



TRADE AND INTERNATIONAL POLICY

At What Cost? The Economic and Human Costs of Russia's Invasion of Ukraine

By Dan Ciuriak

Executive Summary: At the five-month mark, the costs of Vladimir Putin's "special military operation" have soared and spread. The short-term economic costs of the invasion include not only the direct war damage in Ukraine and the immediate consequences of the economic sanctions and counter-sanctions on current economic output in the economies of the combatants, but also the induced negative impacts for global growth, inflation, and commodity supply disruptions, most importantly of food and energy.

The profound shock to the geopolitical status quo – a "Zeitenwende" in the words of Germany's Chancellor – has triggered far-reaching policy adjustments, including the fall of a new iron curtain on trade and investment between Russia and the EU and the reclassification by Japan of Russia from "opportunity" to "threat," which from a trade perspective alone, implies medium-term growth impairment. For Russia, the damage to its brand and the decline in its terms of trade also imply an associated destruction of the value of intangible assets. Further, there are the human costs, which are invariably noted as horrific but rarely quantified.

In this note, I tally the economic costs that have already been effectively booked and suggest how to quantify the human costs. The latter include the toll of dead and wounded; the effect of war trauma in Ukraine; and the spillover effects on third parties, which include the tipping of tens of millions in Sub-Saharan Africa into extreme hunger, the heightened stress worldwide posed by the threat of nuclear war, and the shared or vicarious trauma visited on individuals worldwide (but especially in Europe given proximity) in this, the first social media war.

I arrive at a total on the order of \$9 trillion as a conservative estimate and up to \$14 trillion when adopting higher assumptions for human costs. Russia suffers significant costs but by far the greater share of the costs are borne by Ukraine and third parties.

Note: All figures in this paper are in US\$ at 2022 prices, unless otherwise stated.

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1 INTRODUCTION

At the five-month mark, the costs of Vladimir Putin’s “special military operation” have soared and spread. In this note, I attempt to provide a comprehensive overview of the all-in costs of the war that have already been effectively booked over the politically relevant medium term. The short-term economic costs of the invasion include not only the direct war damage in the Ukraine and the immediate consequences of the economic sanctions and counter-sanctions on current economic output in the economies of the combatants, but the induced negative impacts for global growth, inflation, and commodity supply disruptions, most importantly of food and energy.

The profound shock to the geopolitical status quo – a “Zeitenwende” in the words of Germany’s Chancellor (Schmies 2022) – has triggered far-reaching policy adjustments, including the fall of a new iron curtain on trade and investment between Russia and the EU (Cliffe 2022; Al Jazeera 2022) and the reclassification by Japan of Russia from “opportunity” to “threat” (Agence France-Presse 2022a), which from a trade perspective alone implies medium-term growth impairment. For Russia, the damage to its brand and the decline in its terms of trade also imply an associated destruction of the value of intangible assets.

Further, there are the human costs, which are invariably noted as horrific but rarely quantified. I draw on available estimates of the value of a “statistical life” to provide a sense of the scale of the human costs, which include:

- the toll of dead and wounded, which has mounted steadily as Russia’s military strategy shifted to a Grozny-like war of mass destruction and attrition of forces in the war zone;
- the effect of war trauma in Ukraine; and
- the spillover effects on third parties, which include the tipping of tens of millions in Sub-Saharan Africa into extreme hunger, the heightened stress worldwide posed by the threat of nuclear war, and the shared or vicarious trauma visited on individuals worldwide in this, the first social media war.

The estimates should be understood as impacts that can be plausibly attributed to the war, over and above a baseline non-war scenario, and that have already been effectively booked over the politically relevant medium term.

Importantly, these estimates are based on what appears to have been the general consensus of analysts that the conflict would be largely contained to the Donbas in 2022 and essentially become a frozen conflict thereafter, enabling economic recovery and rebuilding to proceed. The costs could actually prove to be much larger, if and as the conflict escalates. Russian Foreign Minister Lavrov is already on the record as saying that, “The geography is different now. It is not only about the DNR and LNR, but also the Kherson region, the Zaporizhzhia region and a number of other territories” (Agence France Presse 2022b).

The impact of the war on the global economy was taken in the first instance from the change in economic outlook between the January 2022 and April 2022 World Economic Outlooks published by the International Monetary Fund (IMF). The January outlook, which remained focussed on pandemic risks, already had priced in monetary policy tightening and the withdrawal of fiscal stimulus, while warning – in a context of multiple vulnerabilities – of a “....sudden repricing of risk in markets, should investors reassess further the economic and policy outlook, [which] could interact with such vulnerabilities and lead to tighter financial conditions (IMF 2022a; 10). The word “recession” was not mentioned in the January report; in the April report, it was a dominant theme. The “sudden repricing of risks” can safely be attributed to the war; the marginal differences between the two outlooks is thus a reasonable estimate of the impact of the war on global growth at that point. On 26 July 2022, the IMF announced a further downward revision to global growth, driven in part by the war’s impact on growth in Europe and co-ordinated monetary tightening worldwide in response to spiking inflation rates which is due to some combination of the war and China’s pandemic-response-driven supply disruptions (Gourinchas 2022). This additional reduction in growth prospects for 2022-2023 is reflected in the

estimates. The final results could be still greater since the dynamic impact on markets of the initial write-down in the outlook has yet to be factored in.

The total does *not* include the destruction of intangible value in the global equity market turmoil, which at one point wiped as much as \$20 trillion off the value of global equities (Karunakar 2022). How much of this is due to the war is an open question and the answer changes from trading day to trading day. How much is transient and will be recovered is also unclear. Accordingly, the estimates are limited to structural features of the impact of the war for which reasonable benchmarks exist. I take up the question of the extent to which the destruction of intangibles is or is not captured by the impact on real growth; for Russia, it is arguably additional.

As regards the human costs, the various effects included in the tabulation are all mentioned in the literature on costs of war. Chwastiak (2008), for example, provides a thorough itemization of such costs, including post-traumatic stress disorder (PTSD), and notes that, if these costs were routinely made known, wars would be much less palatable to governments – which is to say, these costs are not routinely made known. While this is charted territory, the data on human impacts in the Russian invasion of Ukraine to date are limited. The estimates provided are based on the best available empirical benchmarks but are inherently subject to wide confidence bounds.

There are many costs that could not be included – insofar as the war represents “the straw that broke the camel’s back” for the system of globalization that developed under US hegemony, the impacts will be truly far-reaching in ways that are unknowable. A short list of unaccounted factors is as follows:

- The destruction of community in Ukraine. Some of this would be captured in the estimates of stress impact (see e.g., Frankenberg et al. 2012, for an investigation of the role of loss of community on stress). However, there is a value external to the individual in neighbourhoods through which we come and go but which remain for others – how does one put a value on the destruction of that?

- Budgetary expenditures for the militaries and military assistance to Ukraine.
- Budgetary expenditures for refugee assistance.
- The welfare consequences of the now unavoidable shift from “butter” to “guns” in global expenditures going forward.
- Environmental damage in Ukraine from the war (see, e.g., Ukraine’s announcement of intent to pursue legal damages for war-generated environmental harms; Zinets 2022).
- The delay in addressing the rapidly escalating cost of climate change as the disruption of energy supply drives a temporary reversion to coal.
- The likely decline in international cooperation based on the likely reduction in overall global trade and investment.

I arrive at a total on the order of \$9 trillion as a conservative estimate and up to \$14 trillion when adopting higher assumptions for human costs. The bottom-line results suggest that the human costs are indeed greater than the economic damage as is often stated – if only in a rhetorical sense.

2 THE DIRECT COSTS OF THE WAR TO THE BELLIGERENTS

Russia, Belarus, and Ukraine were expected to comprise an economy with GDP of about \$2 trillion in 2022 (about the size of Canada’s economy in 2021) before the invasion, or almost 2% of the \$100 trillion global economy (IMF 2021a); together they accounted for a similar percentage of global trade.

The direct economic costs include the value of destroyed physical assets and the economic growth forgone. The latter includes the economic losses in 2022, the discounted present value of the forgone output over the coming years and the destruction of intangible asset values, over and above what is already captured in forgone real economic activity. In addition, and most importantly, there is the enormous human cost.

Table 1: War Damage to Ukraine's Economic and Civilian Infrastructure at 22 weeks

Item	Cost at End-July \$ Billions
Residential and Commercial Buildings	71,659
Residential buildings	66,641
Retail facilities	2,860
Administration buildings	1,027
Shopping malls	584
Storage infrastructure	547
Transportation Infrastructure	68,556
Roads	50,827
Civilian airports	6,817
Railway stations and rolling stock	4,522
Bridges and bridge crossings	2,863
Cars	1,638
Ports and port infrastructure ⁴⁷¹	797
Military airfields	792
An-225 Mriya aircraft	300
Industrial enterprises	19,460
Industrial enterprises	19,460
Health, Education & Cultural Institutions	6,253
Secondary and higher education institutions	2,743
Healthcare institutions	1,941
Kindergartens	975
Cultural facilities	457
Religious buildings	137
Land, Energy and Other	15,777
Agricultural infrastructure & assets	8,600
Energy	4,400
Other	2,777
Total	181,705

Sources: Statista (2022a), which is based largely on Kyiv School of Economics tabulation, as of 8 June 2022, adjusted by the author to end-July 2022. Estimates for agricultural and energy infrastructure from Quinn (2022) and Carella (2022) adjusted to end-July.

2.1 Material War Damage

The physical damage to Ukraine's economic and civilian infrastructure at the five-month mark or about 22 weeks is now likely about \$180 billion (Table 1). This is less than the early \$210 billion guesstimate made by Ukraine's Economy Minister

Yulia Svyrydenko (Agence France-Presse 2022c), but of the same order of magnitude.

This figure grows by the week. Indeed, in mid-July, Russian forces were ordered to step up the attacks (Ables et al. 2022). Reports in July document continued attacks on industrial enterprises (e.g., an aerospace plant in Dnipro that

made satellites, including one launched by Elon Musk's SpaceX; Peter 2022), urban infrastructure and housing (e.g., the attack on the commercial centre of Vinnytsia; Wright 2022), universities (e.g., the two main universities in Mykolaiv; Mpoke Bigg 2022), port infrastructure (e.g., the attack on Odesa's grain terminals; Francis et al. 2022), and agricultural assets (Bennett 2022).

Accordingly, it is reasonable to estimate the incremental damage on the basis of weekly averages to date from the available estimates.

2.2 Forgone Economic Output

Ukraine

Ukraine faces a massive economic contraction in 2022 due to the combination of:

- Destruction of Ukrainian economic infrastructure.
- Destruction of industrial enterprises.
- Complete shutdown of about 50% of Ukrainian businesses (UNDP 2022).
- Trade blockade: Ukraine's main export routes through Black Sea ports are mined and have been out of commission since the invasion. Although Moscow and Kyiv reached an agreement on 22 July 2022 to allow shipment of Ukrainian grain, Russian missiles struck the port infrastructure including grain terminals in Odesa the following day raising questions about the reality of the agreement (Francis et al. 2022).
- Workforce decline due to military enlistment, war casualties (likely in the tens of thousands killed and a multiple of that wounded), and mass dislocation of households: an estimated 7.2 million Ukrainians are now displaced internally and about 5.2 million have fled abroad (UNHCR 2022); about 1.3 million have been forcibly removed to Russia.

As regards real output, previous IMF guesstimates had placed the expected decline at up to -35% in

real terms based on evidence from previous wars with a similar scale of destructiveness (Elliott 2022).¹ Similar estimates have been made by Blinov and Djankov (2022) at end-May (-36.5%); and by Reynolds (2022) in June (-36.8%). The most recent World Bank outlook (June 2022) assumes a decline of -45% (World Bank 2022). Ukraine's Economy Minister Yulia Svyrydenko earlier put the decline at as much as -55% (Agence France-Presse 2022c).

Current scenarios call for a rebound in 2023. How strong the rebound might be is highly uncertain: the World Bank projects 2%; a private-sector forecast suggests 9% (reported in Reynolds 2022). Under the "contained conflict" scenario, this would be followed by above-potential recovery growth over the medium term.

Compared to an IMF forecast of October 2021, under the World Bank scenario, Ukraine will realize a loss of GDP evaluated in 2022 US dollars of about \$100 billion in 2022. Over the period 2022-2027, the cumulative loss in terms of forgone output will amount to close to \$600 billion compared to projected growth pre-war, as real output remains well below pre-war levels throughout the period. In present value terms, assuming a 5% social discount rate, this amounts to a loss of over \$520 billion over this period alone (Table 2).

This is likely optimistic; a protracted war, with Russia continuing to destroy Ukrainian economic infrastructure and industry, could lead to much worse outcomes due to impacts across many factors that drive economic growth (see, e.g., Blinov and Djankov for a discussion of the longer-term damage from war-interrupted education).

Russia

Russia also faces a steep short-term contraction given supply chain disruptions from border closure, the disruption of shipping into the Russian market even of non-sanctioned goods (e.g., Maersk pulled out of the Russian market completely because of the operational difficulties at the Russian border and dim prospects for future trade given international sanctions – see, e.g., Almendral

1 On the economic costs of a magnitude 7 war, which the Russian invasion constitutes for Ukraine, see Thies and Baum (2020). Their estimates suggest wars of this scale reduce per capita GDP by 16 to 24%.

2022, and Rytvinskaya 2022), and the shutdown of airspace (which interrupts the supply of high-value, time-sensitive airborne cargo from the west). Added to this are a collapse of business and consumer confidence, an exodus of foreign direct investment (FDI) (over 1,000 international firms have closed shop or suspended operations in Russia; Sonnenfeld et al. 2022), and an exodus of young people, many of them closing up technology businesses and moving abroad to start over. In the latter regard, Volpicelli (2022) reports estimates from RAEK, a Russian technology trade group, that between 50,000 and 70,000 tech workers had already left Russia by the third week of March, and surmised that perhaps 70,000 to 100,000 more were aiming to leave imminently. Russia's brain drain has continued in the months since (Champion and Bedwell 2022). This exodus consists mainly of young, urban, multilingual, outward-looking professionals who were part of a global economy from which Russia now been largely cut off (Arraf 2022).

As regards the GDP implications, preliminary estimates of the negative impact in real terms in the short term ranged from an IMF estimate of -7% for 2022, to JP Morgan's -12.5%, to the Institute for International Finance's -15% (Liesman 2022). Estimates released mid-year are for a relatively modest decline of about 9-10% in 2022: the World Bank (2022) projects -9.1%; Reynolds reports a private-sector forecast of -9.8%. For Russia, the negative factors continue into 2023; a continued decline of about -2% is expected for 2023 in the World Bank scenario. In a 22 July release, the Bank of Russia forecast a shallower GDP decline of between 4.0–6.0% in 2022, with a follow-on decline of 1.0 to 4.0% in 2023 (Bank of Russia 2022). However, Sonnenfeld et al. (2022) argue that Russia's official position that its economy is adjusting to the sanctions is untenable given a range of considerations:

- A weakened position as a commodities exporter given challenges of pivoting to Asia for pipeline-delivered natural gas, coupled with a broad-based return of commodities prices back towards pre-war levels;
- A collapse of imports, especially of crucial inputs, parts, and technology from hesitant

trade partners, which has hobbled sectors like automobile production;

- The hollowing out of its tech sector with the exodus of foreign business and the ongoing brain drain;
- The monetary and fiscal interventions that have propped up the economy to date are unsustainable; and
- The cut-off from access to foreign capital markets removes a possible cushion for firms.

Combined these considerations point to a far more fragile economy and a deeper recession than the international financial institutions currently project.

For the medium term, Russia was projected by the IMF (2021a) to have a trend real growth of about 1.7%. This is likely significantly reduced in any post-war scenario, because of trade and technology considerations. The EU and the United States account for a little under 50% of Russia's exports and about 40% of its imports. This is similar to the United Kingdom's trade intensity with the EU27. The war effectively drops a new iron curtain on this trade, which implies knock-on economic effects at least as significant as those of Brexit for the UK. This is particularly the case for the non-commodity economies of Moscow and St. Petersburg.

Brexit has resulted in UK GDP being substantially lower than it would have been otherwise due to the complications in trade logistics, administrative trade costs, uncertainty effects on investment, the problems of labour market mis-matching, and so forth. Springford (2022) builds a "doppelgänger" economy for the UK and traces its performance since the referendum. He finds:

UK GDP is 5.2 per cent lower than that of the doppelgänger; investment is 13.7 per cent lower; goods trade, 13.6 per cent lower; and services trade 7.9 per cent higher (Springford 2022).

For Russia, the economic decoupling with the EU and the United States will be harsher than Brexit – and importantly, services trade will also be sharply lower. That being said, the decoupling will not be from the context of a single market but from a less integrated structure based on WTO

trade relations. Russia will be able to re-orient its trade, in particular its commodity exports, towards BRICS partners,² most importantly China and India. However, both of these economies have trade specializations that are complementary to the EU and the US, not replacements for them.

The latter consideration applies *a fortiori* to technology trade. China and India developed their technologies largely as complements to those of the West – and dependent in good measure on imports of technology from the West to sustain and develop their own. China has struggled to replace US and EU technology in its computer chip supply chains since the outbreak of the trade and technology conflict, despite effectively unlimited resources being thrown at the problem. China is the “workshop of the world” and possesses the industrial skills that go with that label; Russia’s economy is about the size of Florida’s and most of it is based on commodities.

Finally, as the Russian economy becomes even more dependent on commodities than it has been, it faces a “Dutch Disease” problem as commodity exports work to support a higher valuation of the rouble than is optimal for the industrial sector (for a discussion of Dutch Disease in the context of modern heterogeneous firms trade theory, see Ciuriak 2014). This effect has been accentuated by Russia’s monetary policy choice to control inflation through a high nominal exchange rate which allows lower interest rates to support domestic-economy-oriented investment.

The apparent strength of the rouble, which at end-July is substantially higher than its pre-war value of 83 to the dollar, warrants comments. As Itskhoki and Mukhin (2022) note:

...the value of the rouble is determined on the Moscow Exchange, which has become largely disconnected from international financial markets since the beginning of the war. Western sanctions constrain foreign banks from trading

roubles, and Russian capital controls limit access of Russian residents to foreign markets.

The combination of domestic financial repression and a current account surplus (which reflects sustained inflow of foreign exchange from commodity exports and a steep fall in imports due to sanctions) allows the domestic monetary authority to set the exchange rate. Recall in this regard the Fleming-Mundell monetary policy trilemma that a country can achieve only two of the three policy objectives: free capital mobility, exchange-rate management, and monetary autonomy; Russia has chosen to limit capital mobility to achieve the other two objectives.³

In the context of an open capital account, the rouble exchange rate would likely be a lot lower in real terms than it is at end-July. Notably, the black market exchange rate for the rouble was reportedly in the 110-150 range vis-à-vis the US dollar (Weaver and Duguid 2022). A lower real exchange rate would also be consistent with the negative shock to Russia’s terms of trade from the effect of sanctions (Russia is selling its oil at a discount and faces higher transportation costs as shippers are turning off their transponders to avoid identification as they sell into particular markets; and punitive tariffs on Russian exports will be absorbed by Russian exporters in the form of lower prices, insofar as they can export at all). A lower real exchange rate is also consistent with the UK’s post-Brexit experience, which witnessed lower valuation (on the order of 15%) of pound sterling (Coyle 2021).

Ipsa facto, the official exchange rate is substantially over-valued. An over-valued currency stifles real growth – consider for example Japan’s lost decade following the steep revaluation of the yen following the Plaza Accord (Ciuriak 2002).

For these various reasons, a write-down of Russia’s potential economic growth over the medium term is warranted. Assuming the potential growth rate is cut in half (which is consistent

2 Brazil, Russia, India, China and South Africa.

3 The Bank of Russia has been actively adjusting the stringency of capital controls as monetary conditions change, underscoring the policy choice behind the degree of freedom of capital mobility.

Table 2: War Impact on Growth in Ukraine, Russia and Belarus, Real GDP in 2022 \$Billions

	2021	2022	2023	2024	2025	2026	2027	Total
Prewar Real GDP Projections								
Ukraine	211	219	227	235	244	254	263	1,442
Russia	1,887	1,925	1,964	2,003	2,043	2,084	2,126	12,145
Belarus	72	73	74	75	76	76	77	451
Postwar Real GDP Projections								
Ukraine	211	116	126	136	146	157	169	851
Russia	1,887	1,719	1,685	1,702	1,719	1,736	1,753	10,313
Belarus	72	66	65	65	65	66	66	393
Difference								11,557
Ukraine	0	-103	-100	-99	-98	-96	-94	-591
Russia	0	-206	-279	-301	-325	-348	-373	-1,832
Belarus	0	-7	-9	-10	-10	-11	-11	-58
Difference in Present Value Terms								
Ukraine		-103	-95	-90	-84	-78	-73	-523
Russia		-206	-265	-272	-278	-284	-288	-1,593
Belarus		-7	-9	-9	-9	-9	-9	-51
								-2,167

Note: 2021 data are from the IMF (2021a) converted to 2022 \$ based on the estimated change in the US GDP deflator from the IMF World Economic Outlook database for April 2022.

Source: IMF World Economic Outlook, October 2021 and April 2022; and calculations by the author for the 2022–2027 figures.

with the impact of Brexit on the UK for the first half decade of Brexit), Russia's economy in 2027 will remain well below its 2021 level in constant 2022 US dollar terms. The forgone output in Russia's economy would amount to \$1.8 trillion; in discounted present value terms, this would be \$1.6 trillion. Note that this is not a forecast of the actual path of the Russian economy; rather it is an assessment that, regardless of the actual path the Russian economy follows, it will be on a lower trajectory because of lower potential growth.

Belarus

Belarus is not being spared the impact of the war given that it has allowed its territory to serve as a

staging ground for Russian military strikes against Ukraine. Its economy has entered into a steep recession and will likely experience a larger decline than Russia's as it is structurally more vulnerable:

- It has fewer resources to shield itself from the effect of sanctions.
- It is heavily exposed to the Russian economic downturn and slower future growth.
- Its exchange rate is down about 25% compared to 2021 as its credit rating sinks to CCC.
- It faces a possible credit default: Belarus has started to service international debt payments in Russian roubles rather than hard currency and its bonds have reportedly been trading as low as

15 cents on the dollar (Onoszko and Kudrytski 2022).

Applying the same growth discount to Belarus as to Russia, Belarus faces a loss of production of close to \$60 billion over the medium term; this amounts to a little over \$50 billion in present value terms.

Summary

The combined loss in terms of forgone output for the three economies that are centrally engaged in the war amounts to \$2.3 trillion at 2022 prices. The present value of those losses is about \$2 trillion (Table 2) over the medium term alone.

2.3 The Destruction of Intangible Assets

Stocks on the Moscow Exchange (MOEX) sank by 33% the day after the invasion and remain at about that level at end-June (Yahoo Finance 2022). This is an indication of market views of the economic implications of the war. Notably, MSCI, a division of Morgan Stanley that manages various indexes used by portfolio investors, declared the Russian market to be “uninvestable” following the invasion and removed it from its global indexes (Associated Press 2022). The Russian equity market capitalization as of January 2022 was estimated at \$773 billion (Associated Press 2022). A one-third write-down is a loss of about \$260 billion.

A first question is whether this is plausible as an estimate of the structural reduction in the value of Russian equities?

A significant write-down in the value of capital assets is implied by structural changes that imply lower future returns to Russian capital. A standard capital asset pricing model (CAPM) translates expected lower rates of return into a lower market cap by capitalizing the lower future stream of earnings, assuming some discount rate and a time period. Even a relatively small change in the expected rate of return can drive a large wedge in asset prices. To give an example of such a calculation, the USITC (2011) estimated that China observing US IP laws could raise the rate of return to US capital by 0.4%. Ciuriak (2017) applied the 0.4% improvement to the Standard & Poor's 500 market capitalization of (then) \$15

trillion, discounting at the historic weighted average cost of capital (WACC) for the S&P 500 of 8.3% over the horizon to 2035 and ignoring terminal values. That study found an implied improvement in financial market estimates of the value of US capital of \$345 billion or 2.3% of the value.

As regards the scale of the impact on Russian equities, a useful benchmark is the UK equity market discount post-Brexit: this widened steeply following the Brexit referendum and remains very large more than half a decade later, with UK equities trading at a 30-40% discount in recent months (Whiffin 2022).

A second question concerns whether this wealth effect is additional to the cost of the war captured by the reduced GDP. According to the 2020 IMF Article IV examination of the Russian economy (IMF 2021b; 10), Russian non-financial corporates improved their performance considerably following the 2014 crisis triggered by Russia's initial invasion of the Donbas and annexation of Crimea. As a result, aggregate corporate profits increased their share of GDP from 9% to over 14%. In this context, the market capitalization of Russian equities, which had fallen by 50% in 2014 wiping \$ 384 billion off the value of the market (Statista, 2022b), was rebuilt to \$841 billion in 2021.

If Russian corporates maintained their profit share of GDP over the business cycle, then a reduction in trend growth as assumed above would imply a reduced present value of future profit flow of about the amount of the instantaneous fall in the market capitalization of the MOEX following the invasion. That is one interpretation. In that event, the inclusion of this estimate would be wholly double-counting.

An alternative interpretation is that this decline anticipates a reduction in the profit share of GDP, reversing the gains made since 2014 and wiping out the hard-won improvements of the better part of a decade by Russia's private sector. In this case, the decline would be fully additional to the implicit reduction in profit flows due to lower trend GDP growth. As a reality check, a back-of-the-envelope calculation of a reduction in the profit share of GDP in Russia from 14% to 9%, where it was in 2014, discounted at a WACC of 12% (consistent with Vashakmadze 2008, analysis of historical

trends in Russia's WACC) results in a loss of wealth consistent with that reported above.

A third interpretation is that the invasion, by making the Russian brand toxic in Western markets, has wiped out the intangible value of Russian exports (to the extent they still have markets in the West). A similar conclusion is reached by the consideration that Russian exporters would have to accept lower prices for their exports in the face of higher tariffs abroad (e.g., on 3 March 2022, Canada announced that it would withdraw Most-Favoured-Nation (MFN) tariff treatment from Russia and Belarus, which means the application of a 35% import duty on goods originating in Russia and Belarus; Kenigsberg et al. 2022).⁴

Accordingly, there are sound grounds to consider that there will be a considerable negative wealth impact in Russia over and above the reduction of wealth implicit in the lower real GDP track on which the invasion and its aftermath have put the Russian economy. Moreover, given the risks of a much harsher impact on the Russian economy predicted by Sonnenfeld et al. (2022) than currently is priced into the forecasts, this estimate should be considered to be conservative.

No estimate is included for the value of Ukrainian or Belarussian intangible asset destruction. For Ukraine, this would likely be double counting given the destruction of the underlying tangible business assets; for Belarus, the value of intangibles was negligible to start with.

2.4 The Human Costs

The human costs of the war include death, injury, displacement from homes and work, and the trauma

of exposure to the horrors of war. They also include the emotional stress for hundreds of millions who are outside the warzone but exposed to its brutality in their daily news feeds and social media connections.

To an individual, life is priceless. However, governments assign a value on a "statistical life" (VSL) and by derivation of a statistical life year (VSLY) for cost-benefit analysis in many contexts. These estimates have been applied to assign values to the human cost of war. Appendix 1 elaborates on how these concepts can be used for this purpose in the present context.

In brief, while VSL is commonly used for war, methodologies vary as do estimates of VSL across countries – the potential benchmarks for Ukraine, Russia and other countries thus span a wide range. In this study, I adopt high and low estimates based on the literature to establish a range.

Given an estimate of VSL, the value of a statistical life year (VSLY) can be derived based on assumptions about life expectancy and a discount rate that establishes how much higher we place the value of a year of life now compared to many years in the future.

An estimated VSL can be directly used to assign a cost to a death in war. The cost of injury can also be established based on the estimated VSL and the "disability weight" attributed to the injury. For example, a disability weight of 0.3 implies a given injury – say the amputation of a limb – is equivalent to 30% of the value of a statistical life. In the absence of detailed information on the nature of injuries, I make a simplifying assumption that the average disability weight is 0.25.

It is well established that stress takes years off the life of individuals. The Russian invasion of Ukraine

4 One way to think about this issue is the distinction between "real" GDP growth – which is to say the change in the quantity of production at pre-shock prices – and the change in the value of GDP which takes into account relative price changes which affect a country's terms of trade. In a computable general equilibrium (CGE) modelling context, in which there is no inflation but in which relative prices change, there can be a considerable divergence between the two concepts. For example, in the simulation of the Canada-US-Mexico Agreement (CUSMA), Ciuriak et al. (2019) found that the impact on Canada's real GDP was -0.4% while the impact on the value of Canada's GDP was -0.6% - the difference reflecting a negative terms of trade shock from the protectionist features of that agreement. Colloquially, Canada gets "less buck for the bang" from its continental trade under the new Agreement.

Table 3: Assumptions for VSL and VSLY

	Ukraine	Russia	EU27+UK	African economies facing famine
Per capita income (PPP) at 2022 prices (\$)	15,224	32,786	52,038	3,914
VSL (low), thousands of \$	1,124	3,004	4,000	156
VSL (high), thousands of \$	2,403	4,806	6,300	577
VSLY (Low), thousands of \$	56	149	175	-
VSLY (High), thousands of \$	119	238	276	-

Source: See Appendix 2.

has imposed great stress on Ukrainian citizens in many different ways and under a wide range of circumstances – on soldiers at the front lines, on refugees, on citizens continually exposed to attacks, on those exposed to trauma through social media, and on individuals suffering a sudden negative wealth shock due to loss of home, jobs, connections, etc. I draw on estimates from the literature on the average reduction in life expectancy from severe stress to establish the monetary value assigned to this particular source of human cost from the war.

Note that the severity of stress, like many other phenomena, is likely to follow a power law distribution – that is, a small number of individuals suffer disproportionately greatly (e.g., soldiers at the front line) while a large number of others (e.g., doomsrollers on social media) experience much less debilitating impacts. The use of a simple average masks this heterogeneity of experience.

Table 3 summarizes the assumptions (see Appendix 2 for the detailed discussion of the development of these estimates).

The estimates for Russia's VSL/VSLY are much higher than the Russian government's compensation rates for war casualties, which were announced at 5 million roubles for a death and 2.9 million for a disabling injury. At a real exchange rate into US dollars of 100:1, these figures translate into \$50,000 for a death and \$29,000 for an injury. These figures compare to the low estimates of VSL for Russia of \$3 million and hence \$750,000 for an injury. It should be further observed that the

compensation figures do not represent a cost to Russia as they are a transfer within Russia. The cost to Russian society is much larger.

With these assumptions, we can proceed to tabulate the human costs of the war.

The Civilian Death and Injury Toll

The civilian casualty toll in Ukraine is likely already on the order of 40,000 lives lost and 50,000 more seriously injured, many permanently maimed.

- The UN-verified civilian casualty totals as of 22 June 2022 were 4,677 killed and 5,829 wounded (a ratio of wounded to dead of about 125%). This is generally seen as a significant understatement of the true toll.
- The mayor of Mariupol estimated that at least 22,000 residents had died there (Burman, 2022). I pencil in 25,000 for the number of dead in Mariupol.
- Similarly, elevated numbers are likely for the heavily bombarded areas in the Donbas that have fallen under Russian control and where individual deaths have not been properly tallied. I pencil in 10,000 for unaccounted additional civilian deaths in Russian-controlled areas of the Donbas.

The total comes out to about 40,000 civilian deaths or 8,000 per month through the first five months of the war. Using the UN-reported ratio of 125%, this implies significant injuries at about 50,000 or 10,000 per month through this period. Applying

Table 4: Human Cost – Civilian Death and Injury in Ukraine (to date)

	VSL (\$ millions)	Deaths	Injured	Total (\$ billions)
VSL (low), thousands of \$	1,124	40,000	50,000	59
VSL (high), thousands of \$	2,403	40,000	50,000	126

Source: Calculations by the author.

the calculated VSL, we arrive at figures of about \$59 billion with the low VSL estimate and \$126 billion with the high estimate. The average is \$93 billion.

The Military Death and Injury Toll

Military casualties are notoriously problematic to ascertain since announced totals are assuredly manipulated given the desire of the governments to maintain morale and to deceive the opposing forces. Poast (2022) observes that the war to date has already qualified as one of the bloodiest in recorded history, entering the top quartile (at least 28,000 military personnel deaths) as early as late May 2022.

On 21 March, the Russian tabloid *Komsomolskaya Pravda* reported that 9,861 Russian troops had been killed and 16,153 wounded (Pavlova 2022). While the post was quickly removed, it has been preserved in digital archives. Extrapolated to five months, this rate of attrition would put the Russian casualty toll at about 50,000 dead and 80,000 wounded. However, the change in Russian tactics to emphasize long-range artillery makes the first month figures unrepresentative of the course of the war over the next four months. We have alternative figures from the Ukrainian government of 30,000 and from British Intelligence of 15,000 dead. Sabbagh (2022) reports an estimate of 15,000 to 20,000 as of early June. On 27 July, US Congress members were informed that over 75,000 Russian soldiers are believed to have been killed or wounded, (Zanona and Bertrand 2022). Assuming a ratio of wounded to dead of 2 (see, e.g., Cancian 2022), this implies about 25,000 dead and 50,000 wounded. At the five-month mark, these estimates

are in the mid-range of estimates and seem reasonable to use for the present purposes.

A similar figure seems plausible for Ukraine as well. Initially, Ukrainian casualties were smaller given the tactics; however, in the most recent phase of the war dominated by artillery, the casualties have mounted. Sabbagh (2022) reports estimates as high as 20,000 casualties per month during this latter phase.

Applying the calculated VSL, we arrive at figures for Ukrainian military casualties of about \$42 billion with the low VSL estimate and \$90 billion with the high estimate. The average is \$93 billion for an average of \$66 billion. For Russian casualties, the corresponding totals are \$113 billion and \$180 billion for an average of \$146 billion.

The hidden damage of war: life-shortening stress

The Russian invasion of Ukraine has imposed great stress on Ukrainian citizens in different ways as discussed in more detail in Appendix 1, virtually the entire Ukrainian population has been placed under sustained, severe stress by the war, including:

- the troops at the front;
- the civilians who live under constant threat of shelling or bombing (including the Russian threats to use nuclear weapons), hearing air raid warnings, and often spending nights in underground shelters;
- those who are internally displaced or are refugees abroad, facing wholly uncertain futures, and dealing with the multiple stress factors associated with losing jobs, homes, family and connections, and reduced lifetime earnings; and

Table 5: Human Cost: Military Death and Injury – Ukrainian and Russian Forces (to date)

	VSL (\$ thousands)	Deaths	Injured	Total (\$ billions)
Ukraine				
VSL (low), thousands of \$	1,124	25,000	50,000	42
VSL (high), thousands of \$	2,403	25,000	50,000	90
Russia				
VSL (low), thousands of \$	3,004	25,000	50,000	113
VSL (high), thousands of \$	4,806	25,000	50,000	180

Source: Calculations by the author.

- in this age of social media, constantly exposed to “vicarious trauma” from trending reports of death and destruction – in this sense, social media is a stress multiplier and stress spreader.

While it is well established that stress impacts negatively on life expectancy, placing a specific value on this reduction is difficult. Stress affects the young differently than mature adults; it affects women differently than men; the severity and length of exposure to stress matters. On average across a range of stress cases, heavy stress has been estimated to shorten life expectancy by 2.8 years (Härkänen et al. 2020). This provides a point of reference for the evaluation of the human cost of this war, given estimates of populations at risk and the applicable VSLY.

Applying the calculated VSLY to the 37 million or so civilians living outside the pre-war Russian-controlled Donbas and Crimea, adducing the 2.8 years of average life expectancy reduction, and using the discounted last years of expected life as the VSLY, we arrive at figures for the toll on Ukrainian civilians of \$2.5 to \$5.4 trillion.

3 THE SPILLOVER COSTS OF THE WAR ON THIRD COUNTRIES

For the rest of the world, the war has meant sharply higher energy and food costs, higher interest rates, and reduced business and consumer confidence,

leading to a reduction in economic growth and sharp correction in equity markets. The disruption of food supply from one of the world’s bread baskets has raised the threat and possibly delivered the reality of famine in Africa.

3.1 Global Growth

It is difficult to parse out the separate effect of the war on interest rates from the normalization of fiscal and monetary policy as governments withdraw the stimulus unleashed to support the economy during the pandemic, and from the price effects of supply chain disruptions attributable to the flaring of COVID in several important Chinese cities. However, it is fair to say that, prior to the war, higher inflation was already priced into forecasts and, moreover, was considered to be mostly transient as supply chain disruptions were expected to ease. For example, in the IMF’s pre-war January update, the IMF wrote:

Elevated inflation is expected to persist for longer than envisioned in the October WEO, with ongoing supply chain disruptions and high energy prices continuing in 2022. Assuming inflation expectations stay well anchored, inflation should gradually decrease as supply-demand imbalances wane in 2022 and monetary policy in major economies responds. (IMF World Economic Outlook Update, January 2022.)

Table 6: The Impact of War-Generated Stress on the Ukrainian Population

	Low VSL	High VSL
Population at risk (millions of persons)	37,000,000	37,000,000
Number of life years reduced on average	2.8	2.8
Discounted VSLY for 2.8 years at end of life (\$)	68,186	145,676
Cost (billions of \$ at 2022 prices)	2,523	5,390

Source: Calculations by the author.

Following the invasion, sentiment worsened much more than the marginal addition of the war to recorded inflation rates. The idea of a recession was simply not present in the IMF's review of the world economy in January 2022. In the April 2022 outlook, it was all over the report. The IMF's April 2022 outlook factored in a reduction to global growth of 0.8% in 2022 and 0.2% in 2023 compared to the January 2022 estimate. The only significant new factor was the war and its impact on food and energy prices.

"This report projects global growth at 3.6 percent in 2022 and 2023 – 0.8 and 0.2 percentage points lower than in the January forecast, respectively. The downgrade largely reflects the war's direct impacts on Russia and Ukraine and global spillovers" (IMF, World Economic Outlook, April 2022).

On this basis, I pencil in a reduction in global growth outside of the Ukraine-Russia-Belarus group but due to the war of 0.8% in 2022 and 0.2% in 2023, essentially the difference between the January and April outlooks. For the \$100 trillion global economy, this would be equivalent to a loss of about \$1 trillion over the two years.

In July 2022, the IMF further downgraded the outlook by 0.4% in 2022 and 0.7% in 2023, with about equal emphasis on the pandemic-related lockdowns in China and the war. On this basis, we can pencil in a further 0.2% reduction of growth in 2022 and an additional 0.35% reduction in 2023 for a total 1.55% short-term hit to global GDP from the war, or about \$1.55 trillion.

3.2 European Trend Growth

Russia's invasion of Ukraine has fundamentally transformed Europe's relationship with Russia – the "Zeitenwende" in the words of German Chancellor Scholz. While the EU member states that were formerly part of the Soviet bloc have traditionally been much more wary of Russia than the rest of Europe, Europe as a whole must now re-appraise its relationship. Germany's traditional Ostpolitik based on the principle of "Wandel durch Handel" ("change through trade") is in tatters and an extended trade and technology blockade must now be reckoned with – a new "iron curtain" has descended in the words of both western commentators (e.g., Cliffe 2022) and Russia's foreign minister, Lavrov (Al Jazeera 2022).

Russia's trade intensity with the EU and the UK is similar to that of the UK to the EU27. Accordingly, some insight into the relative growth implications of a significant disruption of trade between Europe and Russia can be read from the relative impact on real growth of a hard Brexit on the UK versus the EU27. Such an estimate can be obtained from CGE modelling studies. For this purpose I draw on Ciuriak et al. (2015) which finds a ratio of about 10%. This implies a present value loss of cumulative real GDP over the period 2024-2027 for the EU27 and the UK combined of about \$90 billion. Appendix 3 sets out the calculations.

A regional impact on Europe is implied by the behaviour of equity markets. The global bear market triggered by the war now exceeds in severity the crash during the Great Financial Crisis of 2008-

09 (Brett 2022). Obviously, not all of this can be blamed on the war. On the day of the invasion, markets were generally well down from January highs. The post-invasion period has seen the downturn deepen in some markets but not in all (Table 7).

Boungou and Yatié (2022) find a significant effect of the war on value of equities globally, with the effect much stronger on those countries nearer to the conflict and those countries that condemned the conflict, which points to a structural component. How much of this will, in the final analysis, prove to be transient is unknown. The implication of this is that the coming rebound will be more subdued than otherwise would have been the case due to the efficiency costs of the new iron curtain facing Russia, which is reflected in the reduced medium-term growth assumption for Europe.

3.3 The Human Cost Abroad

In Europe: Stress

In Europe, the war resulted in a sharp drop in consumer confidence (Pollard and de Vries 2022), heightened fears of war, including nuclear war (see, e.g., Sanders-Zakre 2022 and Cerullo 2022), and induced some degree of vicarious stress from the constant news cycle on the war and its lack of resolution – a perpetual cliff-hanger that induces doomsscrolling on social media (Tapper 2022). Polling in both Europe and the United States (Fox and Fingerhut 2022) shows that the war and fears about escalation, including nuclear escalation, have become among people's highest-ranked concerns, with older people being the most concerned.

The fact that the war comes with co-stressors such as concerns about recession, inflation, higher food and energy bills results in a mutually reinforcing dynamic that is particularly problematic for the most vulnerable, namely the older and the poorer segments of the population (see, e.g., Ari et al, 2022). About 20% of the EU population is over 65 years of age and about 20% of the EU population is at risk of poverty. There is not much overlap between these segments – only about 10% of older Europeans are at risk of poverty. However, that still leaves almost 9 million people who are

disproportionately concerned about the war and vulnerable to its spillover effects, especially issues such as energy prices or shortages.

Based on European surveys, perhaps a quarter of the respondents are “very concerned” about the war. Let us break down the vulnerable group then into two segments: one which is severely affected (25% of the total) and one which is moderately affected (75% of the total). Taking into account an estimate of the value of a statistical life year at end of life in the EU27, we arrive at a cost of \$1 trillion using the low VSL estimate and \$1.5 trillion using the high estimate. These are very notional estimates but they serve to highlight that these hidden costs might be quite significant.

In Africa: Famine

Difficult as it is to put numbers on the plight of people in drought-stricken East Africa, the impact on them of Vladimir Putin's war cannot be ignored. East Africa in particular depends heavily on grain and cooking oil from Ukraine. The disruption of supply and soaring prices, coming on top of several droughts, plunged millions of people into extreme hunger in the first half of this year (Peralta 2022). Estimates put the number of people across the Sahel and the Horn of Africa pushed into extreme hunger at up to 47 million, with 14 million said to be currently at risk of starvation.

It is well-established that malnourishment significantly shortens life spans even if it does not kill immediately. For example, the estimated annual cost of undernutrition has been estimated at between 2% of GDP for Egypt to 17% of GDP for Ethiopia (WFP 2020). In terms of VSL, even at the low levels calculated for developing countries, the cost would be in the hundreds of billions.

If we draw on the estimates of Robinson et al. (2019) and apply these to per capita GDP at purchasing power parity in the three most affected countries – Ethiopia, Kenya and Somalia – we arrive at estimates of the VSL ranging from a low of about \$156,000 at 2022 prices to \$576,000. Applying these estimates to a current estimate of 14 million on the brink of starvation, and assuming that 25% are likely to be severely affected (i.e., die prematurely) and the remaining 75% survive but with lasting physical and mental damage

Table 7: Equity Market Developments, 2022

	Year-end 2021	23 February 2022	22 July 2022
S&P 500	4,766	4,226	3,962
FTSE 100	7,385	7,498	7,276
Nikkei	29,333	26,450	27,915
DAX	15,885	14,631	13,254
	Year-to-date Change as of 23 February 2022	Year-to-date as of 22 July 2022	Post-Invasion Delta
	<i>Percent</i>		
S&P 500	-11.34	-16.88	-5.54
FTSE 100	1.54	-1.46	-3.00
Nikkei	-9.83	-4.83	4.99
DAX	-7.89	-16.56	-8.67

Source: Google Finance, Market Summary, accessed 24 July 2022.

(the “moderate” group), we arrive at human cost estimates ranging from about \$ 1 trillion to 3.5 trillion. Appendix 2 has the detailed calculations.

4 DISCUSSION AND SUMMARY

The country with the largest land mass in the world, and one with a shrinking population due to its demographics (see, e.g., Cabot 2022), which includes an ageing population, slowing immigration, fleeing young professionals and a likely baby bust given the uncertainty created by the war, is making a land grab to extend its sphere of influence. At what cost? As the above exposition suggests, Vladimir Putin’s war is very expensive for the world.

Table 6 summarizes the estimates developed above and arrives at an estimate on the order of \$10 trillion on the basis of the most conservative estimates and up to \$15 trillion using estimates for human costs that are mid-range. Russia suffers significant costs but by far the greater share of the costs are borne by Ukraine and third parties.

Consistent with the intuition that the human costs are greater than the material costs, the

accounting exercise in this study concludes that the human costs are indeed greater, particularly if we apply the higher estimate of VSL/VSLY. This underscores the importance of making these “hidden costs” explicit. While the estimates for the value of statistical life are large, Bilmes and Stiglitz (2006) point out that US juries have set much higher payments in wrongful death settlements, as high as \$269 million as of that writing. Even though most plaintiffs receive only a fraction of the award (about 10% on average) this still puts the upper end in the tens of millions and well above the high estimates used in the above calculations.

The above accounting focuses on the economic impacts that can be considered as “realized” and in the books. The shock of the invasion has had other, wider effects, which are more than the economic “ripples” and more like seismic shocks to the international institutional framework. As one commentator after another has opined, “Everything has changed.” Three impacts deserve to be singled out.

First, there is the loss of the “peace dividend” (Rathbone 2022). From Germany to Japan, there is a fundamental re-orientation of public policy towards military capability to defend against what had

Table 8: The Impact of War-Generated Stress on the European Population

	Severe	Moderate	Total
Population at risk (millions of persons)	2.24	6.71	8.94
Life Years (years)	2.8	1.4	1.8
Cumulative VSLY (billions of \$ at 2022 prices – low VSL)	390	576	966
Cumulative VSLY (billions of \$ at 2022 prices – high VSL)	614	907	1,521

Source: Calculations by the author.

Table 9: The Impact of War-Exacerbated Famine on Most Vulnerable African Populations, \$Billions at 2022 prices

	Severe	Moderate	Total
Low	547	410	957
Medium	1,262	946	2,208
High	2,019	1,514	3,533

Source: Calculations by the author.

previously been considered an implausible threat. The welfare consequences of the now unavoidable shift from “butter” to “guns” in global economic activity do not permit an easy analysis. National defence is a very real “public good.” As Ukraine is discovering, without it, all else can be lost. At the same time, most countries would prefer to allocate spending to health, education and technology development and not into tanks and missiles.

Second, the scramble to find alternative sources of energy to Russia’s oil and gas has meant the restarting of coal-fired energy plants – Germany, for example, has activated national contingency plans to source electricity from coal plants that had been placed on standby (Posaner and Gehrke 2022). There is thus a costly delay in addressing the rapidly escalating cost of climate change.

Third, the invasion has intensified the concerns about the weaponization of supply chains that was already driving a decoupling dynamic that inevitably will result in a reduction in overall global trade and investment. While there are many critiques of globalization, these focus mainly on the distributional issues not the efficiency gains. The current decoupling dynamic undoes the efficiency gains without self-evidently addressing the distributional issues. Globalization needed “fixing,” but the invasion and its consequences was the not the way to do this.

These impacts drive the world in a different direction than it would have been on otherwise. Canada, like others, will need to revisit its policies to address the implications of the “Zeitenwende,” (Ciuriak 2022b).

Table 10: Summary of Costs of the War, \$Billions

Source of Cost	Low	Moderate
Economic Costs		
Value of GDP (Ukraine, Russia, Belarus), present value of GDP loss, 2022-2027	2,167	2,167
Material Damage (Ukraine)	182	182
Value of Intangible Assets (Russia)	260	260
Human Costs in VSL terms		
Civilian casualties in Ukraine	59	126
Military casualties in Ukraine	42	90
Military casualties in Russia	113	180
Ukrainian war-induced trauma	2,523	5,390
Spillovers on the Rest of the World		
Value of GDP (Rest of World), reduced growth, 2022-2023	1,550	1,550
Impact on trend growth in Europe (present value of GDP loss, 2024-2027)	90	90
Human costs in Europe	966	1,521
Human costs in Africa	957	2,208
Total	8,908	13,765

Source: Calculations by the author.

APPENDIX 1: VALUE OF STATISTICAL LIFE AND WAR-RELATED HUMAN COSTS

It is common practice for many regulatory purposes where a cost-benefit analysis is mandated and where there are implications for human health to calculate the value of a “statistical life” (VSL) and by derivation of a statistical life year (VSLY). This appendix elaborates on how these concepts can be used to monetize the human costs of war.

In cost-benefit analysis, VSL is based on the willingness to pay (WTP) to achieve a stipulated risk reduction (Δ Risk). In simplified terms, suppose a policy promises to reduce risk of an undesirable event occurring from, say 10 in 100,000 to 5 in 100,000. This change of 5 in 100,000 in a given period is the Δ Risk. If the WTP to secure this risk reduction is, say, \$250, then the VSL would be calculated as follows: $WTP/\Delta Risk = (\$250*100,000)/5 = \$5,000,000$. Thus, if the average person in a society were willing to pay \$250 to, say, absorb the regulatory costs of reducing a fatal accident due to the failure of a component in, say, an automobile from 0.01% to 0.005%, then that society places the value of statistical human life at \$5 million.

VSL analysis is well established in many contexts and can be applied to war

VSL-based analysis is applied in many contexts, including war (Chwastiak 2008; Wallsten and Kosec 2005; Bilmes and Stiglitz 2006). The Chwastiak (2008) analysis is particularly relevant for the present exercise as it itemizes the “hidden costs of war” in particular the consequences of physical and psychological injury, death and social trauma and notes that these impacts could be monetized through VSL calculations (although Chwastiak declines to do so herself).

Wallsten and Kosec (2005), however, writing on the Iraq War, provide an explicit accounting of costs of deaths and injuries in terms of VSL, taking into account detailed estimates of the severity of injuries, the budgetary costs of care, and the value of life to an individual based on varying estimates of VSL across coalition partners in that war.

Methodologies vary as do estimates of VSL across countries – potential benchmarks for Ukraine span a wide range

There is no consensus on how establish VSL for any given country. Methods vary by country; different methodologies yield very different results; and the estimates also vary widely for different regions, with higher VSLs for wealthier countries.

A meta-analysis of VSL studies conducted for the OECD by Biausque (2012) found a mean VSL converted to 2022 US dollars on the order of \$4 million (excluding high and low estimates). For Poland, which is reasonably representative for Eastern Europe, the Biausque (2012) estimate was about \$1 million in 2022 dollars, which establishes one point of reference for the present exercise.

Robinson et al. (2019) also provide various estimates for countries with different levels of per capita income based on US practice. This approach adopts a base ratio of VSL to per capita Gross National Income (GNI) and assumes an elasticity of VSL as per capita income changes. For a country with approximately Ukraine’s per capita income in purchasing power parity terms immediately prior to the war (\$15,225 in 2022 \$), the VSL based on the Robinson et al. estimates would be between \$1.12 million and \$2.4 million in 2022 US dollars. This provides a second point of references for the present exercise.

Wallsten and Kosec (2005), using US VSL estimates as a base and elasticities of income to VSL from the literature, determined that Ukraine’s VSL for casualties in the Iraq War was \$3.3 million in 2005 US dollars or about \$4.7 million in 2022 dollars. This provides a third point of reference for the present exercise.

The plausible range for Ukraine based on the available literature is thus very wide, from \$1 million to \$4.7 million.

Given an estimate of VSL the value of a statistical life year (VSLY) can be derived based on assumptions about life expectancy and a discount rate that establishes how much higher we place the value of a year of life now than many years in the future

Recent guidance in Australia puts the value of statistical life at AUD 5.1 million and the value of a current statistical life-year at AUD 222,000 in 2021 dollars (Australian Government, 2021). The convention cited in this guidance is that the “statistical life” is that of a young adult with 40 years of life expectancy. The discount rate assumed is 3%.

Different governments, however, adopt different assumptions for discounting future life years: the Robinson et al. (2019) study based on US practice, assumes a 5% discount rate. Note that the higher the discount rate, the higher the current VSLY is relative to a country’s VSL – in the limit, if we completely discount the value of future life entirely, the value of a current statistical life year would equal the value of a statistical life in its entirety.

Current Canadian guidance is that monetized costs and benefits (e.g., when compensation is to be paid out) should be discounted at 7%, while non-monetized costs and benefits should be discounted at 3% (Government of Canada, 2022; see Treasury Board, 2007, for a discussion of the principles behind this approach). This provides useful direction for the present purposes: since the values to be placed on the costs of war are almost certainly not going to be financially compensated, the 3% discount rate would be most appropriate.

Median life expectancy in Ukraine pre-war was about 30 years based on the population’s median age of 41 and a life expectancy of 71 years. Based on this and a 3% discount rate assumption, the value of a statistical life year for Ukraine can be calculated straightforwardly based on the assumptions made about the value of a statistical life for Ukrainians.

By extension, we can apply the same methodologies to calculate the human toll for other countries. Appendix 2 details these calculations for Ukraine, Russia and the European Union.

The cost of injury can be established based on estimates of VSL and the “disability weight”

Injury can be converted into VSL terms based on the “disability weight” of the injury. For example, in the Australian government guidance, an amputated foot has a disability weight of 0.3 or 30% of a statistical life or life year (depending on which concept is being applied). We have no idea of the severity of war wounds suffered in the Russian invasion of Ukraine to date or the age distribution. An assumption is thus required to convert the cost of injury into a value that can be aggregated with VSL estimates of loss of life.

Here it is important to take into account the source of estimates of injured. It is reasonable to conclude that only the more severe cases are reported as “casualties”. For example, in the Russian bombing of a shopping mall in Kremenchuk on 27 June 2022, the ratio of reported injured to dead was 40:10 or 400%, a lot higher than the 125% ratio in UN reported aggregate casualty figures. In this macabre calculus, I assume that the officially reported injured suffer a disability weight of 0.25, something less than an amputated foot or the loss of an eye, but more than a broken limb or a flesh wound.

War-related stress affects all Ukrainians – and stress takes years off the life of individuals

The Russian invasion of Ukraine has imposed great stress on Ukrainian citizens in different ways. It is well established that exposure to prolonged or severe stress has lasting debilitating effects on individuals. Based on statistical analysis on the impact of such stress on life expectancy, estimates can be developed of the number of statistical life years that the war has cost, allowing a monetization of these costs.

As regards the exposed population, there are in the first instance the troops, often fighting under constant, massive bombardment in what has become a war of attrition in the Donbas (Ebel 2022); these circumstances are reminiscent of WWI which brought the term “shell-shock” into the

	Killed	Wounded	Total Exposed Population
Ukraine 5-month total civilian casualties	40,000	50,000	41,077
Israel 5-month average civilian casualties	50	360	8.5
Israel totals scaled to Ukraine population	242	1,740	41,077
Cumulative VSLY (billions of \$ at 2022 prices – high VSL)	614	907	1,521

Source: Goral et al. (2017); calculations by the author.

lexicon. Many who survive the war will be damaged psychologically, with a plethora of problems ranging from unemployability, to family break-up, to drug and alcohol abuse, to physical ills, exhibiting various symptoms of post-traumatic stress reactivity (PTSR) up to and including clinical post-traumatic stress disorder (PTSD). See Chwastiak (2008) for an enumeration and sources on the various expressions of such stress.

The 37 million Ukrainians who are outside of the Russian-controlled Crimea and Donbas live in a state of constant fear of shelling or bombing (“No such thing as safe in Ukraine anymore”; Rainsford 2022). Consider for example this comment from a Kyiv resident:



Every time I hear a train passing by, I start looking for where to jump because I confuse that sound with the sound of a missile flying toward me.

1:19 PM · Jun 29, 2022 · Twitter for iPhone

This is traumatic and that has its costs. The 9/11 attack on New York’s Twin Towers – a single event – resulted in substantially higher rates of PTSD amongst NY residents than in the general population, even 14 years later (Jordan et al. 2019). In a study of Israelis exposed to rocket attacks (Goral et al. 2017) mean PTSD rates reached about 30% for those directly exposed, 23% among relatives or close friends, and 4% in the general population of the affected community.

The panel below graphically illustrates the massively greater intensity of the conflict for Ukraine than for the Israelis in the study. Given the high ratio of PTSD cases in the Israeli study and the much higher intensity in Ukraine, it is reasonable to conclude that the vast majority of the exposed Ukrainian population is experiencing some degree of PTSD.

Russia is raining missiles on all Ukrainian cities meaning first-hand experience of destruction and air-raid warnings. And Russia has threatened repeatedly to use nuclear weapons. For many, this has meant spending nights in underground shelters. Depression and anxiety as well as numerous physical symptoms associated with clinical PTSD have been reported as a consequence of the pandemic lockdowns (Invitto et al. 2021). And pandemic lockdowns are surely a pale shadow of the stress associated with living in a war zone under the conditions described above.

About one in three Ukrainians has been displaced. Forced displacement due to conflict typically involves non-combatants, the separation of families, and psychological and physical trauma before and/or during their displacement ordeal (Pfeffer and Zwigenberg 2022, provide some illustrative accounts). This can give rise to clinical PTSD (Siriwardhana and Stewart 2013; Buhmann 2014).

Once displaced, these individuals face wholly uncertain futures, often in foreign countries, sometimes without passports, credentials, or the language:

One day you are driving to the dentist. The next you are whispering with strangers in a dark basement ... It is a moment when instinct – to save your children, to get through the next checkpoint – takes over and emotions are blocked. Finally, it is the shocking realization that suddenly, unwillingly, you are a refugee, dependent on the generosity of strangers, no longer a middle-class person in charge of your own life (Tavernise 2022).

On top of the multiple stress factors associated with losing jobs, homes, family and connections, the reduced lifetime earnings that such disruption typically impose translates through into shorter life expectancy (Mohney 2018; Pool et al. 2018).

Finally, this is the first social media war (Ciuriak 2022a). The war and its anxieties are common themes on Ukrainian social media: no-one inside Ukraine is isolated from the realities of war. One missile into a shopping centre in Kremenchuk killed 20 and wounded 59, of whom 25 were hospitalized (Feng 2022). But the trauma was felt almost immediately by virtually the entire population as the news, the comments, and the screenshots circulated on various social media platforms. This gives rise to what might be termed “vicarious trauma.” This term is normally used to refer to the trauma suffered by professionals such as first responders whose work continually exposes them to victims of trauma. However, “doomscrolling” gives rise to a similar effect, even without the direct exposure. The pandemic has given us our own experience of doomscrolling inducing stress (Watercutter 2020). In this sense,

social media is a stress multiplier and stress spreader.

To summarize, heavy stress is known to shorten life expectancy of soldiers (Elder et al. 2009), refugees (Buhmann 2014), citizens continually exposed to attacks (Goral et al. 2017), those exposed to trauma through social media, and individuals suffering a sudden negative wealth shock (Pool et al. 2018).

While it is well established that stress impacts negatively on life expectancy, placing a specific value on this reduction is difficult. Stress affects the young differently than mature adults; it affects women differently than men; the severity and length of exposure to stress matters. On average across a range of stress cases, heavy stress has been estimated to shorten life expectancy by 2.8 years (Häkkinen et al. 2020). This provides a point of reference for the evaluation of the human cost of this war, given estimates of populations at risk and the applicable VSLY.

The decline in life expectancy in Russia following the collapse of the Soviet Union is testimony that this is far from an exaggeration of the impacts of the war on Ukraine. Russia's life expectancy fell steeply in the years following the collapse and its population shrank by 4.8 million between 1990 and 2008. In VSL terms, this would be in the tens of trillions.

APPENDIX 2: CALCULATION OF VSL/VSLY FOR THE RELEVANT COUNTRIES

VSL is usually scaled according to level of per capita income. Robinson et al. (2019) provide estimates of VSL at 2015 prices for countries with differing levels of per capita GNI. For the present exercise, I draw on estimates of GDP in international dollars at purchasing power parity (PPP) at 2022 prices taken from the IMF's April 2022 World Economic Outlook database to establish the relevant per capita incomes.

Ukraine

Per capita GDP for VSL/VSLY Calculations

		2021
Ukraine Per Capita GDP at PPP, \$current prices		14,325
At 2022 prices (based on change in US GDP deflator 2021 to 2022)		15,224
Conversion factor		1.0627
Source: IMF WEO, April 2022.		

Income Levels Relevant for Ukraine

			Average
Country GNI 2015 prices	10,000	15,000	
Country GNI 2022 prices	12,016	18,024	15,020
Conversion factor	1.2016		
Source: Robinson et al. (2019).			

As can be seen, the average of the Robinson et al (2019) income levels for their VSL estimates, when converted to 2022 prices is about the same as Ukraine's for 2021, prior to the war. Accordingly,

I adopt the average of the VSLs reported in Robinson et al. (2019) to estimate low, medium and high VSLs for Ukraine. For the estimates reported in the paper, the range is established by the low and medium estimates.

Ukrainian Value of Statistical Life Estimates, millions of \$ at 2022 prices

VSL in 2015 Prices	GNI=10,000	GNI=15,000	Average
Low	0.67	1.2	
Medium	1	1.5	
High	1.6	2.4	
VSL in 2022 \$	GNI=12,016	GNI=18,024	Average
Low	0.81	1.44	1.12
Medium	1.20	1.80	1.50
High	1.92	2.88	2.40

Source: Robinson et al. (2019) and calculations by the author.
Conversion factor = 1.2016.

Median life expectancy in Ukraine pre-war was about 30 years based on the population's median age of 41 and a life expectancy of 71 years. Accordingly, Ukrainian VSLY is calculated as the value that, discounted at 3% over 30 years, sums to the low and high estimates respectively. These values are \$55,700 and \$119,000 respectively. For the life-shortening effects of stress/PTSD, I use the last 3 years of the life span, reduced by the ratio of 2.8/3.0 to calculate the impacts. These figures are: \$68,186 and \$145,676 for the low and high scenarios respectively.

Russia

Per capita GDP for VSL/VSLY Calculations

	2021
Russia Per Capita GDP at PPP, \$current prices	30,850
At 2022 prices (based on change in US GDP deflator 2021 to 2022)	32,786
Conversion factor	1.062743
Source: IMF WEO, April 2022.	

Income Levels Relevant for Russia

	Average
Country GNI 2015 prices	25,000
Country GNI 2022 prices	30,040
Conversion factor	1.2016
Source: Robinson et al. (2019).	

As can be seen, the Robinson et al (2019) income level of \$25,000, when converted to 2022 prices is about the same as Russia's for 2021, prior to the war. Accordingly, I adopt the VSLs reported in Robinson et al. (2019) to estimate low, medium and high VSLs for Russia. For the estimates reported in the paper, the range is established by the low and high estimates.

Russian Value of Statistical Life Estimates, millions of \$ at 2022 prices

VSL in 2015 Prices	GNI=10,000
Low	2.5
Medium	2.7
High	4.0
VSL in 2022 \$	GNI=12,016
Low	3.0
Medium	3.2
High	4.8

Source: Robinson et al. (2019) and calculations by the author.
Conversion factor = 1.2016.

Russian life expectancy according to official estimates in 2021 was 70.06 years. The median age in Russia in 2021 was about 39.6, implying about the same remaining life span as in Ukraine or about 30 years. Accordingly, we retain the same framework for Russia as for Ukraine. Russian VSLY is calculated as the value that, discounted at 3% over 30 years, sums to the low and high estimate respectively. These values are \$148,800 and \$238,050 respectively.

EU27 and UK

Per capita GDP for VSL/VSLY Calculations

	2021
EU+UK Per Capita GDP at PPP, \$current prices	48,965
At 2022 prices (based on change in US GDP deflator 2021 to 2022)	52,038
Conversion factor	1.0627

Source: IMF WEO, April 2022.

Robinson et al (2019) do not provide estimates for an economy with the EU's per capita GNI. Accordingly, I use the ratio of per capita GDP at PPP to Russia and derive estimates of VSL of \$4.0 million for a low estimate and \$6.3 million for a high estimate. These are well within the range of existing estimates for the EU.

EU27+UK Value of Statistical Life Estimates, millions of \$ at 2022 prices

	2021
Low	4.0
High	6.3

Source: Calculations by the author.

EU life expectancy according to official estimates in 2021 80.4 years. The median age in the EU in 2021 was about 43.7, implying a median remaining life span of about 37 years. Accordingly, EU27+UK VSLY is calculated as the value that, discounted at 3% over 37 years, sums to the low and high estimate respectively. These values are \$175,200 and \$275,940 respectively.

For the life-shortening effects of stress/PTSD, I use the last 3 years of the life span, reduced by the ratio of 2.8/3.0 to calculate the impacts, for the most severely affected. These figures are: \$68,186 and \$145,676 for the low and high scenarios respectively.

For the less severely affected, I assume an impact on average life span of half that for the severely impacted. This is done by summing the VSLY over the last 2 years of the life span, reduced by the ratio of 1/4/2.0. These figures are: \$85,899 and \$135,291 for the low and high scenarios respectively.

Africa Famine Exacerbation

Per capita GDP for VSL/VSLY Calculations

	2021
Per Capita GDP at PPP, \$ current prices, for Ethiopia, Kenya and Somalia	3,683
At 2022 prices (based on change in US GDP deflator 2021 to 2022)	3,913
Conversion factor	1.0627

Source: IMF WEO, April 2022.

The average per capita GDP for the three most famine-affected countries is about \$3,913. This is similar to the average of the Robinson et al. (2019) GNI per capita income categories of \$1,000 and \$5,000 when converted from 2015 prices to 2022 prices.

Income Levels Relevant for African famine countries

			Average
Country GNI 2015 prices	1,000	5,000	
Country GNI 2022 prices	1,202	6,008	3,604
Conversion factor	1.2016		

Source: Robinson et al. (2019).

*African Value of Statistical Life Estimates, millions
of \$ at 2022 prices*

VSL in 2015 Prices	GNI=10,000	GNI=15,000	Average
Low	0.02	0.24	
Medium	0.1	0.5	
High	0.16	0.8	
VSL in 2022 \$	GNI=12,016	GNI=18,024	Average
Low	0.02	0.29	0.16
Medium	0.12	0.60	0.36
High	0.19	0.96	0.58

Source: Robinson et al. (2019) and calculations by the author.
Conversion factor = 1.2016.

Famine Impacts

Applying the average estimates of the low, medium and high VSLs to the total number of impacted persons, yields the following estimates of the human cost of the famine.

	Severely affected	Moderately affected	Total
Population Affected (persons)	3,500,000	10,500,000	14,000,000
% of VSL applied	100%	25%	
VSL Estimate		Impact (\$Billions)	
Low	547	410	957
Medium	1,261	946	2,208
High	2,019	1,514	3,533

APPENDIX 3: EU GROWTH DISCOUNT FROM THE NEW “IRON CURTAIN”

Russia's trade intensity with the EU and the UK is similar to that of the UK to the EU27. Accordingly, some insight into the growth implications of a significant disruption of trade between Europe and Russia can be read from the Brexit impacts. An estimate of the relative impact on real growth of a hard Brexit on the UK versus the EU27 can

be obtained from CGE modelling studies. For this purpose I draw on Ciuriak et al. (2015). This ratio can be applied to the assumed growth discount for Russia to generate an estimate for the related impact on Europe. This calculation is set out in the following panel.

EU Trend Growth Discount from the New “Iron Curtain”	Percent
The Brexit Ratio	
UK real GDP loss @ 7 years	-2.306
EU27 real GDP loss @ 7 years	-0.266
Ratio	0.115
Russia cumulative growth discount 2024-2027	-4.201
Implied EU cumulative growth discount 2024-2027	-0.485
Annualized EU trend growth discount	-0.121
Implied real GDP loss (present value) \$ at 2022 prices	\$90 billion

Note that the implied cumulative growth discount for the EU is applied to the level of real GDP in the EU27 plus the UK in 2023 based on the revised growth outlook for the short-term. It does not therefore include the effects of the short-term growth reduction.

Source: Calculations by the author.

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