Effects of the Second World War on Postwar Population in European Countries

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Abstract: The impacts of the death in the Second World War (WW2) on the size and the quality of the population in the European countries after the war are investigated in the present study. Both the short- and long-term effects are discussed. To make it convenient for the qualitative and quantitative analysis, the annual natural change rate and the life expectation are employed to quantify the size and the quality of the population, respectively, while the death in the WW2 is converted to $\ln(\text{death}/1000)$. Our linear regression analysis in different time scales indicates that the death during the WW2 has significant short-term impacts on the annual natural change rate and the life expectation after the war, which lasts for approximately 10 and 25 years, respectively. In contrast, the influences of the death during the WW2 on the size and the quality of the population can be considered totally extinguished in the long run after 55 years from the end of the war. Additionally, we discover for the first time that the effects of the war decays rapidly on the annual natural change rate while slowly on the life expectation as time passes by.

Keywords: Second World War; European Countries; Population

1. Introduction

The Second World War (WW2) was a global war lasted from 1939 to 1945, which was by far the deadliest conflict in human history, and has a great impact on all the aspects of the human society. It involved the vast majority of the world's countries—including all of the great powers, forming two opposing military alliances: the Allies and the Axis powers. Numbers of previous studies have discussed extensively on the impacts of the WW2 on the population, economic, technological aspects.

In the view of population, the WW2 spreads from Europe to Asia, from the Atlantic to the Pacific. Over 61 countries and regions and more than 2 billion people have been involved in the war, covering an area of 22 million square kilometers. According to incomplete statistics, there were more than 90 million military and civilian casualties in the war. Tens of millions of people died due to varieties of reasons such as diseases, starvation, etc. For example, an estimated 11 to 17 million civilians died as a direct or as an indirect result of Hitler's racist policies (Niewyk et al., 2003), including mass killing of around 6 million Jews, along with Roma, homosexuals, at least 1.9 million ethnic Poles and millions of other Slavs, and other ethnic and minority groups (Niewyk et al., 2003).

In the economic side, the involved countries utilized plenty of resources from economic construction to the battlefield, which leads to the stagnation of the economic developments. Meanwhile, the war has damaged the economy around the world, causing economic losses more than 500 billion dollars (Kesternich et al., 2014; Pollard, 2002). In contrast, the outbreak of the WW2 prompted the rapid development of many technologies, including the innovation of aviation, telecommunication, medicine, etc. Specifically, aircraft was used to assist the rapid transportation of high-value materials, equipment and personnel (Tucker and Roberts, 2004), and the jet-propelled plane was first developed near the end of the WW2, which later became the standard equipment and transportation facility all over the world (Schrift, 2009). In telecommunication, the major belligerent countries constantly cracked their enemies' complex passwords, and made efforts to strengthen their communication security, benefiting the postwar development of telecom industries (Ratcliff, 2006). In addition, Penicillin was first mass-produced and extensively applied during the war, accelerating the reformation of medicine (Gaynes, 2017).

Although there are numerous studies on the effects of the WW2, the existing results are either focused on the estimations of the precise number of victims (e.g. DeBakey and Simeone, 1946; Ekamper et al., 2017; Jdanov et al., 2005) or the summaries of the qualitatively impacts of the war on the populations, economics and other sides (e.g. Gleditsch et al., 2002; Kesternich et al., 2014)

after the war. In order to gain a deep and quantitative insight of the relationship between the WW2 and the postwar population, we would like the demographic methods to study the short- and long-term effects of the war in the present study. More specifically, in demography, people are always interested in the size and quality of population. The former can be quantified by examining the number or the growth rate of the population, while the latter is often studied using the life expectancy, education levels, etc. In the present study, we select the growth rate and the life expectancy of the population in European countries after the WW2, considering that the former is directly related to the size of the population, while the latter is a representation of the synthetic effects of all the other factors, such as economy, education, and technology, on the quality of population. Based on the data collected, linear regression between the death during the WW2 and the growth rate as well as the life expectancy of the population for several decades after the war is used to show the short- and long-term effects of the war, respectively.

The remaining of the manuscript is arranged as followings: the data set we used are briefly described in section 2. The results of our analysis are shown in sections 3 and 4. The former one discusses the effects of the WW2 on the size of the population in the European countries in the short and long runs. While the latter section devotes to the investigations on the short- and long-term impacts of the WW2 on the quality of the European population. At last, concluding remarks are given in section 5.

2. Description of data set

In this section, the analyzed data is briefly described. In the present study, we are interested in the death during the WW2, the number and the natural growth rate of population and the life expectations and their relationship for European countries.

Table 1 lists the total death during WW2 in the eight European countries, with four selected from the Axis powers (Germany, Italy, Hungary and Bulgaria) and four from the Allies (France, Netherland, Denmark and UK), to make the manuscript concise. As shown, Germany contributes the greatest to the total death in the war while Denmark the least among the countries selected. Moreover, the total death during the WW2 is several order different from country to country, which causes inconvenient for our further analysis on its impacts on the population size and quality. As a result, we also calculates $\ln(\text{death}/1000)$ in table 1, which is in the similar magnitude and maintain the corresponding order for different countries.

Alliance	Country	Total Death During WW2	$\ln(\text{death}/1000)$
The Axis powers	Germany	4,440,000 (Deutschland, 2009)	8.398
	Italy	319,200	5.766
	Hungary	200,000 (Stark, 1995)	5.298
	Bulgaria	12,000 (Clodfelter, 2002)	2.485
The Allies	France	210,000 (Frumkin, 1951)	5.347
	Netherland	6,700	1.902
	Denmark	2,100	0.742
	UK	383,700	5.950

Table 1. List of total death during WW2 in eight European countries.

The data for Italy, Netherland, Denmark and UK is from "*Ufficio dell'Albo d'Oro of the Italian Ministry of Defence*", "*Central Bureau of Statistics (CBS)*", "*Hvor mange dræbte danskere?*" and "*Commonwealth War Graves Commission*", respectively. Other data resource is referred in the table.

The numbers of population for different countries are obtained from their national official statistical offices or statistical institute, for example, the number of Germany population is downloaded from "Startseite - Statistisches Bundesamt (Destatis)". While the life expectation is from Department of Economic and Social Affairs in United Nations. Considering the data set is quite massive, we do not plan to show the number and life expectation of the population in the manuscript. One can easily find them in the corresponding website.

3. Effects on size of population

In this section, we focus on the short- and long-term impacts of WW2 on the size of population in European countries, respectively. The change of the number of population and the annual natural change rate with time is first qualitatively examined. The linear regressions are then used to quantitatively discuss the relation between the annual natural change rate and the death in WW2.

Figure 1 displays the number of population (in million) of two axis powers, i.e. Germany and Hungary, as a function of year from 1930 to 1960 across WW2. During WW2, there are remarkable decreases of the number of population in these two countries, compared with the time before and after the war. The local minimum of the population is located near 1945, at which year WW2 ended. Beginning at 1946, the number of population continues to increase.

The number of population (in million) of two allies, i.e. France and Belgium are presented in figure 2 as a function of year from 1930 to 1960 across WW2. Similar to figure 1, the local minimum of the population is also observed near the war-ending year 1945, and the population starts to growth since 1946. The resemblance of figure 1 and 2 indicates that there is no significant difference between the variations of the number of population in axis powers and allies across the war time. As a result, the data from the two camps is integrated for the quantitative studies in the following sections.

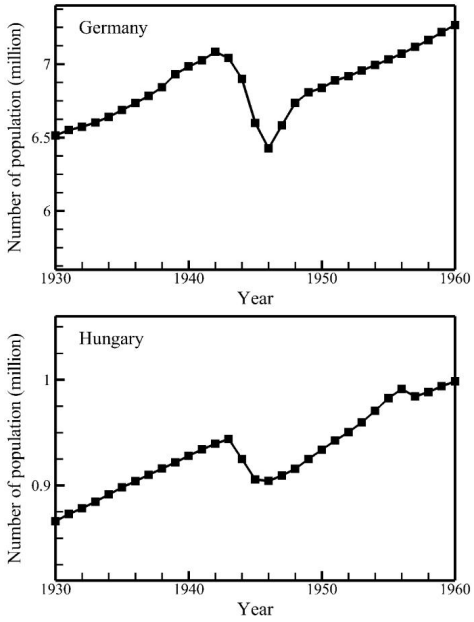

Figure 1. Number of population (million) of two axis powers as a function of year. Top: Germany; bottom: Hungary.

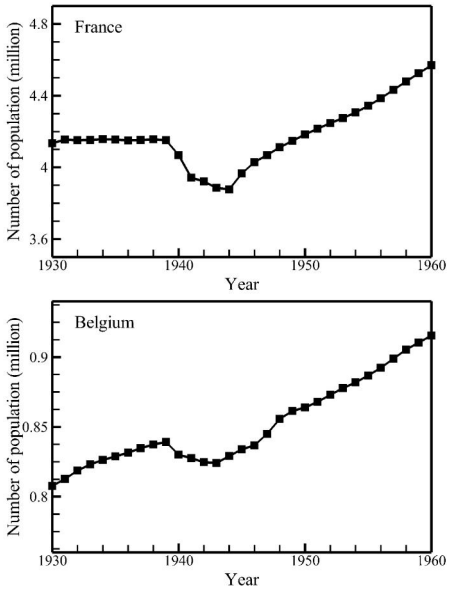

Figure 2. Number of population (million) of two allies as a function of year. Top: France; bottom: Belgium.

It is necessary to scale the variations of the number of population before relating it to the death in WW2, since the population bases can be extremely different in different countries. A natural idea is to use the annual natural change rate of the population, which is defined as the change of the number of population of a year relative to that of one year before. Mathematically, the annual natural change rate is equal to the difference between the annual birth rate and the annual death rate of population, as other effects on the size of population, such as migration, are not dominant in the European countries.

Figure 3 shows the annual natural change rate of population (in ‰) of the axis powers and allies as a function of year from 1930 to 1960, respective. The first common fact is that during the WW2, the annual natural change rate of population in every European country experiences a dramatic decrease or even becomes negative, although the occurrence of such decrease is at different year for different forces. The decrease of the annual natural change rate can be attributed to two reasons. First, the death of

the militaries and the civilians directly makes a great contribution to the increase of the annual death rate of population. On the other hand, since the militaries are mainly composed of men, their death leads to the gender imbalance, which in turn results in a significant decline of the annual birth rate of population.

The second common point indicated in figure 3 is that compared with the war time, the annual natural change rate becomes remarkably higher right after the WW2 (e.g. from 1946 to 1950), although it is quite different in different countries. We will show that such difference of the postwar annual natural change rate in the short run can be explained by the death during the WW2, which is discussed in the followings.

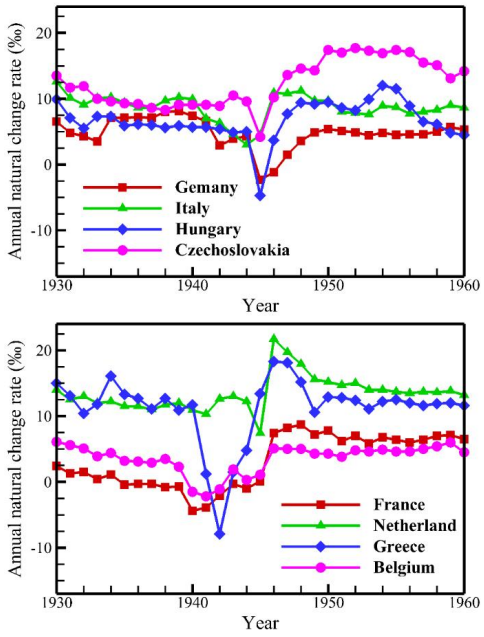

Figure 3. Annual natural change rate of population (‰) of axis powers (top) and allies (bottom) as a function of year.

In order to investigate the linkage between the death during the WW2 and the annual natural change rate of population after the war in the short run, figure 4 plots the annual natural change rate in year 1946 as a function of $\ln(\text{death}/1000)$ for different European countries. Here, we have rescaled death to $\ln(\text{death}/1000)$ to make it convenient for our analysis. As expected, the annual natural change rate in 1946 is negatively related to $\ln(\text{death}/1000)$, and all the data points are located near a straight line that is sloped to bottom-left. Using the least-squared regression, we have obtained this straight line as

$$\text{Annual natrual change rate in } 1946 = -1.896 * \ln\frac{\text{death}}{1000} + 18.821 \quad \#(1)$$

The negative gradient of the line suggests that the annual natural change rate in 1946 is decreased as the increase of the death during the WW2. Another significant factor in the linear regression is the correlation coefficient r^2, which is calculated as 0.530. This value of r^2 indicates that the annual natural change rate right after the WW2 is strongly related to the death during the war, which is consistent with our qualitative observations from figure 3.

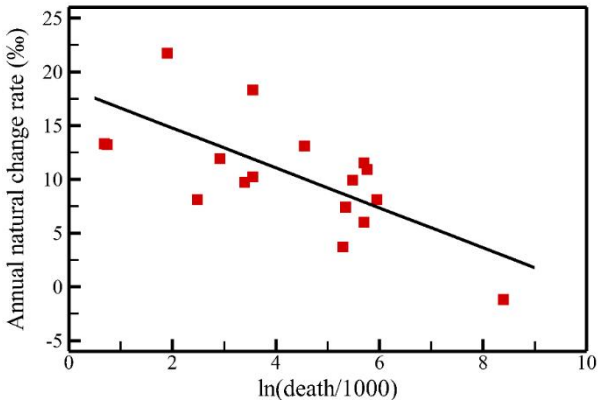

Figure 4. Annual natural change rate in year 1946 as a function of $\ln(\text{death}/1000)$ for different European countries. Red rectangle: data for different countries; black line: the linear regression of the data points.

In the present study, we are also interested in the long-term effects of the WW2 on the postwar annual natural change rate of

population. The annual natural change rates for different countries are first plotted as data points against $\ln(\mathrm{death}/1000)$ in figure 5, from 1946 to 2000. To get a clear picture on our focus, the annual natural change rate has been averaged across a five-year interval, for example, the annual natural change rate is the averaged one from 1946-1950 in figure 5 (a). After a quick glance, we can easily tell that at the time close the end of the WW2, the correlation between the annual natural change rate and $\ln(\mathrm{death}/1000)$ is reasonably good. For instance, figure 5 (a) shows that all the data points are located near a negative sloped straight line, which is similar to figure 4. Nevertheless, when the time is far away from the end of the war, the negative correlation between the annual natural change rate and $\ln(\mathrm{death}/1000)$ disappears, for example, in figure 5 (f), all the data points are scattered with no obvious regulations. This indicates that the long-run impacts of the WW2 on the postwar annual natural change rate of population is extremely weak.

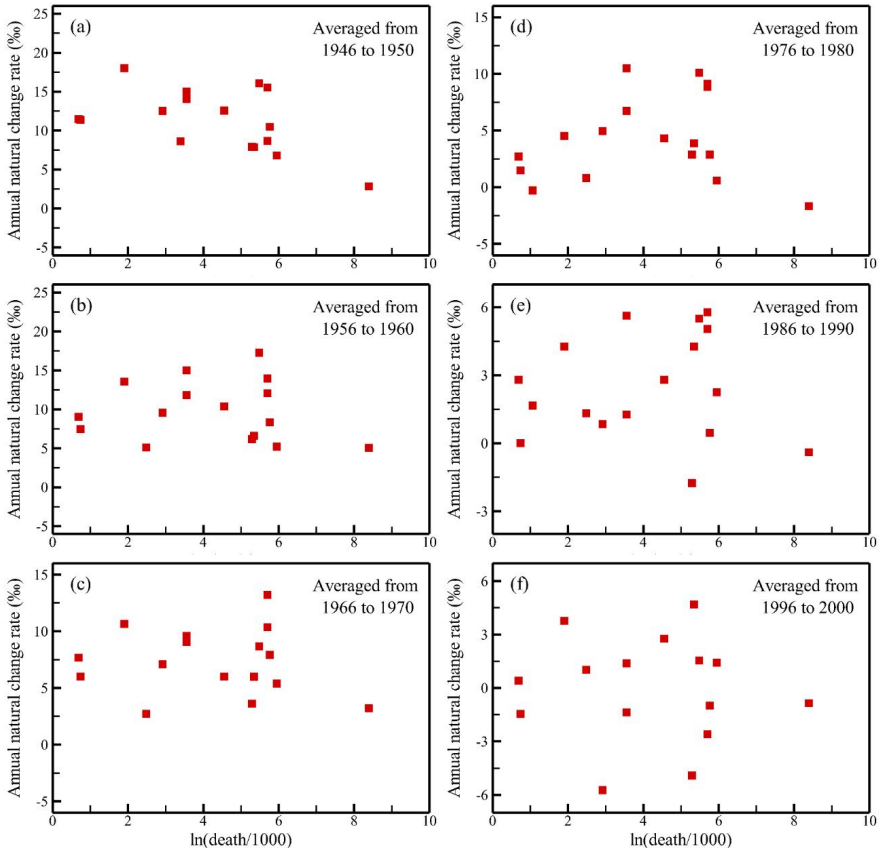

Figure 5. Annual natural change rate as a function of $\ln(\mathrm{death}/1000)$ for different European countries. (a): averaged from 1946 to 1950; (b): averaged from 1956 to 1960; (c): averaged from 1966 to 1970; (d): averaged from 1976 to 1980; (e): averaged from 1986 to 1990; (f): averaged from 1996 to 2000.

The correlation coefficient r^2 of the data points in figure 5 corresponding to the respective linear regression is calculated to quantitatively compare the relation between the annual natural change rate and the death during the WW2 in different time scales. Figure 6 displays r^2 as a function of years from 1946. As shown, as time passes by, r^2 decays quite fast. At the time 5 years to the end of the war, r^2 becomes approximate 0.3, which indicates a weaker correlation between the annual natural change rate and the death during the WW2. While at the time 15 years to the end of the war, r^2 is nearly zero, in the order of 0.01 or even smaller, suggesting no correlation between the annual natural change rate and the death during the WW2. Conventionally, if $r^2 \leq 0.2$, the two investigated quantities are taken as no correlations. Therefore, we set $r^2 = 0.2$ as a threshold in the present study to judge whether there is a correlation between the annual natural change rate and the death during the WW2. From figure 6, it is justified to conclude that the death in the WW2 has detectable impacts on the annual natural change rate of population, and thereby the size of population, within approximately 10 years from the end of the war. However, after 10 years from the end of the WW2, the variation of the annual natural change rate and the size of population cannot be explained by the death in the war. In other words, the death during the WW2 dominates the change of the number of population after the war in the short run rather than in the long run.

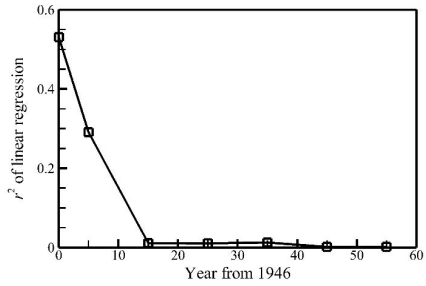

Figure 6. Correlation coefficient r^2 of data points in figure 5 corresponding to the respective linear regression as a function of years from 1946.

To summarize this section, we have investigated the effects of the death during the WW2 on the number of population in the European countries. It is discovered that the number of the population in every European countries decreases during the war due to the death in the WW2 while increases rapidly after the war, regardless of the axis powers or allies. To quantify the variation of the size of the population, we have introduced the annual natural change rate. The linear regression between the annual natural change rate and the death in the WW2 shows a strong correlation between them at 1946 right after the end of the war. In the short run or less than 10 years from the war, the annual natural change rate is still reasonably dominated by the death during the WW2, while in the long run or after 10 years from the war, the correlations become pretty weak, which is nearly zero, meaning that the death in the WW2 has little impacts on the size of the population in the European countries.

4. Effects on quality of population

Apart from the number of the population, another important factor in the study of demography is the quality of the population, which is examined in this section. In the present study, we select life expectation as the representation of quality of the population among the amounts of other parameters. This is because life expectation can be considered as one of the most directly impacted parameters by the death of the war while other parameters, such as GDP, level of education, etc., are substantially influenced by other economic factors to some extent. Similar to section 3, we investigate the short- and long-term effects of the WW2 on the life expectation in the European countries.

Using the data available from the World Population Prospects provided by United Nations, the life expectation is plotted as a function of $\ln(\text{death}/1000)$ in figure 7. Here, all the life expectations are averaged over five years and the earliest data is from 1950-1955. Since the years 1950-1955 are less than ten years from the end of the WW2, it is reasonable to explain the corresponding results as the short-term effects.

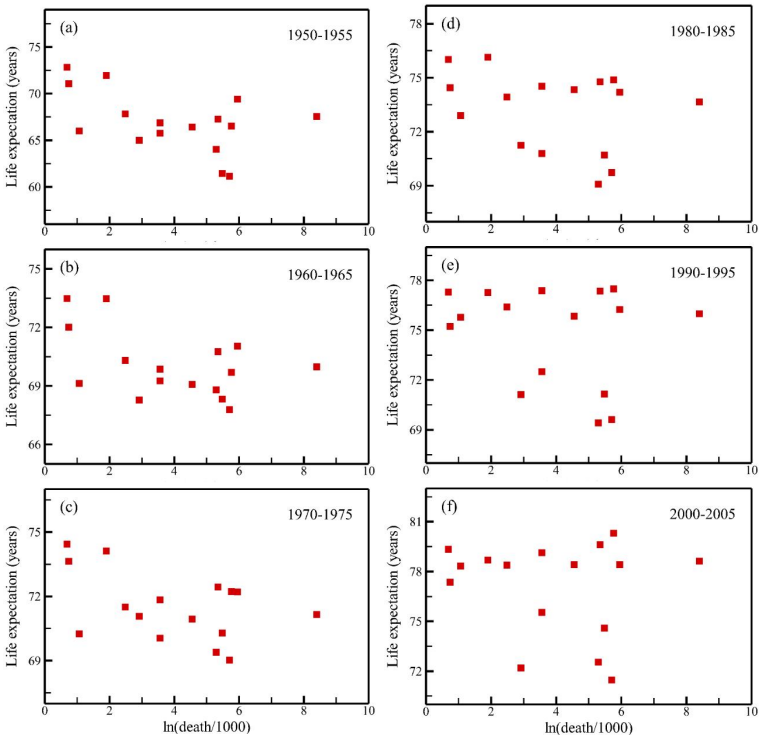

Figure 7. Life expectation as a function of $\ln(\text{death}/1000)$ for different European countries. (a): averaged from 1950 to 1955;

(b): averaged from 1960 to 1965; (c): averaged from 1970 to 1975; (d): averaged from 1980 to 1985; (e): averaged from 1990 to 1995; (f): averaged from 2000 to 2005.

Figure 7 shows that the correlation between the life expectation and $\ln(\text{death}/1000)$ are reasonable good near the end of the WW2 while it becomes weaker as time passes by. To be specific, all the data points in figure 7 (a) locates not far away from a negative-sloped straight line, indicating that the increase of the death in the WW2 leads to the decline of the life expectation from the year 1950 to 1955. The similar trend is also observed in figure 7 (b) and 7 (c), which suggests that the death during the war has a significant impact on the life expectation for at least 25 years after the end of the war. However, the good correlation between the life expectation and $\ln(\text{death}/1000)$ is destroyed beginning at 1980 shown in figure 7 (d). At time 1990-1995 and 2000-2005, the data points are totally scattered in figure 7 (e) and (f), meaning that the life expectation cannot be explained by the death in the WW2 in such a long run.

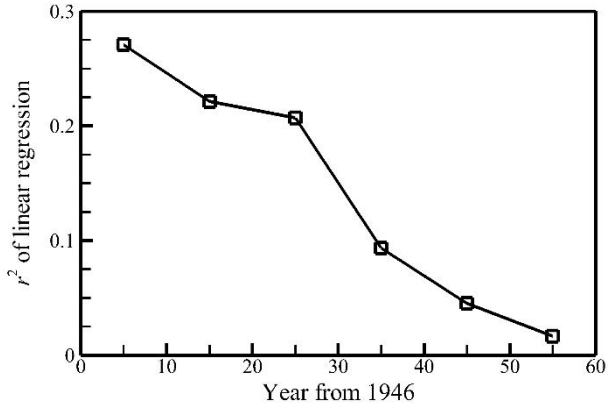

Figure 8. Correlation coefficient r^2 of data points in figure 7 corresponding to the respective linear regression as a function of years from 1946.

In order to quantitatively compare the relation between the life expectation and the death during the WW2 in different time scales, the correlation coefficient r^2 of the data points in figure 7 corresponding to the respective linear regression is calculated and plotted in figure 8 as a function of the year from 1946. It is shown that r^2 is 0.271, 0.221, and 0.207 in the time after 5, 15, and 25 years from the end of the WW2, respectively. These value of r^2, larger than 0.2, indicates that it is plausible to employ the death during the war to explain the different life expectations in different countries. Beginning at approximately 30 years from the end of the WW2, r^2 is decreased to less than 0.1, which means that the long-term influences of the death in the war is relatively weak on the life expectation.

Before ending this section, it is worth to make some comparisons between the correlation of the size of the population and the quality of the population correlated with the death during the WW2 by carefully checking figure 6 and 8. First, our results show that the death during the WW2 has longer effects on the life expectation than the annual natural change rate of the population, with the former lasting for approximately 25 years and decreasing slowly while the latter for less than 10 years and decreasing quite fast. Moreover, in the long run, for example, after 35 years from the end of the WW2, the correlation between the annual natural change rate and the death during the war is considered as zero, meaning that there are exactly no impacts of the war on the size of the population at that time scale. In contrast, the correlation coefficient r^2 between the life expectation and death in the WW2 is nearly 0.1. This indicates that the effect of the war on the quality of the population has not disappeared totally, even though such effect seems extremely weak.

In conclusion, the effects of the WW2 on the quality of the population, which is represented by the life expectation, in the European countries has been studied in this section. Our analysis shows that we are capable of relating the different life expectation in different countries to the different death during the WW2 to some extend for at least 25 years after the end of the war. While in the long run, e.g. for 55 years after the war, the impacts of the death in the war becomes extremely weak. In addition, different from the size of the population, the decrease of the influences of the WW2 on the quality of the population is more slowly.

5. Concluding remarks

In the present study, we have investigated how the size and the quality of the population in the European countries are affected by the death of the WW2, which is one of the most widespread war all over the world. The focus is on both the short- and long-term effects.

In the manuscript, the annual natural change rate and the life expectation are employed to quantify the size and the quality of

the population, respectively. This makes it convenient for both our qualitative and quantitative analysis, considering that the annual natural change rate scales the variation of the number of population in different countries in the same order while the life expectation is one of the most directly impacted parameters by the death of the war. On the other hand, we have selected $\ln(death/1000)$, which represents the death during the WW2, and meanwhile, overcome the huge differences among different countries.

In the aspects of the size of population, it is found that due to the death in the WW2, the number of the population in every European countries decreases remarkably during the war while increases rapidly after the war, regardless of the axis powers or allies. The linear regression between the annual natural change rate in the time less than 10 years from the end of the war and the death in the WW2 shows a strong correlation. This indicates that in the short run the annual natural change rate is reasonably dominated by the death during the WW2. Nevertheless, after 10 years from the end of the war, such correlations decrease rapidly and become extremely weak, which is in the order of 0.01 or even less, meaning that the death in the WW2 has extinguished impacts on the size of the population in the European countries in the long run.

In the analysis of the correlation between the life expectation and the death in the WW2, we have shown that it is capable of relating the different life expectation or quality of population in different countries to the different death during the WW2 to some extend for at least 25 years after the end of the war. While in the long run, the influences of the WW2 on the quality of the population slowly, which different from the rapidly decreasing impacts of the war on the size of the population. At 55 years after the end of the WW2, the effects of the death in the war has been reduced significantly and becomes extremely weak.

The present study has found and quantified the reasonable correlation between the death during the WW2 and the size and the quality of the population for the first time. We have also discovered the differences on the effects of the war between the size and the quality of the population, which has never been reported in the previous studies. The longer lasting effects on the quality than the size of the population indicates that people should be careful when dealing with a problem related to the population due to an important events of mankind such as the WW2 in the future studies. To the end of the manuscript, it is necessary to point out that digging out the reason behind this difference is another interesting research topic but beyond the work of the present study, which will be the focus of the deep analysis in our future investigations.

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