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Asymmetric effects of long-term war on human resource development in Af…ghanistan: evidence from NARDL approach

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Abstract

This study explores the effects of war on human resource development in Afghanistan using non-linear autoregressive distributed lags (NARDL) and asymmetric causality analysis. The results of the NARDL bound test support an asymmetric long-run relationship between predictors. It reveals that positive and negative shocks from the per capita cost of war, child mortality rate, and population growth rate asymmetrically affect the school enrollment rate in both the short and long runs. Furthermore, it shows that positive shocks from per capita GDP and per capita government expenditures on education increase the school enrollment rate, while their negative shocks have adverse effects, in both the short and long runs. This implies that school enrollment is highly sensitive to changes in the per capita cost of war and reacts swiftly. Moreover, the results reveal significant causality from both the positive and negative components of the per capita cost of war, per capita GDP, per capita government expenditures on education, and population growth to both the positive and negative components of the school enrollment rate. However, there is only a causal nexus from the negative component of the child mortality rate to the school enrollment rate. Based on these findings, relevant policy implications are discussed.

Keywords Asymmetric · Afghanistan · NARDL · War · Human resource development

JEL Classification A2 · B23 · I25

Abbreviations

HRD	Human resource development
QLD	Queensland
ADF	Augmented Dickey–Fuller
ARDL	Autoregressive distributed lags
AIC	Akaike information criterion
NARDL	Non-linear autoregressive distributed lags
GDP	Gross domestic product
HQIC	Hannan–Quinn information criterion

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WDI	World development indicators
ADB	Asian development bank
PP	Phillips–Perron
WB	World Bank
SER	School enrollment rate
SIC	Schwarz information criterion
COW	Per capita cost of war
PGDP	Per capita gross domestic product
GEE	Per capita government expenditure on education
PGR	Population growth rate
CMR	Child mortality rate

1 Introduction

Since the end of World War II, major political powers worldwide have generally experienced relative peace, while the developing world has often been marred by violence and high insecurity (Kang and Meernik 2005). The achievement of peace in some regions has been commendable, but it has often come at a significant cost (Gentry 2008). According to Licklider (Licklider 2006), there were 213 interstate wars between 1816 and 1997, with 104 occurring from 1944 to 1997. Additionally, more than 90 civil wars have been recorded from 1945 to 2007, with 20 still ongoing today. The destructive nature of war not only devastates the social and economic infrastructure of nations but also exacts a heavy toll on governments and civilians alike (Djankov and Reynal-Querol 2010). Afghanistan stands as a stark example of prolonged conflict, witnessing immense social and economic devastation over the past four decades. Apart from the destruction of physical infrastructure, the war has resulted in millions of deaths and injuries, internal displacements, and significant loss of private investments (Ritchie 2021). The prolonged civil wars have led to an exodus of both educated individuals and investors from Afghanistan. For instance, between 2015 and 2019, Afghanistan experienced over 1000 armed attacks targeting teachers, students, and educational institutions, making it one of the most war-affected nations globally (Barr 2022). These conflicts have had a profound impact on the school enrollment ratio, with female students, a significant portion of potential human capital in Afghanistan, bearing a particularly heavy burden due to the ban on secondary education. Moreover, the loss of a substantial number of professors, teachers, and the collapse of numerous private schools and higher education institutions have further exacerbated the situation.

Thus, it is crucial to provide empirical insight into the magnitude and effects of long-term war on human capital development in Afghanistan. The existing literature contains a wealth of empirical studies analyzing the impact of war on various socioeconomic indicators across different countries. For instance, Karimi and Shafaee (2018) and Waterbury (2019) for Syria; Capasso (2020), Nyere (2020), and Zoubir (2020) for Libya; Elayah and Verkoren (2020), Ruggiero (2019), and Sharp (2020) for Yemen; Šlaus et al. (2007) and Susić et al. (2014) for Croatia; Liyanag and Jayawardena (2013), Wakkumbura and Wijegoonawardana (2017), and Yusoff and Sarjoon (2017) for Sri Lanka; Hovorun (2020) and Stukalo and Simakhova (2018) for Ukraine; and Serneels and Verpoorten (2015) for Rwanda. However, studies in the context of Afghanistan are scarce, if not entirely nonexistent. This scarcity has resulted in two primary shortcomings. First, the descriptive analytical reports on the status and impacts of war on socioeconomic indicators have led to ambiguous conclusions about Afghanistan (see, for instance, Skovdal et al. 2014; O'Leary et al. 2018; Panter-Brick et al. 2009a). Second, the absence of comprehensive studies has left us with limited knowledge about the scale and magnitude of the effects of long-term war on human resource development in Afghanistan. To address these existing gaps and broaden the scope of our analysis on the effects of long-term war on human resource development, the key objectives of the present study are framed as the following contemporary research questions: First, is long-term war associated with human resource development in Afghanistan? Second, does long-term war have an asymmetrical short-run and long-run effect on human resource development? Third, does long-term war asymmetrically cause human resource development in Afghanistan? Providing rational and evidence-based answers to these questions will not only assist policymakers but also establish a solid foundation in the literature on Afghanistan's war-human resource development nexus.

This study is unique in the existing literature on the effects of war on human resource development in Afghanistan, and its contributions are threefold. First, distinctively and unlike most recent studies, this research delves into quantitative analysis, enabling us to determine the precise effects of war on human resource development in Afghanistan. Second, innovatively, the study employs the asymmetric ARDL model to explore the short-run and long-run asymmetric effects of war predictors on human resource development, thus revealing both the scale and magnitude of these asymmetries and allowing for the presentation of consistent and accurate results. Third, it builds on foundational literature by assessing the concurrent and residual effects of war on socioeconomic predictors in Afghanistan during and after the war period. Among others, three findings emerge as particularly significant. First, the study reveals that war asymmetrically correlates with human resource development, impacting it differently in the short and long runs. Second, statistical evidence supports the hypothesis that war has both concurrent and long-run effects on human resource development in Afghanistan, thus aligning with the theoretical expectation of war's negative impact on socioeconomic indicators. Third, intriguingly, the study also finds that both the positive and negative components of war significantly cause human resource development in Afghanistan.

The remaining sections of this article are structured as follows: Section two presents a brief theoretical review of the subject and reviews the available empirical literature on the effects of war on human resource development. Section three describes the data and variables used in the study. Section four explains the methodology employed for data analysis. Section five presents the results and provides a thorough discussion. Section six outlines the practical contributions of the study. Finally, section seven concludes the article and offers both general and specific policy recommendations.

2 Literature review

2.1 Theoretical review

The study of war encompasses various definitions and theoretical perspectives that shed light on its complex nature and multifaceted impacts on societies. War, as a concept, holds diverse definitions across disciplines. It is commonly understood as a state of armed conflict among different groups of people within or between two or more countries, driven by political, economic, and hegemonic motives (McNeill and Mueller 1990). Arreguín-Toft (2001) contributes significantly to this understanding by providing a comprehensive framework for civil wars. He delineates the dynamics between governments, often representing the "on-power-side," and rebel groups, the "off-power-side," each vying for control and dominance. These conflicts are not merely clashes of military might but intricate power struggles with profound societal implications. Despite the evolution of warfare through technological advancements, the fundamental nature of war as a societal tragedy remains unchanged (Moosa 2019). From the grand strategies of global superpowers to the insurgencies of rebel factions, the devastation wrought by war reverberates across generations, leaving scars on landscapes and psyches alike (Kersnovski 2021). The effects of war on human resource development are far-reaching and multifaceted. The process of developing human resources begins with access to education, ranging from primary schooling to advanced technical and higher education. Interstate wars disrupt this process profoundly, leading to the destruction of economic, social, and technological infrastructures (Collier et al. 2004). The consequences are stark: loss of lives, internal displacement, and the flight of skilled individuals from war-torn regions (Hameed et al. 2023). Children are often the most vulnerable victims, with their education disrupted or denied entirely (Justino & Verwimp 2013). This loss of educational opportunities not only hampers immediate development but also undermines the long-term growth potential of nations (Anyanwu 2002). However, amid the devastation, wars have also been known to spur industrial advancement and economic growth in certain contexts. The need for rapid production of goods and services for the war effort can stimulate technological innovation and infrastructure development (Grossman & Helpman 1994). In post-conflict settings, reconstruction efforts often lead to a surge in construction, manufacturing, and service industries, albeit with considerable challenges in governance and equity (Lis 2018). Additionally, economic theories offer varied perspectives on the duration and extent of war's effects on human capital. Neoclassical growth theory, a cornerstone of economic thought, posits that economies possess inherent mechanisms for recovery and return to their long-term growth paths (Solow 1956). In this framework, the loss of human capital during war is seen as a temporary setback, with economies adjusting through investment in education and technology (Acemoglu 2012; Surya et al. 2021). Contrastingly, alternative models suggest that the recovery from war-induced human capital loss may be prolonged and arduous. Factors such as institutional fragility, social unrest, and persistent conflict dynamics can impede the restoration of human capital (Shemyakina 2011). Nations caught in cycles of violence and instability may find themselves trapped in low-level equilibria, where the loss of human capital perpetuates further conflict (Collier & Hoeffler 1998). Consequently, war is a multifaceted phenomenon with profound implications for human resource development and economic stability. Understanding its theoretical underpinnings is crucial for devising effective strategies to mitigate its negative impacts and promote sustainable peace and development. As such, a multidisciplinary approach that considers the social, economic, and political dimensions of war is essential for comprehending its complexities and crafting informed policies.

2.2 Empirical review

The empirical literature extensively documents the multifaceted impacts of long-term war on various socioeconomic indicators. Traditional measurements of war effects often encompass monetary costs, the economic toll of war, lost productivity, as well as the psychological, human, and societal tolls, including the number of casualties, wounded individuals, and displaced populations. However, there is a noticeable gap in the literature concerning complex methodological studies specifically examining the effects of war on human resource development. Despite a gradual decline in the trend of global warfare over the past two centuries, the prevalence of civil wars has shown a rapid upward trajectory in the last four decades (Yum and Schenck-Hamlin 2005). Civil conflicts, in particular, have a profound impact on the working-age population and consequently, on the human resource development processes within affected economies (Gleditsch 2004). A seminal work by Iden (1971) explored the implications of war on human capital in the context of Vietnam. The author argued that war serves as a quintessential example of the disinvestment in human capital, resulting not only in individual and societal costs borne by citizens and the military but also in the diversion of resources away from essential investments in human development, such as education, health, training, and strategic geographic deployments. Further research by Sunder (2004, 2006) delved into the significant suppression of overall strategies pertaining to human capital development in developing economies affected by armed conflicts. These strategies, often integral to a nation's agenda for growth and development, face considerable adversities in the wake of civil wars and conflicts. The diversion of resources, disruptions to educational systems, and the flight of skilled individuals all contribute to a diminished capacity for human capital accumulation, thereby hindering long-term socioeconomic development.

Lai and Thyne (2007) examined the negative effects of war on education expenditure and enrollment rates. They considered two causal mechanisms: war's destructive effects on the education system through loss of human capital and infrastructure, and the increase in funds to cover military expenditures. Using a UNESCO dataset from 1980 to 1997, they found that war has a negative effect on the education system and enrollment rate. However, no statistical evidence was provided to indicate the adverse effects of budget reallocation from education to military operations. Merrouche (2011) utilized district-level data in Cambodia to evaluate the long-run effects of civil war on human capital. Employing the difference-in-differences and instrumental variable estimators' methods, the study found weak overall effects of war on human capital, as proxied by school students. However, these results were confounded by specification and measurement biases. Diwakar (2015) employed a dataset relevant to Iraq's household socioeconomic indicators to assess the impact of long-term war on the education process. The study found a strong correlation between war and the education of both boys and girls. However, the negative impact of war was significantly higher on boys, who were more exposed to war proliferation. Similarly, Dabalen and Paul (2014) examined the effects of war on years of schooling in Côte d'Ivoire, using the difference-in-difference method to analyze data relevant to all aging cohorts. The study found a drop in average years of education ranging from 0.2 to 0.9 fewer years. They further documented that the effects of war were extensive on males between 19 and 22 years of age. Furthermore, Swee (2015) investigated the effects of war on educational achievement in Bosnia between 1992 and 1995, examining probable mechanisms of influence. Using regional variation in conflict intensity and birth cohort variation, the study found that cohorts experiencing higher war intensity were less likely to complete secondary schooling, though primary schooling was not affected. These impacts were more pronounced in males than in females, and draftee male cohorts exhibited worse physical and mental health than female and non-draftee cohorts. Studies by Gat (2015) and Johnson (2017) revealed that armed conflicts impose serious limitations on accessing education, forcing affected governments to focus on poverty alleviation rather than developing human resource capacities for producing high-quality economic goods and rendering necessary services for human welfare. Furthermore, Gurses (2015) stated that human resource development plays a significant role in the nation-building process in war-affected countries, encompassing basic, secondary, and higher education, trainings, capacity building, and cultural advancement. Ouili (2017) investigated the effects of war and political instability in Ivory Coast, using a nationally representative household dataset. By examining temporal and geographic variations in Ivorian political instability from 1999 to 2011, the study determined its causal effect on children's schooling and mortality. The author found that individuals in conflict zones during the era of instability had a 10% reduced chance of enrolling in school, and students attending school during the conflict faced a one-year gap in their educational attainment.

Weldeegzie (2017) examined the long-run effects of war on childhood well-being and schooling outcomes in Ethiopia, using child-level panel data and the difference-in-difference method. The study found that children exposed to war had one-third standard deviation lower height and a 12% higher incidence of childhood impedance. Exposed children were less likely to be enrolled in school, completed fewer grades, and showed more reading complications. Safranchuk et al. (2020) evaluated the perceptions of high-ranking participants and witnesses of the war in Afghanistan from 1979 to 1989, using historical descriptive data. The study presented a holistic view, defined as a patriotic perception and its elements, indicating the key peculiarity of the formation and support of interpretations of current international events to rationalize a positive valuation of the long-run war in Afghanistan. Moreover, Juárez et al. (2020) noted in their study that the flight of human capital is the most costly aspect of war in terms of both money and time in a country. Education, fundamental to human resource development, requires simultaneous investments in time and money. However, war often necessitates the reallocation of budgets from education to military operations. Mayai (2022) estimated the causal impact of war on school enrollment as a proxy for gauging human capital in Sudan, using regional variance in exposure to violence. Employing the difference-in-differences method, the author found a statistically significant link between school enrollment rate and war. Schools in South Sudan's combat zones lost 18.5 percent of their entire enrollment. The decline in girls' enrollment was not connected to the war, likely due to sociocultural constraints such as gendered domestic responsibilities, early marriage, and out-of-wedlock pregnancies. Lastly, O'Brien (2022) assessed the residual effects of armed conflicts on human capital flight, using logistic regressions and Tajikistan's 2007 living standards dataset. The author found that war mortalities were insignificant in impacting successive human capital flight, while the relationship between development and conflict was significant and negative. Table 1 provides additional highlights from recent empirical literature on the effects of war on human capital.

2.3 Insights from empirical review

The review of the state of the art reveals a consensus on the empirical effects of civil wars on the school enrollment rate, human capital flight, diminishing opportunities for human capital development, and the loss of resources. These factors, either individually or collectively, impose substantial costs on an economy, leading to a prolonged recovery period beyond initial expectations. In terms of the literature's focus, existing studies primarily conduct country-specific analyses, emphasizing the consequences of civil wars on economic growth, factors of production, gender dynamics, schooling, and capital flight (see, for example, Shemyakina 2011; Gat 2015; Johnson 2017; Ouili 2017; Juárez et al. 2020; O'Brien 2022). Regarding the analytical approach, while informative-based studies

Table 1 Summary of some relevant literature

Authors' name and year of publication	Study context	Methods	Key findings
Miguel et al. (2004)	Panel of African countries	Instrumental variables regression model	The authors found that civil armed conflicts have a significant negative impact on the macroeconomic indicators, especially on growth
Shemyakina (2011)	Tajikistan	Survey-based analysis	War has a significant impact on female student's enrollment rate
Chamarbagwala and Morán (2011a, b)	Guatemala	Difference in difference model	The authors found strong negative effects of war on the education of the two most disadvantaged groups, namely rural Mayan males and female
Miguel and Roland (2011)	Vietnam	Cross-sectional regression analysis	The authors argue that heavy armed conflict, such as bombing, did not generate local poverty traps in Vietnam
León (2012)	Perú	Regression analysis	The authors exploited the variation in conflict location and birth cohorts to identify the short and long-run effects of war on educational attainment. They found that in the short term, the effects are stronger than in the long run
Serneels and Verpoorten (2015)	Rwanda	Micro-data analysis	The authors found that by distinguishing between war and genocide, the returns to a steady state, and by implication, correlate with the intensity of war and violence
O'Leary et al. (2018)	Afghanistan	Descriptive analysis	The authors provided descriptive analysis on the negative effects of long-run war on the middle age children of primary schools
Capasso (2020)	Libya	Descriptive analysis	The author observes that war has a significant negative impact on socioeconomic indicators, following Libya's slow shift from a progressive revolutionary state to a comprador state and a staging ground for global class warfare

constitute a significant portion of the literature, there has been a noticeable increase in empirical analyses over the past decade. Various studies have employed subject-specific proxies for war, indicating a divergence from a unanimous consensus on the ideal war proxies. Lastly, a critical observation from the state of the art is the apparent scarcity of relevant empirical studies analyzing the effects of war on human capital development in Afghanistan, despite the country's enduring status as the site of one of the longest civil wars.

3 Data and variables

This study utilizes a set of time-series data covering the period from the third quarter of 2002 to the first quarter of 2020, focusing on Afghanistan. The datasets were sourced from the World Development Indicators of the World Bank Group and the US Department of Defense Budget. The chosen variables align with the theoretical framework and findings of recent studies (Ali 2004; Umeh 2008; Maqbool 2017; Hassan et al. 2019): School Enrollment Rate (SER) as the dependent variable, Per Capita Cost of War (PCW), Per Capita Gross Domestic Product (GDP), and Per Capita Government Expenditure on Education (GEE) as the independent variables, and Population Growth Rate (PGR) and Child Mortality Rate (CMR) as control variables. The school enrollment rate functions to gauge the gross enrollment of children in primary schools across a country, reflecting the fundamental efforts towards human resource development, particularly crucial in post-conflict nations like Afghanistan, where social development is integral to the nation-building process. Recent studies (Oketch 2006; Mohamed 2020; Harry and Emeh 2021) have utilized various proxies for human resource development, including budget allocation for education, training, capacity building, and enrollment in secondary and higher education. The cost of the war quantifies the United States' expenditures in Afghanistan from 2002 to 2020. Due to limited data availability, the cost of war presents aggregate figures for Afghanistan without provincial disaggregation, despite differing war intensities across provinces during the study period. Notably, this proxy offers two distinct advantages over previous proxies: it allows for more precise estimation than casualties, and it furnishes actual expenditure data on military operations. Gross Domestic Product (GDP) tracks changes in total costs, investments, and expenditures over time, providing a control measure for the effects of GDP fluctuations on human resource development. Theoretically, human capital is believed to correlate with aggregate production, encompassing education, training, and capacity-building efforts within a nation (Keji 2021; Matousek and Tzeremes 2021; Oketch 2006). Government expenditure on education quantifies the national investment in education. While a substantial portion of Afghanistan's budget was funded by the United States and its allies, some expenditures originated from the country's national income. This variable is included separately in the analysis to avoid potential omitted variable bias. Finally, the population growth rate indicates the annual population change and is used to capture its direct and indirect effects on human resources. Existing literature indicates that population growth significantly influences human resource development (Adeosun and Popogbe 2021).

The data presented in Table 2 provides key highlights of the variables under consideration. Along with the descriptions of these variables, it reveals that the average school enrollment rate is 44.07%, reaching a maximum of 57% in the first quarter of 2020. The per capita cost of war stands at 9.27 million US dollars, with a minimum of 4.14 million US dollars and a maximum of 19.43 million US dollars. Over the same period, per capita GDP rose from $330 to $587. Additionally, summary statistics indicate an

Table 2 Variables and summary statistics

Variable	Symbol	Measurement	Summary statistics				
			Mean	SD	Min	Max	Obs
School enrollment rate	SER	Annual (%)	44.07	13.89	13.00	57.00	73
Per capita cost of war	COW	USD	9.27	5.69	2.14	19.43	73
Per capita GDP	PGDP	Constant USD	487.77	96.55	330.30	587.56	73
Per capita government expenditure on education	GEE	Total GEE (%)	3.81	1.17	1.05	5.23	73
Child mortality rate	CMR	Per 1000 children	4.90	1.12	3.10	6.20	73
Population growth rate	PGR	Annual (%)	3.02	0.64	2.30	4.70	73

Sample size adjusted from 2002Q3 to 2020Q1

Std. Dev. standard deviation, *Min.* minimum, *Max* maximum, *Obs* number of observations, *USD* United States dollars, *GEE* Government expenditure on education

upward trend in population growth and child mortality rates, while per capita government expenditure on education also increased proportionately from 1.05% to 5.23%. Considering the similar trends observed among the predictors in the initial descriptive statistics, it is crucial to examine their correlations before proceeding with model specification (O'Brien 2007). Hence, the results of the correlation matrix are presented in Table 3.

These results reveal both positive and negative weak correlations among the predictors, suggesting that there is no perfect or extreme correlation between the variables. This supports the decision to proceed with the model specification (Farrar and Glauber 1967).

Table 3 Correlation analysis

Variables	SER	COW	PGDP	GEE	CMR	PGR
SER	1.00					
COW	0.45	1.00				
PGDP	0.26	0.29	1.00			
GEE	0.59	0.54	0.20	1.00		
CMR	0.14	− 0.22	0.27	− 0.28	1.00	
PGR	0.11	− 0.11	− 0.40	− 0.48	0.38	1.00

Sample size adjusted from 2002Q3 to 2020Q1

SER school enrollment rate, *COW* per capita cost of war, *PGDP* per capita GDP, *GEE* Government expenditure on education, *CMR* child mortality rate, *PGR* population growth rate

4 Methods

This section outlines the econometric methods used to examine the asymmetric effects of long-term war on human resource development in Afghanistan. To capture these effects accurately and consistently, the following sub-sections detail the sequential econometric models used to test the competing hypotheses.

4.1 Unit root test

In time-series analysis, initiating the estimation with a unit root analysis is essential (Smeekes and Wijler 2020). This step helps in determining the integrating order of the predictors, thereby avoiding model misspecification. Particularly, when the null hypothesis of symmetries is rejected (as shown in Table 8), conventional unit root tests assuming linearity may yield biased results. Hence, this study employs Kapetanios and Shin's (2008) unit root test, utilizing the technique proposed by Otero and Smith (2017). This method is considered superior as it accounts for the non-linearity of the series when testing the null hypothesis of non-stationarity of a variable (Olaniyi et al. 2022). Furthermore, to capture the true stationarity properties of the variables and account for any potential breaks, the study employs the Augmented Dickey-Fuller model of generalized least squares, as proposed by Elliott-Rothenberg-Stock (1992).

4.2 Cointegration test

To examine the long-run relationship among the predictors, this study employs the ARDL (Autoregressive Distributed Lags) bound test to cointegration model proposed by Pesaran et al. (2001). This method is suitable when there are structural breaks in the data (Bist and Bista 2018). Therefore, the ARDL bound test equation can be expressed as:

$$\begin{aligned}\Delta SER_t &= \phi_{SER}SER_{t-1} + \phi_{COW}COW_{t-1} + \phi_{RGDP}RGDP_{t-1} \\ &+ \phi_{GEE}GEE_{t-1} + \phi_{CMR}CMR_{t-1} + \phi_{PGR}PGR_{t-1} + \varpi k_t \\ &+ \sum_{i=1}^{u-1} \vartheta_{iSER}\Delta SER_{t-i} + \sum_{i=0}^{v-1} \vartheta_{iCOW}\Delta COW_{t-1} + \sum_{i=0}^{v-1} \vartheta_{iRGDP}\Delta RGDP_{t-1} \\ &+ \sum_{i=0}^{v-1} \vartheta_{iGEE}\Delta RGEE_{t-1} + \sum_{i=0}^{v-1} \vartheta_{iCMR}\Delta CMR_{t-1} \\ &+ \sum_{i=0}^{v-1} \vartheta_{iPGR}\Delta PGR_{t-1} + \varepsilon_t\end{aligned} \tag{1}$$

where the change sign Δ is the first difference operator, ϕ is the long-run coefficient, ϑ_i is the short-run coefficient, ϖ presents the trend coefficient,ε is the error term of the model, and all other variables hold the same meaning as described before. The optimal lag length is selected using the AIC, SIC, and HQIC methods. Equation (1) is cointegrated if it rejects the null hypothesis of $\phi_{SER} = \phi_{COW} = \phi_{RGDP} = \phi_{GEE} = \phi_{CMR} = \phi_{PGR} = 0$ jointly or separately as $\phi_{SER} = 0$ and $\phi_{COW} = 0$, $\phi_{RGDP} = 0$, $\phi_{GEE} = 0$, $\phi_{CMR} = 0$, and $\phi_{PGR} = 0$, using the F-statistics. The null hypothesis is rejected if the F-statistics exceed the upper bound I(1) critical value, while it cannot be rejected if it falls below the lower bound I(0) critical value. If the F-statistics lie between the lower and upper bound critical values, the test is inconclusive about the null hypothesis. The ARDL bound test offers two primary advantages over other common cointegration methods. First, it does not necessitate all predictors to have the same integrating order. Second, it provides efficient and accurate results even with small samples.

4.3 NARDL model

Based on the study's objective, a non-linear approach is employed to capture the parametric relationship of both the short- and long-run asymmetries of the long-term war effects on human resource development. Assuming that the predictors exhibit mixed integrating orders of I(0) and I(1) without any I(2) series (Kisswani 2017), this study utilizes the non-linear ARDL (NARDL) model proposed by Shin et al. (2014) to capture potential asymmetric effects of negative and positive changes in the predictors. Furthermore, the NARDL model is applied to investigate non-linear shifts from short- to long-run effects, aligning with the theoretical assumption of asymmetries in civil wars developed by Arreguín-Toft (2001). This theory predicts that outcomes of asymmetric wars are influenced by factors such as the power of the war actors, the type and technology of weapons used, and the international support received. The interaction of these factors does not exhibit symmetries, making linear models inappropriate. Therefore, Eq. (1) is adjusted to incorporate the long-run asymmetric components of the per capita cost of war and the explanatory variables as follows:

$$\begin{aligned} SER_t = {} & \phi^+ COW_t^+ + \phi^- COW_t^- + \phi^+ RGDP_t^+ + \phi^- RGDP_t^- + \phi^+ GEE_t^+ \\ & + \phi^- GEE_t^- + \phi^+ CMR_t^+ + \phi^- CMR_t^- + \phi^+ PGR_t^+ + \phi^- PGR_t^- + u_t \end{aligned} \tag{2}$$

where ϕ^+ and ϕ^- are the partial sum of positive and negative changes in the explanatory variables. ϕ^+ and ϕ^- are augmented in the model by the function, say, $COW_t = COW_t + COW_t^+ + COW_t^-$ using the following framework:

$$COW_t^+ = \sum_{j=1}^{t} \Delta COW_j^+ = \sum_{j=1}^{t} \max(\Delta COW_j, 0), \;\; COW_t^- = \sum_{j=1}^{t} \Delta COW_j^- = \sum_{j=1}^{t} \min(\Delta COW_j, 0) \tag{3}$$

where linear stationarity, say, I(0) combination (ω_i) of Eq. (2) and the asymmetric partial sum of squares would be expressed as:

$$\begin{aligned} \omega_i = k = {} & \varphi_1^+ SER_t^+ + \varphi_2^- SER_t^- + \phi_1^+ COW_t^+ + \phi_2^- COW_t^- + \phi_3^+ RGDP_t^+ + \phi_4^- RGDP_t^- \\ & + \phi_5^+ GEE_t^+ + \phi_6^- GEE_t^- + \phi_7^+ CMR_t^+ + \phi_8^- CMR_t^- + \phi_9^+ PGR_t^+ + \phi_{10}^- PGR_t^- + u_t \end{aligned} \tag{4}$$

and stationarity is achieved if $\omega_i = I(0)$ with a long-run asymmetric cointegration for the rejected null hypothesis of $\varphi_1^+ = \varphi_2^- = \phi_1^+ = \phi_2^- = \phi_3^+ = \phi_4^- = ... = 0$. Moreover, to overcome the potential multicollinearity issues in Eqs. (2) and (4), their dynamic forms are rational to address them before analysis. Therefore, Eqs. (2) and (4) can be adjusted as:

$$SER_t = \sum_{i=1}^{p} \eta un_{t-i} + \sum_{i=1}^{q} \begin{pmatrix} \varphi_1^+ COW_t + \varphi_2^- COW_t + \varphi_3^+ RGDP_t + \varphi_4^- RGDP_t + \varphi_5^+ GEE_t \\ +\varphi_6^- GEE_t + \varphi_7^+ CMR_t + \varphi_8^- CMR_t + \varphi_9^+ PGR_t + \varphi_{10}^- PGR_t \end{pmatrix} + u_t \tag{5}$$

where η and $(\varphi_1 - \varphi_{10})$ are the autoregressive and dynamic adjusting parameters, which incorporate the cointegration dynamics. Therefore, based on the above and in line with the context of this study, the NARDL model of Shin et al. (2014) can be written as:

$$\begin{aligned} \Delta SER_t = {} & \rho SER_{t-1} + \phi_1^+ COW_t^+ + \phi_2^- COW_t^- + \phi_3^+ RGDP_t^+ + \phi_4^- RGDP_t^- + \phi_5^+ GEE_t^+ + \phi_6^- GEE_t^- \\ & + \phi_7^+ CMR_t^+ + \phi_8^- CMR_t^- + \phi_9^+ PGR_t^+ + \phi_{10}^- PGR_t^- + \sum_{i=1}^{p} \delta_i SER_{t-1} + \sum_{i=0}^{q} \vartheta_{i,1}^+ \Delta COW_{t-i}^+ \\ & + \sum_{i=1}^{q} \vartheta_{i,2}^- \Delta COW_{t-i}^- + \sum_{i=1}^{q} \vartheta_{i,3}^+ \Delta RGDP_{t-i}^+ + \sum_{i=1}^{q} \vartheta_{i,4}^- \Delta RGDP_{t-i}^- + \sum_{i=1}^{q} \vartheta_{i,5}^+ \Delta GEE_{t-i}^+ \\ & + \sum_{i=1}^{q} \vartheta_{i,6}^- \Delta GEE_{t-i}^- + \sum_{i=1}^{q} \vartheta_{i,7}^+ \Delta CMR_{t-i}^+ + \sum_{i=1}^{q} \vartheta_{i,8}^- \Delta CMR_{t-i}^- + \sum_{i=1}^{q} \vartheta_{i,9}^+ \Delta PGR_{t-i}^+ + \sum_{i=1}^{q} \vartheta_{i,10}^- \Delta PGR_{t-i}^- + u_t \end{aligned} \tag{6}$$

where all the variables are explained before, $\phi^+(\phi^-)$ are the long-run coefficients, $\vartheta^+(\vartheta^-)$ are the short-run coefficients, and u is the error term of the model. Equation (6) is designed to estimate both short-term and long-run asymmetric effects, aligning with the study's objectives. Additionally, this study explores how human resource development responds to dynamic asymmetric shocks from the war in the long run, utilizing the dynamic multiplier approach. The dynamic multiplier serves to accelerate the sequential growth element as it transitions from environments of previous short-term dynamics and early instabilities into a new equilibrium following a standard shock. The equation employed is expressed as:

$$mh^+ = \sum_{i=0}^{h} \frac{\partial(SER_t)}{\partial(x_t^+)} = \sum_{i=0}^{h} \varphi_i^+, \; mh^- = \sum_{i=0}^{h} \frac{\partial(SER_t)}{\partial(x_t^-)} = \sum_{i=0}^{h} \varphi_i^- \tag{7}$$

where SER is the dependent variable; $x_t^+(x_t^-)$ are the positive (negative) partial sum of the explanatory variables; such as COW, RGDP, GEE, CMR, and PGR; and $mh^+(mh^-)$ are the asymmetric long-run coefficients and are empirically consistent when m tends to infinity.

4.4 Asymmetric causality test

Finally, this study examines the causal relationships among the indicators. For this purpose, the asymmetric causality test proposed by Hatemi-J (2012) is employed. This test assesses the upside and downside causality nexus between human resource development and the war predictors, considering that the school enrollment rate is asymmetrically influenced by these predictors and reacts differently to positive and negative shocks from the war. In such a scenario, conventional methods may not adequately capture the nuanced causal relationships between the indicators. The asymmetric causality test, however, accounts for the distinct positive and negative asymmetrical causal effects of the predictors on the outcome variable—human resource development (Toda and Yamamoto 1995). This method is preferred over other common causality tests as it also considers potential structural breaks in the data. It is important to note that this study does not delve into the statistical properties of the Hatemi-J (2012) asymmetric causality test (for detailed discussion, see Cevik et al. 2017). Instead, it focuses on the test's specification relevant to the context of this study. Therefore, let the positive and negative shocks of each predictor in a cumulative form be $y_{1t}^+ = \sum_{i=1}^{t} \varepsilon_{1t}^+$ and $y_{1t}^- = \sum_{i=1}^{t} \varepsilon_{1t}^-$, $y_{2t}^+ = \sum_{i=1}^{t} \varepsilon_{2t}^+$ and $y_{2t}^- = \sum_{i=1}^{t} \varepsilon_{2t}^-$ with a permanent effect

Table 4 Unit root test results

Variables	Kapetanios and Shin (2008)		ADF-GLS	
	I(0)	I(1)	I(0)	I(1)
School enrollment rate	−4.367***	−7.018***	−3.143***	−6.112***
Per capita cost of war	−0.912	−3.605***	−1.887	−8.341***
Per capita GDP	−1.666	−4.238***	−1.351	−7.660***
Government expenditures on education	−1.208	−3.962***	−1.292	−6.531***
Child mortality rate	−3.451***	−7.420***	−1.741	−8.508***
Population growth rate	−3.927***	−7.812***	−3.906***	−8.434***

Table 5 ARDL bound test results

Test statistics	Values	Significance (%)	Critical values	
			I(0)	I(1)
F-statistics (k=5)	22.134***	1	3.15	4.43
t-statistics	−10.168***	1	−3.43	−4.99

*** significant if ($p<0.01$), ** if ($p<0.05$), and * if ($p<0.10$). The null hypothesis indicates a long-run cointegration among the indicators. k=5 (number of regressors fit in the regression), Critical values come from Pesaran et al (2001)

on the underlying indicator. Thus, $y_t^+ = (y_1^+, y_2^+)$ and $y_t^- = (y_1^-, y_2^-)$ vectors are employed to test for the asymmetric causality nexus in the following vector autoregressive (VAR p-q) model:

$$y_t^+ = v + A_1 y_{t-1}^+ + \dots + A_p y_{t-p}^+ + u_t^+ \tag{8}$$

where v,y_t^+, u_t^+, and A present the 2×1 vector of the intercept, 2×1 vector of the predictors, 2×1 vector of the error term, and the 2×2 matrix of parameters for k ($k = 1, 2, 3, \dots, p$) lag orders, respectively. Based on the Toda and Yamamoto (1995) approach, three step computation is performed to test the asymmetric causality nexus among predictors, such as unit root test to determine the integrating order of the variables, optimal lag length selection, and the estimation of modified VAR model with $k + d_{\max}$. Finally, the Wald test following asymptotic chi-squared distribution is applied to test the null of no asymmetric causal relationship between the variables. Moreover, to control the abnormal and ARCH (autoregressive conditional heteroskedasticity) effects in the residual, the present study employs bootstrap simulation with 1000 replications to find the critical values.

5 Results and discussions

5.1 Unit root analysis

This section begins with the unit root analysis of the predictors using Kapetanios and Shin's (2008) method, coupled with the ADF-GLS method proposed by Elliott et al. (1996), with an automatically optimized lag length selected by the AIC and SIC frameworks. The results are presented in Table 4, revealing that the predictors are either I(0) or I(1) without any I(2) series. Specifically, the p-values for the school enrollment rate, child mortality rate, and population growth rate are significant at the level, rejecting the null hypothesis of non-stationarity, while the remaining variables become significant after taking their first difference. This indicates that the variables exhibit either I(0) or I(1) properties.

5.2 Cointegration analysis

Considering the formulated hypotheses, this study employs the ARDL bound test approach proposed by Pesaran et al. (2001) to examine the long-run relationship among the predictors. The optimal lag length is selected using the AIC, SIC, and HQIC frameworks with the maximum six lags criterion, determined by the "varsoc" command in Stata 17. The results, presented in Table 5, indicate a long-run relationship between the school enrollment rate and the regressed predictors, including the per capita cost of war, per capita GDP, per capita government expenditure on education, child mortality rate, and population growth rate. This suggests that, intuitively, the long-term war in Afghanistan, lasting over four decades, is intricately linked with human resource development, moving together in the long run. Consistent with the theoretical background, the prolonged war in Afghanistan is associated with both concurrent impacts and residual effects, influencing the socioeconomic variables in tandem. To delve deeper into the concurrent relationship, Eq. (6) is utilized to conduct the asymmetric bound test, deriving the Wald statistics to examine the short- and long-run asymmetries of the predictors on human resource development. The results of the asymmetric ARDL bound test and the Wald statistics are reported in Table 5, with the upper part of the table presenting the asymmetric ARDL bound test, and the lower part reporting the Wald statistics.

The results of the asymmetric ARDL bound test and Wald statistics, as presented in Table 6, offer deeper insights into the cointegration among the predictors (see, for instance, Bernstein and Nielsen 2019). The statistics indicate a long-run asymmetric nexus between

Table 6 Asymmetric cointegration and Wald test results

Model estimates	Values	1% critical values	
		I(0)	I(1)
Asymmetric ARDL bound test			
F-statistics	18.871***	3.15	4.43
t-statistics	−14.088***	−3.43	−4.99
Wald test			
Short-run asymmetries, $\sum_{j=0}^{p-1} n_j^+ = \sum_{j=0}^{p-1} n_j^-$ test statistics	933.481***	[0.000]	
Long-run asymmetries, $-\xi^+/\varphi = -\xi^-/\theta$ test statistics	1246.003***	[0.000]	

***Significant if ($p<0.01$), ** if ($p<0.05$), and * if ($p<0.10$). Critical values come from Pesaran et al (2001). [] presents the p-values for the Wald test statistics school enrollments, the per capita cost of war, and other augmented predictors, confirming similar results obtained from the symmetric ARDL bound test in Table 5. Therefore, it suggests us testing the null hypothesis of $H_0 : \phi_1^+ = \phi_2^- + \vartheta_3^+ = \vartheta_4^- = \ldots = 0$ (symmetries) against its alternative $H_A : \phi_1^+ \neq \phi_2^- + \vartheta_3^+ \neq \vartheta_4^- \neq \ldots \neq 0$ (asymmetries), using the Wald test. The results of the Wald test, with significant values for both short-run asymmetries (933.418) and long-run asymmetries (1246.003), reject the null hypothesis of symmetries. This implies that the per capita cost of war, per capita GDP, per capita government expenditure on education, child mortality rate, and population growth rate has different asymmetrical effects on the school enrollment rate. Overall, these results affirm the significant impact of the predictors on human resource development. Consequently, the study proceeds to estimate the asymmetric ARDL model to examine the scale and magnitude of the asymmetric effects of the cost of war on human resource development.

5.3 Non-linear ARDL results

In this section, the NARDL model is utilized through Eq. (6) to examine the asymmetric impacts of the per capita cost of war and other explanatory variables on Afghanistan's school enrollment rate, which reflects human resource development. The estimation of Eqs. (6–7) employs an optimal lag length determined by the AIC, SIC, and HQIC frameworks. The results are detailed in Tables 7 and 8. Table 7 presents the standard asymmetric ARDL estimates, showcasing both positive and negative partial sum effects. Meanwhile, Table 8 provides the short and long-run estimates of the NARDL model. Finally, key post-estimate diagnostic tests relevant to Eq. (6) are presented in the latter part of Table 9.

The findings in Table 7 reveal noteworthy insights. A positive partial sum change in the per capita cost of war corresponds to a decrease of 0.547% in the School Enrollment Rate (SER), while a negative partial sum change in the per capita cost of war leads to a 0.564% increase in the SER. This result not only confirms the asymmetric effects of the per capita cost of war on the SER but also aligns with the theoretical understanding of

Table 7 Asymmetric ARDL estimates

Estimates	Model estimates: NARDL					
	COW_{t-i}^+	COW_{t-i}^-	$PGDP_{t-i}^+$	$PGDP_{t-i}^-$	GEE_{t-i}^+	GEE_{t-i}^-
Coefficients	−0.547***	0.564***	0.190***	−0.119*	8.012***	−3.186***
t-statistics	−4.321	9.124	6.635	−3.016	5.642	−10.331
p-values	0.002	0.000	0.000	0.091	0.000	0.000
	CMR_{t-i}^+	CMR_{t-i}^-	PGR_{t-i}^+	PGR_{t-i}^-		
Coefficients	1.888	−1.935***	−1.514***	1.971***		
t-statistics	1.081	−22.100	−6.115	8.004		
p-values	0.319	0.000	0.002	0.000		

***Significant if ($p<0.01$), ** if ($p<0.05$), and * if ($p<0.10$). Sample size adjusted from 2002Q1 to 2020Q1

SER school enrollment rate, *COW* per capita cost of war, *PGDP* per capita GDP, *GEE* per capita government expenditure on education, *CMR* child mortality rate, *PGR* population growth rate. [+] and [−] present positive and negative partial sum of squares, respectively

Table 8 Short and long run asymmetric effects

Variables	Short-run effects			Long-run effects		
	Coefficients	t-statistics	*p*-values	Coefficients	t-statistics	*p*-values
COW^{+}_{t-i}	−1.382***	−6.45	0.000	−0.189***	−4.72	0.000
COW^{-}_{t-i}	3.099***	4.93	0.000	0.195***	5.28	0.000
$PGDP^{+}_{t-i}$	0.021***	5.65	0.000	0.066**	2.27	0.029
$PGDP^{-}_{t-i}$	−1.365***	−9.41	0.000	−0.022***	−4.89	0.000
GEE^{+}_{t-i}	0.998***	10.33	0.000	0.414***	4.98	0.000
GEE^{-}_{t-i}	−0.701**	−2.88	0.022	−0.779***	−11.36	0.000
CMR^{+}_{t-i}	−1.228*	−1.88	0.068	−1.027**	−2.25	0.024
CMR^{-}_{t-i}	0.641***	3.91	0.000	1.858	1.09	0.465
PGR^{+}_{t-i}	−1.674***	−3.31	0.001	−1.858***	−3.871	0.001
PGR^{-}_{t-i}	1.989***	3.89	0.000	1.099***	4.74	0.000
Diagnostic checks						
Adjusted r-squared	0.871				CUSUM	Stable
F-statistics [20, 50]	9.59*** (0.000)				CUSUMSQ	Stable
Portmanteau [chi^2]	41.97 (0.142)					
Breusch-Pagan heteroskedasticity test [chi^2]	1.38 (0.325)					
Ramsey RESET [F]	0.64 (0.740)					
Jarque–Bera [chi^2]	1.32 (0.552)					

***Significant if ($p<0.01$), ** if ($p<0.05$), and * if ($p<0.10$). Sample size adjusted from 2002Q1 to 2020Q1

SER school enrollment rate, *COW* per capita cost of war, *PGDP* per capita GDP, *GEE* per capita government expenditure on education, *CMR* child mortality rate, *PGR* population growth rate. [+] and [−] present positive and negative partial sum of squares, respectively. () indicates *p*-values

armed conflict's impact on human resource development within a conflict setting (Poirier 2012; Buvinić et al. 2014). Echoing a practical survey by Catani et al. (2009) on the Afghan war, our results affirm that heightened war intensity significantly diminishes the school enrollment rate, whereas a reduction in war intensity leads to a temporary relaxation, resulting in a higher SER. Furthermore, an increase in per capita GDP is associated with a 0.19% rise in the school enrollment rate, while its negative partial sum brings about an 11.9% decline. Similarly, the per capita government expenditure on education exhibits analogous positive and negative partial sum effects on the SER, albeit at different magnitudes of 8.012% and 3.186%, respectively. Additionally, the findings show that positive partial sum changes in the child mortality rate correspond to a 1.88% increase in the school enrollment rate, whereas negative changes result in a 1.935% decrease. These results align with theoretical expectations, indicating that a positive change in the population growth rate reduces the SER, while a negative change increases it. This is in line with the notion that rapid population growth can divert resources away from productivity-enhancing technologies and industries toward human capital and education, which are presumed to have lower rates of return. Given the substantial costs associated with maintaining educational standards, expanding education coverage and levels presents a challenging task in post-conflict environments (Kelley 1996; Meeks 1982). The

Table 9 Asymmetric causality results

Causality direction	d_{max}	Test statistics	Critical values		Result
			1%	5%	
$COW^{+}_{t-i} \rightarrow SER^{+}_{t-i}$	2+5	12.443***	7.106	3.934	Reject H_O
$SER^{+}_{t-i} \rightarrow COW^{+}_{t-i}$	2+5	3.815	7.106	3.934	Do no reject Ho
$COW^{-}_{t-i} \rightarrow SER^{-}_{t-i}$	2+5	22.016***	7.106	3.934	Reject H_O
$SER^{-}_{t-i} \rightarrow COW^{-}_{t-i}$	2+5	2.962	7.106	3.934	Do no reject Ho
$PGDP^{+}_{t-i} \rightarrow SER^{+}_{t-i}$	2+5	34.001***	7.106	3.934	Reject H_O
$SER^{+}_{t-i} \rightarrow PGDP^{+}_{t-i}$	2+5	1.088	7.106	3.934	Do not reject Ho
$PGDP^{-}_{t-i} \rightarrow SER^{-}_{t-i}$	2+5	18.189***	7.106	3.934	Reject H_O
$SER^{-}_{t-i} \rightarrow PGDP^{-}_{t-i}$	2+5	1.333	7.106	3.934	Do not reject Ho
$GEE^{+}_{t-i} \rightarrow SER^{+}_{t-i}$	2+5	10.336***	7.106	3.934	Reject H_O
$SER^{+}_{t-i} \rightarrow GEE^{+}_{t-i}$	2+5	2.109	7.106	3.934	Do not reject Ho
$GEE^{-}_{t-i} \rightarrow SER^{-}_{t-i}$	2+5	16.762***	7.106	3.934	Reject H_O
$SER^{-}_{t-i} \rightarrow GEE^{-}_{t-i}$	2+5	2.320	7.106	3.934	Do not reject Ho
$CMR^{+}_{t-i} \rightarrow SER^{+}_{t-i}$	2+5	3.841	7.106	3.934	Do not reject H_O
$SER^{+}_{t-i} \rightarrow CMR^{+}_{t-i}$	2+5	0.886	7.106	3.934	Do not reject Ho
$CMR^{-}_{t-i} \rightarrow SER^{-}_{t-i}$	2+5	4.212**	7.106	3.934	Reject H_O
$SER^{-}_{t-i} \rightarrow CMR^{-}_{t-i}$	2+5	2.187	7.106	3.934	Do not reject Ho
$PGR^{+}_{t-i} \rightarrow SER^{+}_{t-i}$	2+5	27.449***	7.106	3.934	Reject H_O
$SER^{+}_{t-i} \rightarrow PGR^{+}_{t-i}$	2+5	1.007	7.106	3.934	Do not reject Ho
$PGR^{-}_{t-i} \rightarrow SER^{-}_{t-i}$	2+5	19.389***	7.106	3.934	Reject H_O
$SER^{-}_{t-i} \rightarrow PGR^{-}_{t-i}$	2+5	0.906	7.106	3.934	Do not reject Ho

***Significant if ($p<0.01$), ** if ($p<0.05$), and * if ($p<0.10$). Sample size adjusted from 2002Q1 to 2020Q1

SER school enrollment rate, *COW* per capita cost of war, *PGDP* per capita GDP, *GEE* per capita government expenditure on education, *CMR* child mortality rate, *PGR* population growth rate. [+] and [−] present positive and negative partial sum of squares, respectively

results presented in Table 7 demonstrate that, except for the positive partial sum of the child mortality rate, all predictors are significant at the 1% level.

Table 8 presents the short-run and long-run asymmetric effects of the predictors on the school enrollment rate, reflecting human resource development in Afghanistan. The results indicate that a positive partial sum change in the per capita cost of war COW^{+}_{t-i} *leads to a decrease in the school enrollment rate both in the short and long runs, by 1.382% and 0.189% respectively. Conversely, as expected, a negative partial sum changes in the per capita cost of war* COW^{-}_{t-i} results in an increase in the SER by 3.1% and 0.195% in the short and long runs, respectively. This suggests that a positive change in the per capita cost of war has a negative impact, while a negative shock increases the school enrollment rate in Afghanistan. This aligns with the observed significant negative impact of war on socioeconomic indicators and human resource development, both in the short and long term. For instance, war-affected societies often experience declining production, increased poverty, plummeting education due to proliferation and human capital flight, and intense displacement, both internally and internationally (Musisi and Kinyanda 2020). Interestingly, $PGDP^{+}_{t-i}$ and COW^{-}_{t-i} present a counterevidence. They indicate that a positive partial sum change in per capita GDP spurs the school enrollment rate, while its negative shock reduces the SER in both the short and long runs. Per capita GDP serves to represent the economic size and overall variability of economic activity during the armed conflict period in the country.

A rise in GDP, reflecting economic activity, has a positive impact on the overall sector, including education. This aligns with the theoretical concept of the growth-education nexus, as seen in Dahliah and Nirwana (2021), where an increase in GDP is expected to expand coverage and improve schooling standards in Third World countries (see, for example, Buvinić et al. 2014; Keji 2021; Maqbool 2017). Regarding the per capita government expenditure on education GEE^{+}_{t-i}, the results demonstrate an adverse effect on the school enrollment rate (SER) in both the short and long runs. A positive shock from per capita government expenditure on education reduces the SER, while a negative shock increases it. This result mirrors the situation in Afghanistan during the study period, where a significant portion of public expenditure was allocated to military operations, leaving little for other sectors of the economy. On the control variables' front, the results show that a positive partial sum change in the child mortality rate CMR^{+}_{t-i} increases the school enrollment rate by 1.228% and 1.027% in the short and long runs, respectively, and vice versa. Lastly, the population growth rate (PGR) has been included in the model to account for its effects on the school enrollment rate. The results indicate that PGR has adverse effects on the SER. A positive partial sum shock from PGR decreases the SER, while a negative shock increases it in both the short and long runs. Rapid population growth increases the cost of schooling and necessitates a corresponding expansion in schooling coverage, which can be challenging for countries facing long-term war, such as Afghanistan. Liu and Yamauchi (2014) found that rapid population growth raises household consumption, negatively impacting food security in developing economies and reducing potential investments in human capital. For model validity, several important diagnostic tests have been conducted and are presented below Table 8. The Portmanteau, Breusch-Pegan, and Jarque–Bera results do not reject the null hypothesis of no autocorrelation, homoskedasticity, and normal distribution of the residuals. Additionally, the adjusted r squared, CUSUM, and CUSUMSQ results demonstrate the model's high fitness, coefficient stability, and model stability, respectively. The results of the CUSUM and CUSUMSQ tests are also visualized in Fig. 1, showing that the residuals are within the 5% significance bound, indicating stable coefficients and model.

Finally, this study delves into the dynamic multiplier behavior, capturing the temporal dynamics of the per capita cost of war and other augmented predictors. This approach considers the backgrounds influenced by short-run dynamics and the initial disequilibrium

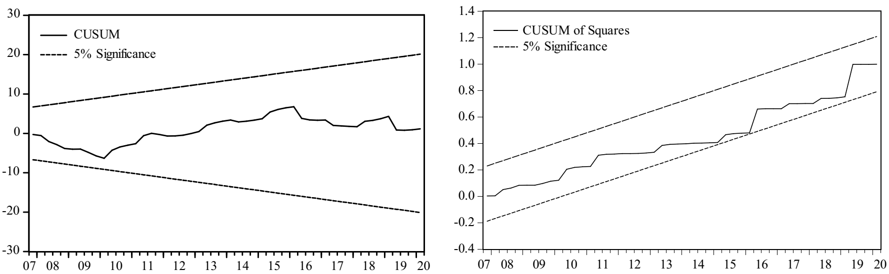

Fig. 1 NARDL CUSUM and CUSUMSQ test results. Note: CUSUM: Cumulative sum, CUSUMSQ: Cumulative sum of squares

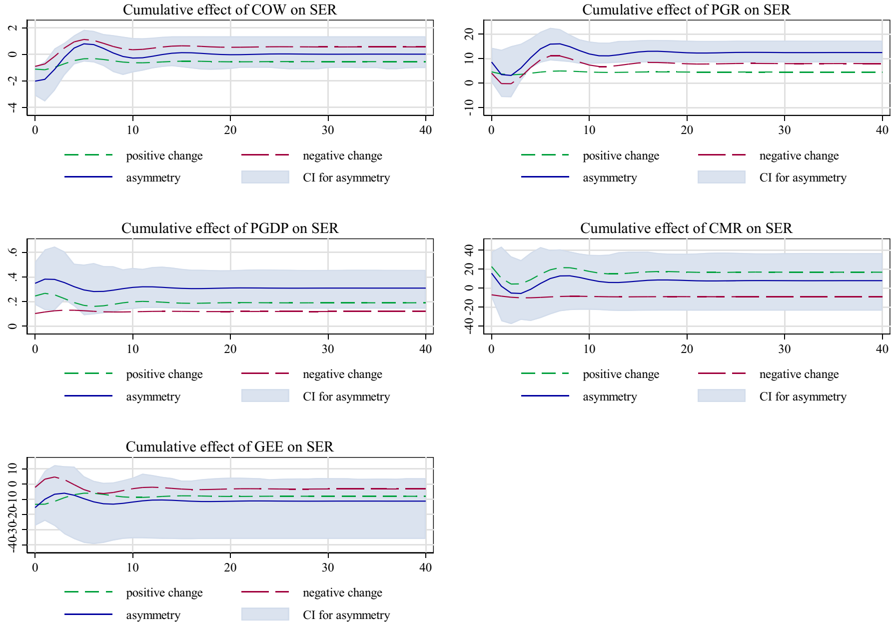

Fig. 2 Dynamic multipliers. Note: 95% confidence interval bootstrap is based on 100 replications

due to shocks on human resource development, proxied by the School Enrollment Rate (SER). The rejection of the null hypothesis, as shown in the upper part of Table 5, indicates the existence of an initial equilibrium or a long-run nexus among predictors. Employing dynamic multipliers offers deeper insights into the statistical validity of the asymmetric results presented in Tables 7 and 8. Figure 2 illustrates the standard shock effects of both the positive and negative partial sums of the predictors on human resource development over the runs. It shows that a decrease in the per capita cost of war positively impacts the school enrollment rate (as seen in the cumulative effects of COW on SER, depicted by the red line), while an increase in the per capita cost of war adversely affects the SER (green line). The results also present a contrasting scenario for the effects of PGDP on SER: a standard positive partial sum shock from PGDP decreases the SER, whereas a negative shock increases it. Regarding per capita government expenditure on education (GEE), the results suggest that a positive shock increases the SER, while a negative shock distorts it. Similar results are observed for the population growth rate (PGR), with a positive shock increasing the SER and a negative shock decreasing it. However, the results for Child Mortality Rate (CMR) are opposite, indicating that a positive partial shock to CMR decreases the SER, while a negative shock increases it. These results align with the impacts of war and armed conflicts, which have resulted in a high number of child deaths and physical disabilities. Additionally, the proliferation of armed attacks on schools has heightened parental fear, leading to decreased school attendance in Afghanistan (Catani et al. 2008). These findings are consistent with the research of Cameron et al. (2021), who explored the effects of violence against Afghan children at the community level during the armed conflict period (see also, Panter-Brick et al. 2009a, b).

5.4 Asymmetric causality test results

As a final step in the analysis, this study estimates the asymmetric causality nexus between the School Enrollment Rate (SER), per capita cost of war, per capita GDP, per capita government expenditure on education, child mortality rate, and population growth rate, using Hatemi-J's (2012) method based on the modified VAR model approach of Toda and Yamamoto (1995). The results are detailed in Table 9, with an optimal lag length of (2) selected using the AIC, SIC, and HQIC frameworks, employing a modified VAR order of $d_{max} = 2 + 5$ for estimation. The study utilizes the bootstrap technique with 1000 replications based on the asymptotic chi-squared distribution for the Wald test, deriving critical values to assess the null hypothesis of no asymmetric causality among predictors. The results indicate a significant asymmetric causal relationship between the predictors at a 1% significance level. Specifically, both positive and negative shocks from the per capita cost of war strongly influence school enrollment rates, rejecting the null hypothesis at a 1% significance level. Furthermore, both positive and negative shocks from per capita GDP, per capita government expenditure on education, and population growth rate exhibit bidirectional significant asymmetric causal relationships with the school enrollment rate. Interestingly, the negative shock from the child mortality rate is found to significantly influence the school enrollment rate, while its positive shock remains insignificant. The findings underscore a bidirectional asymmetric causality from predictors to the school enrollment rate, with the opposite causality direction being statistically insignificant. The study's conceptual framework aims to uncover the asymmetric causal nexus between human resource development and the predictors of war.

The results depicted in Tables 6 and 7 are robustly substantiated by the findings reported in Table 9, which confirm the presence of both asymmetric effects of war on human resource development and an asymmetric causality nexus among these variables. These outcomes underscore that the enduring conflict in Afghanistan coexists with a gradual decline in human capital within the nation, manifesting a slow convergence pattern. Furthermore, these results align with the discoveries of Serneels and Verpoorten (2015) concerning the wartime impact in Rwanda during the early 1990s. Empirical evidence suggests that irrespective of geographical location or economic size, war and armed conflicts lead to a simultaneous decline in human resource development during the conflict period and its aftermath, with an undefined period required for the community to revert to its pre-war status (see also, Alade et al. 2021; Carbonnier and Wagner 2015).

6 Practical contributions

This study addresses the implications of long-term civil wars on human resource development in Afghanistan, aiming to bridge a significant gap in existing literature. Given the limited understanding of war's impact on socioeconomic indicators, this study seeks to enrich empirical knowledge regarding the consequences of war on human resource development within a nation embroiled in civil conflict for over four decades. Drawing on Arreguín-Toft's (2001) asymmetric theory of civil wars, the study examines the practical armed conflicts between the Afghan government (well-equipped) and rebel groups. This is further supported by the rejection of the null hypothesis of symmetries between long-term war and human resource development (see Table 6). The results (see Tables 7 and 8) provide statistical evidence that variations in the intensity of civil wars, both positive (increases) and negative (decreases) shocks, play a crucial role in explaining their impact on human resource development, while controlling for other variables. A key distinction between previous studies and this one is that while previous research demonstrated significant asymmetries in civil war occurrences, they primarily focused on the static and dynamic contemporaneous relationships between various socioeconomic indicators and armed conflicts within their respective contexts (see, for instance, Miguel et al. 2004; Miguel and Roland 2011; Merrouche 2011; León, 2012; Dabalen and Paul 2014; Moosa 2019; Alade et al. 2021). Furthermore, this study reveals that assuming a contemporaneous link between war and human resource development not only diverges from theoretical predictions but also leads to perplexing conclusions (Table 9).

7 Conclusions

This study examines the effects of long-term war on human resource development in Afghanistan, spanning from 2002Q1 to 2020Q1. The study hypothesizes the asymmetric impacts of long-term war alongside other prominent socioeconomic indicators on human resource development. Data was collected from reliable sources and the analytical approach employed consists of a non-linear autoregressive distributed lags and asymmetric causality techniques. The analysis yielded several noteworthy findings: First, the variables exhibited mixed integrating orders and revealed both long-run symmetric and asymmetric relationships. Specifically, positive partial sum shocks from the per capita cost of war, child mortality rate, and population growth were found to exert negative asymmetric impacts on the school enrollment rate, while their negative partial sum shocks resulted in an increase. Conversely, per capita GDP and per capita government expenditures on education exhibited counter-effects on the school enrollment rate, with positive partial sum shocks showing a positive effect and negative partial sum shocks leading to a negative effect on the school enrollment ratio. Furthermore, the from dynamic multipliers showcased that asymmetric shocks, both positive and negative, of the predictors significantly influenced the school enrollment rate, with a decrease in the per capita cost of war positively impacting it. Lastly, the findings from an asymmetric causality technique highlighted a significant causal relationship from both positive and negative components of the per capita cost of war, per capita GDP, per capita government expenditures on education, and population growth to both positive and negative components of the school enrollment rate. Additionally, the findings revealed a causal link only from the negative component of the child mortality rate to the school enrollment rate.

7.1 Policy implications

The study's findings suggest several key policy implications that can be outlined as follows:

The primary recommendation is to strive to avoid war if possible. However, in the unfortunate event that war persists in Afghanistan, efforts should focus on minimizing the loss to human capital.

Strategies should be implemented to reduce human capital flight and brain drain to acceptable levels. This can be achieved through incentive-based approaches, particularly targeting teachers and instructors, to ensure the continuity of schools. Schools serve as

vital institutions for nurturing future human capital, which is crucial for post-conflict reconstruction efforts.
The government should prioritize the provision of consistent and adequate safeguarding tools and equipment to schools during wartime, as well as provide sufficient financial support post-war to ensure their sustainability.
Government organizations, social activists, and the media play important roles in promoting the institution of families as bastions of commitment, strength, and pride. This can significantly boost school enrollment rates, fostering a positive environment for human resource development in Afghanistan.

7.2 Limitations of the study

While efforts were made to minimize the limitations of the study regarding scope and applicability, one limitation remains due to the lack of disaggregated data at the state level to test the sensitivity of rural and urban school enrollment rates to war effects, and the study does not account for the theological reasons that led to several interventionist wars in Afghanistan, suggesting that future studies could consider employing an instrumental variable approach to examine this predictor alongside other factors.

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Data availability Datasets relevant to school enrollment ratio, GDP, population, and government final expenditure on education are collected from the World Development Indicators sources available at (https://databank.worldbank.org/source/world-development-indicators) and dataset relevant to cost of war is collected from the Department of Defense Budget of the United States available at (https://www.state.gov/countries-areas/afghanistan/).

Declarations

Competing interests The authors do not have any competing interests to declare.

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