Appendices

Appendix A : considerations about the nature of the counterfactual

In the case of Northern Ireland, the number of deaths attributed to the Troubles has already been estimated carefully and directly, for example through studious collation of coroners’ records and newspaper reports. (See, e.g. (Smyth, 1998), (McDowell, 2008), (Curran, 2001)) These estimates cannot, of course, count any hypothetical deaths that may have been *averted* as a result of the Troubles, nor any that resulted *indirectly* from the Troubles. An example of an *averted* death could be if a young adult (most likely male) *would have* died of a vehicle-related fatality in an alternate Northern Ireland in which the Troubles did not occur, but due perhaps to the elevated police and military presence in the real Northern Ireland in the 1970s and 1980s, and consequent road speed restrictions and enforcement thereof, did not die of this cause, and so did not die in early adulthood. And an example of a death *indirectly* caused by the Troubles would be if an individual died of suicide or alcohol due to the emotional stress caused by living in this distinct sociocultural environment.

Given the near-philosophical nature of the above hypothetical scenarios of averted deaths and indirectly caused deaths, the counterfactual can never be truly known. What both the visualisations of mortality risks on Lexis surfaces, and the subsequent statistical model, aim to do is demonstrate what can be inferred about the human costs of violent sectarian conflicts from all-cause mortality records alone. All-cause mortality records (knowing whether someone has died) are invariably more readily available for populations than cause-specific mortality records (knowing why someone has died), and are less subject to economic and cultural variations in coding practice which can hinder meaningful comparison over large swathes of time and space. An example of temporal variation is the changes in ICD classification systems that periodically occur. [FURTHER DETAILS] An example of economic variation is the effect that limited public resource has on official record keeping and the construction of coroner reports. And an example of cultural variation could be the differential degree to which a coroner may be willing to designate an alcohol-related death or suicide *as alcohol-related or suicides* in a country with religious prohibitions on either consumption of alcohol or death by (‘committing’) suicide. By developing the Impulse-decay model and producing mortality estimates based on all-cause mortality records in the case of Northern Ireland, in which cause-specific estimates are available for comparison, the general utility and applicability of the model structure and broader model-development approach outlined here can be inferred for less economically developed populations which have also experienced sectarian conflict. Examples of possible applications are sadly numerous, and include Afghanistan and Pakistan/India in the 1980s; Algeria, Yugoslavia, and Rwanda in the 1990s; Iraq and Syria in the 2000s and 2010s; and Israel and its neighbours since 1948.

Appendix B: Additional considerations about the model specification

#### Considerations in representing background rates of mortality improvement

In addition to the distinct Impulse-decay feature which is the focus of this paper (‘the Shape of the Troubles’), it is also important to adequately represent longer-term trends in age-specific mortality rates. One of the most population actuarial models, the Lee-Carter model, assumes that all ages experience the same constant ‘drift’ towards lower log mortality over time. [REFs: Lee-Carter; Girosi & King] The intuition of this model assumption is as follows: imagine the Lexis surface of log mortality rates were drawn as a contour plot, as with a spatial map showing variation in height above sea level as a function of latitude and longitude. Each specific contour line in a Lexis surface of log-mortality rates therefore represents a fixed mortality hazards. The central assumption of the Lee-Carter model is that each of these contours ‘drift’ upwards from left to right at an angle somewhat shallower than 45 degrees (the angle indicating a single age cohort), and does so at all ages and for all periods of observations. For example, a given contour line, indicating a specific fixed mortality hazard, might be encountered at age 40 in 1950, age 45 in 1975, and age 50 in 2000; each mortality ‘hurdle’ is therefore put off to a slightly older age, and the overall result is a continuing improvement in life expectancies. The assumption that this rate of upwards drift in mortality hazards (in effect projecting forwards the Lexis surface along its first principal component) applies at all ages and is constant over time is a highly simplistic assumption, but often produces surprisingly good estimate of population life expectancy trends, because it tends to be a reasonable approximation of what has happened to mortality rate trends in older age (from about age 50 onwards), which is when most deaths occur.

In younger adulthood, and especially for male populations, the simplifying assumption of the Lee-Carter model appears less appropriate. The ‘Shape of the Troubles’ is a case in point, but mortality risks in young adulthood do tend to be more variable over in young adulthood than older ages due to risks of deaths from external causes, which claim a disproportionate share of lives in early adulthood, tending to be variable across time and place than deaths from many other causes. More complicated models for representing the way that mortality risks often increase sharply with the onset of adulthood in populations, especially males, have been developed, but these are difficult to fit and often do not also incorporate projections about changing age-specific mortality risks over time. [REFs]

#### Model specification and selection of mortality rate improvement phases

In order to try to represent how age-specific mortality risks are likely to have changed over time in the absence of the Troubles, the Lexis surfaces of log mortality rates in Northern Ireland were carefully explored within the 15-45 year age range for both indications of Lee-Carter style ‘drift’, and also discontinuities in the rate of ‘drift’ over time. Separate models were fit to represent changes in log mortality over time at each age in single years, but these models included a number of shared parameters. By looking at the extent to which mortality ‘bands’ of particular colours (the level plot analogue of contour lines in a contour plot) appeared to move upwards at different rates over time (See figure 5), it appears that underlying trends in mortality rate improvement fit within three distinct phases.

Appendix C: Methods for estimating additional deaths caused by the Troubles

### Visualisation and estimating of effect of the Troubles on mortality

After having developed a final model specification by comparing a number of possible candidate models using standard model summary measures such as adjusted R-Square, AIC, and BIC, as well as by comparing residuals surfaces, and after ‘tuning’ the decay parameter k in T(t) using AIC, it is important to make the model predictions intelligible and substantively meaningful. This does not mean presenting a long series of statistical model coefficients and associated p values, but instead showing how the *surface* of age-years specific mortality rates produced by the selected model compare with the observed surface of values for the same range of ages and years. As the final model includes the Impulse-decay (‘Troubles’) function as a discrete term, a counterfactual prediction surface, in which the Troubles did not occur, can also be produced by setting the associated parameter value () to zero for all ages and years.

By applying observed age-year specific population counts to both the standard (‘with Troubles’) and counterfactual (‘without Troubles’) model prediction surfaces, an estimate of the number of additional lives lost as a result of the Trouble can then be produced. More formally, the numbers of deaths at each age and in each year are estimated by applying the model’s predicted mortality risks to the populations exposed to these risks, i.e. , where is the number of deaths at age and in year under the active conflict scenario A, and indicates the size of the population at this age and in this year exposed to the mortality risk.

A counterfactual surface of risks is modelled by setting to 0 in all years. The total number of conflict-attributable deaths estimated by the model in this age range is then the sum of differences in deaths estimated under both scenarios, i.e. .

Finally, in the fifth phase of the analysis, the numbers of deaths at each age and in each year are estimated by applying the model’s predicted mortality risks to the populations exposed to these risks, i.e. , where is the number of deaths at age and in year under the active conflict scenario A, and indicates the size of the population at this age and in this year exposed to the mortality risk. A counterfactual surface of risks is modelled by setting to 0 in all years. The total number of conflict-attributable deaths estimated by the model in this age range is then the sum of differences in deaths estimated under both scenarios, i.e. .

**Appendix D: The relationship between AIC and decay parameter k in the ID component of the model**

Figure 8 shows the model fit as a function of the decay rate, k.

*E:\repos\northern_ireland_troubles\figures\fig07_fit_decay.tiff*

**Figure 8: The relationship between decay parameter and model fit using AIC. (Lower AIC value = better)**

E:\repos\northern_ireland_troubles\figures\fig09_troubles_coeff.tiff

**Figure 10: Coefficient of the ‘Troubles parameter’ by age in single years for males (blue triangle) and females (red circle).**

For males the effect is positive at almost all ages, and is largest at age 18, then falls at most older ages; for females it tends to be negative, suggesting the model may be misspecified for females, and instead captures broader continual improvements in mortality risks over this time period.

**Appendix E: Further discussions on the implications of the model structure to Northern Ireland and the potential implications of Brexit**

The power sharing arrangement following the Good Friday Agreement (GFA) has been described as an example of ‘consociationalism’, a system of government in which coalition by both Republicans and Loyalists is mandated.(Anderson, 2008) The consociational arrangement following the GFA has led to little change in the ethno-sectarian identity focus of any of the main parties within Northern Ireland. Indeed, the political success of Sinn Fein at the expense of the more moderate Social Democratic and Labour Party (SDLP) in capturing the Irish Nationalist voting block after the GFA suggests sectarian identity may have come to matter more, not less, to voting intentions following the GFA.(McGlynn, Tonge, & McAuley, 2014) Cross-ethnic political parties have seen only limited success after the GFA compared with sectarian political parties, and this lack of success has been attributed to the consociationalist institutions established in the wake of the GFA to accommodate (rather than attempt to blend) rival identities.(Murtagh, 2015) Questions have therefore been raised about whether the GFA represents or helps to bring about conflict *resolution*, or is simply conflict *management*, or more pessimistically, conflict deferment.(Anderson, 2008)

Whereas ethno-national conflict since the establishment of Northern Ireland in 1921 sharpened the border with the Republic of Ireland, the European Single Market made it more permeable.(Anderson & O’Dowd, 1999) EU Peace Programmes for Northern Ireland and the Border Counties began in 1995 with the Special Support Programme for Peace and Reconciliation (Peace I) which provided €500 million in structural funds to the region, supplemented with an additional €167 from government; followed by the Programme for Peace and Reconciliation (Peace II), which provided €531million via the EU and an additional €304 from national governments between 2000 and 2004.(Buchanan, 2008) The third phase of the EU programme for Peace and Reconciliation in Northern Ireland took place over the years 2007 to 2013. (Karari, Byrne, Skarlato, Ahmed, & Hyde, 2013) Whereas the GFA focused on building peace by addressing the leaders of political factions, EU-led initiatives focused on economic investment and to greater community engagement as a means of building more lasting stability in Northern Ireland and the Irish border. The UK’s departure places the future of further initiatives in doubt, though the Irish border remains a key priority for EU-UK Brexit negotiations.