German East-West Mortality Difference: Two Cross-Overs Driven by Smoking

Authors ordered by proximity of birth place to Rostock:

Tobias Vogt, Mikko Myrskylä, Pavel Grigoriev, Alyson van Raalte

Abstract

Before the Fall of the Berlin Wall 25 years ago, mortality was considerably higher in the former East than West Germany. The gap narrowed rapidly after the German unification. The convergence was particularly strong for women, to the point that since the late 1990s Eastern women aged 50-64 had *lower* mortality than in the West, despite having lower incomes and worse overall living conditions. Prior research shows that a major contributor to this cross-over was lower smoking rates among East German female cohorts born in the 1940-1950s. For more recent cohorts, however, smoking prevalence is higher for East than West German women. We hypothesize that the reversal in smoking prevalence will lead to another cross-over in which mortality for East German women returns to above-West levels. We forecast mortality for East and West German women using a the Preston's et al (2014) approach that accounts for smoking histories and find evidence suggesting that the current mortality advantage enjoyed by East German women is temporary, and higher smoking rates among younger East German cohorts will reverse the contemporary mortality advantage. Traditional mortality forecasting methods that do not account for smoking would, perhaps misleadingly, forecast a growing mortality advantage for East German women.

Introduction

Germany was divided into East and West after the Second World War and until the Fall of the Berlin Wall and unification in 1990. Over the decades of separation, the East started to lag behind the West in living standards, health care, and ultimately life expectancy (Diehl 2008; Dinkel 2000; Gjonça, Brockmann and Maier 2000; Luy 2004). For example, in 1989 East German life expectancy was 2.5 years below that of the West for men, and 2.6 years for women (Human Mortality Database 2015). Since the unification 25 years ago, East Germans have experienced remarkable mortality improvements. Among women, the mortality difference has practically disappeared, being 0.1 years in 2011; among men the gap has narrowed but is still 1.2 years in 2011.

The pre-unification mortality differential was mostly due to cardiovascular and respiratory diseases (Höhn and Pollard 1991), which are usually attributed to differences in the economic, social, and medical environments (Diehl 2008; Dinkel 2000; Gjonça et al. 2000; Luy 2004). The factors driving the post-unification mortality convergence are less well understood. Reunification brought major change to the living conditions of East Germans and the relative importance of the various factors remains subject to continued debate (Vogt 2013, Kibele 2012, Diehl 2008). Following the adoption of the West German social, economic and political system, East Germans benefited from access to the modern western health system that helped to reduce circulatory mortality as the prime cause of death. Likewise, they witnessed a manifold increase in nominal income and purchasing power as the West German Mark was introduced at a highly beneficial exchange rate of 1:1. In general, social expenditures for health care and pensions converged to the generous western level which helped to reduce the mortality differentials between the two parts of Germany (Vogt and Kluge2014). In addition to improved living standards and the adoption of Western health care technology and practices, it has been suggested that the convergence could have been driven in part by decreases in psychosocial stress resulting from the deprived living and working conditions in the East (Cockerham 1999; Diehl 2008; Dinkel 2000; Häussler, Hempel and Reschke 1995; Riphahn 1999).

Despite these improvements, East Germany continues to lag behind the West in terms of living standards. Therefore it is surprising that for some age groups mortality has declined below that of the West, as shown in Figure 1. This mortality cross-over has been documented before and attributed not to period changes following the unification, but to higher rates of smoking among West German women in the 1930s-1940s birth cohorts (Myrskylä and Scholz 2013). Other health behaviours could also be partially responsible for the convergence, but prior research suggests that at least for drinking, the trends declined in parallel in both East and West over the 1990s (Bloomfield 2005).

Even though lower smoking rates have helped East German women to reach or even go below West German mortality levels, it is less clear if this advantage will remain in the future. Smoking is the most important behavioural factor influencing mortality and one of the key elements in contributing to mortality differentials across (Preston, Glei and Wilmoth 2010a) and within national populations (Preston and Wang 2006). If East German women were catching up with the West also in terms of smoking prevalence, it might be expected that their mortality advantage was short-lived.

In this paper we analyze the future of the East-West female mortality difference using the Preston’s et al (2014) approach that accounts for smoking histories. Based on individual smoking histories taken from the German Socioeconomic Panel (GSOEP), we calculate the cumulative number of years smoked by age 40 for East and West German female and male cohorts born between 1922 and 1992. This measure has been shown to be a reliable predictor for smoking related mortality (Preston and Wang 2006). The smoking histories reveal that there was no major difference in smoking patterns between men in the East and the West. However, among all female cohorts born before the year 1950, the cumulative years spent as a smoker were considerably lower in the East than in the West. For more recent cohorts, East German women have smoked more than West German women. Currently, we restrict our analysis to women because of these sharper distinctions. In the future, we plan to add men.

We incorporate the smoking histories into our mortality forecasts using the Preston et al. (2014) method and find evidence suggesting that the current mortality advantage enjoyed by East German women is temporary, as higher smoking rates among younger East German cohorts will reverse the contemporary mortality advantage. Traditional mortality forecasting methods that do not account for smoking would forecast a widening mortality advantage for East German women, which seems implausible. The results have important implications for understanding the post-unification and future East-West mortality dynamics in Germany.

Data and Methods

Data

We use a modified version of the Preston et al. (2014) method to forecast future mortality by age, sex, and region (East and West Germany). This method uses past smoking histories to forecast lung cancer mortality, and then incorporates the lung cancer death rates into total mortality forecasts.

We used the German Socioeconomic Panel (SOEP 2014) to estimate cumulative years smoked by age 40 for East and West German cohorts (Figure 2). The question about start and cessation of smoking was asked in waves 2002 and 2012. This allowed us to get precise information on the smoking behavior of German cohorts born between 1920 and 1992.

Our mortality data came from 4 sources. Lung cancer death counts for Western Germany came from the WHO mortality database for years 1956-1990 and data from the German health monitoring website (GBE-Bund) for 1991-2010. We reconstructed the time series of lung cancer death counts in Eastern Germany for the years 1956-1997.[i] From 1998-2010 Eastern data was obtained from GBE-Bund. Population exposure was retrieved from the Human Morality Database (HMD) for years 1956-2011.

Two adjustments needed to be made to the GBE-Bund data. First, the original data combined ICD categories “Malignant neoplasm of larynx, trachea, bronchus and lung”. Using WHO data, we averaged the proportion of larynx cancer death counts in a combined lung and larynx cancer category by age, across the years where this was available (1973-1990 except 1979 in the East, 1956-1990 in the West). Making the assumption that this proportion was stable over time (no discernable time trend was noticed), we applied these age-specific proportions (East and West separate) to the GBE-Bund data to subtract the larynx cancer death counts. Second, data from 1998 onward do not contain separate estimates for East and West Berlin. To split lung cancer death counts in Berlin, we assumed that the lung cancer proportions in East and West Berlin were similar to the all-cause mortality proportions in East and West Berlin. The latter was calculated by taking the difference between East and West German death counts estimated in the HMD and East and West GBE-Bund death counts which did not include Berlin. This assumption poses greater concern for bias in the East, since East Berlin makes up a larger percent of the Eastern German population than West Berlin does of western Germany.

Lung cancer death rates were calculated for each year, 1956-2011, by 5-year age group (ages 50-54 up to ages 75-79).[ii] These were the ages where changes in smoking habits were expected to make the largest differences to future all-cause mortality. Moreover, at older ages, there is some question about the validity of estimates regarding the relationship between lung cancer and all-cause mortality from the Preston-Glei-Wilmoth method which we used (Rostron 2010). The period trends in lung cancer were smooth in both East and West, and no breaks could be found over years transitioning between data sources or ICD codes.

Forecasting mortality using cohort smoking histories

A number of methods have recently been developed that incorporate cohort smoking histories into mortality forecasts. Wang and Preston (2009) incorporated information about the mean cumulative number of smoking years a cohort has smoked by the age of 40, S^c, into a Lee-Carter projection framework. We also tried this approach but found the coefficient linking S^c and all-cause mortality to be overly sensitive to the inclusion or exclusion of certain cohorts.

Janssen et al. (2013) suggested separate forecasts of smoking-attributable and non-attributable mortality. The former was modeled based on future assumptions about cohort smoking patterns. The cohorts with the peak etiological fraction were determined via APC methods and the decline in smoking-attributable mortality was modeled based on the observed male pattern. Unfortunately in the East German case, the youngest partially observed female cohort, 1982, had the highest level of self-reported smoking, preventing us from identifying the peak etiological fraction and using this method.

The method we use is based on the Preston et al. (2014) two-step projection method, which first projected lung cancer mortality, and then based their all-cause mortality projections on the macro-statistical relationship between lung cancer mortality and mortality from other causes of death.

The first step, projecting lung cancer, was done by a modification of the Wang & Preston (2009) methodology, as in Preston et al. (2014). Rather than predicting the relationship between all-cause mortality and the cohort smoking years S^c, they suggested to use the following negative binomial regression equation to estimate the relationship between lung cancer and cohort smoking patterns:

$$\ln(M_a^c) = A + \beta_a X_a + \beta_s \ln(S^c) + \in \tag{1}$$

where M_a^c is the lung cancer death rate at age *a* in cohort *c*, X_a is an indicator of age category *a* and β_a its coefficient, β_s is the coefficient of $\ln(S^c)$, log of the mean cumulative number of smoking years a cohort has smoked by the age of 40.

We created a data frame that combined the information from the German Socioeconomic Panel on cohort smoking histories (cohorts 1922 to 1967) with observed lung cancer arranged by age, period and cohort as described in footnote 4 of Preston et al. (2014). In order to get information about cumulative years smoked for cohorts who have not reached age 40 yet we followed the approach of Wang and Preston (2009) and predicted their numbers based on cumulative smoking experiences at different younger ages.

We combined East and West German data to fit the model (1) in order to increase the statistical power of the estimate, and because we had no reason to believe that the relationship between the cumulative number of years smoked and lung cancer should differ between East and West. Our estimated β_s was 0.912. This was remarkably close to the 0.929 β_s estimated by Preston et al. (2014) for American females, further attesting to the robustness of the method.

To validate our self-reported data on smoking from the German SOEP, we re-estimated the above equation for East and West Germany separately, substituting S^c with cohort lung cancer dummies. As can be seen in Figure 3, the estimated lung cancer cohort coefficients line up well with the self-reported smoking histories over cohorts, though the lung cancer coefficients show a sharper rise and fall over cohorts in West Germany than the self-reported cumulative years of smoking.

Using the coefficients estimated from equation (1), we forecasted lung cancer death rates separately for East and West Germany to 2034, the year when our youngest partially observed cohorts turned 40. The method performed well over the selected age range. No discernable jump was noticed at the jump-off period (Figure 4). Cohort patterns can be made out in pattern of temporal change. For instance among West German women, a first lung cancer peak can be seen in the early 1980s for 60-64 year-olds. This peak becomes more pronounced as it progresses by 5 years for each successive 5-year age interval.

In the second step, Preston et al. (2014) translated lung cancer forecasts to all-cause mortality by using the PGW method (Preston, Glei and Wilmoth 2010b; Preston, Glei and Wilmoth 2011). The PGW method estimates the macro-statistical relationship between lung cancer mortality and mortality from all other causes based on 21 countries over the period 1950-2006. The model included effects for age, sex, period, and country, and interactions among them.

Our approach for translating the lung cancer mortality rate to mortality from other causes of death follows the spirit of Preston et al. (2014) but departs in the details. There are three reasons why we are using a modified approach. First, the 21 countries on which the PGW method is based on do not include Germany, so the validity of the translation coefficients for our purposes is questionable. We use German data to estimate comparable translation coefficients. We restrict the time period from which we estimate the coefficients to the years 1991-2012 in order to avoid complications arising from the sharp changes in mortality trends before and after the unification.

Second, direct implementation of the PGW method would result in a jump in the first forecast year. We translate the forecasting problem from forecasting the log of mortality from non-lung cancer causes (log Mo) to forecasting the *change* in the *East-West difference:* log(Mo_East_t/Mo_West_t)-log(Mo_East_t-1/Mo_West_t-1). With this approach, we avoid jumps in the first forecast year, and also reduce the complexity of the forecasting model considerably, as explained below.

Third, we adopt the most parsimonious defensible regression model that links lung cancer mortality to non-lung cancer mortality. We do this because the database for estimating the relationship between lung cancer and other causes of death is much smaller than in the original PGW method: only 2 regions (East and West Germany) and 22 years. Thus instead of fitting categorical age and categorical age*lung cancer interactions, we use quadratic age for both. Instead of fitting annual year coefficients, we fit a linear time trend, although we allow the trend to differ between East and West. Moreover, we do not include the lung cancer-time interaction because this was not significant. Fenelon and Preston (2014) used a PGW-type approach to analyze smoking attributable mortality in the U.S., and dropped the time-lung cancer interaction for similar reasons. Figure 5 shows the estimated coefficients that we will be using. For ages close to 50 these are slightly higher than those given in the PGW papers. This might be expected given that the smoking epidemic is comparatively recent among German women by western standards. Fenelon and Preston (2014) found lower coefficients when the estimation was restricted to American women, which they attributed to the maturity of the smoking epidemic there. As a robustness check, we estimate our results also using coefficients that are 50% smaller than our preferred coefficients.

We use the PGW approach, with coefficients based on German data, to translate the forecasted lung cancer death rates into East-West differences in mortality from other causes of death. We assume that overall mortality trends that are not influenced by smoking are similar in the East and West in the future. This is a conservative assumption as the East has already caught up with the West, and it would be bold to assume that mortality in the East would continue to decline faster than in the West. With this assumption, the one step ahead forecast for East-West mortality rate difference (in %) for causes other than lung cancer is:

$$\begin{aligned}\text{Ln}(\text{Mo\_East\_t+1}/\text{Mo\_West\_t+1}) &= \text{Ln}(\text{Mo\_East\_t}/\text{Mo\_West\_t})\\ &\quad + \text{B}*[(\text{ML\_East\_t+1}-\text{ML\_West\_t+1})-(\text{ML\_East\_t}-\text{ML\_West\_t})]\end{aligned}$$

where Mo_East_t+1 and Mo_West_t+1 are the one step ahead forecasts of non-lung cancer mortality (Mo) for East and West, Mo_East_t and Mo_West_t are the same for the observed time period t, B is the age-specific coefficient shown in Figure 5, and ML_East_t+1, ML_West_t+1 are lung cancer mortality rates for East and West.

Recursive use of the one step ahead forecast gives us forecasts up to the year 2034. The logic in this equation is to use changes in lung cancer mortality difference between East and West to inform changes in mortality from other causes between East and West. As seen from the equation, the number of unknowns is small. The limitation from using this simple equation is that we do not forecast levels of mortality, only differences.

Results

Figure 2 shows the observed and partially forecasted cumulative number of years smoked by age 40 for East and West German female cohorts born between 1935 and 1992. Among all female cohorts born before the year 1950, the cumulative years smoked are considerably lower in the East than in the West. For more recent cohorts, however, the number of years smoked is higher for East than West German women, and grows with the year of birth. The cumulative years of smoking peaked for West Germans around the 1960 birth cohort, but continues to increase among East German women.

Figure 4 shows observed and forecasted lung cancer mortality rates for East and West German women by age. In most age groups and most years, lung cancer mortality is higher in the West in the observed data. However, for the age groups 50-64 for which earlier research has shown that total mortality is lower in the East than in the West, the lung cancer mortality difference is projected to narrow and eventually reverse—lung cancer is forecasted to increase in the East as a result of increased smoking and decline in the West. The cross-over is expected to happen first for the youngest age groups, in around year 2020 for the ages 50-54, and by about 2035 we project that also for the age group 60-64 East German lung cancer mortality catches up with that of the West. For the older age groups, we forecast continued higher lung cancer mortality in the West. Eastern women at older ages may still benefit from lower smoking rates in the past and have a comparatively reduced risk to die from lung cancer in the future.

The different lung cancer risk patterns will impact mortality differences between East and West from causes other than lung cancer (Figure 6). Mortality from causes other than lung cancer among East German women aged 50-64 declined below that of West German women in the late 1990s and early 2000s. This absolute advantage has been attributed to less smoking among the East German cohorts. Our forecasts suggest that this advantage is at risk given the very different cohort smoking patterns for cohorts born in the 1980s and 1990s. Our forecasts shown in Figure 6 suggest that mortality from causes other than lung cancer among East German women aged 50-54 will increase again above that of the West by year 2015, and for the age groups 55-59 and 60-64 the second cross-over is expected to happen in around 2020 and 2025, respectively.

If we combine the qualitative message of these forecasts for mortality for other causes than lung cancer (Figure 6) with those for lung cancer (Figure 4), we can expect that for total mortality, East will fall behind West in the age group 50-54 in 2025 at the latest. For ages 55-59 and 60-64 the second cross-over for total mortality is expected to happen around years 2025 and 2030 (respectively) at the latest.

For age groups 65-79 we expect that mortality from causes other than lung cancer will continue to be higher in the East than in the West (Figure 6).

Our forecasted 2nd cross-over that is driven by differential smoking patterns is based on a regression model that links lung cancer mortality to mortality from other causes of death. It is possible that we have overestimated the strength of this association. We conducted a robustness test that uses the original coefficients multiplied by 0.5 to see if the qualitative conclusions are sensitive to small changes in the model coefficients. Figure 7 shows the results. Even with these diluted coefficients, we forecast that East falls behind West in each of the age groups between 50-64 in the years 2019-2034.

Discussion

After the unification in 1990 the German East-West mortality difference narrowed particularly rapidly for women, and by late 1990s and early 2000s mortality in the age groups 50-64 had declined below that of the West. This mortality cross-over has been attributed to higher smoking of the West German cohorts. In this paper we show that the smoking advantage of the East German cohorts is ending, and use demographic forecasting methods to study the implications of the reversing smoking advantage to differentials between the East and West German women in lung cancer mortality, mortality from causes other than lung cancer, and all-cause mortality.

Our results show that the increases in smoking rates among younger cohorts will have a strong impact on the future mortality differentials. East German women between the ages 50 and 64, who currently enjoy a lower mortality than their West German peers, will in the next two decades fall again behind West Germany both in terms of lung cancer mortality and all-cause mortality. These results show that future mortality differentials between the East and the West are heavily influenced by past smoking behaviors.

Past research on the post-unification mortality differences between the East and the West have often treated the unification as a “natural experiment” and interpreted the post-unification changes in mortality as arising from factors related to the unification (Chruscz 1992; Cockerham 1999; Dinkel 1992; Häussler et al. 1995; Vaupel, Carey and Christensen 2003). Four main factors are often named for being responsible for the changes in post-unification mortality differences: medical care, living standards, psychosocial stress, and health behaviours (for a review see Kibele 2010).

Each of these four factors may have been important in the past convergence, and our results are not inconsistent with the literature suggesting that standard of living, psychosocial stress, or medical care have been important in decreasing mortality in East Germany after the unification. However, there has been only convergence, not cross-overs in these factors. Smoking, in contrast, shows a fluctuating pattern across cohorts, and in particular the difference in smoking between the East and the West changes back and forth across cohorts. As smoking is the most important behavioural factor influencing mortality, we would expect these changes to help explain past cross-overs in mortality, and also inform us about future changes. The effect of smoking on mortality is mostly lagged, with a gap of two-to-three decades between a population-level increase in smoking prevalence and marked increases in smoking-related mortality. This is critically important, and useful, for forecasting as we can use observed smoking behaviour to forecast future mortality rates.

Our results suggest that the mortality advantage of the Eastern 50-64 year old age group disappears as mortality improvements in the East in comparison to the West are suppressed because of increasing smoking. Our prediction rests on the assumptions that the general living conditions in terms of health care, wealth or pollution will not diverge again in the future. This is a reasonable assumption as we do not expect that the two former parts of Germany will follow different political, social or economic paths as they did in the past. There might still be regional differences in these realms 25 years after reunification but there is a growing shift to a North-South pattern replacing the East-West difference. Certain regions in the South of the former East Germany nowadays exhibit the highest life expectancy among German women.

Our analysis is not able to predict future all-cause mortality for German women. Yet, the aim of our study was to exemplify how plastically smoking impacts observed mortality differences. Past smoking behaviors first allowed East German women to reach lower mortality levels than women in the West. Contemporary smoking habits will again reverse the differential within the next 20 years. Since more women started to smoke or smoked longer after reunification, the success story of East German women will end and East German women will return to higher overall mortality. Our findings on the role of smoking have important implications for understanding the future mortality dynamics among the more than 40 million German women.

References

Bloomfield, K., Grittner, U., and Kramer, S. (2005). Developments in alcohol consumption

in reunited Germany. Addiction, 100(12):1770-1778.

Chruscz, D. 1992. "Zur Entwicklung der Sterblichkeit im geeinten Deutschland: die kurze Dauer des Ost-West-Gefälles." *Informationen zur Raumentwicklung 9/10*:691-699.

Cockerham, W.C. 1999. *Health and Social Change in Russia and Eastern Europe*. New York, London: Routledge.

Diehl, K. 2008. "Mögliche Faktoren für die rasche Reduktion der ostdeutschen Übersterblichkeit nach der Wiedervereinigung. Warum leben Ostdeutsche seit der Wiedervereinigung länger?" *Zeitschrift für Bevölkerungswissenschaft* 33(1):89-110.

Dinkel, R.H. 1992. "Kohortensterbetafeln für die Geburtenjahrgänge ab 1900 bis 1962 in den beiden Teilen Deutschlands." *Zeitschrift für Bevölkerungswissenschaft* 18(1):95-116.

—. 2000. "Fertilität und Mortalität als Bestimmungsfaktoren der Bevölkerungsentwicklung in Mecklenburg-Vorpommern." *Schweriner Wissenschaftstage 2000*:16-30.

Gjonça, A., H. Brockmann, and H. Maier. 2000. "Old-Age Mortality in Germany prior to and after Reunification." *Demographic Research* 3(1).

Häussler, B., E. Hempel, and P. Reschke. 1995. "Die Entwicklung von Lebenserwartung und Sterblichkeit in Ostdeutschland nach der Wende (1989-1992)." *Das Gesundheitswesen* 57:365-372.

HMD. "Human Mortality Database. University of California, Berkeley (USA), and Max Planck Institute for Demographic Research (Germany). Available at www.mortality.org (data downloaded on October 10, 2014) ".

Höhn, C.and J. Pollard. 1991. "Mortality in the two Germanies in 1986 and trends 1976-1986." *European Journal of Population* 7(1):1-28.

Janssen, F., L.J. van Wissen, and A.E. Kunst. 2013. "Including the smoking epidemic in internationally coherent mortality projections." *Demography* 50(4):1341-1362.

Kibele, E. U. B. (2012). Regional mortality differences in Germany. Springer.

King, G.and S. Soneji. 2011. "The future of death in America." *Demographic Research* 25:1.

Luy, M. 2004. "Verschiedene Aspekte der Sterblichkeitsentwicklung in Deutschland von 1950-2000." *Zeitschrift für Bevälkerungswissenschaft* 29(1):3-62.

Preston, S., D. Glei, and J. Wilmoth. 2010a. "A new method for estimating smoking-attributable mortality in high-income countries." *Int J Epidemiol.* 39(2):430-438.

Preston, S.and H. Wang. 2006. "Sex mortality differences in The United States: The role of cohort smoking patterns." *Demography* 43(4):631-646.

Preston, S.H., D.A. Glei, and J.R. Wilmoth. 2010b. "A new method for estimating smoking-attributable mortality in high-income countries." *International Journal of Epidemiology* 39(2):430-438.

Preston, S.H., D.A. Glei, and J.R. Wilmoth. 2011. "Contribution of smoking to international differences in life expectancy." Pp. 105-131 in *International Differences in Mortality at Older Ages: Dimensions and Sources*, edited by E. Crimmins, S. Preston, and B. Cohen. Washington, D.C.: The National Academy Press.

Riphahn, R.T. 1999. "Die Mortalitätskrise in Ostdeutschland und ihre Reflektion in der Todesursachenstatistik." *Zeitschrift für Bevölkerungswissenschaft* 24(3):329-363.

Rostron, B. 2010. "A modified new method for estimating smoking-attributable mortality in high-income countries." *Demographic Research* 23(14):399-420.

SOEP "Socioeconomic Panel. German Institute for Economic Research (DIW), data for the years 2002, 2012, version 30, 2014

Stewart, S.T., D.M. Cutler, and A.B. Rosen. 2009. "Forecasting the effects of obesity and smoking on US life expectancy." *New England Journal of Medicine* 361(23):2252-2260.

Vaupel, J.W., J.R. Carey, and K. Christensen. 2003. "It's Never Too Late." *Science* 301(5640):1679-1680.

Vogt, T. C. (2013). Money or medicine? - the importance of rising pension income and modern health care for old age survival in the natural experiment setting of the German reunifcation. Dissertation.

Vogt, T. C. and Kluge, F. A. (2014). Can public spending reduce mortality disparities? findings from East Germany after reunification. The Journal of the Economics of Ageing.

Wang, H.and S.H. Preston. 2009. "Forecasting United States mortality using cohort smoking histories." *Proceedings of the National Academy of Sciences* 106(2):393-398.

Figures

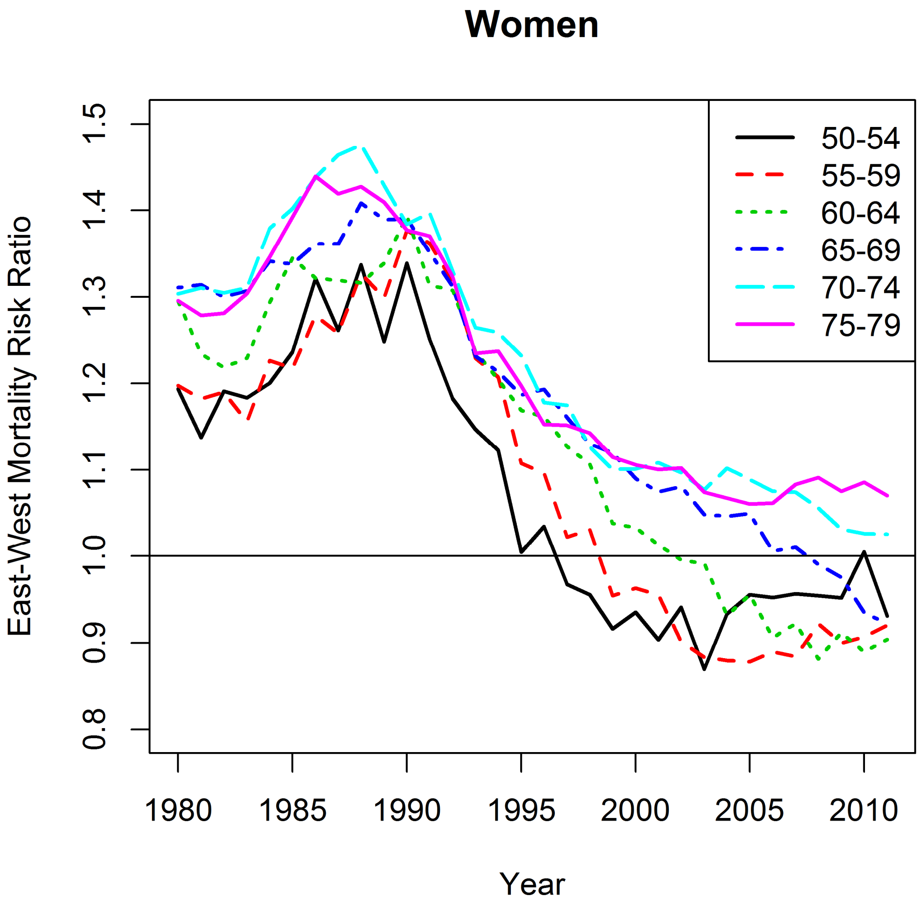

Figure 1: Mortality risk ratios for all-cause mortality convergence and crossover for women in East and West Germany

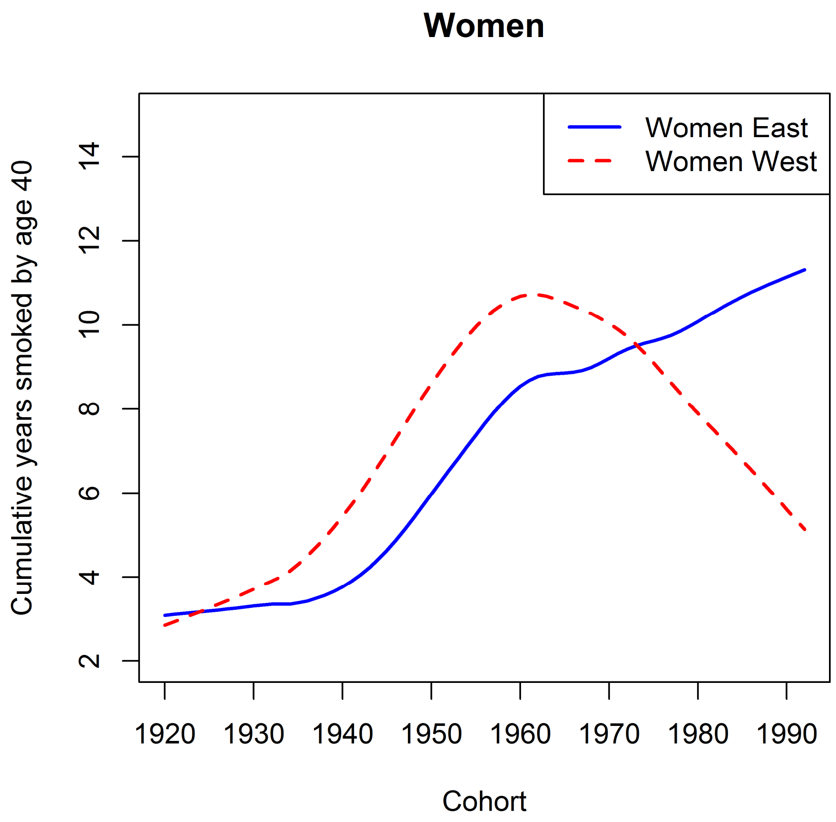

Figure 2: Cumulative years smoked by the age of 40 (smoothed) by birth year. The last fully observed cohort was born in 1972. We forecast the cumulative smoking years for the younger cohorts based on smoking patterns of older cohorts and the years smoked by each cohort at least by age 20. Therefore, our last cohort that was born in 1992 reached age 20 in 2012.

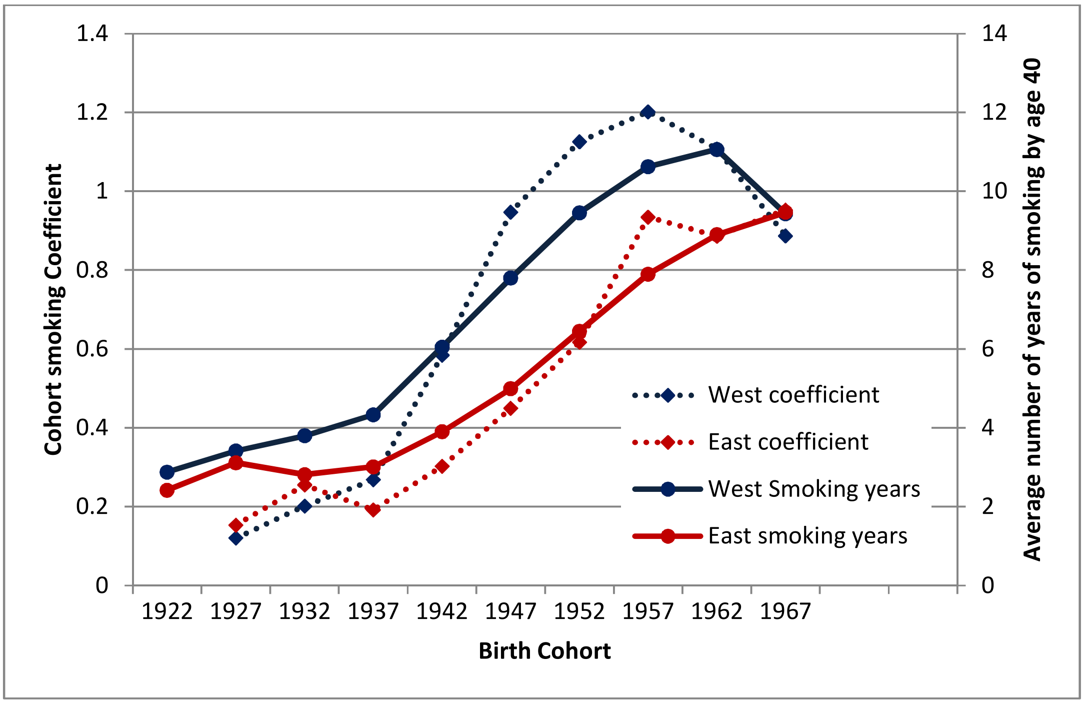

Figure 3: A comparison of the cohort smoking coefficients obtained using regression equation 2 from Preston et al. (2014: 40) [left y-axis] and the mean cumulative number of years that each cohort spent as a smoker by the age of 40, based on data averaged over the two SOEP rounds for cohorts fully observed to age 40. What is noteworthy is that the regression equation was based on cohort lung cancer deaths and did not include the self-reported data from the SOEP. The similar time trend in the two sets of lines gives us confidence in the accuracy of our SOEP data which we used to project lung cancer to 2034.

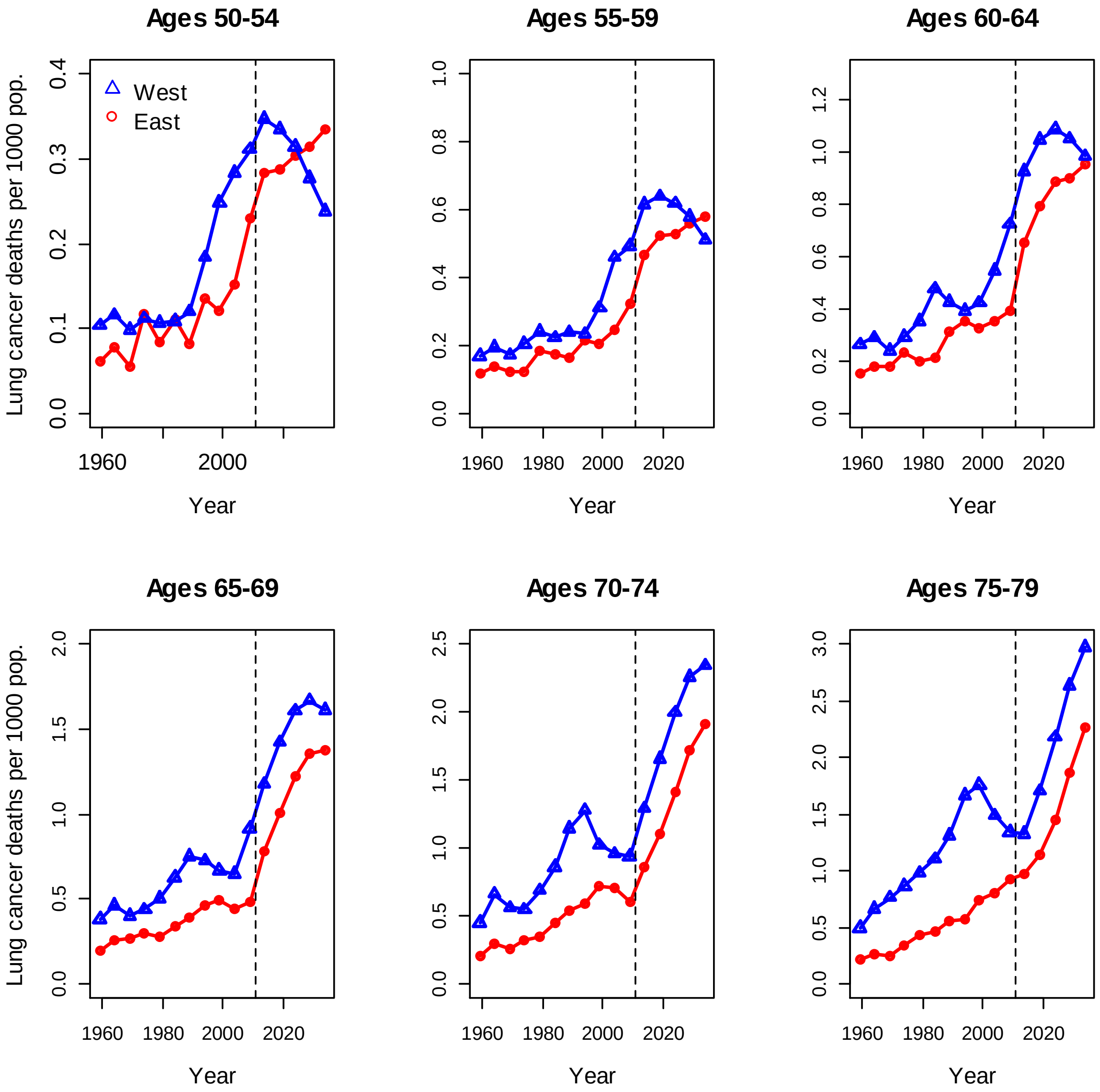

Figure 4: Lung cancer death rates for East and West Germany (observed 1959-2009, forecasted 2014-2034).

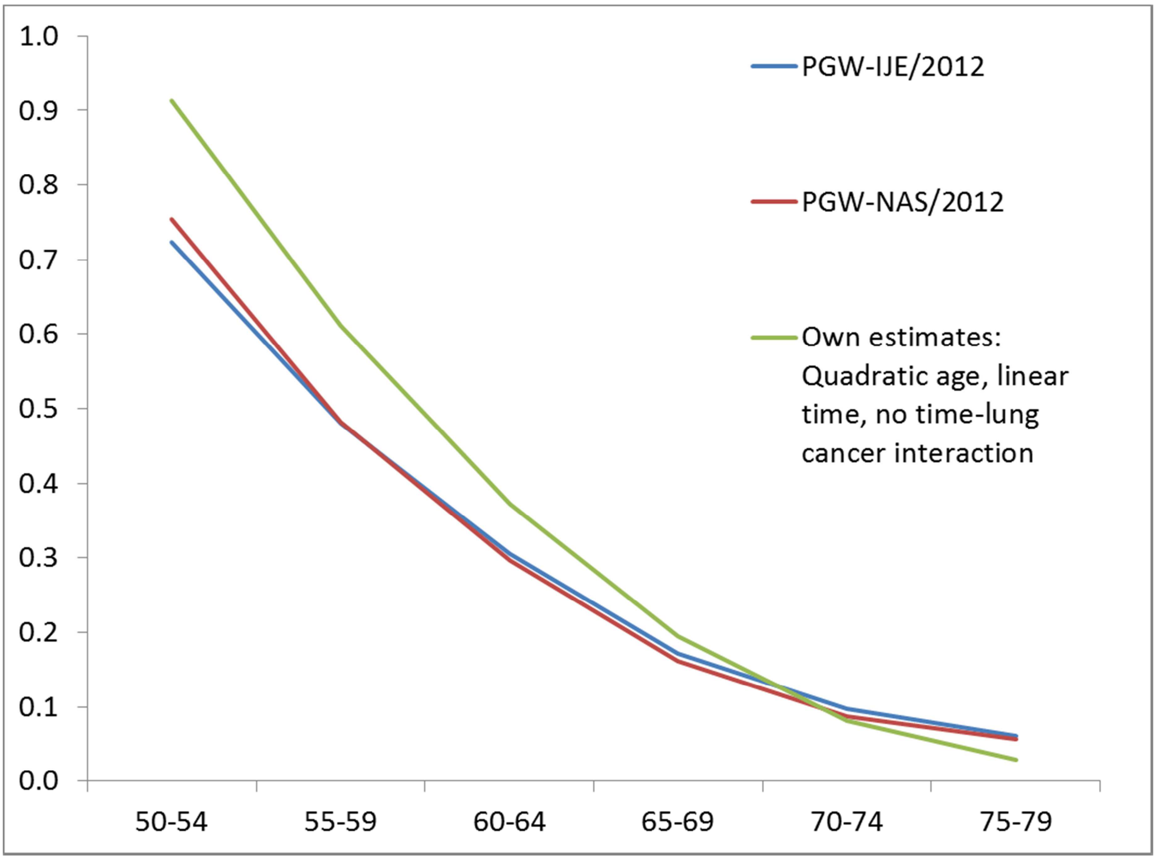

Figure 5. Coefficients that are used to estimate the relationship between lung cancer mortality and mortality from other causes of death. PGW-IJE and PGW-NAS refer to Preston et al. (2010a) and Preston et al. (2010b). We use the coefficients estimated using German data (Own estimates).

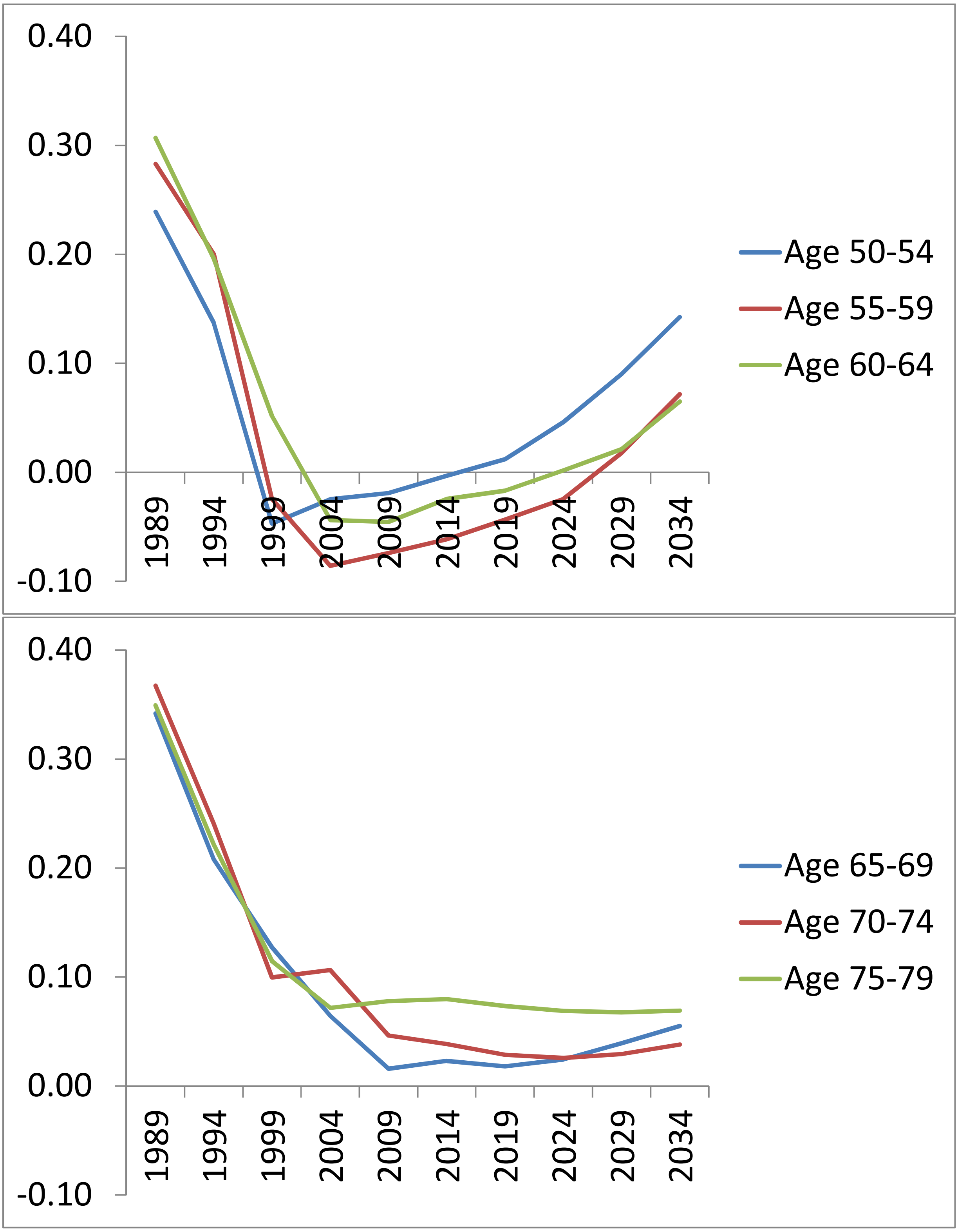

Figure 6. Observed and forecasted mortality difference from causes other than lung cancer between East and West German women. Translation of lung cancer difference to mortality from other causes based on coefficients shown in Figure 5.

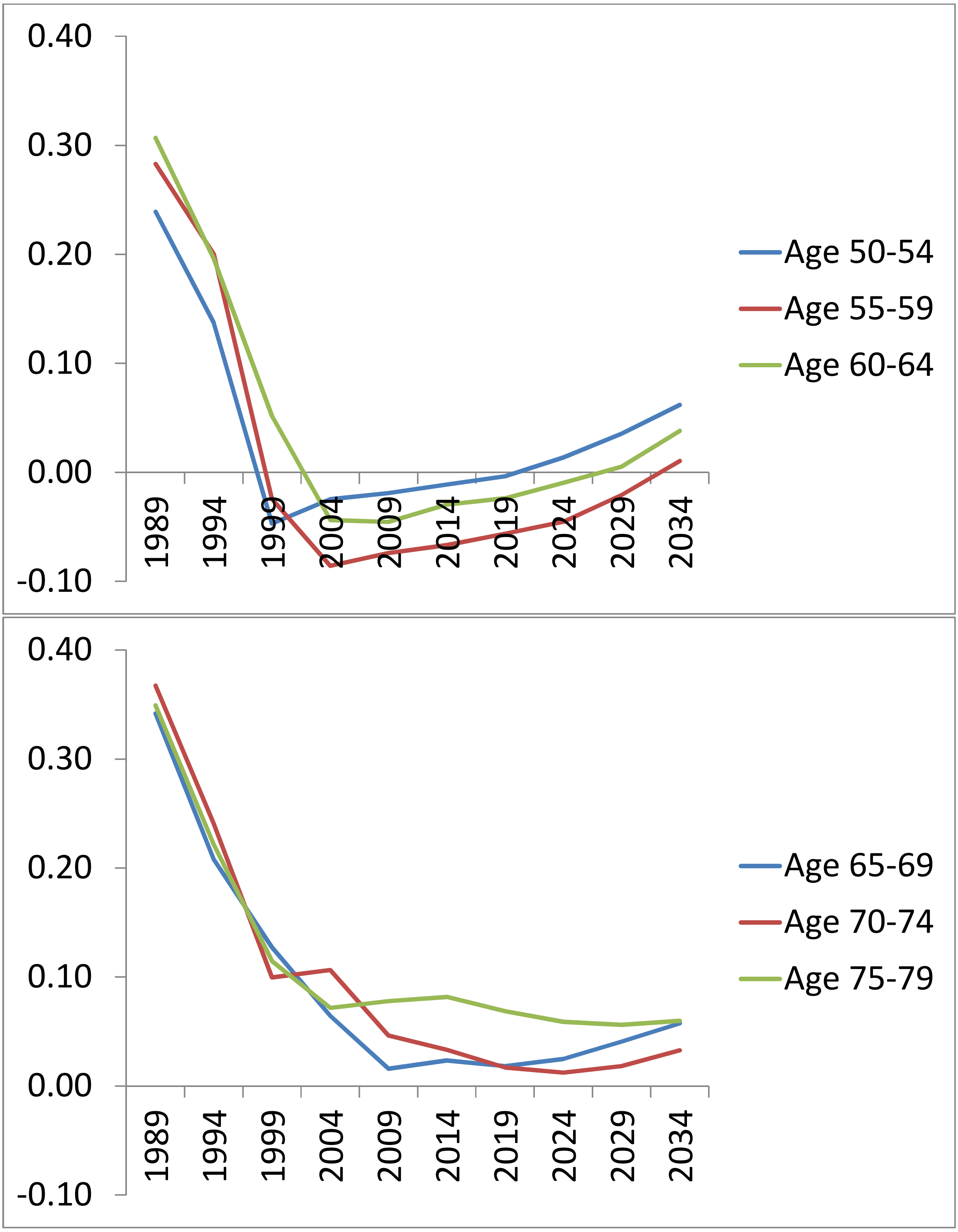

Figure 7. Robustness test: Observed and forecasted mortality difference from causes other than lung cancer between East and West German women. Translation of lung cancer difference to mortality from other causes based on coefficients shown in Figure 5 multiplied by 0.5.

Notes

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[i] Lung cancer was designated as item "*Malignant neoplasm of trachea, bronchus, and lung*". This item was present in all German Democratic Republic (GDR) classifications of causes of death. For years 1956–1959, however, it did appear as such in statistical tables. Instead, item 735 "*Bösartige Neubildung der Luftröhre, Bronchien und Lunge*" is incorporated into a broader category 73 "*Bösartige Neubildung der Ohres und des Atmungssystems".* Following standard reconstruction procedures it was possible to estimate death counts for these earlier years on the basis of the composition of group 73 observed in 1960. Item 735 dominated group 73, accounting for 92 and 79 per cent of all deaths for males and females, respectively. Year 1979 was a particular one. This was the first year of the transition to a new cause-of-death classification, the ICD-9 (East). However, mortality data for 1979 were available for 35 items only. Fortunately, item *"Malignant neoplasm of larynx, trachea, bronchus, and lung"* which combines item 161 "*Malignant neoplasm of larynx" and 162 "Malignant neoplasm of trachea, bronchus, and lung"* was among them. A correction factor was applied to remove larynx cancer from the 1979 data as described in the text.

[ii] Given the different data sources for the numerator and denominator, we multiplied lung cancer death counts with the ratio of all-cause mortality deaths from the numerator data source to the HMD death counts for each age and period. In most cases the ratio was 1.0.