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The Domestic Welfare Loss of Syrian Civil War: An Equivalent Income Approach*

Harun Onder[†] Pierre Pestieau[‡] Gregory Ponthiere[§]

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Abstract

This paper uses an equivalent income approach to quantify the domestic welfare loss due to the Syrian Civil War. Focusing on the (income, life expectancy) space, we show that the equivalent income has fallen by about 60 % in comparison to the pre-conflict level. We also find that the differential between the equivalent income and the standard income for 2016 lies between \$75 and \$144. Although this low willingness to pay for coming back to pre-conflict survival conditions can be explained by extreme poverty due to the War, the small gap between standard and equivalent incomes tends to question the extra value brought by the latter for the measurement of standards of living in situations of severe poverty. We examine some solutions to that puzzle, including a more general specification of the utility function, the shift from an *ex ante* approach (valuing changes in life expectancy) to an *ex post* approach (valuing changes in distributions of realized longevities), as well as considering population ethical aspects. None of those solutions is fully successful in solving the puzzle.

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1 Introduction

What is the welfare loss associated to the Syrian Civil War? That question is complex, since the consequences of the War are numerous, and involve various dimensions of life. The Syrian Civil War, which started in 2011, is at the origin of thousands of deaths and injured persons, and caused the displacement of thousands of refugees.[1] The War also contributed to a strong contraction of economic activity and to massive destructions (including important cultural sites). As shown in Table 1, a brief look at some basic indicators gives an idea of the magnitude of the consequences of the Syrian Civil War at the economic and demographic levels.[2]

	Before Conflict (2010)	Conflict (2016)
Population (inside Syria)	20.7 million	18.5 million
Per Capita Income (current $)	$2806	$1215
Life expectancy at birth	74.4 years	69.5 years

Table 1: Basic indicators, Syria, 2010 and 2016. Sources: World Bank.

If one focuses on income and survival conditions only, Table 1 leads to a clear conclusion: given that both income per capita and life expectancy have decreased due to the conflict, the pre-conflict situation unambiguously dominates, in welfare terms, the conflict situation, and there is a clear deterioration of standards of living.

But how large is that deterioration of welfare? That - more accurate - question is more difficult to answer, since income and life expectancy are expressed in different units: dollars and life-years. Those distinct measurement units can hardly be aggregated into a single metric. Thus the quantification of the welfare loss due to the War requires to find a way to make income and life-years commensurable, in order to aggregate these into an index of standards of living.

This paper proposes to quantify the domestic welfare loss due to the Syrian Civil War by adopting the equivalent income approach (see Fleurbaey and Blanchet 2013). For that purpose, we focus on the (income, life expectancy) space, and compute the hypothetical income which, combined with the pre-conflict survival conditions, would make a representative agent indifferent with the conflict conditions (in terms of income and survival conditions). That approach has been widely used by economists and economic historians in studies aimed at valuing changes in survival conditions (see Usher 1973, 1980; Williamson 1984; Crafts 1997; Costa and Steckel 1997; Murphy and Topel 2003; Nordhaus 2003; Becker et al 2005; Fleurbaey and Gaulier 2009).[3]

[1] On the estimation of the number of deaths and injured persons, see the report of the Syrian Centre for Policy Research (2016).

[2] Note that we are well aware of the problems concerning the comparability of income and life expectancy statistics before and during the conflict. Given the large number of victims and refugees, the underlying populations differ substantially, leading to selection effects, making those figures hardly comparable. However, in order to try to quantify the welfare loss due to the conflict, we need to rely on some figures, although of imperfect comparability.

[3] Note that the equivalent income approach is also used for international comparisons of standards of living including many other dimensions than longevity, such as unemployment

Our motivations for applying the equivalent income approach to the quantification of the welfare loss due to the Syrian Civil War are twofold.

Our first motivation is to contribute to enrich the description of the consequences of the War. Although individual, non-aggregated indicators of standards of living (such as income and life expectancy) cast substantial light on the consequences of the War, each of those indicators captures only one single aspect of standards of living, so that it matters to construct an aggregated indicator that provides a (more) global picture of the welfare loss due to the War. In the same way as economic historians such as Crafts (1997) and Costa and Steckel (1997) drew a global picture of the impact of technological shocks on standards of living, we believe that it is also important to draw a (more) aggregated picture of the impact of military shocks on standards of living.

Our second motivation is of methodological nature. When constructing an aggregated indicator of standards of living, an important difficulty concerns the way to correctly *weight* the various dimensions of standards of living under study. The weighting exercise matters a lot, since the extra value of an aggregated indicator lies in its capacity to aggregate single indicators in a meaningful, non-arbitrary way. From that perspective, the equivalent income approach, which relies on preferences defined on multidimensional bundles, has some intuitive appeal, explaining why it has become increasingly used. Note, however, that most historical studies using the equivalent income focused on periods during which both income and life expectancy have been growing.[4] By applying the equivalent income approach to the case of the Syrian Civil War, we would like to learn more about the capacity of equivalent incomes to aggregate several dimensions of standards of living when there is a strong deterioration of these.

In order to quantify the welfare loss due to the Syrian Civil War, this paper constructs an equivalent income in the (income, life expectancy) space, while using the survival conditions prevailing before the conflict (2010) as a reference. The method that we adopt is the same as the one used in the literature (see references above). Some assumptions are made on the form of individual preferences in the (income, life expectancy) space; then, following the general practice, preference parameters are calibrated while relying on the literature on the value of a statistical life (VSL). Then, once preference parameters are calibrated, the equivalent income can be computed, and compared with the standard income.

Anticipating on our results, our calculations show that the equivalent income has fallen by about 60 % in comparison to its pre-conflict level. Moreover, we show that the differential between the equivalent income and the standard income for 2016 is equal to only \$75 (under the lower bound of the VSL) and \$144 (under the higher bound of the VSL). Those amounts are quite low with regard to the 5-year decrease in life expectancy. We show that these low values of the willingness to pay (WTP) for coming back to pre-conflict survival conditions can be explained by the extreme poverty due to the War. More technically, those

status and self-reported health (see Decancq and Schokkaert 2016).

[4] One interesting exception is Costa and Steckel (1997), who applied the equivalent income approach to the early American industrial revolution, during which survival conditions deteriorated temporarilly.

low WTP levels come from the fact that the standards of living in Syria in 2016 lie in an area of the (income, life expectancy) space where the indifference curve has a very strong slope, so that a very low additional amount of income suffices to bring compensation. This explains the low gap between the standard income and the equivalent income.[5]

The low WTP for coming back to pre-conflict survival conditions is not, *per se*, a paradox. Indeed, this can be explained by extreme poverty due to the War. However, the low WTP has a corollary that is somewhat paradoxical or puzzling: the low differential between standard and equivalent incomes implies that focusing only on standard incomes can be a good proxy to measure the whole decline in standards of living due to the War (on *both* income and longevity dimensions). Thus, this low gap tends to question the extra value brought by equivalent incomes for the measurement of standards of living in situations of extreme poverty, for which standard incomes seem to do the job very well (making thus equivalent incomes somewhat redundant).

The rest of the paper explores some ways to escape from this paradox. We first examine the robustness of our results to the calibration of preference parameters. We then consider the possibility to defend a more paternalistic approach in the calibration, as well as the possibility to take other dimensions into account, such as interests for joint survival. We show that none of those solutions is convincing. This leads us to examine three alternative solutions in more details: (1) assuming a more general specification of the utility function; (2) shifting from an *ex ante* approach (valuing changes in life expectancy) to an *ex post* approach (valuing changes in distributions of realized longevity); (3) considering population ethical aspects, to account for the fact that the comparison of welfare before and during the War constitutes what Parfit (1984) called a different number problem. We show that, although those solutions can make the puzzle less salient, none of these can solve the puzzle entirely.

By applying the equivalent income approach to the case of the Syrian Civil War, this study contributes to the literature on equivalent incomes applied to the valuation of changes in survival conditions (Usher 1973, 1980; Williamson 1984; Crafts 1997; Costa and Steckel 1997; Murphy and Topel 2003; Nordhaus 2003; Becker et al 2005; Fleurbaey and Gaulier 2009). While that literature focused generally on long-run improvements in survival conditions arising in expanding economies, our paper applies the same methodology to the case of an economy in war, which experiments both a worsening of survival conditions and a decline in income. This allows us to point out to a - so far unnoticed - problem associated to the equivalent income method, i.e., its tendency to be redundant to standard income when standard income is extremely low.

Beyond the study of the equivalent income approach, this paper also relates to the general literature on the measurement of standards of living. In particular, our analysis of the low WTP for coming back to pre-conflict survival

[5] Note that previous studies on equivalent incomes in the (income, life expectancy) space did not obtain such results, since these were usually computing the value of gains in life expectancy achieved in economies becoming richer over time, and thus located in an area of the indifference map where variations in life expectancy are strongly valued.

conditions can be related to the critique made by Ravallion (2012) against the treatment of longevity achievements within the new form of the Human Development Index (HDI).[6] Ravallion shows that, as a consequence of its multiplicative form, the new HDI assigns a lower implicit weight to longevity achievements in poor countries, relatively to rich countries. Like the new HDI, the equivalent income involves some form of multiplication of longevity achievements by some transform of income, which explains the low WTP for coming back to pre-conflict survival conditions. Thus our work is clearly related to the "troubling trade-offs" highlighted by Ravallion (2012) concerning the new HDI.

This paper is organized as follows. The equivalent income method is presented in Section 2. Section 3 computes equivalent incomes for Syria before and during the conflict. Section 4 discusses our results, and considers briefly alternative - possibly paternalistic - calibrations and the inclusion of interests for joint survival. A more general specification for the utility function is considered in Section 5. Section 6 compares equivalent incomes based on the *ex ante* and the *ex post* approaches, and studies the role of inequality aversion. Population ethical aspects are examined in Section 7. Conclusions are drawn in Section 8.

2 The equivalent income approach

Let us consider the construction of an equivalent income in the (income, life expectancy) space, in line with the approach pioneered by Usher (1973, 1980). We consider a simple representative agent model. That representative agent faces risk about the duration of life. For the sake of simplicity, we assume that his preferences on lotteries of life satisfy the expected utility hypothesis (i.e. preferences on lotteries can be represented by a weighted sum of utilities associated to the different possible durations of life, with weights representing the probabilities of occurrence of those different durations).[7] Assuming that the utility of a scenario of life is additive in temporal utilities, and that temporal utility depends only on his income, his preferences can be represented as follows:[8]

$$EU\left(\mathbf{y},\mathbf{s}\right)=\sum_{i=0}^{T-1}s_{i+1}u\left(y_i\right) \tag{1}$$

where $\mathbf{y}$ is a vector of size T, whose entries are income levels at age i, i.e. y_i. $\mathbf{s}$ is a vector of size T, whose entries are unconditional survival probabilities to age i, i.e. $s_i=\prod_{j=0}^{i}(1-d_j)$ where d_j is the probability of dying at age j. T is the maximal duration of life. The temporal utility $u\left(y_i\right)$ is supposed to be increasing and concave.

[6] The new HDI consists of a *geometric* average of indexes on income, education and life expectancy, in contrast with the initial HDI, which was based on an *arithmetic* average of those indexes (see UNDP 1990).

[7] We abstract here from pure time preferences. Survival probabilities play here the role of biological discount factors.

[8] As usual, the utility of being dead is normalized to 0.

The constant equivalent income profile $\hat{\mathbf{y}}$ can be defined as the hypothetical income level profile which, combined with the survival conditions of reference $\bar{\mathbf{s}}$, would make the representative agent indifferent with respect to his current situation:

$$EU\left(\hat{\mathbf{y}}, \bar{\mathbf{s}}\right) = EU\left(\mathbf{y}, \mathbf{s}\right) \tag{2}$$

Let us assume that temporal welfare takes the form (see Becker et al 2005):

$$u\left(y_i\right) = \frac{\left(y_i\right)^{1-\sigma}}{1-\sigma} - \alpha \tag{3}$$

with $\sigma > 0$ and $\alpha \lesseqgtr 0$.

If one supposes, for simplicity, a constant income $y_i = y$, the constant equivalent income profile $\hat{\mathbf{y}}$ has a constant entry $\hat{y}$, which can be derived as:

$$\hat{y} = \left[(1-\sigma)\left[\left(\frac{(y)^{1-\sigma}}{1-\sigma} - \alpha\right)\frac{e}{\bar{e}} + \alpha\right]\right]^{\frac{1}{1-\sigma}} \tag{4}$$

where $e \equiv \sum_{i=0}^{T-1} s_{i+1}$ is life expectancy, while $\bar{e} \equiv \sum_{i=0}^{T-1} \bar{s}_{i+1}$ is the life expectancy for the reference survival conditions.

3 Results

In order to compute the equivalent income for Syria before and during the conflict, we need first to calibrate preference parameters. Regarding the calibration of σ, we follow Blundell et al (1994) and take $\sigma = 0.83$. Concerning α, this can be calibrated using studies on the value of a statistical life (VSL), defined as the marginal rate of substitution between income and mortality risk:

$$VSL = -\frac{\frac{\partial EU}{\partial d_0}}{\frac{\partial EU}{\partial y_0}} = \frac{\frac{e}{s_0}\left[\frac{y_0^{1-\sigma}}{1-\sigma} - \alpha\right]}{s_0\left(y_0\right)^{-\sigma}} \tag{5}$$

In order to calibrate α on the basis of VSL estimates, we rely here on the meta-analysis of VSL studies carried out by Miller (2000). Miller collected 68 studies estimating VSL across 13 countries, while using various methodologies (wage-risk studies, contingent valuation methods, behavioral studies), in order to estimate rules of thumb, which relate the VSL to the level of GDP per capita. The interest of those rules of thumb is the following. Most VSL studies have focused exclusively on rich countries, whereas for most countries there exists no direct VSL estimate. Hence, the rules of thumb estimated by Miller allow us to extrapolate VSL estimates for any country, by merely knowing the GDP per capita of that country. This is the case for Syria, for which there exists no direct VSL estimate. Thus Miller's rules of thumb allow us to have an indirect estimate of the VSL for Syria, and to use it for our calibration.[9]

Following Miller's (2000) rules of thumb, the VSL amounts to between 120 and 180 times GDP per capita. Hence, on the basis of the pre-conflict income per head (\$2806), we obtain two values for α: α equal either to 16.46 (lower bound of VSL) or to 13.35 (upper bound of VSL).[10]

Figure 1 compares incomes and equivalent incomes (under low and high VSL) computed while taking the pre-conflict survival conditions (2010) as a reference. The equivalent income for 2016 is computed as the hypothetical income which, combined with the survival conditions of 2010, would make the representative agent indifferent with respect to the 2016 situation (with 2016 income and survival conditions). The equivalent income for 2016 is, without surprise, lower than the standard income. This difference is due to the deterioration of survival conditions during the conflict.

When looking at Figure 1, one can see immediately, by comparing years 2010 and 2016, the strong deterioration in standards of living due to the War. Whatever the indicator on which one relies, it appears clearly that it takes a much larger value before the War (in 2010) than during the War (in 2016). The decline represents about 60 % of the pre-conflict income level.

Concerning the quantification of the welfare loss due to the War, one may expect that equivalent incomes, which incorporate the variation in survival conditions, should show a much stronger decline of standards of living in comparison to the standard income, which does not incorporate variations in survival conditions. However, contrary to what one may expect, the size of the differential between the standard income and the equivalent income is quite small.[11] The gap, for 2016, equals only $\$1215 - \$1140 = \$75$ under the lower bound of the VSL, and $\$1215 - \$1071 = \$144$ under the higher bound of the VSL. Note that measuring the differential between the equivalent and the standard income in *relative* terms rather than in absolute terms can make the gap seem less small. In relative terms, the gap lies between $\frac{\$1215-\$1140}{\$1215} = 6$ % (under low VSL) and $\frac{\$1215-\$1071}{\$1215} = 12$ % (under high VSL) of the standard income in 2016. Those relative magnitudes seem larger, but given that the standard income is quite low (\$1215), 6 or 12 % of it still constitutes a small amount.

[9] Note that relying on rules of thumb constitutes an approximation. One limitation of using rules of thumb is that this assumes some form of stability of preferences concerning income-risk trade-offs across countries and time periods. Back to the case of Syria, if the War modified preferences in a particular way, this will not be captured by our calibrations based on Miller's rules of thumb.

[10] We take here, as a proxy, $s_0 \approx 1$.

[11] Note that what one considers as "small" or not is a matter of personal appreciation, and depends also on what one may expect *a priori*.

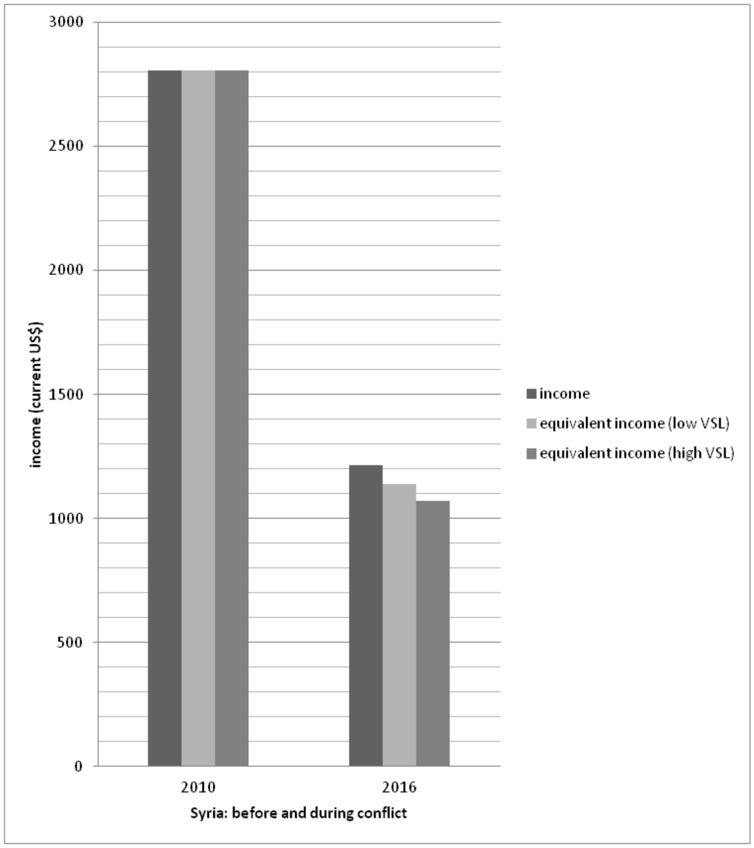

Figure 1: Income and equivalent income in Syria, 2010 and 2016.

The small differential between the standard income and the equivalent income for 2016 means that individuals in 2016 have a low willingness to pay (WTP) for coming back to pre-conflict survival conditions, despite the strong deterioration of survival conditions due to the conflict (equal to about 5 years in terms of life expectancy at birth). How can one explain those low WTP for coming back to pre-conflict survival conditions? The technical explanation comes from the fact that, as shown on the indifference map (Figure 2), the point (1215, 69.5) in the (income, life expectancy) space lies in a part of the graph where income is very low, and where the slope of indifference curves is high, coinciding with a low value of a statistical life. This explains why a small movement along the indifference curve - and thus a small income reduction - suffices to compensate for the 5-year improvement in life expectancy when the reference (pre-conflict) survival conditions are imposed.

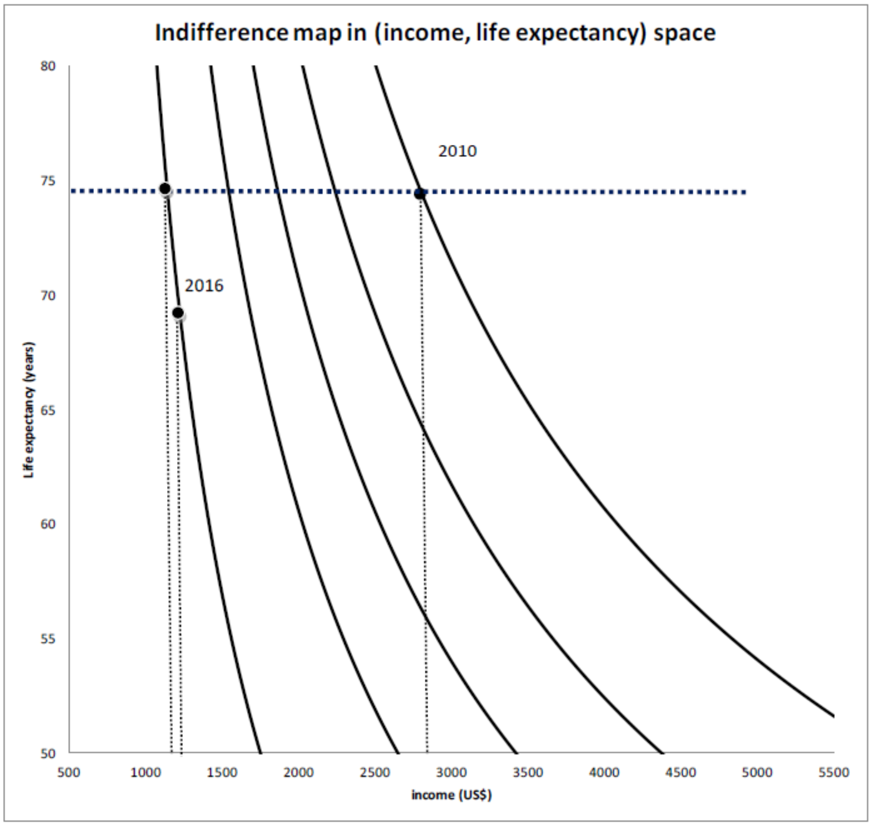

Figure 2: Construction of the equivalent income for 2016 (VSL lower bound).

Thus the small differential between the standard income and the equivalent income can be explained by the fact that the representative agent lies on an area of the (income, life expectancy) space where income is low, and where the VSL is low (i.e. the slope of indifference curves is strong), and where small reductions in income suffice to compensate large losses in terms of life expectancy. Thus the technical explanation says that, from the perspective of a Syrian, who currently faces extreme poverty due to the conflict, the particular way in which income/mortality risks trade-offs are solved leads to a very low value for changes in survival conditions. That perspective is very different from the one of a North American citizen or a European citizen who would consider a 5-year reduction in life expectancy in a very different position. Under incomes that are 20 times larger, we would be much more on the right of the indifference map, where the VSL is much larger (i.e. the slope of indifference curves is smaller), and thus a much larger compensation would be required to remain on the same indifference curve while facing a 5-year reduction in life expectancy.

Besides that explanation, one can also underline the role of the reference survival conditions. If we had taken the conflict survival conditions (i.e. the ones prevailing in 2016) as a reference (instead of the pre-conflict ones), the movement along the 2010 indifference curve would have taken place in a less steep segment of the indifference curve, leading to a larger gap between the equivalent income and the standard income for 2010 (equal to about $500). Note, however, that taking the survival conditions of the War as a reference is not intuitive at all. It is more intuitive, when trying the quantify the welfare loss due to the War, to take pre-conflict survival conditions as a reference.

4 Discussions

In the light of the technical explanation - based on the slope of indifference curves at low income levels -, the low WTP for coming back to pre-conflict survival conditions does not, *per se*, constitute a paradox. This is the mere consequence of extreme poverty due to the War. However, the low WTP has a corollary that is somewhat paradoxical or puzzling. The small differential between the equivalent income and the standard income raises some questions regarding the extra value - on descriptive grounds - brought by equivalent incomes for the measurement of standards of living in situations of extreme poverty.

The problem can be formulated as follows: Figure 1 suggests that focusing *only* on standard income constitutes a good proxy to measure the whole decline in standards of living due to the War (on *both* income and longevity dimensions). The gap between standard and equivalent incomes is so small that focusing only on the standard income leads to underestimate the decline in standards of living, but only by a minor extent.[12] Hence, under extreme poverty (leading to a low WTP), the standard income constitutes a good measure of standards of living, making the equivalent income somewhat redundant. If considering standard incomes suffices to measure the welfare loss under severe poverty, what is the extra value brought by equivalent incomes?

The rest of this paper proposes to examine that puzzle, by exploring the extent to which the low differential between the standard income and the equivalent income (which makes the latter somewhat redundant) is robust to the assumptions underlying the construction of the equivalent income.

From that perspective, a first thing to do is to turn back to the calibration of preference parameters α and σ. For that purpose, Table 2 computes the gap between standard and equivalent incomes under various pairs (α, σ). Table 2 shows that the gap between the standard income and the equivalent income is quite robust to the calibration. Even when one takes values of σ between 0.25 and 1.50, this does not fundamentally affect our results. At most, the gap between the equivalent income and the standard income for 2016 reaches $262.

[12] Indeed, given the quite small size of the differential between the standard income and the equivalent income in 2016, considering a fall from $2800 to $1215 or a fall from $2800 to $1140 or $1071 does not really make a substantial difference.

	$\alpha = -418.70$	$\alpha = -22.21$	$\alpha = 13.35$	$\alpha = -0.88$	$\alpha = -0.08$
	$\sigma = 0.25$	$\sigma = 0.50$	$\sigma = 0.83$	$\sigma = 1.25$	$\sigma = 1.50$
y_{2016}	\$1215	\$1215	\$1215	\$1215	\$1215
$\hat{y}_{2016}$	\$953	\$1013	\$1071	\$1124	\$1154
gap	\$262	\$202	\$144	\$91	\$61

Table 2: Robustness to the calibration of (α, σ), VSL upper bound.

An alternative approach could consist in questioning our reliance on rules of thumb for the VSL (taken from Miller 2000). From a universalist perspective, one could argue that each human life has an equal value, whatever the person lives in a rich or a poor country. Hence, instead of taking a VSL for Syria equal to 120/180 times \$2806, one should have made the calibration while taking U.S. or E.U. income levels, leading to a VSL of 4/5 millions of dollars. Such a universalist approach makes lots of sense. This would motivate a kind of paternalistic way of calibrating preference parameters, in such a way as to impose on Syrian living conditions the perspective of a Westerner who lives in a much richer world, and solves trade-offs in a different way. Such a paternalistic calibration would definitely change the value of the parameter α - and, hence, the indifference map -, but this would not solve our problem entirely, since it would still remain true, at the end of the day, that income is very low in Syria, so that we remain in a part of the (income, life expectancy) space where indifference curves are steep. Thus the puzzle that we face is likely to survive - to some extent - despite this paternalistic calibration of preference parameters.

Another line of reasoning may consist in underlining that our analysis only focuses on *one* aspect of longevity: longevity variations for a single person. However, when survival conditions deteriorate, the victims include not only those who died prematurely, but, also, all the parents, children, brothers, sisters, friends, neighbors, colleagues, all people who were affected (see Ponthiere 2016). We certainly have those persons in mind when thinking informally about the value of life-years. Note, however, that although taking those interests for joint survival into account would definitely reduce the values of equivalent incomes, this could not solve our puzzle, since the economy remains in a low income area, so that money/own death risk and money/others' death risks trade-offs would be solved in areas where money has, at the margin, a large value. Thus taking the interest for joint survival into account cannot solve the puzzle.

Given that those approaches do not solve the puzzle, we have to consider alternative extensions of the baseline framework. Section 5 studies the robustness of our results to a more general specification of the utility function. Then, Section 6 considers a shift from the standard *ex ante* approach to the *ex post* approach (valuing changes in the distribution of realized longevity). Finally, Section 7 reexamines the problem while accounting for ethical population aspects raised by the decrease in population size due to the War.

5 A more general utility specification

Up to now, our analysis relied on a particular specification for the utility function, which exhibits some form of double additivity: it is additive across the different possible scenarios of life (following the expected utility hypothesis), and also additive across time periods. Although that formulation is standard in the literature (see, for instance, Becker et al 2005), one may argue that our paradoxical results may be due to that particular specification of the utility function. In order to examine the robustness of our results to the specification of the utility function, this section considers a more general functional form, and revisits the calculation of the equivalent income in that more general framework.

An important limitation of the standard utility function may come from its time-additive form, which, as stressed by Bommier (2006), involves implicitly the - questionable - assumption of net risk-neutrality with respect to the duration of life. Bommier (2006) defines net risk-neutrality with respect to the duration of life as follows. An individual exhibits net risk-neutrality with respect to the duration of life if, when facing lotteries of life with constant income per period and an equal life expectancy, the individual is indifferent between these, even though one lottery may exhibit a much riskier lifetime than the other. To see why our specified utility function exhibits net risk-neutrality with respect to the duration of life, remind first that, under a constant income along the life cycle, the expected utility function can be rewritten as:

$$EU(\mathbf{y}, \mathbf{s}) = e\left[\frac{(y)^{1-\sigma}}{1-\sigma} - \alpha\right]$$

It is thus linear in life expectancy e. Thus, it is straightforward to see that the representative agent will be indifferent between lotteries having the same life expectancy and the same income per period, independently from the degree of riskiness of the lottery (concerning longevity outcomes), and, hence, exhibits, in the model, net risk-neutrality with respect to the duration of life.

This implicit assumption of net risk-neutrality with respect to the duration of life is not particularly appealing. As stressed by Bommier (2006), it is likely that individuals are, in general, not (net) risk-neutral with respect to the duration of life. This is confirmed by the recent study of Delprat et al (2016) showing, on the basis of the RAND American Life Panel, that about 75 % of respondents are not neutral towards longevity risk, and exhibit some (but low) degree of (net) risk-aversion towards the length of life.

Hence, by relying on the standard utility specification, previous sections may thus have missed an important dimension through which the Civil War in Syria contributed to deteriorate individual welfare. The deterioration did not only take place through the fall of income and life expectancy, but, also, through a rise in the degree of riskiness about the duration of life.

In order to examine how relaxing the net risk-neutrality assumption affects the measurement of the welfare loss of the Syrian Civil War, we will now consider a more general utility specification, which allows for net risk-aversion with respect to the duration of life. We now define the expected utility as follows:

$$EU(\mathbf{y},\mathbf{s}) = \sum_{\ell=0}^{T-1} p_\ell \phi(U_\ell) \quad (6)$$

where $p_\ell = d_\ell s_\ell = d_\ell \prod_{j=0}^{\ell-1}(1-d_j)$ is the probability of a duration of life of exact length ℓ, and where $U_\ell = \sum_{i=0}^{\ell-1}\left(\frac{(y_i)^{1-\sigma}}{1-\sigma} - \alpha\right)$ is the utility of a life of length ℓ. The function $\phi(\cdot)$, which is supposed to be strictly increasing in its argument (i.e. $\phi'(\cdot) > 0$), captures the attitude of the representative agent towards risk about the duration of life. When $\phi''(\cdot) = 0$, the agent is (net) risk-neutral with respect to the duration of life; when $\phi''(\cdot) < 0$, the agent exhibits (net) risk-aversion with respect to the duration of life. Finally, when $\phi''(\cdot) > 0$, the agent is (net) risk-lover with respect to the duration of life.

In this section, we will adopt the following form for the function $\phi(\cdot)$:

$$\phi(U_\ell) = \frac{(U_\ell)^{1-\theta}}{1-\theta} - \omega \quad (7)$$

with $\theta \gtreqless 0$ and $\omega \gtreqless 0$. θ captures the degree of (net) risk-aversion with respect to the duration of life. When $\theta = 0$, the function $\phi(\cdot)$ is linear, and we are back to the baseline model with net risk-neutrality with respect to the duration of life. When $\theta > 0$, individuals exhibit net risk-aversion with respect to the duration of life. Regarding ω, it should be stressed that this parameter is not redundant with the parameter α. Under $\theta \geq 0$, α determines the income level that allows one additional life-period to bring a positive utility contribution to lifetime well-being, whereas the parameter ω determines the lifetime utility threshold below which a life as a whole is not worth being lived. The parameter ω plays an important role, since this allows for individuals to have high degrees of (net) risk-aversion with respect to the duration of life without necessarily implying that a life is not worth being lived.[13]

Substituting for p_ℓ and $\phi(U_\ell)$, we obtain:

$$EU(\mathbf{y},\mathbf{s}) = \sum_{\ell=0}^{T-1}\left[d_\ell \prod_{j=0}^{\ell-1}(1-d_j)\right]\left[\frac{\left(\sum_{i=0}^{\ell-1}\left(\frac{(y_i)^{1-\sigma}}{1-\sigma} - \alpha\right)\right)^{1-\theta}}{1-\theta} - \omega\right] \quad (8)$$

If one supposes, for simplicity, a constant income $y_i = y$, the constant equiv-

[13] A negative ω allows $\phi(U_\ell)$ to be non-negative even when $\theta > 1$, that is, when there is a high net risk-aversion with respect to the duration of life.

alent income profile $\hat{\mathbf{y}}$ has a constant entry $\hat{y}$, which can be derived as:

$$\hat{y} = \left[(1-\sigma) \left[\frac{\sum_{\ell=0}^{T-1} d_\ell s_\ell \ell^{1-\theta}}{\sum_{\ell=0}^{T-1} \bar{d}_\ell \bar{s}_\ell \ell^{1-\theta}} \right]^{\frac{1}{1-\theta}} \left(\frac{(y)^{1-\sigma}}{1-\sigma} - \alpha \right) + \alpha (1-\sigma) \right]^{\frac{1}{1-\sigma}} \tag{9}$$

since $\sum_{\ell=0}^{T-1} d_\ell s_\ell = \sum_{\ell=0}^{T-1} \bar{d}_\ell \bar{s}_\ell = 1$. It is easy to check that, when $\theta = 0$, the formula vanishes to $\hat{y} = \left[(1-\sigma) \left[\left(\frac{(y)^{1-\sigma}}{1-\sigma} - \alpha \right) \frac{e}{\bar{e}} + \alpha \right] \right]^{\frac{1}{1-\sigma}}$, as in Section 2.

Under that alternative formulation, the VSL becomes:

$$VSL = -\frac{\frac{\partial EU}{\partial d_0}}{\frac{\partial EU}{\partial y_0}} = \frac{1}{1-d_0} \frac{(y_0)^\sigma}{1-\theta} \frac{\sum_{\ell=0}^{T-1} d_\ell s_\ell \left[\left(\sum_{i=0}^{\ell-1} \left(\frac{(y_i)^{1-\sigma}}{1-\sigma} - \alpha \right) \right)^{1-\theta} - \omega(1-\theta) \right]}{\sum_{\ell=1}^{T-1} d_\ell s_\ell \left(\sum_{i=0}^{\ell-1} \left(\frac{(y_i)^{1-\sigma}}{1-\sigma} - \alpha \right) \right)^{-\theta}} \tag{10}$$

Regarding the calibration of preference parameters $\{\alpha, \sigma, \theta, \omega\}$, we adopted the following strategy. Concerning the calibration of σ, we keep the standard value of 0.83. As far as α is concerned, we take, as a benchmark, the value $\alpha = 14.25$, which implies that any income strictly above (resp. below) \$0.5 a day allows one additional life-period to bring a positive (resp. negative) utility contribution to lifetime well-being. Regarding the parameter θ, Delprat et al (2016) show that there is, in general, some degree of net risk-aversion with respect to the length of life, but that it takes in general a low value. Given that our goal is to assess the robustness of our results to the degree of net risk-aversion with respect to the length of life, we will consider here 7 distinct values for θ, from $\theta = 0$ (net risk-neutrality) to $\theta = 5$ (strong net risk-aversion). Finally, for each of those combination of values for $\{\alpha, \sigma, \theta\}$, there is a unique value of the parameter ω that is compatible with the VSL estimate.[14]

In comparison to our baseline approach, the calculation of the equivalent income requires here to have more information than the life expectancy. For that purpose, Figures 3 and 4 show the evolution of survival curves for, respectively, Syrian men and women, for 2010 (pre-conflict) and 2015 (conflict).[15] Each survival curve shows, conditionally on age-specific probabilities of death prevailing the year under study, the probability to survive to a particular age. Those survival curve show a strong deterioration of survival conditions due to

[14] We take here the upper VSL estimate. See the Appendix for the calibration.

[15] Those survival curves are computed from lifetables (with 5-year age groups). Source: World Bank.

the conflict, both for men and women. The gap between the pre-conflict and conflict survival curves is significantly larger for men above age 20.

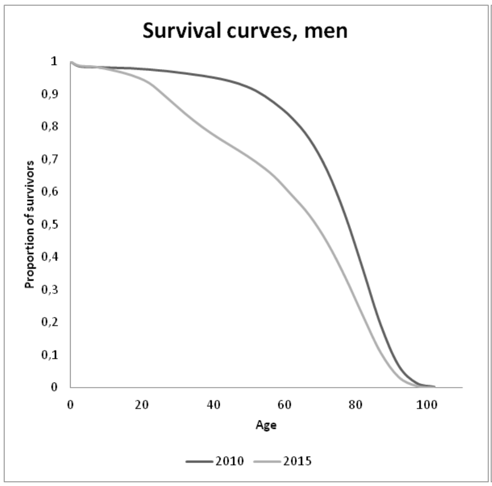

Figure 3: Survival curves, Syrian men, 2010 and 2015. Source: World Bank.

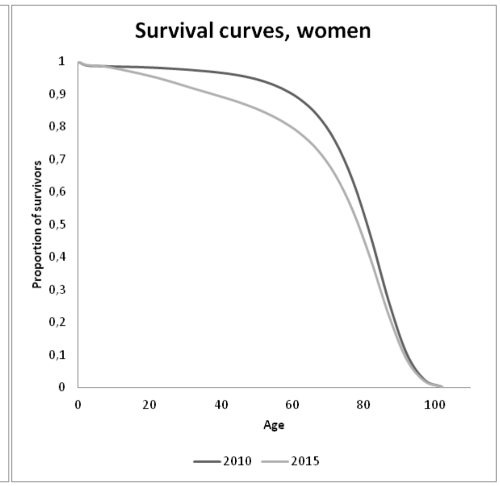

Figure 4: Survival curves, Syrian women, 2010 and 2015. Source: World Bank.

Figures 5 and 6 summarizes our results, by comparing, for men and women separately, the standard income with the equivalent incomes obtained under different degrees of net risk-aversion with respect to the duration of life. Given that our most recent lifetable concerns year 2015, the 2015 table is taken as a proxy for the computation of equivalent incomes during conflict, whereas the lifetable for 2010 is taken as a reference (i.e. pre-conflict survival conditions).[16]

Introducing some degree of (net) risk-aversion with respect to the duration of life contributes to affect the gap between the standard income and the equivalent income, but the impact of (net) risk-aversion with respect to the duration of life (captured by the parameter θ) is non monotonous. A higher value for the parameter θ tends first to decrease the equivalent income, and, then, to increase it. The underlying intuition goes as follows. When a small degree of (net) risk-aversion is introduced (θ becomes strictly positive), this makes the representative agent more sensitive to the deterioration of survival conditions, which have a stronger marginal impact on expected lifetime welfare, leading to a lower equivalent income, and to a larger gap with respect to the standard income. However, once θ becomes too large, the concavification of lifetime welfare becomes so strong that survival conditions have a less important impact on expected lifetime well-being (since in that case the different scenarios of

[16]For simplicity, we assume here an equal income per capita for men and women. This constitutes of course a simplification, but our main focus here is on the gap between equivalent incomes based on different degrees of (net) risk-aversion with respect to the duration of life for a given gender group.

the lottery of life in terms of longevity become closer and closer in terms of lifetime welfare), which implies that the gap between the standard income and the equivalent income becomes less sizeable.

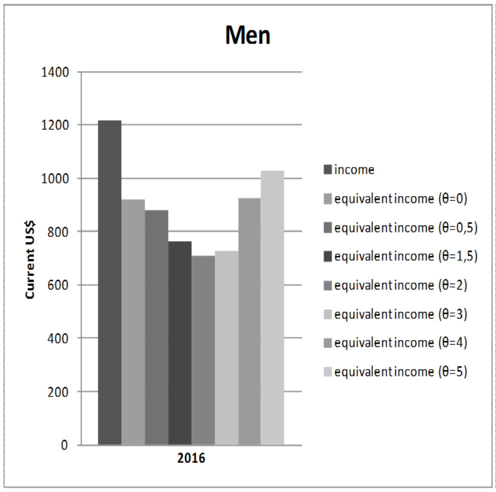

Figure 5: Equivalent incomes under various degrees of (net) risk-aversion wrt the duration of life, men, 2016.

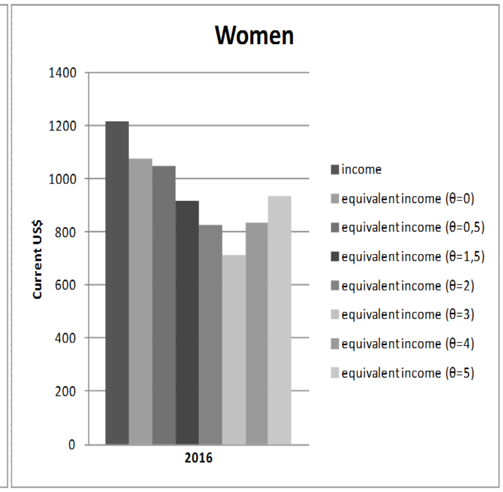

Figure 6: Equivalent incomes under various degrees of (net) risk-aversion wrt the duration of life, women, 2016.

The largest value for the gap between the standard income and the equivalent income arises when $\theta = 2$ (for men) and when $\theta = 3$ (for women). In those cases, the differential equals about \$507 for men and \$392 for women. Those levels are much larger than those obtained under our baseline specification of preferences, which was based on the implicit postulate of net risk-neutrality with respect to the duration of life. This suggests that assumptions on the degree of net risk-aversion with respect to the duration of life play a key role for the valuation of the deterioration of survival conditions, and, hence, for the measurement of the welfare loss due to the Syrian Civil War.

It should be stressed, however, that values of θ equal to 2 or 3 are quite high. If we refer to the empirical study of Delprat et al (2016), the degree of (net) risk-aversion with respect to the duration of life is generally positive - implying a positive θ - but low. Hence, if we refer to the equivalent income obtained under $\theta = 0.5$ (low net risk-aversion), we obtain gaps that are equal to only \$336 for men and \$171 for women, which, although slightly larger than the gaps obtained under net risk-neutrality (\$297 for men and \$141 for women), remain quite small. Thus, assuming plausible degrees of net risk-aversion with respect to the duration of life increases the size of the gap, but does not suffice to raise it substantially. Therefore, adopting this more general specification for the utility function can only make the puzzle less salient, but does not suffice to solve it.

6 Ex ante *versus* ex post valuations

In the previous sections, we computed the equivalent income by adopting an *ex ante* approach, i.e. by calculating the hypothetical income that would, if combined with the pre-conflict survival conditions, bring the same expected utility as the standards of living prevailing under the conflict (with income and survival conditions prevailing in conflict). That approach is standard in the literature. But one could question it on the grounds that this *ex ante* approach, which values changes in a lottery, tends to ignore large inequalities in final outcomes. Clearly, the 5-year reduction in life expectancy hides large inequalities in realized terms (i.e. *ex post*), between persons who died because of the War, and persons whose longevity was not affected by the War.

Hence, from that *ex post* perspective, what we should consider is the change in the distributions of realized income and longevity outcomes before and during the conflict. The current *ex ante* approach just averages out all those extremely different outcomes into a small monetary compensation, whereas that *ex post* approach would show extreme inequalities, and extreme compensations required for victims, in particular if one assumes a high degree of inequality aversion. Note, however, that it is not clear *a priori* that the same problems as under the *ex ante* approach would not arise again in an *ex post* setting. The reason is that incomes remains very low also from an *ex post* perspective, so that the life-years lost may remain valued at lower levels than under a rich economy for each segment of the population.

In order to check the robustness of our results to adopting an *ex post* - rather than an *ex ante* - approach, one needs to compute an equivalent income taking into account the changes in the distributions of realized longevity between the pre-conflict situation and the conflict situation.[17]

For that purpose, let us define the following social welfare function (Atkinson and Stiglitz 1980):

$$W(\mathbf{y},\mathbf{s}) = \sum_{\ell=0}^{T-1} n_\ell \frac{(U_\ell)^{1-v}-1}{1-v} \tag{11}$$

where n_ℓ is the proportion of individuals with achieved longevity ℓ (the n_ℓ sum up to 1), and U_ℓ the *ex post* lifetime well-being of a person with achieved longevity ℓ.[18] The parameter v is the degree of inequality aversion.

It is important to stress here that, although the RHS of expression (11) looks close to the RHS in expression (8), the two expressions differ, since parameters v and θ are of different natures. In expression (11), the parameter v is an ethical parameter, which reflects the degree of inequality aversion present in the social welfare function (SWF). On the contrary, the parameter θ in expression (8) is a parameter capturing individual preferences, in particular individual attitude

[17] Due to the limited availability of data on income inequalities, this section only considers inequalities in longevity outcomes (obtained from life tables), and, hence, leaves aside income inequalities.

[18] Using the Law of Large Numbers, we have that $n_\ell = p_\ell = d_\ell s_\ell$.

towards risk with respect to the duration of life.[19]

We can now define the equivalent income as the hypothetical income which, if combined with the survival conditions of reference (i.e. the pre-conflict, 2010, survival conditions), would bring the same social welfare as the one prevailing in 2015 (given the 2015 income and survival conditions):

$$W(\hat{\mathbf{y}}, \bar{\mathbf{s}}) = W(\mathbf{y}, \mathbf{s}) \tag{12}$$

Substituting for the social welfare function $W(\cdot)$, and assuming constancy of incomes, the equivalent income $\hat{y}$ satisfies the equality:

$$\sum_{\ell=0}^{T-1} \bar{n}_\ell \frac{\left(\ell\left(\frac{(\hat{y})^{1-\sigma}}{1-\sigma} - \alpha\right)\right)^{1-v} - 1}{1-v} = \sum_{\ell=0}^{T-1} n_\ell \frac{\left(\ell\left(\frac{(y)^{1-\sigma}}{1-\sigma} - \alpha\right)\right)^{1-v} - 1}{1-v}$$

where $\bar{n}_\ell$ is the number of individuals with achieved longevity ℓ under the survival conditions of reference (i.e. pre-conflict survival conditions).

Hence we have:

$$\hat{y} = \left[(1-\sigma)\left[\left[\left(\frac{(y)^{1-\sigma}}{1-\sigma} - \alpha\right)^{1-v} \frac{\sum_{\ell=0}^{T-1} n_\ell \ell^{1-v}}{\sum_{\ell=0}^{T-1} \bar{n}_\ell \ell^{1-v}}\right]^{\frac{1}{1-v}} + \alpha\right]\right]^{\frac{1}{1-\sigma}} \tag{13}$$

Note that, when there is a zero degree of inequality aversion, i.e., $v = 0$, the formula vanishes to:

$$\hat{y} = \left[(1-\sigma)\left[\left(\frac{(y)^{1-\sigma}}{1-\sigma} - \alpha\right)\frac{e}{\bar{e}} + \alpha\right]\right]^{\frac{1}{1-\sigma}}$$

which corresponds to the *ex ante* equivalent income derived in Section 2. But for $v \neq 0$, the two formulae differ, on the grounds that the formula for the *ex ante* equivalent income focuses only on differences in life expectancies before and during the conflict, whereas the formula for the *ex post* equivalent income takes into account differences in the distributions of realized longevity, which are taken to the power $1-v$, in such a way as to give more weight to the worst off (i.e. those having a short life).[20]

[19] The difference in nature implies also a difference regarding the calibration of those parameters: the calibration of θ must be made jointly with other individual preference parameters, so as to be compatible with the VSL estimate. On the contrary, the parameter v reflects ethical judgement on the attitude of the social planner towards inequality, and its value is not constrained at all by the VSL estimate.

[20] It should be stressed here that the analysis that we call *ex post* relies, like the *ex ante* approach, on period survival data, and not on cohort data, which are available only when the entire cohort is dead (i.e. those data will only be available one century from now).

In order to examine how the degree of inequality aversion affects the levels of equivalent incomes, Figures 7 and 8 compare, for men and women, standard incomes with equivalent incomes under various degrees of inequality aversion, from $v = 0$ (baseline equivalent income) to $v = 200$ (extreme inequality aversion). Given that our most recent lifetable concerns year 2015, the 2015 table is taken as a proxy for the computation of equivalent incomes during conflict, whereas the lifetable for 2010 is taken as a reference (i.e. pre-conflict survival conditions).[21] Equivalent incomes are computed under the upper bound for the VSL (i.e. $\alpha = 13.35$), whereas σ takes its benchmark value (i.e. $\sigma = 0.83$).

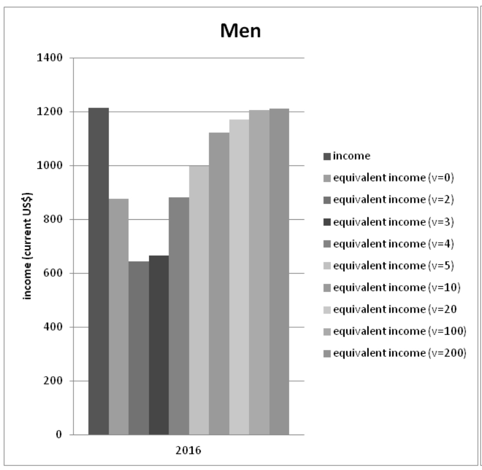

Figure 7: Equivalent incomes under various degrees of inequality aversion, men, 2016.

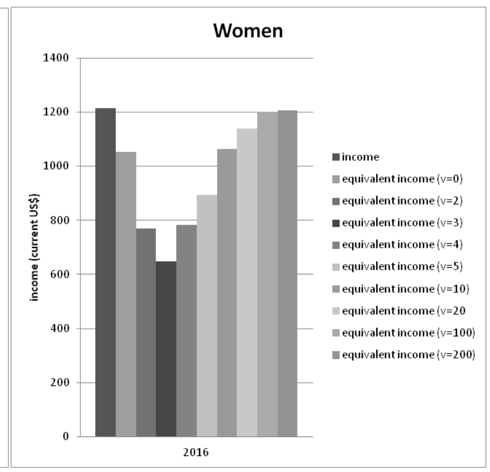

Figure 8: Equivalent incomes under various degrees of inequality aversion, women, 2016.

Figures 7 and 8 show that the relationship between the 2016 equivalent income and the degree of inequality aversion is not monotonous, and takes a U-shaped form. Clearly, starting from $v = 0$, a rise in the degree of inequality aversion first reduces the equivalent income, but, then, beyond $v = 3$, the equivalent income starts increasing with the degree of inequality aversion. Thus, the gap between the standard income and the equivalent income first goes up when inequality aversion increases, but, beyond some level of v, it starts going down. For men, the maximum gap (achieved when $v = 3$) is equal to \$1215 − \$644 = \$571. This gap is larger than in the absence of inequality aversion (i.e. $v = 0$), at which the gap equals: \$1215 − \$875 = \$340.[22] Thus taking, to some

[21] Here again, we abstract from gender inequalities in income.

[22] This magnitude is significantly larger than the one shown above, since we focus here on the male population, for which the deterioation of survival conditions has been stronger (see Figures 3 and 4).

extent, inequality aversion into account can raise the gap between equivalent income and standard income.

The right parts of Figures 7 and 8 also show that, when inequality aversion tends to be extremely large, the equivalent income converges towards the level of the standard income. The underlying intuition goes as follows. When inequality aversion becomes very high, this tends to make differences in survival conditions between the actual survival conditions and the survival conditions of reference (i.e. pre-conflict) irrelevant for social valuations, since in both cases there are some prematurely dead persons (even though the proportion of prematurely dead persons is larger under the conflict than before the conflict).[23] Thus, taking inequality aversion into account can only raise the gap between equivalent incomes and standard incomes provided we adopt an intermediate degree of inequality aversion. Adopting extreme inequality aversion tends to completely annihilate the gap, by making the deterioration of survival conditions due to the conflict irrelevant, because of the presence of extremely short-lived persons both before and during the conflict (independently from their numbers).

In sum, this section shows that shifting from an *ex ante* approach to an *ex post* approach does not suffice, on its own, to make the puzzle disappear. Actually, our calculations show that it is only for intermediate degrees of inequality aversion that the *ex post* equivalent income is much reduced, and that the gap with respect to the standard income is increased. For low degrees of inequality aversion, the gap remains almost unchanged, and for high degrees of inequality aversion the equivalent income converges towards the standard income.

7 Population ethics

When examining the robustness of our results, another point that can be raised concerns the treatment of population size. Our baseline approach, by focusing on outcomes on average, may have missed a major dimension of the welfare loss due to the War: the reduction of the population size.

Actually, the Syrian Civil War affected the size of the population, by reducing it from 20.7 millions in 2010 to 18.5 millions in 2016. Hence, given that the pre-conflict and conflict situations involve populations whose sizes differ, we are here in presence of what Parfit (1984) called a "different-number problem". A consequence of this is that our welfare comparisons must necessarily rely on some (more or less implicit) postulates on how population size is valued. The previous sections, by relying on a representative, average view, assumed some form of average utilitarianism. Whereas that SWF is often implicitly assumed in the equivalent income literature based on representative agent models (see Section 1), it involves a particular value judgement on population size.

While the average utilitarian SWF can lead to some well-known counterin-

[23] In other words, when v becomes very large, the ratio $\sum_{\ell=0}^{T-1} n_\ell \ell^{1-v} \Big/ \sum_{\ell=0}^{T-1} \bar{n}_\ell \ell^{1-v}$ becomes close to 1.

tuitive results, such as the Mere Addition Paradox presented in Parfit (1984), one may be skeptical regarding its adequacy for the particular purpose at hand. By focusing on what happens "on average", this SWF may lead to leave aside the strong reduction of the population size due to the War (minus 10 %), and, hence, may miss an important source of welfare loss at the social level.

In order to examine the robustness of our results to the postulated ethical view on numbers, this section will rely on an alternative, more general, SWF, which includes the average utilitarian view as a special case. That SWF is the Number-Dampened Utilitarian SWF proposed by Ng (1986):[24]

$$W\left(\mathbf{y},\mathbf{s},N\right) = \left(N\right)^{\varphi} \sum_{\ell=0}^{T-1} n_{\ell} U_{\ell} \tag{14}$$

where N is the total population size, $n_{\ell} = d_{\ell} s_{\ell}$ and $U_{\ell} = \ell \left[\frac{(y)^{1-\sigma}}{1-\sigma} - \alpha\right]$. The parameter φ reflects the ethical view on population size. When $\varphi = 0$, the SWF collapses to the average utilitarian SWF. When $\varphi = 1$, $W(\cdot)$ becomes the classical utilitarian SWF, in the spirit of Bentham (1789): situations are then compared by computing the total sum of welfare across individuals.

We can now define the equivalent income as the hypothetical income which, if combined with the survival conditions of reference and the population size of reference (i.e. the pre-conflict, 2010, survival conditions and population size), would bring the same social welfare as the one prevailing in 2015 (given the 2015 income, survival conditions and population size):

$$W\left(\hat{\mathbf{y}},\bar{\mathbf{s}},\bar{N}\right) = W\left(\mathbf{y},\mathbf{s},N\right) \tag{15}$$

where $\bar{N}$ is the population size of reference (i.e. the one of year 2010), while $\bar{\mathbf{s}}$ is the survival condition of reference (also the ones of 2010).

Substituting for the social welfare function $W(\cdot)$, and assuming constancy of incomes along the lifecycle, the equivalent income $\hat{y}$ satisfies the equality:

$$\left(\bar{N}\right)^{\varphi} \sum_{\ell=0}^{T-1} \bar{n}_{\ell} \ell \left[\frac{(\hat{y})^{1-\sigma}}{1-\sigma} - \alpha\right] = \left(N\right)^{\varphi} \sum_{\ell=0}^{T-1} n_{\ell} \ell \left[\frac{(y)^{1-\sigma}}{1-\sigma} - \alpha\right]$$

Hence the equivalent income is:

$$\hat{y} = \left[(1-\sigma)\left[\frac{(N)^{\varphi}}{\left(\bar{N}\right)^{\varphi}}\left[\frac{(y)^{1-\sigma}}{1-\sigma} - \alpha\right]\frac{e}{\bar{e}} + \alpha\right]\right]^{\frac{1}{1-\sigma}} \tag{16}$$

Note that, when the SWF is average utilitarian (i.e. $\varphi = 0$), the equivalent income formula vanishes to its baseline expression studied in Section 2.

In order to examine the robustness of our calculations to the underlying ethical view on population, Table 3 compares the standard income and the

[24]Note that, for the sake of identifying the pure effect of the ethical view on numbers on the construction of equivalent incomes, we abstract here from the issue of inequality aversion discussed in the previous section, and set the parameter v to 0.

equivalent income under different values of the ethical parameter φ, from average utilitarianism ($\varphi = 0$) to classical utilitarianism ($\varphi = 1$).[25]

	$\varphi = 0$ average utilitarianism	$\varphi = 0.25$	$\varphi = 0.50$	$\varphi = 0.75$	$\varphi = 1$ classical utilitarianism
y_{2016}	\$1215	\$1215	\$1215	\$1215	\$1215
$\hat{y}_{2016}$	\$1071	\$1018	\$969	\$924	\$881
gap	\$144	\$197	\$246	\$291	\$334

Table 3: Robustness to the ethical view on population.

Quite interestingly, Table 3 reveals that, once a larger ethical value is assigned to the population size, the gap between the standard income and the equivalent income goes up significantly. Under the classical utilitarian SWF, the gap equals \$334, which is more than twice larger than the gap under average utilitarianism (\$144).

Hence, when trying to quantify the welfare loss of the Syrian Civil War, the particular way in which we treat the substantial fall in population size plays an important role. If one focuses only on living standards "on average", without considering the reduction of the population size, one obtains a relatively low gap between the standard income and the equivalent income. If, on the contrary, one adopts a more aggregate perspective, and adheres to the total utilitarian SWF, then the equivalent income becomes much lower, and this raises the gap with respect to the standard income.

Thus the postulated ethical view on different numbers comparisons affects the quantification of the welfare loss of the Syrian Civil War. Having stressed this, can we conclude that taking population ethics seriously can bring a solution to our puzzle, i.e. the low gap between standard and equivalent incomes? The answer is not simple. On the one hand, the fall in population size was caused by the Civil War, so that it is normal to take this population fall into account when calculating the welfare loss due to the War. On the other hand, taking variations in population size into account only leads to a significantly larger gap between standard and equivalent incomes provided the SWF assigns a sufficiently strong weight to population size. Thus this solution lacks robustness. Moreover, taking the population size into account does not necessarily solve the puzzle, since one may imagine hypothetical situations where, despite a strong deterioration of standards of living, the total population size remains unchanged.[26] Then, whatever the ethical judgement on numbers, the equivalent income would remain at its baseline level, and the gap between standard and equivalent incomes would remain as low as under the baseline setting.

[25] To facilitate the comparison with the baseline results, our calculation relies here on the baseline calibration under the upper bound estimate of the VSL ($\alpha = 13.35$ and $\sigma = 0.83$).

[26] For instance, one could think about a conflict, where the associated rise in fertility would exactly compensate, in terms of population size, the rise in mortality and migration, leaving the population size unchanged.

8 Conclusions

Trying to measure, by means of an equivalent income approach, the welfare losses due to the Syrian Civil War is a complex exercise. Obviously, losses are enormous and multidimensional, and have affected the Syrian territory in an asymmetric way across space.[27] Moreover, those losses have long-lasting effects for future generations, which are even harder to evaluate (unborn children, broken dynasties, broken careers, population displacements, etc.).[28] From that perspective, focusing only on two dimensions of life - income and longevity - oversimplifies the picture.

Our calculations showed that the equivalent income has fallen by about 60 % in comparison to its pre-conflict level (2010). Moreover, we found that the differentials between standard incomes and equivalent incomes for 2016 are low (between \$75 and \$144).[29] Although this low WTP for coming back to pre-conflict survival conditions can be explained by extreme poverty due to the War, it remains that the low differential between standard and equivalent incomes shown on Figure 1 questions the extra value brought by equivalent incomes for the measurement of standards of living under extreme poverty. If focusing on standard income provides a good proxy for measuring the evolution of standards of living, what is then the extra value brought by equivalent incomes?

This paper explored various solutions to that puzzle. We examined the robustness of our calculations to different - possibly paternalistic - calibrations of preference parameters, and to the inclusion of interests for joint survival. None of these solutions is fully convincing. We then examined three other solutions: (1) adopting a more general specification for the utility function; (2) shifting from an *ex ante* approach to an *ex post* approach; (3) taking ethical population aspects into account. We showed that solution (1) can significantly raise the gap between standard and equivalent incomes only if a sufficiently high degree of net risk-aversion with respect to the length of life is assumed, for which there is no empirical support. Moreover, solution (2) is not robust, since it raises the gap between standard and equivalent incomes only if the underlying social welfare function exhibits intermediate degrees of inequality aversion. Finally, although solution (3) raises the gap between the standard income and the equivalent income, one cannot interpret this as a solution to our puzzle, since it is not robust to the underlying ethical view on population size. Furthermore, under a constant population size, the standard income would still provide a good proxy

[27] Note that, due to the limited availability of data, we were not able, in this paper, to study the question of inequalities in income and wealth, and the dynamics of inequality induced by the War. This constitutes an important limitation of this work.

[28] Another important issue, which could not be considered here, includes changes in preferences and/or identities due to the War.

[29] As far as we know, such counterintuitive results were not obtained in previous analyses (such as Costa and Steckel 1997 or Becker et al 2005), since papers using the equivalent income approach usually considered the valuation of increases in life expectancy (with respect to baseline, worse, survival conditions) experienced in countries becoming richer and richer over time, so that the VSL was also naturally raised. In our case, we consider a worsening of survival conditions with respect to the baseline, in an area of the indifference map where income is so low that longevity has a low value for individuals.

of the evolution of standards of living.

Thus, in the light of all this, the low gap between the standard income and the equivalent income constitutes a robust result. Of course, it is tempting to argue that this low gap, which comes from extreme poverty due to the War, arises only because of very specific circumstances, and, as such, does not question the use of equivalent incomes in general. This is true that the problem arises because of extreme poverty, but this does not imply that the problem is restricted to very specific situations. Two examples can illustrate why the problem may be more widespread than one may believe at first glance.

Take, for instance, the measurement of standards of living in the Middle Ages. Because of very low incomes per capita, the WTP for increasing life expectancy is low, implying that the equivalent income is very close to the standard income. Hence, for long periods of stagnation in the Middle Ages, equivalent incomes do not seem to have more to say than standard incomes, despite potentially large fluctuations in survival conditions (because little value is assigned to these). This means that the welfare loss due, for instance, to the Black Death (1346-1353), would be - almost - entirely captured by the pattern of standard income, which is puzzling.[30]

A second example is given by climate change, and all its damages in terms of income, environmental quality, health, etc. If, in the future, the climate change is so severe that standard incomes are strongly reduced, then, if these low standard incomes imply also low WTP for improving environmental quality or health, it will be the case that equivalent and standard incomes are very close, which reduces the extra value brought by equivalent incomes for the measurement of the welfare loss due to climate change.

Hence the problem discussed in this paper concerns a broad set of situations. Actually, as soon as standard income is very low, the problem will emerge, and the equivalent income - a multidimensional indicator of standards of living - will turn out to vanish (almost) to a one-dimensional indicator of standards of living (standard income), which is, in some sense, quite puzzling.

Note that the equivalent income is not the only one to face problems when valuing longevity under low incomes: we are here in presence of "troubling trade-offs" close to the ones identified by Ravallion (2012) in his analysis of the new, multiplicative HDI. From that perspective, our analysis points to a general problem for the measurement of standards of living under low incomes, which does not only concern equivalent incomes, but a broader set of indicators.

All in all, this paper exemplifies well the questions and problems that arise when constructing and computing aggregated indicators of standards of living. It is quite difficult to synthesize, in a single number, things as different as changes in income and survival conditions due to the Syrian Civil War. Our explorations confirm that, in the 21st century, Leontief (1966)'s claim about aggregation difficulties remains more valid than ever before: qualitative variety can only be reduced at the cost of higher quantitative indeterminacy.

[30] This would be so except if there is some strong ethical concerns for population size, as stressed in Section 7.

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10 Appendix

10.1 Calibration under the general utility function

The following tables presents the values of preference parameters $\{\alpha, \sigma, \theta, \omega\}$. Note that each combination of parameters is compatible with the upper bound estimate of the VSL.

Men							
α	14.25	14.25	14.25	14.25	14.25	14.25	14.25
σ	0.83	0.83	0.83	0.83	0.83	0.83	0.83
θ	0.00	0.50	1.50	2.00	3.00	4.00	5.00
ω	-272.15	-1.56	-0.34	-0.03	-0.001048	-0.000064	-0.000004

Women							
α	14.25	14.25	14.25	14.25	14.25	14.25	14.25
σ	0.83	0.83	0.83	0.83	0.83	0.83	0.83
θ	0.00	0.50	1.50	2.00	3.00	4.00	5.00
ω	-219.33	4.94	-0.29	-0.02	-0.001071	-0.000069	-0.000005