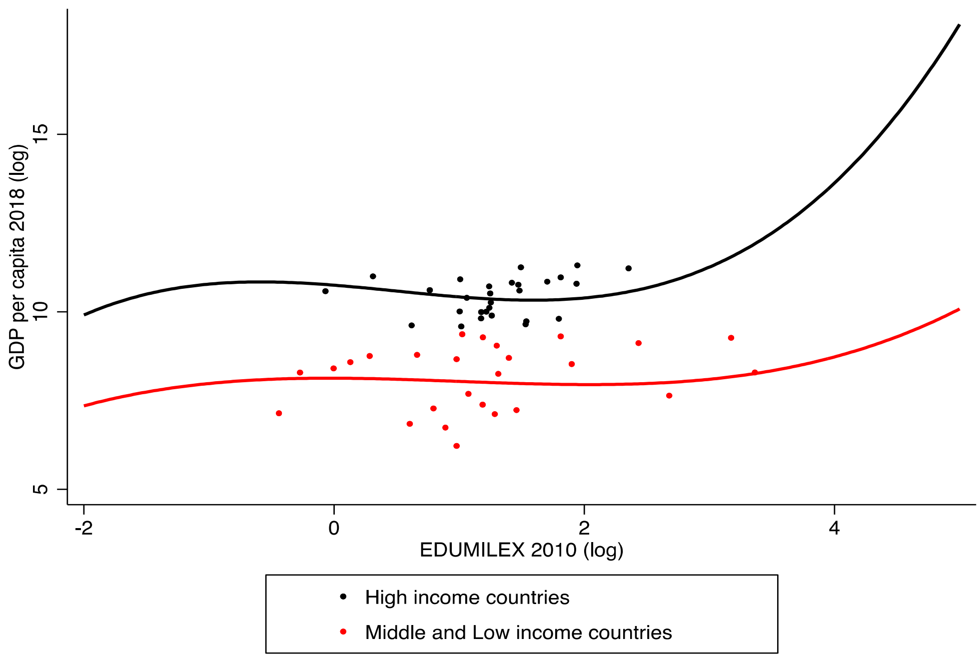
Table 8: Baseline results: Middle and low income countries

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Dependent variable	*GDP per capita (log)*	*GDP per capita (log)*	*GDP per capita (log)*	*GDP per capita (log)*	*Labor productivity (log)*	*Labor productivity (log)*	*Labor productivity (log)*	*Labor productivity (log)*
GDP per capitat-1 (log)	**0.747***** (0.023)	**0.736***** (0.023)	**0.667***** (0.033)	**0.641***** (0.041)				
Labor Productivity$_{t-1}$ (log)					**0.773***** (0.021)	**0.762***** (0.020)	**0.668***** (0.036)	**0.638***** (0.040)
EDUMILEX$_{t-5}$ (log)	0.005 (0.036)	0.009 (0.035)			0.016 (0.034)	0.022 (0.034)		
EDUMILEX$_{t-5}$ (log) squared	-0.033 (0.024)	-0.031 (0.023)			-0.016 (0.021)	-0.013 (0.020)		
EDUMILEX$_{t-5}$ (log) cubic	0.007 (0.005)	0.006 (0.005)			0.003 (0.005)	0.002 (0.004)		
EDUMILEX$_{t-8}$ (log)			0.026 (0.032)	0.046 (0.029)			0.036 (0.029)	**0.058**** (0.025)
EDUMILEX$_{t-8}$ (log) squared			**-0.088***** (0.022)	**-0.105***** (0.023)			**-0.077***** (0.019)	**-0.096***** (0.019)
EDUMILEX$_{t-8}$ (log) cubic			**0.025***** (0.005)	**0.029***** (0.006)			**0.025***** (0.005)	**0.029***** (0.005)
Military conscription		-0.012 (0.039)		**-0.142***** (0.033)		-0.001 (0.029)		**-0.139**** (0.021)
Electoral Democracy Index		**0.203***** (0.069)		**0.258***** (0.083)		**0.230***** (0.065)		**0.307***** (0.078)
Constant	**2.086***** (0.183)	**2.060***** (0.190)	**2.733***** (0.280)	**2.867***** (0.332)	**2.084***** (0.182)	**2.047***** (0.177)	**3.043***** (0.325)	**3.203***** (0.362)
Groups	440	440	348	348	440	440	348	348
Obs.	32	32	32	32	32	32	32	32
R-squared within	0.7829	0.7866	0.5257	0.5428	0.8418	0.8449	0.5693	0.5864
R-squared between	0.9987	0.9966	0.9983	0.9826	0.9990	0.9947	0.9984	0.9748
R-squared overall	0.9867	0.9850	0.9867	0.9707	0.9862	0.9826	0.9855	0.9622
F-stat	**398.89*****	**341.05*****	**211.33*****	**160.18*****	**551.43*****	**520.50*****	**190.20*****	**222.01*****

Notes: Robust standard error in parentheses. *** significant at 1%, **significant at 5%, *significant at 10%. For sake of readability statistically significant coefficients are in bold.



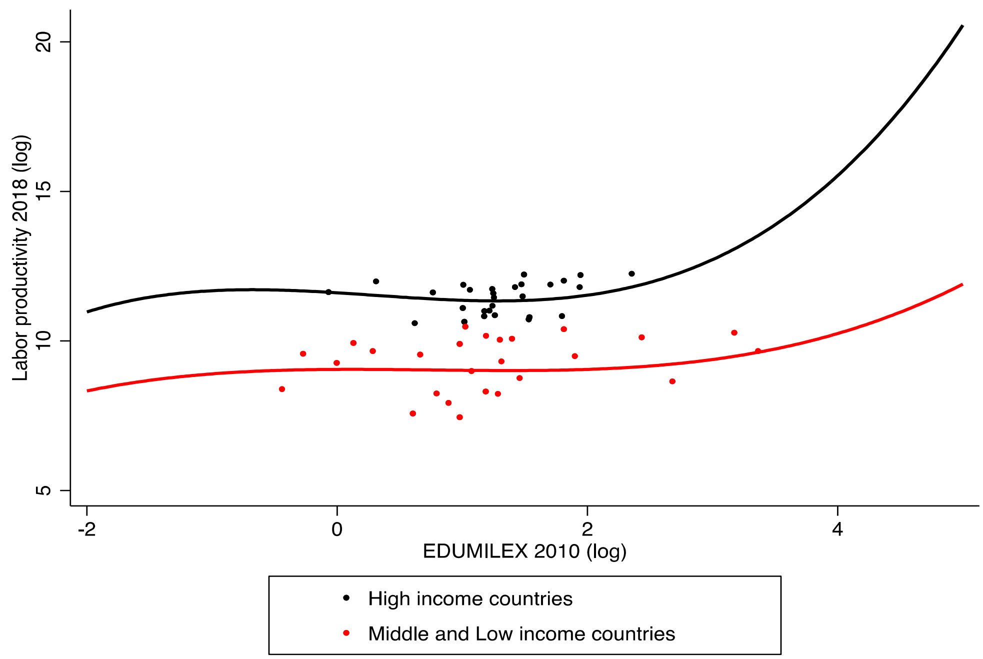


Figure 4: GDP per capita 2018 and labor productivity 2018 against EDUMILEX ratio

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Conclusion

The aim of this article was to propose a target variable for a peaceful economic policy based on the evidence that education and military expenditures are countervailing factors in securing long-run growth. The key implication from a policy perspective is that appropriately balancing investments in education and the burden of unproductive military spending is a first-order importance for positive economic performance in the long-run. In order to analyze that, the ratio between public investment in education and military expenditures, here named EDUMILEX, was employed as the relevant variable to capture the impact of such balance on economic growth over time. The findings of the empirical analysis show a non-linear relationship between the EDUMILEX ratio and both GDP per capita and labor productivity. In particular, the results suggest that a cubic relation exists between GDPs per capita and the EDUMILEX ratio. This means that for very low levels of EDUMILEX, an increase of the ratio will result in increased GDP per capita until a turning point—after which GDP per capita decreases. Eventually however, beyond a further turning point, an additional increase of EDUMILEX ratio generates further GDP per capita growth.

From a policy perspective, it is reasonable to consider the minimum turning point of the function derived from the regression as a target variable for economic policy. In fact, when considering GDP per capita as the dependent variable and EDUMILEX eight years lagged, the computed target variable is 4.5 for high-income countries and 8.9 for middle- and low-income countries. When labor productivity is considered, the target variable computed is 3.8 for high-income countries and 6.3 for middle- and low-income economies. Looking at current data, it is clear that several developed economies appear to be far from such values.

Needless to say, this work cannot be considered as conclusive evidence, but it does provide a point of departure for future research intended to provide policymakers with a workable set of instruments for peaceful economic policy.

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