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Some notes on how to catch a red herring
Ageing, time-to-death & care costs for older people in Sweden*

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Abstract

In this paper we test the 'red herring' hypothesis for expenditures on long-term care. The main contribution of this paper is that we assess the 'red herring' hypothesis using an aggregated measure that allows us to control for entering the final period of life on the individual level. In addition we implement a model that allows for age specific time-to-death (TTD) effects on Long Term Care. We also account for the problem that mortality, and therefore TTD, are themselves influenced by care expenditure. For our analysis we use administrative data from the Swedish statistical office.

In contrast to many previous empirical studies, we are able to use the entire population for estimation instead of a sample. Our identification strategy is based on fixed effects estimation and the instrumental variable approach to achieve exogenous variation in TTD. Our results indicate that although time-to-death is a relevant indicator for long term care, age itself seems to be much more important for the projection of long-term care expenditure.

Keywords: Ageing, Mortality, Long Term Care Expenditures

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1 Introduction

Most developed countries' populations are ageing rapidly with consequent implications for public spending on long-term care (LTC), pensions and health care. The Swedish dependency ratio (the number of retired people per 100 people of working age) is projected to increase from 28 today to 40 in 2050.

Such demographic changes are expected to have a significant impact on the demand for care services. Most consumers of LTC are over age 80; for example, in Sweden, almost 80 per cent of care home inhabitants belong to this age group (SALAR 2009). Since increasing life expectancy implies this group is growing faster than the general retired population, there is concern that the demographic burden could make the current system of financing LTC unsustainable. Indeed, in many countries there has been a trend towards concentrating resources only on individuals with severe disability (Karlsson et al. 2004). Even if there is no silver bullet how to deal with this problem, modern societies and policy makers need to know how many resources are needed due to the changes in the demand for care services. Therefore, a precise projection of the impact of ageing on care services is necessary. An often discussed issue is whether there is the problem of an omitted variable. If the period of intense care needs is simply postponed when life expectancy increases, age itself has limited explanatory power once time-to-death (TTD) of older people is also taken into account. Empirical studies controlling for this variable are marred with several issues. In addition to the problem of omitted variables, one problem that has not been solved to satisfaction is the possibility of simultaneity the fact that supply of care services may also affect TTD, and hence bias the estimates. The current study has three main aims: Firstly, we use a new and innovative TTD-measure to estimate its impact on institutional and domiciliary LTC-costs with aggregated administrative data, which is publicly available. In comparison with existing research on the 'red herring' hypothesis that uses population sub-samples with individual data, this approach has the advantage that the findings are representative for the whole population. Secondly, we test to what extent costs occurring with TTD vary between different age groups. Thirdly, we attempt to address the endogeneity problem associated with TTD. Our identification strategy is twofold: As a first step, we implement the fixed effects estimator to allow for unobserved heterogeneity and in a second step, we instrument the TTD variable, using different sources of regional specific variation in mortality.

This paper is organised as follows: In the next section, we review the economic literature on the relationship between ageing, morbidity and care expenditure. In the third section, we present the data-set and discuss our empirical strategy. Then our results are presented, which are used to quantify budget effects of a 1 year increase in life expectancy. The final section summarises our findings and their implications for policy.

2 Health and Population Ageing

There is a related literature stream in economics, which analyses the implications of population ageing for health care costs. Much attention has been devoted to the so-called 'red herring' hypothesis, according to which care costs are unrelated to age once remaining lifetime has been controlled for. In a seminal paper, Zweifel et al. (1999) used individual-level Swiss data to investigate this issue. They show that the impact of age on health care costs decreases once 'time-to-death' (TTD) is taken into account. During the last two years of life, an individual's actual age seems to be completely irrelevant. This leads to their conclusion that age is not necessarily an important determinant of health care expenditures.

Subsequent studies by Salas and Raftery (2001) and Seshamani and Gray (2004) criticise the approach of Zweifel et al. on several grounds. First, they claim that there might be a problem of collinearity of the explanatory variables, which makes it impossible to disentangle the contribution of different explanatory factors. Second, there is possibly reverse causation running from care expenditures to TTD, which would lead to endogeneity bias. Using a similar data-set and a similar approach to Zweifel et al. but including additional variables, Seshamani and Gray (2004) conclude that while morbidity is highly relevant for health care costs, age also remains important.

Zweifel et al. (2004) address these issues. They use past health care expenditures as instrumental variables for current expenditures and they estimate their model in two steps to avoid potential collinearity problems. Nevertheless, they conclude that in most age groups, TTD is more important than age. In a related study, Stearns and Norton (2004) use an American panel data-set. They find both age and TTD to be statistically significant, but the impact of TTD much larger. Werblow et al. (2007) focus on LTC and use panel data from Switzerland. They decompose the effect for different categories of care and show that most components of health care expenditure are driven, not by age, but by TTD. An exception is expenditures on acute care for long-term patients for which TTD comes out insignificantly.

In a related study from the US, Shang and Goldman (2008) find that age has limited predictive power once remaining individual life expectancy is introduced into the model. Similarly, Weaver et al. (2009) use panel data from the US and focus mainly on LTC costs since they account for the bulk of care costs for older people. They implement a simultaneous equations probit model to address joint decisions of demand for LTC and cohabitation with an adult child. Their findings suggest that TTD is the main cost driver, but being married reduces its importance.

Using a Dutch data-set on home care utilisation, de Meijer et al. (2009) differentiate between different causes of death and analyse the impact of morbidity. Once morbidity and disability are controlled for, the age effect remains relevant, whereas TTD becomes insignificant. They conclude that TTD cannot causally affect care expenditures and might itself be seen as a red herring: it is simply a proxy for morbidity and disability. In a recent study, Felder et al.

(2010) address the reverse causality problem by using instrumental variables for TTD. Their findings suggest that the increase in health care expenditures is much more likely caused by a shift of medical technology than by ageing of the population – so TTD seems to matter.

The argument that TTD is a proxy for morbidity (cf. de Meijer et al, 2009) can be challenged with reference to Gerstorf et al. (2010). In their study, the decline in well-being prior to death is being investigated. Using individual-level data from Germany, the UK the US, they estimate separate well-being curves for each country. Their findings suggest that there is a significant kink in the well-being curve in the last few years of life. The use of different data sources allows comparing this phase of decline in different populations, and it appears to vary between 3 and 5 years.
There is also evidence on the 'red-herring' hypothesis using aggregated data; e.g. Bech et al. (2010) focus on the relation of population demographics, mortality, life expectancy and health expenditure costs for the the EU-15 countries, using mortality rates to control health care expenditures. They suggest that rather past than present values, of life expectancy and mortality rates, are predictors of health care expenditures. They explain this phenomenon via a delay of policy budget decisions.

We are aware of some other studies, which formally test the 'red herring' hypothesis for Sweden. Batljan and Lagergren (2000) find the ratios for Swedish elderly people who need help, as well as the ones who receive help, declining over time. They suggest that ageing is not the main determinant of care services. In another study Batljan and Lagergren (2004) analyse Swedish individual level data of one county. They focus on both in and outpatient health care during the period from 1992-1997, and use the data to disentangle age and mortality related costs. Based on official Swedish mortality and population projections up to 2030, they then compare 2 scenarios for the development of health care costs. They show that the increase of health care costs will be about 37 percent lower when mortality is accounted for than a simple demographical extrapolation would suggest. A study by Karlsson and Klohn (2011) use the same data source than this study. Simple mortality rates are used to measure the impact of TTD on expenditures on social care for the overall population. Compared this study their model does not account for age specific TTD-effects and the problem of reverse causation. Their findings suggest ageing to be the main predictor of Swedish social care expenditures.

In a recent study, Larsson, Kåreholt and Thorslund (2008) evaluate the effect of age and TTD on care for older people in Sweden. The emphasis is on utilization of home help services, institutional care and hospital care. They conclude that TTD has twice the impact of actual age – thus giving support for the 'red herring' hypothesis. Other studies that address the age profile of care costs in Sweden have been conducted by e.g. Gerdtham (1993), Thorslund and Parker (1995), Gerdtham, Lundin and Sáez-Martí (2005).

Although the theoretical concept of TTD seems to be quite intuitive, the academic debate about its meaning/interpretation is controverse and the empirical implementation differs between the mentioned studies. First, this variable should not be seen as continuous, as its name suggests, since morbidity is not a linear combination of an individual's age. Second, in practice TTD should rather be seen as controlling for morbidity, being related to the time period before dying, in which individuals are in need of external help and care.

In conclusion, the jury is still out on the "red herring" hypothesis, and there is clearly a need for more studies which corroborate previous findings with more sophisticated methods.

3 Empirical Strategy

In this paper, we analyse the impact of population ageing on the expenditures on social care services using adminstrative data from Swedish authorities. In particular, we contrast a simple demographic model for explaining social care expenditure with models that allow for compression of morbidity by assuming that old-age morbidity is a function not only of age, but also of TTD.

In Sweden, social care policies are the responsibility of municipalities, of which there are 290 in total. Directly elected politicians decide on the supply of services and also raise the revenues necessary to cover operating costs. Local income taxes are the main source of funding, and out-of-pocket payments are of limited importance (3.7 per cent of total costs, as of 2007; SALAR, 2009). The national government lays down general principles and responsibilities for social care in law and monitors the quality in care homes. Furthermore, it redistributes funds to create equal opportunities for the provision of LTC in all parts of the country despite immense differences in need as well as in the local tax bases.

Even though the market share of private providers has tripled over the last two decades (e.g. from 5.4 to 13.7 per cent for nursing home slots; cf. Socialstyrelsen, 2002, 2008) virtually all formal social care provided in Sweden is still funded and monitored by local authorities, which keep meticulous records of the amounts, types and costs of care services provided. These data are collected by the National Board for Health and Welfare, which ensures that they are comparable between municipalities and over time. Thus, the possibilities to conduct analysis of the impact of demographic changes on demand for social care are excellent, as we have access to high-quality data aggregated on the regional level that cover the entire population of a country. This is a huge advantage compared to most previous research on the 'red herring' hypothesis..

3.1 Dataset

To implement the concept of TTD in our model, we consider contemporary and future mortality rates of the 65+ population. In our framework, we assume a high mortality rate of the 65+ individuals being related to a high care level and therefore, also positively related to long-term care expenditures. The following period's mortality rate should be related to a higher quantity of long-term care as well, since these individuals are also assumed to have a high probability of being in contemporary need for external support. Our main variable of interest is average local costs of social care, defined as the sum of institutional and home care expenditures for older people. Standardised information is available for the time range 1998-2008. For demographic data, we use official records provided by Statistics Sweden. These data-sets include the number of residents in each age cohort and for each municipality. Also, mortality rates are available for each local authority. Our main units of observation are the 290 municipalities. In our

Tabelle 1: Summary statistics

Variable	**Descrition**	**Mean**	**Std. Dev.**
Total	Total care costs per 65+ inhabitant in kSEK	57.376	9.002
Inst	Institutional care costs per 65+ inhabitant in kSEK	36.749	7.890
Dom	Domiciliary care costs per 65+ inhabitant in kSEK	18.146	5.619
age6569	People aged 65-69 divided by population 65+	0.265	0.032
age7074	People aged 70-74 divided by population 65+	0.233	0.015
age7579	People aged 75-79 divided by population 65+	0.209	0.016
age8084	People aged 80-84 divided by population 65+	0.159	0.017
age8589	People aged 85-89 divided by population 65+	0.091	0.013
age9094	People aged 90-94 divided by population 65+	0.035	0.007
age95100	People aged 95-100+ divided by population 65+	0.008	0.003
mrt	Deaths (65+) divided by the elderly population	0.051	0.007
mrtL1	Next period's mrt for population at t-1	0.053	0.007
TTD65+	Aggregate of mrt and mrtL1	0.102	0.011
TTD6569	TTD for population 6569	0.007	0.002
TTD7074	TTD for popultion 7074	0.011	0.003
TTD7579	TTD for population 7579	0.017	0.004
TTD8084	TTD for population 8084	0.023	0.004
TTD8589	TTD for population 8589	0.024	0.004
TTD9094	TTD for population 9094	0.014	0.003
TTD95100+	TTD for population 95100+	0.005	0.002
medinc65_08	Median income of 65+ population	153.652	19.414
wom65	Share of women of 65+ population	0.555	0.019
density	Population density	126.722	416.08
rightwing	Share of the right-winged parties seats	0.345	0.097
TTD2554	TTD of 25-54 aged people in each municipality	0.003	0.001
absmrtdiff	Absolute value of difference between dying men and women divided by population (80+)	0.019	0.011

analysis we focus on the subpopulation of inhabitants aged 65+, since only this group is eligible for LTC. Our main regressand is therefore overall care costs divided by the average population that is 65 years or older, but we also provide regressions separately for institutional and domiciliary care costs. Using the average 65+ population per year as the denominator for our care expenditure variables, we avoid the problem that the contemporary mortality rate in our TTD variable is controlling for a decreasing demand for care services.

One innovation of the methodology used in this study is that we model the TTD variable in a way that allows to control for TTD effects that arise on the individual level in a reasonable way. For this purpose we define the TTD variables in our study as

$$TTD_{it}^{a} = (1 - (1 - mrt_{it}^{a}) \times (1 - mrt_{i,t+1}^{a+1})) \times \frac{N_{it}^{a}}{N_{it}^{65+}}$$

which can be interpreted as the probability to die within 2 years for people in specific age group. The mortality rates *mrt* are calculated as the number of older people in a specific age group a deceased within a year, divided by the number of people (N_{it}^{a}) in age group a alive at the beginning of the respective period. Mortality rates shall capture aggregate TTD in a municipality. For example, the current-year mortality rate corresponds to all individuals in age group a who had less than one year left to live at the beginning of the year. The next year's mortality rate is calculated with respect to age group a, i.e. we use the aggregated mortality for a specific contemporary age group, accounting for the fact that population age shifts by 1 year, from year to year. In our baseline model a is simply the 65+ population but group specific TTD variables (e.g. TTD_{it}^{6569} is the aggregated mortality for the 65 to 69 year old people) are also used in our analysis.

Other main explanatory variables are those capturing the age structure amongst the old in each municipality. These variables are defined as the number of older people, measured in intervals of five years, divided by the number of people aged 65+. Again, these variables are measured at the beginning of each year.

Since all variables are expressed in terms of averages per 65+ inhabitant, all estimated parameters correspond exactly to their individual-level equivalents. To account for inflation, we standardised all costs according to the Swedish producer price index: they are expressed in 2008 crowns. As can be seen in Table 1[1], the average costs for overall care are around 57,400 SEK (6,400 Euro) per capita, but they range between 23,500 and 94,400 SEK. The aggregates of contemporary and next period's mortality rate range between 0.03 and 0.09. Turning to the variables representing the age structure, we see that they follow the expected pattern: the shares decrease rapidly at advanced ages. Other variables used for robustness checks are the median income of the people aged 65+ (kSEK), the centre-right parties share of all seats in the town hall, population density and the share of women in the 65+ population.

In our IV estimates, we introduce two further variables, which we believe to be suitable instruments for TTD. Firstly, we use the absolute value of the difference between the mortality of women and men, being 80 years and older, divided by the total population of this age group. Secondly, we use the aggregate of this year's and next year's mortality rate of the middle aged population (25-55 years) as an instrumental variable. We will discuss the rationale behind our approach and the assumptions made in more detail below.

3.2 Fixed Effects Estimation

We assume a flexible relationship between our explanatory variables (age groups and aggregated mortality rate of the elderly) and the dependent variable (care

[1] More detailed in Appendix A1

costs per 65+ population). If there are region-specific confounders which correlate with the demographics and our dependent variable, a Random Effects estimate based on this model will be biased. Even though the age structure can be seen as exogenous, this will possibly not be the case with TTD, which may be correlated with many unobserved characteristics of the municipalities. This would lead to biased estimates of the impact of TTD, thus also influence the estimated the age effects. A Hausman test strongly supports this hypothesis, so that the consistency of the Randon Effects model can be rejected. We therefore rely on the Fixed Effects estimator, assuming that possible confounders are constant over time. We also control for factors that might have changed over time, but are assumed to be constant for all regions in our analysis, e.g. changes of life expectancy due to pharmaceutical innovations (Schnittker, Karandinos, 2010). Therefore, we include time dummies in our model.

In separate analysis, we provide estimates with other covariates included to evaluate the robustness of our findings. Furthermore, we estimate the impact of age and TTD on care costs, allowing for age specific TTD-effects in our model. To account for heteroskedasticity in our model, all estimates use weighted least squares. The weights reflect the inverse relation between the variance of the outcome variable and the size of the population.

3.3 Instrumenting time-to-death

Although we assume that the fixed effects estimator already reduces potential bias due to the problem of reverse causality – the fact that expenditure on care for older people might influence TTD – we also use 2 stage least squares in a separate analysis. We need to find a good instrument that is on the one hand relevant (i.e., has a significant impact on TTD) and on the other hand randomly assigned. Using aggregated mortality of older people as a measure for their morbidity makes it natural to take advantage of other demographic information related to the population's morbidity.

One instrumental variable we use is the absolute value of the difference between the mortality of men and women, being 80 years and older, divided by the total population in this age group:

$$\frac{|M^{80+}_{women} - M^{80+}_{men}|}{N^{80+}}$$

With this variable we want to account for effects of marriage (e.g. Gardner, Oswald, 2004) and social relationships (e.g. Cohen, Janicki-Deverts, 2009) on individual health. The intuition behind this variable is that if one person in a relationship dies, this might have direct influence on the living partner‘s health, either directly or via a decreasing social interaction to other people. Although we are not able to compare a couple's morbidity and mortality on the individual level with our data, we hope that our instrumental variable allows to control for such a mechanism on an aggregated level. To exclude the possibility of endogeneity of this IV, we have to assume that LTC expenditures do not influence the morbidity of women and men differently.

If standard assumptions are satisfied, there still is the concern about our IV estimates that it is difficult to tell whether the subpopulation affected is representative. We would like to assume that the impact of TTD on expected care costs is the same for the entire older population, but this is not necessarily the case, especially since our IV is just defined for the 80+ population. Thus, we would like to check whether the impact of TTD is the same irrespective of the exogenous variation used for identification. For this reason, we consider a second instrumental variable which is based on the mortality rates of the middle aged population (25 to 54 years old):

$$TTD_{it}^{2554} = 1 - (1 - mrt_{it}^{a=25,..,54}) \times (1 - mrt_{i,t+1}^{a+1})$$

It cannot have an impact on LTC because this group is by law not eligible to use elderly LTC services. We aggregate both the contemporary and next year's mortality rates to have an instrumental variable that is in parallel defined to the endogeneous variable TTD. We assume our IV not to have a direct influence on the endogeneous variable, but it is assumed to account for regional specific mortality that is varying over time. This assumption is firstly, just reasonable if the mortality is correlated between the middle aged and elderly people, which is testable in the first stage of our 2SLS estimation. Secondly, we not have to necessarily assume that our variable is itself related to functional impairments of the younger population, but we have to assume that it is correlated with morbidity amongst older people in the population. Müller-Nordhorn et al. (2008) are investigating cardiovascular mortality in Europe. Classifying countries into high- and low risk categories, they find several diseases also varying on the regional level. The reasons for this are manifold and in principle one can imagine that every factor that is influencing population health, and is varying regionally, can potentially lead to a heterogeneous morbidity outcome in different regions. Given that the mechanisms linking both instrumental variables to care needs and TTD are quite different, we assume them to be an ideal combination for our purposes.

4 Results

4.1 Fixed Effects Estimates

In *Table 2*, the results of our Fixed Effects specifications are displayed. The first column shows the coefficients of a regression of overall care costs per capita on the population shares of older people. In the following 2 columns, we successively introduce contemporary and next period's mortality rate respectively to see if the age group coefficients are affected – which would be an indication of a red herring problem. The 4th, 5th and 6th column allow a comparison between overall, institutional and domiciliary care costs.

Focusing first on the analysis for overall care costs, the coefficients for most age groups are positive and significant, except for the ones aged 70 to 74, which turn out to be insignificant. This suggests that age related costs are not a big issue in these younger cohorts.

In the column excluding the mortality rate, FE (1), the coefficient for 80 to 84 year old people indicates that an individual in this age group incurs an increase of total care costs of 35,800 SEK (€ 4,000) per year (in addition to the average for an individual aged 65 to 69, captured by the constant).

Table 2: LTC

	(1) Total	(2) Total	(3) Total	(4) Total	(5) Inst	(6) Dom
age7074	-6.95	-7.46	-8.54	-8.55	16.60	-18.35
	(15.12)	(15.08)	(14.99)	(14.99)	(16.97)	(13.83)
age7579	7.49	6.45	4.26	4.22	-5.83	9.41
	(15.36)	(15.40)	(15.30)	(15.30)	(19.87)	(15.81)
age8084	35.80**	34.09*	30.26*	30.24*	15.05	22.25
	(17.70)	(17.88)	(17.84)	(17.85)	(19.81)	(14.87)
age8589	129.43***	126.08***	120.34***	120.03***	56.15**	57.18***
	(19.59)	(20.01)	(20.26)	(20.24)	(22.15)	(18.75)
age9094	226.06***	220.41***	209.74***	209.35***	75.21*	132.97***
	(29.30)	(29.83)	(29.73)	(29.66)	(40.49)	(32.02)
age95100	287.98***	280.23***	271.39***	270.00***	138.14	152.52**
	(59.74)	(60.43)	(60.40)	(60.21)	(83.87)	(69.40)
mrt		21.52	25.56			
		(14.96)	(15.69)			
mrtL1			37.80**			
			(14.89)			
TTD65+				34.11**	49.08***	-13.36
				(14.10)	(16.08)	(13.07)
Constant	26.95***	26.95***	26.91***	26.82***	18.65*	4.50
	(9.04)	(9.03)	(9.00)	(9.00)	(10.60)	(8.35)
Observations	3009	3009	3009	3009	3009	3009
R^2	0.593	0.594	0.595	0.595	0.275	0.485

Fixed Effects, Time dummies included, Clustered standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01,

In accordance with the 'red herring' hypothesis, the coefficients for most age groups decrease once the mortality rate and its future values are included into the model. However, the effect of including these variables seems to be very modest. Thus, our results give some evidence of the existence of a 'red herring', but age itself seems to have a strong impact on care costs even after controlling for the mortality rates. The mortality rates are positive in all specifications[2], the future mortality rate and the aggregated one are found to be significant at the 5 percent level. In economic terms, they are highly significant: each additional death is associated with cost increases of 21,500-63,300 SEK, depending on specification, suggesting that these variables are able to cover the end of life morbidity impact on total care costs. Wald tests also do not reject the null hypothesis of the equality of current and future mortality rates, suggesting that they control for the same mechanism influencing care costs. Therefore, we regard aggregation of both variables to be an appropriate way to control for the overall effect using just the aggregated variable – TTD^{65+}.

A separate specification for institutional and domiciliary LTC costs reveal differing cost for most age groups, suggesting ageing to be a more relevant predictor for domiciliary care, whereas morbidity seems to be more relevant for institutional costs. The differing signs of the coefficients for TTD might be interpreted as an indicator of age related switching behavior from domiciliary into institutional care; economically this makes sense the two services are interpreted as substitutes, which is a reasonable assumption.

Overall the estimated morbidity effects in all scenarios are dwarfed by the increase in expected costs at higher ages. Thus, our conclusion in this part differs significantly from that of Larsson, Kåreholt and Thorslund (2008), who find that TTD is twice as important as age.

In order to check whether our estimates suffer from omitted variable bias, we furthermore consider a specification that takes into account other sociodemographic controls[3]. We have chosen the 65+ population's median income, agglomeration (population density), gender (share of females in the 65+ population), and the centre-right parties' share of all seats in the municipality. We find the coefficients for the age cohorts being higher than in our baseline model. The only new variable which is significantly correlated with overall care costs, is the median income of the elderly population. This positive correlation is an interesting finding, since financial wealth usually can be interpreted as an indicator for a reduced health risk (Mackenbach, 2006). Our finding raises the question if this reflects a higher LTC demand, or if we measure a positive selection effect of the wealthiest old into LTC services. Since we do not know whether these covariates cause overall care costs, or if the changes are just due to a partial correlation of age with the new variables, we later on prefer the baseline specification to discuss the implications of our estimates on the basis of this more conservative approach.

4.2 Age Specific TTD Effects

In addition to the above specifications, we now try to analyse the 'red herring' hypothesis in more detail by testing whether the impact of TTD on care expen-

[2]Estimates in column 3 clearly overestimate the aggregate costs, since mrt is serielly correlated.

[3]Regression table is provided in the appendix A2.

ditures is different in different age groups. If TTD effects are age-specific, age coefficients might pick up TTD-related variation in care costs. Thus, it is important for a test of the 'red herring' hypothesis to allow for this possibility. We therefore estimate our baseline model for overall, domiciliary and institutional costs with age specific TTD-variables, i.e. instead of the single TTD measure TTD^{65+} , we include a group specific TTD variable for every age cohort in our model.

The results suggest that LTC costs differ both between age groups and between domiciliary and institutional care. Compared to our baseline model, the inclusion of age specific TTD-variables increases the impact of age for the oldest age group, whereas the coefficient for the corresponding TTD variable becomes negative. We suppose that this finding, which is mainly driven by institutional costs, might be due to the fact that LTC services for the oldest old include less expensive treatments compared to LTC for younger individuals. The estimated coefficients strongly suggest a heterogeneous impact of TTD between institutional and domiciliary LTC costs. Again ageing seems to be most relevant for domiciliary care. Interestingly, institutional LTC costs related to morbidity, can to a large extent, be explained by a relatively young cohort, the 70 to 74 year old people, for whom age is not a relevant determinant of LTC costs at all.

As in the estimate with the overall TTD variable included, differing signs of the TTD coefficients suggest a switching behaviour from domiciliary to institutional LTC. The main finding is that population ageing is again the main driving force of our care expenditure variables, even if we allow for age specific TTD impacts.

4.3 Implications

To illustrate how our findings can be used for cost projections, we calculated the expenditures arising due to an increase in life expectancy by one year for the 65+ population in 4 different scenarios. We did this for total, institutional and domicliary care costs on the basis of our estimators, combined with the Swedish age structure and age specific mortality rates of the year 2008. This cost - life expectancy relation[4] can be described as

$$\triangle LTC_i = \begin{cases} \sum\limits_{k=65}^{\infty} \left(\alpha^j + \beta_k^j\right)(s_{k-1} - s_k) \ with\ j = i & , for\ i = 1,2 \\ \sum\limits_{k=65}^{\infty} \left(\left(\alpha^j + \beta_k^j\right)(s_{k-1} - s_k) + \delta_k^j \left(TTD_{k-1} - TTD_k\right)\right) \ with\ j = i & , for\ i = 3 \\ \alpha^{j=1} & , for\ i = 4 \end{cases}$$

We differentiate between a "naive demographic extrapolation" (i.e. TTD not taken into account), 2 specifications where TTD variables are included into the regression model, and a pure red herring scenario (i.e. all age-related costs are costs of dying). $\triangle LTC$ is the change of care costs in each scenario i. α

[4]The formula for cost increase per year is provided in appendix A3.

Table 3: Single TTD Variables

	Total	Inst	Dom
age7074	-12.60	14.21	-21.23
	(15.20)	(17.24)	(14.09)
age7579	6.76	-1.94	5.58
	(15.92)	(20.14)	(16.05)
age8084	33.30*	18.32	20.42
	(18.24)	(20.18)	(15.03)
age8589	132.72***	59.05**	65.50***
	(21.99)	(23.71)	(19.71)
age9094	224.84***	60.18	163.71***
	(35.22)	(46.26)	(34.37)
age95100	322.57***	181.84	159.47*
	(91.32)	(115.53)	(90.62)
TTD6569	71.14	62.66	-30.12
	(47.15)	(49.60)	(43.97)
TTD7074	145.83***	121.34***	28.14
	(41.19)	(44.80)	(39.55)
TTD7579	28.97	6.66	38.53
	(35.02)	(36.25)	(29.88)
TTD8084	31.71	41.15	-8.83
	(29.51)	(37.07)	(28.94)
TTD8589	-9.40	40.77	-46.40*
	(30.71)	(36.43)	(27.70)
TTD9094	10.11	97.14**	-88.11**
	(40.30)	(46.10)	(41.55)
TTD95100+	-43.01	-35.33	-4.99
	(90.01)	(102.57)	(83.57)
Constant	25.01***	17.76*	4.81
	(9.08)	(10.60)	(8.32)
Observations	3009	3009	3009
R^2	0.597	0.277	0.487

Fixed Effects, Time Dummies included, Clustered standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.01

captures our model's constants, β represents our estimated age coefficients (and is therefore constant within 5-year intervals). s are survival rates and TTD TTD variables calculated for individual age k = {*65,..,100*}. For *j=1* we use results from a regression where TTD is not controlled for, *j=2* says that TTD^{65+} is included and *j=3* indicates the inclusion of TTD^a_{it} into the regression model. The TTD variables are just included into the formula for the specification where age specific TTD effects are controlled for since they occur just once in a lifetime and are therefore just influenced by a change in life expectancy if they are varying with age. Results are presented in Figure 2. The upper panel shows the implied change in lifetime care costs (from the current level of 947 kSEK in scenario 1 for total care costs) and the lower panel shows the corresponding increase in average costs per person per year (assuming a stationary population). Although our results imply somewhat lower cost increases for total and institutional care costs once TTD^{65+} is controlled for, the inclusion of the TTD^a variables increases the care costs for all 3 kinds of services which is driven by the relatively high age coefficients for the oldest old.

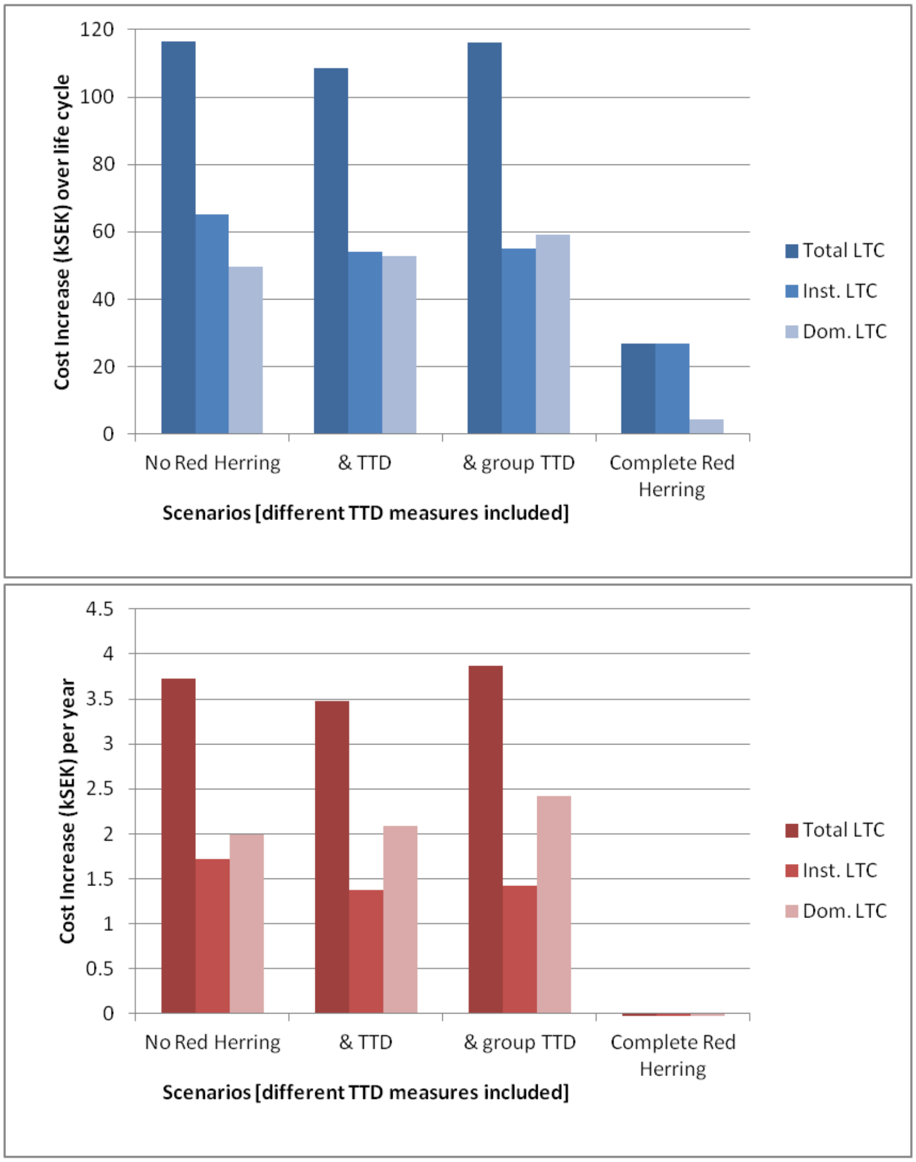

Figure 1: Cost increases associated with a one-year increase in life expectancy for various scenarios

4.4 IV Estimates

In *Table 4* we compare the baseline FE estimate for overall care costs with the use of our 2 instrumental variables[5]. To avoid the problem of more than one endogenous explanatory variable we now just account for the single overall TTD

[5]First stages of 2SLS in Appendix A4

measure.

Table 4: 2SLS

	Total	Total-IV1	Total-IV2	Total-IV1+2
age7074	-8.55	-14.32	-0.81	-11.30
	(14.92)	(16.51)	(20.32)	(15.50)
age7579	4.22	-7.56	20.04	-1.40
	(15.23)	(20.84)	(35.04)	(19.01)
age8084	30.24*	10.21	57.12	20.69
	(17.77)	(31.00)	(56.51)	(27.40)
age8589	120.03***	86.17*	165.49*	103.88**
	(20.15)	(45.46)	(96.40)	(40.99)
age9094	209.35***	149.17*	290.15*	180.65***
	(29.52)	(76.11)	(166.88)	(65.33)
age95100	270.00***	205.26**	356.92*	239.13***
	(59.93)	(97.81)	(188.00)	(88.21)
TTD65+	34.11**	156.95	-130.81	92.69
	(14.03)	(142.96)	(345.46)	(125.28)
Observations	3009	3009	3009	3009
R^2	0.595	0.578	0.564	0.591
F-test		15.66	2.97	10.10
Hansen p-value				0.44

Fixed Effects, Time dummies included, Clustered standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01

Due to the fact that we have 2 instrumental variables, we are able to provide an overidentification test[6], which supports the validity of our IVs (p-value=0.44). Using the IV controlling for marital status and network effects on mortality (column 2), we find ageing to be less relevant than in the baseline model, but economically still much more important for the prediction of LTC than TTD. TTD we find to be statistically insignificant, but economically much more important than in the baseline specification, which seems to be reasonable if there is a negative reverse causation from care services on mortality. The F-Statistic suggests this IV to be strongly relevant.

Our 2nd instrumental variable (column 3) exposes to be significant in the first stage of 2SLS, the results of this IV specification should not be interpreted to be causal because the F-statistic does not go beyond the critical value of 10. We find the TTD coefficient to be negative but statistically insignificant. The age coefficients lose some significance but their economic impact is even higher

[6]IV-estimates and test statistics are based on xtivreg2 (Schaffer, 2010).

than in the pure Fixed-Effects estimates.

Overall, our findings are twofold: First, there is some evidence for the 'red herring' hypothesis since the impact of ageing loses some relevance, once TTD is controlled for, in all our preferred specifications. Secondly, TTD itself is just statistically significant in the baseline specification, suggesting that there is a lot of variation in end of life morbidity. In addition, it seems that the age of the older people still remains an important predictor of care costs - even if we account for end of life morbidity.

5 Conclusion

In this paper, we analysed the effect of ageing and increases in longevity on care costs in Sweden. These relationships are of immense importance to policy makers since they determine the need of future LTC, hence influencing care costs due to demographic changes and shifts of life expectancy.

There are many missing pieces in this puzzle. The epidemiological literature on the implications of increased longevity for morbidity and population health remains inconclusive. Also, the related economic literature on the relationship between ageing and health care costs has failed to deliver unambiguous results.

In an attempt to increase our knowledge on these issues, we used Swedish administrative data to estimate an econometric model of the LTC determinants in Swedish municipalities. By controlling for local mortality rates, we were able to address the issue of whether TTD is a better predictor of care costs than age. An advantage of our study is that the data used cover the entire Swedish population. Therefore, our estimates can be assumed to be representative for Sweden as a whole. Besides, since we have a panel dataset, our model allows for unobserved heterogeneity. We used the Fixed Effects estimator and also considered IV estimation to achieve exogenous variation in TTD, and hence to account for the potential problem of reverse causality. The main innovation of our paper is that our measure for TTD allows us to control for the individual end-of-life morbidity effects on the aggregated level. Based on our findings in the baseline specification we calculated the financial consequences of an increased life expectancy by one year for various scenarios.

In addition to our baseline model, we considered several other specifications: Separate estimations for institutional and domiciliary LTC costs revealed a morbidity related substitution into institutional care. In another specification we allowed for age specific TTD-effects revealing the costs of end of life morbidity itself to be strongly related to actual age at death. This issue is usually not accounted for in the literature. In our study we find the impact of TTD on LTC costs to be mainly driven by a relatively young cohort, the 70 to 74 year old persons.

The general message emerging from our analysis regarding changes of future care costs is pessimistic. Even though care costs of the elderly are strongly associated with local mortality rates – our estimates for this variable are not very precise, but the economic significance is considerable – the age structure of a municipality remains a strong predictor of overall LTC costs even after we account for mortality. Especially the number of the oldest old remains a relevant predictor for LTC costs. Hence, it appears that as far as LTC in Sweden is concerned, an 'expansion of morbidity' can be expected, meaning that unhealthy years are added to life when life expectancy increases.

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Table A1: Summary statistics

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Total	57.376	9.002	23.464	94.41	3009
Inst	36.749	7.890	14.771	70.396	3009
Dom	18.146	5.619	3.598	43.024	3009
age6569	0.265	0.032	0.203	0.457	3009
age7074	0.233	0.015	0.19	0.281	3009
age7579	0.209	0.016	0.142	0.264	3009
age8084	0.159	0.017	0.084	0.21	3009
age8589	0.091	0.013	0.045	0.132	3009
age9094	0.035	0.007	0.014	0.06	3009
age95100	0.008	0.003	0.001	0.021	3009
mrt	0.051	0.007	0.031	0.089	3009
mrtL1	0.053	0.007	0.03	0.082	3009
TTD65+	0.102	0.011	0.065	0.147	3009
TTD6569	0.007	0.002	0.001	0.018	3009
TTD7074	0.011	0.003	0.003	0.023	3009
TTD7579	0.017	0.004	0.005	0.034	3009
TTD8084	0.023	0.004	0.007	0.041	3009
TTD8589	0.024	0.004	0.006	0.041	3009
TTD9094	0.014	0.003	0.005	0.029	3009
TTD95100+	0.005	0.002	-0.001	0.015	3009
TTD2554	0.003	0.001	0	0.008	3009
absmrtdiff	0.019	0.011	0	0.116	3009
medinc65_08	153.652	19.414	94.625	240.874	3009
wom65	0.555	0.019	0.496	0.633	3009
density	126.722	416.08	0.2	4307.8	3009
rightwing	0.345	0.097	0.105	0.764	3009

Table A2: Robustness

	Total	Total
age7074	-8.55	-6.42
	(14.99)	(14.60)
age7579	4.22	8.37
	(15.30)	(15.72)
age8084	30.24*	43.80**
	(17.85)	(17.83)
age8589	120.03***	141.85***
	(20.24)	(20.90)
age9094	209.35***	230.27***
	(29.66)	(31.18)
age95100	270.00***	302.39***
	(60.21)	(60.74)
TTD65+	34.11**	32.09**
	(14.10)	(13.81)
medinc65_08		0.17***
		(0.05)
wom65		3.93
		(21.45)
density		-0.00
		(0.01)
rightwing		-4.57
		(5.00)
Constant	26.82***	-5.96
	(9.00)	(16.08)
Observations	3009	3009
R^2	0.595	0.601

Fixed Effects, Time dummies included,
Clustered standard errors in parentheses,
* p<0.10, ** p<0.05, *** p<0.01

A3:Changes in cost increase per 65+ life year

$$\triangle LTC_i \, per \, Year = \begin{cases} \sum_{k=65}^{\infty} \left(\alpha^j + \beta_k^j\right) \left(\frac{s_{k-1}}{\sum_{k=65}^{\infty} s_{k-1}} - \frac{s_k}{\sum_{k=65}^{\infty} s_k} \right) \; with \; j = i & , for \; i = 1, 2 \\ \sum_{k=65}^{\infty} \left(\left(\alpha^j + \beta_k^j\right) \left(\frac{s_{k-1}}{\sum_{k=65}^{\infty} s_{k-1}} - \frac{s_k}{\sum_{k=65}^{\infty} s_k} \right) + \delta_k^j \left(\frac{TTD_{k-1}}{\sum_{k=65}^{\infty} s_{k-1}} - \frac{TTD_k}{\sum_{k=65}^{\infty} s_k} \right) \right) \; with \; j = i & , for \; i = 3 \\ \frac{\alpha^j + \sum_{k=65}^{\infty} \left(\alpha^j + \beta_k^j\right) s_{k-1}}{\sum_{k=65}^{\infty} s_{k-1}} - \frac{\sum_{k=65}^{\infty} \left(\alpha^j + \beta_k^j\right) s_k}{\sum_{k=65}^{\infty} s_k} \; with \; j = 1 & , for \; i = 4 \end{cases}$$

Table A4: First Stage 2SLS

	TTD65+	TTD65+	TTD65+
age7074	0.05**	0.05**	0.05**
	(0.02)	(0.02)	(0.02)
age7579	0.10***	0.10***	0.10***
	(0.02)	(0.02)	(0.02)
age8084	0.17***	0.16***	0.17***
	(0.02)	(0.02)	(0.02)
age8589	0.28***	0.28***	0.28***
	(0.03)	(0.03)	(0.03)
age9094	0.48***	0.49***	0.48***
	(0.05)	(0.05)	(0.05)
age95100	0.52***	0.52***	0.52***
	(0.10)	(0.10)	(0.10)
absmrtdiff	0.04***		0.04***
	(0.01)		(0.01)
TTD2554		0.31*	0.32*
		(0.18)	(0.18)
Observations	3009	3009	3009
R^2	0.364	0.361	0.365

clustered standard errors in parentheses, time dummies included, * p<0.10, ** p<0.05, *** p<0.01