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A COMPREHENSIVE SIMULATION OF THE RUSSIA-UKRAINE ARMED CONFLICT: APPLYING THE POST-WAR ECONOMIC IMPACT SIMULATOR (PEI-SIMULATOR)

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Abstract. This paper introduces a new economic simulator in the case of a war, this new economic simulator is entitled "The Post-War Economic Impact Simulator (PEI-Simulator)." The primary objective of the PEI-Simulator is to analyse wars at various stages to assess their overall socio-economic impact in both the short and long term. Additionally, it shifts away from the traditional benefit-cost analysis of war, introducing a new simulator that represents war scenarios from a more complex and dynamic perspective. The PEI-Simulator assesses the economic impacts of countries thorough the possible scenario of a partial or full war in three different stages: (i) pre-war stage; (ii) war stage; (iii) post-war stage. The analysis makes use of different indicators such as economic desgrowth from war (-δwar), war intensity (I), war losses (-Lwar), economic wear from war (Πwar), level of war tension (Twar), level of diplomatic negotiations (D), and the total economic leaking from war (Ωwar). Lastly, this research applies the PEI-Simulator to evaluate a possible full war between Russia and Ukraine.

Keywords: Russia, Ukraine, War, Economic Simulating, Economic Desgrowth.

JEL: C60, Q48, R11

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Introduction

The paper written by Pethick Lawrence hundred and seven years ago in 1915 introduce the first theoretical analysis of war economics modelling. Lawrence's paper offers a simplified explanation of the economic high price of war from a qualitative point of view. Additionally, the same paper enumerates twelve negative economic effects of war, including large losses in the international trade, high debts, currency depreciation, taxation, high military expenditures, and huge inflation that can generate a slowdown in the economic growth in the short run. In fact, the paper marks a first, valiant attempt to apply economics to analyse the relationship between war and economic performance (Ruiz Estrada, Park, and Kim, 2015).

Different models to evaluate the damage of war applies the cost-benefit analysis constantly, comparative historical data, correlations, and forecasting. In this connection, (Blattman and Miguel, 2010) explain the differential effects of war on the economic growth. Other notable research papers pertaining to war economics include Pasvolsky, Leo. (1942), Boden (2008), Rasler and Thompson (1985), Markusen (1992), Barro and Lee (1994), Collier (1999), and Murdoch and Sandler (2002). A large part of these papers is using classical models or neoclassical models. Both variants of models are based on the analysis of basic economic variables such as government spending, production costs, consumption, inflation, and unemployment. According to Bergsten (1990), the unconditional relation between war and economic growth contains limited information. For example, a lack of a relation does not necessarily imply that wars do not affect economic performance if different types of war were associated with different patterns and environments, and the combination of the different factors and led to a zero unconditional effect.

According to Smith (2014), the most recent evaluations of the economic costs of war and military conflicts are presented with a detailed examination of various research papers. This includes works by Stiglitz and Bilmes, which highlight the financial implications of the Iraq war for the U.S., as well as studies on other conflicts, such as those in Afghanistan and the Basque region. These analyses employ diverse methodologies, including accounting procedures, statistical techniques (time series, cross-sectional, and panel data analysis), and financial assessments such as stock market analyses.

Smith's document primarily focuses on the methodologies used to quantify the costs of war, emphasizing the evaluation of material and human losses, albeit superficially. While existing studies predominantly rely on analytical statistical models, they lack a comprehensive mathematical simulator capable of capturing the full spectrum of war dynamics—spanning pre-war, war, and post-war phases. In this context, we propose a comprehensive and dynamic tool called the "Post-War Economic Impact Simulator (PEI-Simulator)." This simulator aims to address the limitations of existing methodologies by providing a holistic and systematic approach to analysing the economic impacts of war across all stages.

The primary objective of PEI-Simulator is to evaluate an economy in times of a war. We hope that PEI-Simulator can fill the gap in the economic modelling literature. The

PEI-Simulator is based on seven basic indicators - economic desgrowth from war (-δwar), war intensity (Iwar), war losses (-Lwar), economic war wear (Πwar), level of war tension (Twar), level of diplomatic negotiations (D), and the total economic leaking from war (Ωwar). The methodology and approach used in the PEI-Simulator applies different mathematical and graphical analytical frameworks. To illustrate and illuminate the PEI-Simulator, we apply the Simulator to a full armed conflict between the Russia and Ukraine. We believe that this research makes a contribution toward a more systematic measurement of the war impact on any economy.

An important value-added of the PEI-Simulator, in the context of contributing to a more precise understanding of wars damages from material and human perspective, is that it accounts for the uncertainty changes inherent in any war. The PEI-Simulator does so within the theoretical framework of a Dynamic Imbalanced State (DIS) (Ruiz Estrada and Yap, 2013) and the Omnia Mobilis assumption (Ruiz Estrada 2011). The idea is to move beyond classical economic modelling such as cost benefit analysis, CGE Simulator, and RECIPE Simulator to a new economic modelling to evaluate the damages of any war from ex-ante (before war) to ex-post (after war) – by utilizing Econographicology (Ruiz Estrada, 2017). We think that this alternative simulator can yield interesting and relevant insights which can proper forward the measurement of the war effects in the economic performance in the short run.

1. An Overview of the Economic Condition

1.1. An Overview of the Economy of Russia

Russia's economic situation in 2024 reflects a mix of resilience and structural challenges. The economy is expected to grow 3.6% in 2024, a revision from the 3.2% forecast, mainly due to increased government spending. Especially in the areas of defense and public infrastructure. Oil and gas revenues continue to play an important role. Supported by the weakening ruble... occurred, which increased the value of energy exports in local currency. And strong global demand (The Moscow Times, 2024; Meduza, 2024), non-oil revenues increased significantly thanks to VAT, generating $36.3 billion in the first quarter alone (Meduza, 2024). But Russia still faces challenges… In September 2024, inflation stood at 8.6%, driven by a tight labour market and high government spending. to cope with inflationary pressures The Russian Central Bank raised interest rates to 19%, resulting in a slowdown in consumer activity and the growth of private investment. military spending It is expected to increase about 30% to $145 billion by 2024, which currently represents 40% of federal spending. This raises concerns about the convergence of investments in other areas. Importantly (TASS, 2024; Meduza, 2024), despite shrinking from 3.2 trillion rubles in 2023 to a projected 2.5 trillion rubles in 2024, this fiscal deficit remains. is a cause for concern Analysts warn that this reform is short-term and highly dependent on privatization of state assets and energy progress. The sustainability of the fiscal strategy is questionable. This is especially true when inflation

affects public finances and consumer purchasing power (Meduza, 2024; The Moscow Times, 2024). In summary, although the Russian economy is showing improved short-term resilience, it is strengthened by strategic government policies and strong energy revenues. But its long-term stability depends on managing inflationary pressures and diversifying its economic base.

1.2. An Overview of the Economy of Ukraine

The period between the 1991 and 2014 marked a time of Ukraine dark history. This was a period in time that witnessed an almost inexplicable, difficult and protracted armed conflict that claimed thousands of lives and destroyed the economic and social fabric of the country. The country was hard hit with high inflation, unemployment and poverty such that the Growth National Production rate could not respond to population growth rate. The policies proposed include (i) floating the exchange rate to keep competitive exports in the international market and attract Foreign Direct Investments (FDI); (ii) more controls on money supply by the central bank; (iii) the increment of taxation (direct and indirect taxes); (iv) the reduction of government expenditure justified by the large bureaucracy and inefficient public companies results; (v) the privatization of public services and companies (such as electricity, water supply, transportation systems, telecommunications systems, infrastructure systems, public education, low cost housing credit, and public health care system). Sadly, these policies after their implementation did not deliver the positives expected of the economy but negatively impacted majority of Ukrainians in light of increased poverty.

Since the 1919 up into the 1990's, Ukraine was highly dependent on Russian military and economic support. Hence, it was heavily reliant on imports, which registered a constant growth rate estimated at 45% annually and which consequently, increased the country's negative trend in its balance of payments in trade and escalating external debt. In fact, this marked the period many economists dubbed "lost decade" in Ukraine economic history. Here in this research, we refer to this particular period as the Ukrainian economic lower growth. From an ideological and political view point, the cold war of the 1919 to the 1991 that divided countries and groups along ideologies of capitalism and socialism undeniably sowed the seeds of chaos and the protracted armed struggle in the country. This period witnessed the formation and rise of armed confrontations between the Russian army and Ukrainian army, which led to decades of war that tore apart and stalled the country's economic development and progress. The country's battle with Russia and Ukraine army was of crucial geopolitical, ideological and military interest for the Russia during the cold war in light of the serious threats coming from United States and Europe Union expansion in East Europe such as the case of Poland. Out of desperation to stop such expansion, the Russians heavily supported dictators, military cupola and right-wing political parties with huge military logistic cooperation and assistance in the form of finance, training, equipment, and armament to contain the capitalism advances in East Europe. With these developments came the absolute dictatorship of the military regime in power that was synonymous with violence,

repression and coercion as its tactics to subdue society. From the 1919's up into the 1990's. The middle of the 1990's however, saw a turning point as the country made significant progress towards stability and improvement in its democratic process and human rights. The cold war and the internal ideological war that ensued in Ukraine left a vicious cycle of violence and a host of criminal organizations such as paramilitary groups, militia groups that continue to ravage Ukrainian society and image up to this day with deleterious consequences to its socio-economic and political wellbeing.

2. Economic Desgrowth from war ($-\delta_{war}$) and Total Economic Leaking from War (Ω_{War})

In this section, we discuss the concept of economic desgrowth from war ($-\delta_{war}$) according to Ruiz Estrada, Yap, and Park (2014), which plays an essential role in the construction of the *PEI-Simulator*. The main objective of inclusion of "economic desgrowth from war ($-\delta_{war}$)" is to create an economic indicator that can help us to analyse how controlled and non-controlled shocks from war can adversely affect GDP in the short run. Economic desgrowth from war ($-\delta_{war}$) is delineated as "an indicator that can show different leakages, originated from controlled and non-controlled events from war that can bear on the execution of the final GDP formation into a period of one year". At the same time, the PEI-Simulator includes the Lorenz transformation assumptions (Lorenz, 1993) to facilitate the analysis of economic desgrowth from war ($-\delta_{war}$).

In addition, the PEI-Simulator assumes that economic degrowth resulting from war ($-\delta_{war}$) represents the extent to which GDP deteriorates due to the total economic leakage from war (Ω_{war}). This leakage perpetually expands, exerting a continuous negative influence on GDP formation over the course of a year, as modelled by the simulator.

The total economic leakage from war (Ω_{war}) originates from numerous small-scale economic disruptions, which collectively and significantly impact GDP performance. According to the PEI-Simulator, this leakage is determined by nine critical variables, these nine variables were selected based on macro-socio-economic and military variables. They are as follows: (i) α_{war11} is equal to β_1 (active population between 15 and 65 years old) to the power of exp-1 (soldiers demand growth rate); (ii) $\alpha_{war\,12}$ is equal to β_2 (military production) to the power of exp-2 (arms and guns production growth rate); (iii) α_{war13} is equal to β_3 (natural resources supply in Km^2) to the power of exp-3 (raw material, food supply, and water for war in Km^2); (iv) α_{war21} is equal to β_4 (national budget for military defense) to the power of exp-4 (taxation growth rate); (v) α_{war22} is equal to β_5 (military infrastructure in Km^2) to the power of exp-5 (budget for military infrastructure growth rate); (vi) α_{war23} (military research and development) is equal to by β_6 (military R&D investment) to the power of exp-6 (financial resources for military R&D); (xii) α_{war31} is

equal to β_7 (international credit for war) to the power of $^{-}$exp-7 (debts growth rate); (xiii) α_{war32} is equal to β_8 (total population affected from war by Km^2) to the power of exp-8 (refugees growth rate); (ix) α_{war33} is equal to β_9 (international reserves in US$) to the power of exp-9 (exchange rate depreciation growth rate). The final measurement of total economic leaking from war (Ω_{war}) is derived by applying a large number of multi-dimensional partial derivatives on each variable (9 variables) to evaluate the changes of each variable between the present time (this year) and the past time (last year) according to expression 1. Additionally, the exponent [(exp−i)={1,2,3,4,5,6,7,8,9}] is applied to each economic leakage, representing nine growth rates that indicate the variation in the total output of each variable between the current year (t) and the previous year (t−1).

$$\Delta\Omega_{war}i = \sum\partial\beta_i^{exp\text{-}I}{}_{(t)}/\partial\beta_i^{exp\text{-}j}{}_{(t\text{-}1)} \geq \mathbb{R}_+ \leq 0 \quad (1)$$

Where the exponent $^{exp\text{-}I\ or\ exp\text{-}j}$ can be replaced by any of the nine different exponents in (see expression 2).

$$Bi^{exp\text{-}I\ or\ exp\text{-}j} = (exp\text{-}1,\ exp\text{-}2, exp\text{-}3, exp\text{-}4, exp\text{-}5, exp\text{-}6, exp\text{-}7, exp\text{-}8,\ exp\text{-}9\backslash) \quad (2)$$

The next step in the calculation of total economic leaking from war (Ω_{war}) is to calculate the denominator by applying the Jacobian determinant under the first-order derivatives. At the same time, we apply an inverse matrix (see expression 3).

$$\Delta^{-1} = \begin{pmatrix} \Omega_{war11} & \Omega_{war12} & \Omega_{war13} \\ \Omega_{war21} & \Omega_{war22} & \Omega_{war23} \\ \Omega_{war31} & \Omega_{war32} & \Omega_{war33} \end{pmatrix}^{-1} \quad (3)$$

The final step is to determine the total economic leaking from war (Ωwar) by dividing 1 by the inverse matrix from (see expression 3) to the power of 2 (see expression 4).

$$\Omega_{war} = 1/(\Delta^{-1})^2 \quad (4)$$

Lastly, it is possible to calculate economic desgrowth from war ($-\delta_{war}$) as in (see Expression 5).

$$-\delta_{war} = \sqrt{GDP_{rp}}\,[1/\,\Omega_{war}]\text{-}1 \Rightarrow 0 \geq -\delta_{war} \leq -1 \quad (5)$$

The computation of economic desgrowth from war ($-\delta_{war}$) is based on the final GDP in real prices (GDP_{rp}) and total economic leaking from war (Ω_{war}) from expression 4. Boundary conditions for economic desgrowth from war ($-\delta_{war}$) is equal to expression 6.

$$-\delta_{war}' = \partial\text{-}\delta_{war}'_0/\partial T \mid_{t=0} = 0,\ \partial\text{-}\delta_{war}'_1/\partial T \mid_{t=1} = 1,\ \partial\text{-}\delta_{war}'_2/\partial T \mid_{t=2} = 2,\ \ldots,\ \partial\text{-}\delta_{war}'_\infty/\partial T \mid_{t=\infty} = \infty \quad (6)$$

On the other hand, the full potential GDP (GDPPOT) calculation is shown in expression 7. We find the maximum output of capital formation, labour output, land exploitation, and technology uses maximization:

$$GDP_{POT} = [1/\sum(\Delta Capital_{fo}, \Delta Labor_{fo}, \Delta Land_{fo}, \Delta Tehnology_{fo})]^2 \quad (7)$$

The calculation of economic desgrowth from war ($-\delta_{war}$) is based on the application of the Omnia Mobilis assumption of Ruiz Estrada (2011) to generate the relaxation of the total economic leaking from war (Ω_{war}) calculation (non-controlled and controlled events) and the full potential GDP (GDP_{POT}).

2.1. PEI-Simulator

In this section, we derive the PEI-Simulator, which can be classified into three stages: (i) pre-war stage; (ii) war stage; and (iii) post-war stage. The PEI-Simulator uses three different groups of players. The first group of players is the main conflict players ($P_{i \text{ and }} P_2$). The second group of players is the regional players (RP_j; j= (1,2,…, ∞)). The last group of players is the large war partners (LWP_k; k= (1,2,…, ∞)).

2.1.1. Pre War Stage

The *PEI-Simulator* assumes that there are four main causes of war: (i) historical issues (H); (ii) economic expansion (E); (iii) ideological differences (I); and (iv) military rivalry (M). These four factors directly affect "the level of war tension (T)", which is a function of four variables as in expression 8.

$$T = f(H, E, I, M) \quad (8)$$

So, the following measure is to compute the minimum and maximum level of war tension (T) through the application of the first derivative according to expression 9.

$$f'(T) = (\partial T/\partial H) + (\partial T/\partial E) + (\partial T/\partial I) + (\partial T/\partial M) \quad (9)$$

Moreover, the level of war tension (T) applies a second derivative to find the inflection point according to (10).

$$f''(H, E, I, M) = (\partial^2 T/\partial H^2) + (\partial^2 T/\partial E^2) + (\partial^2 T/\partial I^2) + (\partial^2 T/\partial M^2) \quad (10)$$

To probe the level of war tension (T) we apply the Jacobian determinants under the first-order derivatives (see expression 11).

$$|J'| = \begin{pmatrix} \partial T/\partial H & \partial T/\partial E \\ \partial T/\partial I & \partial T/\partial M \end{pmatrix} \quad (11)$$

On the other hand, the application of the Jacobian determinants under the second-order derivatives can help to find the inflection point in the level of war tension (T) between the two players $(P_1 \wedge P_2)$ (see Expression 12).

$$|J''| = \begin{pmatrix} \partial^2 T/\partial H^2 & \partial^2 T/\partial E^2 \\ \partial^2 T/\partial I^2 & \partial^2 T/\partial M^2 \end{pmatrix} \quad (12)$$

Consequently, initial conflict is necessary to assume that the level of war tension (T) (endogenous variable) is going to determine the level of diplomatic negotiations (D) (exogenous variable) in the form of international community intervention under regional organizations (RO_b; b= (1,2,…, ∞)) or supranational organizations (SO) such as the United Nations. In this part of the *PEI-Simulator* if the level of war tension (T) is escalating then the level of diplomatic negotiation (D) is going to be more intensive until all possibilities to secure peace between the two players are exhausted. Hence, the level of diplomatic negotiations (D) depends directly on the level of war tension (T) in the short run. The supranational organization (SO) may play a crucial role in the diplomatic negotiations (D). If the level of war tension (T) rises, then the level of diplomatic negotiations (D) will play an important role in reducing tension between the two players $(P_1 \wedge P_2)$.

$$T = x\log_2(D) \Rightarrow \{ D / D : RO \cap SO \} \quad (13)$$

2.1.2. War Stage

The war or military conflict stage consists of two stages – (i) war preparation stage and (ii) war stage.

2.1.2.1.War Preparation Stage

In the pre-war stage, it is necessary to assume that both players $(P_1 \wedge P_2)$ have different economic desgrowth from war ($-\delta_{war}$) levels (see expression 14).

$$P_1(-\delta_{war}) \neq P_2(-\delta_{war}) \quad (14)$$

Therefore, the levels of total economic linking from war (Ω_{war}) for both players ($P_1 \wedge P_2$) have different proportions (Δ) according to (15).

$$P_1(\Delta\Omega_{war}) \neq P_2(\Delta\Omega_{war}) \quad (15)$$

In the period of war, both players fully reject any diplomatic negotiation. This means that if the level of war tension (T) reaches its maximum limit then diplomatic negotiations (D) fail (see Expression 16).

$$T_{max} = f'(D) = \partial x \log_2(T)/\partial D > 0 \quad (16)$$

Accordingly, this part of the PEI-Simulator requires the application of a second derivative to observe the estimate the inflection point.

$$T_{max} = f''(D) = \partial^2 x \log_2(T)/\partial D^2 > 0 \quad (17)$$

2.1.2.2.Actual War Stage

If war starts now between ($P_1 \wedge P_2$) then economic desgrowth from war ($-\delta_{war}$) can expand quickly, butt in different magnitudes $P_{(}(\Delta-\delta_{war}) \neq P_{(}(\Delta-\delta_{war})$. The intensity of the war (I) is going to define the focal ratio of total economic leaking from war (Ω_{war}). The intensity of the war (I) is calculated using nine main variables. These nine variables are based on: (i) external military support (I_1); (ii) war technological systems (I_2); (iii) army size (I_3); (iv) strategy, information, and logistic systems (I_4); (v) natural and geographical conditions (I_5); (vi) society support (I_6); (vii) military know-how (I_7); (viii) transportation, communications, and IT systems (I_8); and (ix) industrial structures (I_9) (see Expression 18). The *PEI-Simulator* also assumes that in the long run economic desgrowth from war ($-\delta_{war}$) and war losses (-L) can seriously impede the recovery of both players ($P_1 \wedge P_2$) albeit to different extents in the post-war stage.

$$|J'(I)| = \begin{pmatrix} \partial I/\partial I_1 & \partial I/\partial I_2 & \partial I/\partial I_3 \\ \partial I/\partial I_4 & \partial I_i/\partial I_5 & \partial I/\partial I_6 \\ \partial I/\partial I_7 & \partial I/\partial I_8 & \partial I/\partial \alpha_9 \end{pmatrix} \quad (18)$$

Therefore, economic wear from war (Π_{war}) depends on the changes of economic desgrowth from war ($-\delta_{war}$) and war losses (-L) according to expression 19.

$$\Pi_{war} = f(-\delta_{war}, -L) \quad (19)$$

The final step is to calculate economic wear from war (Π_{war}) according to (20).

$$\Pi_{war} = [\int_{0}^{1} \Omega WAR(\Omega i,-L)^{-nt}\, dt]-[\int_{0}^{1} -\delta_{war(\Omega i,-L)}^{-nt}\, dt] \quad (20)$$

We estimate the marginal economic wear from war (Π_{war}) by first-order derivatives (see expression 21). At the same time, we apply the second-order derivative on economic wear from war (Π_{war}) to find the inflection point (see Expression 22)].

$$\Pi_{war}' = \partial\Pi_{war<t>}/\partial\Pi_{war<t+1>} \quad (21)$$

$$\Pi_{war}'' = \partial^2\Pi_{war<t>}/\partial\Pi_{war}^2{}_{<t+1>} \quad (22)$$

Hence, the boundary conditions for economic wear from war (Π_{war}) are equal to (23).

$$\Pi_{war}' = \partial\Pi_{war}'_0/\partial T \,\big|_{t=0} = 0,\ \partial\Pi_{war}'_1/\partial T \,\big|_{t=1} = 1,\ \partial\Pi_{war}'_2/\partial T \,\big|_{t=2} = 2,\ \ldots,\ \partial\Pi_{war}'_\infty/\partial T \,\big|_{t=\infty} = \infty \quad (23)$$

2.1.2.3.Post-War Stage

Warfare of between the two players($P_1 \wedge P_2$) creates a loser and winner. The winner usually suffers less economic leaking from war (Ω_{war}), war losses (-L), and economic desgrowth from war ($-\delta_{war}$) during the war. In the *PEI-Simulator,* the winner is identified as P_1. On the other hand, the loser suffers relatively more economic leaking (Ω_T), war losses ($-\pi$), and economic desgrowth ($-\delta$) in the war and in the *PEI-Simulator*, the loser has been denoted as P_2.

$$P_1(-L, -\delta war, \Omega_{war}) < P_2(-L, -\delta war, \Omega_{war}) \quad (24)$$

The *PEI-Simulator* assumes that the winner (P_1) will find it difficult to recover from the war. The compensation of economic wear from war (Π_{war}) from the loser to the winner will levy huge burden to its own economy which will slow down the economic recovery of the losing player (P_2). Intuitively, recovery from the economic desgrowth from war ($-\delta_{war}$) will be quicker for the winning prayer (P_1) than the losing player (P_2). To improve economic desgrowth from war ($-\delta_{war}$) and war losses (-L), the losing player (P_2) requires a multilateral reconstruction plan, international assistance, and institutional and society re-organizing in order to rebuild a new post-war structure such as political, societal, technical, and economic systems.

$$P_1(\partial-\delta_o/\partial-\delta_f) < P_2(\partial-\delta_o/\partial-\delta_f) \quad (25)$$

In the long run the winning player (P_1) and losing players (P_2) can experience different magnitudes (Δ) and trends of economic desgrowth from war ($-\delta_{war}$) and war losses (-L). Additionally, the recovery of both players $(P_1 \wedge P_2)$ depend on their integral social, economic, technological, and political development model until the war losses (-L) is equal or close to zero.

$$[P_1(\partial\text{-}\delta_o/\partial\text{-}\delta_f) \leq 0] \text{ v } [P_2(\partial\text{-}\delta_o/\partial\text{-}\delta_f) \leq 0] \quad (26)$$

3. Application of the PEI-Simulator: A War Simulation Between Russia and Ukraine

In this section, we apply the *PEI-Simulator* in case a full war between Russia and Ukraine in the year 2024. Tension between the two nations has recently been intensifying. Underlying the tension is the unrelenting ascent of Russia as a super military power, and a corresponding relative decline in the power of Ukraine. The immediate flashpoint is a festering maritime dispute over the ownership of land that is part of Ukraine known as Donbass (see Figure 1). We seek to evaluate the effects of a possible war between Russia and Ukraine by applying the *PEI-Simulator*. The example employs three different groups of players. The partnership players are three large military powers (A_i) - U.S. (A_1), EU (A_2), and China (A_3). At the same time, we have A_i that represent alliances. Hence, we have three different sets of countries denoted by 27, 28, and 29.

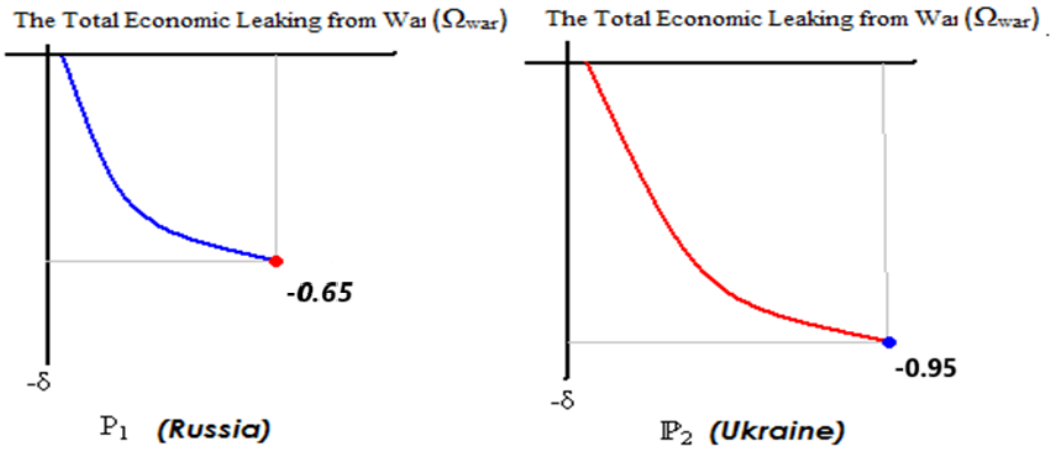
$$P_1 = \{x/x{:}A_3\} \quad (27)$$
$$P_2 = \{x/x{:}\ A_1 \cup A_2\ \} \quad (28)$$
$$(P_1 \cap A_1) \Leftrightarrow (P_2 \cap [A_1 \cup A_2]) \quad (29)$$

The PEI-Simulator assumes that P1 (Russia) is going to get support from China ($\mathbb{A}_1$). On the other hand, P_2 (Ukraine) will get support from EU (A_1); USA (A_2). The three main elements that can precede to a war between P_1 (Russia) and P_2 (Ukraine) are: (i) historical issues stemming from the Cold War; (ii) rapid military expansion of Russia; and (iii) rivalry for military supremacy and hegemony in East Europe. These factors have jointly generated a high level of war tension (T) between P_1 and P_2.

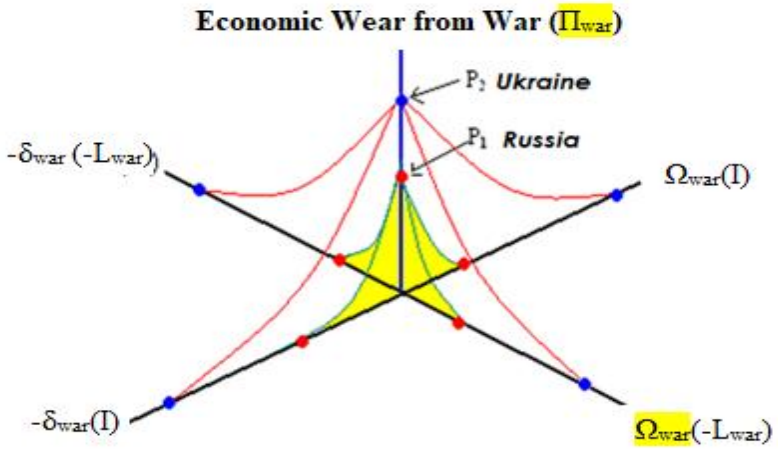
According to the *PEI-Simulator* for year 2024, we have the level of military tension (T) between P_1 (Russia) and P_2 (Ukraine) increases from 0.35 in 2014 to 0.97 in 2024.

The average economic leaking from war (Ω_{war}) between the two rivals are 0.35 (P_1) and 0.75 (P_2) in the 1990s and 0.37 (P_1) and 0.99 (P_2) in 2024. Economic desgrowth from war ($-\delta_{war}$) of P_1 (Russia) and P_2 (Ukraine) is averaged -0.33 and -0.63 in the 1990s, and -0.55 and -0.97 in 2024. Average war economic wear (Π_{war}) of P_1 (Russia) and P_2 (Ukraine) was 0.37 and 0.43 in the 1990s and 0.55 and 0.99 in 2024. On the other hand, if war erupts between the two East European countries, we need to take into account the

relative weighing that exists between the two players (P_1:P_2). According to *PEI-Simulator*, the relative weighting for different dimensions is as follows: military external support (1:2); war technological systems (9:2); army size (11:1); strategy, information, and logistic systems (10:2); natural and geographical conditions (10:1); society support (10:3); military knowhow (10:2); viii) transportation, communications, and IT systems (10:2); and industrial structures (10:1). In the simulation for year 2024, we can see that P_1 (Russia) clearly enjoys a superior position relative to P_2 (Ukraine). Therefore, P_1 (Russia) is more likely to win the war over P_2 (Ukraine). Economic leaking from war (Ω_{war}) of P_1 (Russia) and P_2 (Ukraine) during the war is equal to 0.70 and 0.99 respectively. The economic desgrowth from war ($-\delta_{war}$) of P_1 (Russia) and P_2 (Ukraine) is estimated to -0.65 and -0.95 (see Fig. 1). Finally, war losses (-L) of P_1 (Russia) and P_2 (Ukraine) can reach -0.65 and -0.95. Economic wear from war (Π_{war}) in P_1 (Russia) and P_2 (Ukraine) is equal to 0.60 and 0.95 (see Fig. 2). To minimize the economic desgrowth from war ($-\delta_{war}$) and war losses (-L), the losing player P_2 (Ukraine) should arm with a systematic multilateral reconstruction plan, international aid, as well as institutional and society re-organization, the major source of postwar restoration of the country.



Graph 1: Economic Desgrowth from war (-δwar) in Post-War Stage between Russia (P1) and Ukraine (P2) for year 2024.
Source: Author calculations



Graph 2: Economic Wear from War (Πwar) in Post-War Stage between Russia and Ukraine for year 2024.
Source: Author calculations

Figure 1: Land Border Conflict between Russia and Ukraine
Source: Open Street Maps, Time Reporting, Doug Stevens/@LA-times-graphics

4. Concluding Observations

In most of the cases, wars have a huge impact on economic performance yet such economic impressions are seldom formally modelled. The key objective of our paper is proposing a new simulator which analyse the impact of war on the economic performance. The Post-War Economic Impact Simulator (PEI-Simulator) assesses the economic effects of participating countries in accordance with the possible scenario of war in three different stages: (i) pre-war stage; (ii) war stage; and (iii) post-war stage. The *PEI-Simulator* introduces a number of new indicators, including economic desgrowth from war ($-\delta_{war}$), war intensity (ı), war losses (-L), economic wear from war (Π_{war}), level of war tension (I), level of diplomatic negotiations (D) and total economic leaking from war (Ω_{war}). The underlying intuition is that the economic impact of war depends on a country's vulnerability to international or regional conflict, which jointly determines the leakage from economic growth from war ($-\delta_{war}$) and hence the impact on economic growth performance. We believe that the PEI-Simulator will contribute to a better and deeper apprehension of the economic impact from war.

The estimation results derived from *the simulator* for year 2024 shows that if GDP growth rate in real prices (GDP_{rp}) is small, then the total economic leaking from war (Ω_{war}) will severely affect the performance of any economy. At the same time, this economy will experience permanent economic desgrowth from war ($-\delta_{war}$). On the other hand, if the GDP growth rate in real prices (GDP_{rp}) is large, in the short run, the total economic leaking from war (Ω_{war}) will have rather limited impact on the performance of the economy while it may later rise to a level that can cause economic desgrowth from war ($-\delta_{war}$). Here, the economic wear from war (Π_{war}) analysis is based on four main variables such as economic desgrowth from war ($-\delta_{war}$), war losses (-L), the total economic leaking from war (Ω_{war}), and the intensity of war (ı). Our analysis demonstrates that war losses (-L) and economic leaking from war (Ω_{war}) can affect economic wear from war (Π_{war}) performance directly. We find that country, who suffers less war losses (-L) and war intensity (I) volumes, which would reduce the extent of total economic leaking from war (Ω_{war}) and economic desgrowth from war ($-\delta_{war}$), is most likely to win the war over the other. The longer the period of war between the two countries, the higher the economic desgrowth from war ($-\delta_{war}$) due to a considerable damage in war losses (-L) and war intensity (I). The recovery evolvement of the two participants in terms of economic desgrowth from war ($-\delta_{war}$) rates will differ in magnitude (Δ). Recovery progress depends directly on achieving a better GDP growth pace in real prices (GDP_{rp}). It also relays on greater control of the total economic leaking from war (Ω_{war}) and reduction of war losses (-L) in the short run.

Finally, applying the *PEI-Simulator* on a full war between Russia and Ukraine, we find that Russia will presumably win the war over Ukraine. The analysis presents that economic leaking from war (Ω_{war}) can amount to 0.70 for Russia and 0.99 for Ukraine in case of the war in year 2024. The corresponding figures for economic desgrowth from war ($-\delta_{war}$) during the war are -0.65 for Russia and -0.95 for Ukraine. Accordingly, the war losses (-L) reach -0.65 for Russia and -0.95 for Ukraine. Lastly, economic wear from war (Π_{war}) is 0.65 for Russia and 0.95 for Ukraine. The winner and loser in the post-war

stage will depend on the level of economic desgrowth from war ($-\delta_{war}$), total economic leaking from war (Ω_{war}), and war losses (-L). We believe *PEI-Simulator* will present a more precise picture of the economic effects of war between Russia and Ukraine. As we had witnessed from the two world-wars, wars impose significant consequences to the war participation agencies and sometimes to the world economy. Despite of such imperative fall out of war, modelling of its economic effect has been rarely explored. This is not surprising as wars are fraught with uncertainty and often driven by non-economic factors such as geopolitical self-interest or nationalism.

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Conflicts of interest

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