

Layte, Richard; O'Hara, Sinead; Bennett, Kathleen

**Working Paper**

## Explaining structural change in cardiovascular mortality in Ireland 1995 - 2005: A time series analysis

ESRI Working Paper, No. 300

**Provided in Cooperation with:**

The Economic and Social Research Institute (ESRI), Dublin

*Suggested Citation:* Layte, Richard; O'Hara, Sinead; Bennett, Kathleen (2009) : Explaining structural change in cardiovascular mortality in Ireland 1995 - 2005: A time series analysis, ESRI Working Paper, No. 300, The Economic and Social Research Institute (ESRI), Dublin

This Version is available at:

<https://hdl.handle.net/10419/50055>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

## Explaining Structural Change in Cardiovascular Mortality in Ireland 1995-2005: A Time Series Analysis

Richard Layte<sup>1</sup>, Sinead O'Hara<sup>1</sup> and Kathleen Bennett<sup>2</sup>

**Abstract. Background:** Deaths from circulatory respiratory causes among older age groups in Ireland fell sharply between 1995 and 2005 as did the seasonality of deaths from these causes. **Objective:** To examine whether a structural break has occurred in deaths from circulatory causes in Ireland between 1995 and 2005 and test whether this can be explained by changes in the prescribing of cardiovascular medications during the same period controlling for weather trends. **Methods:** Grouped logit Time series models were used to identify if and at which quarter a structural break occurred in Irish circulatory deaths between 1995 and 2005. Data on cardiovascular prescribing and temperature within the quarter were entered into the trend-break model to examine whether the structural break could be explained. **Results:** There was a reduction in circulatory deaths of 0.82%/quarter among men 1995-2005 which increased by 0.5%/quarter after the final quarter of 1999. The 25% excess winter deaths among men fell by 9% after Q4 1999. Among women the long term decline in deaths of 0.53%/quarter increased by 0.48% after Q1 2000 and seasonality was reduced by 6.8%. The structural break in trend and seasonality was higher among those aged 85+. Controlling for temperature, beta-blocker, ace-inhibitor and aspirin medications rendered the structural break indicator insignificant among all age groups for men. Diuretic, statin and calcium channel blocker medications could not explain the break point for men aged 75 to 84. Beta blocker, aspirin and calcium channel blocker medications explained mortality trends among all age groups among women. Ace inhibitor and statin could not explain trends amongst women aged 65-74 and nitrates and diuretics did not explain trends for any age group. **Conclusions:** Models suggest that cardiovascular prescribing significantly reduced circulatory mortality among men and women aged 65+ after 1999 in Ireland but the effect of prescribing was lower among women than men. Beta-blocker, ace inhibitor and aspirin medications were more successful than statin, diuretic and nitrates at explaining trends.

*Corresponding Author:* Richard.Layte@esri.ie

<sup>1</sup> Economic and Social Research Institute, Whitaker Square, Sir John Rogerson's Quay, Dublin 2.

<sup>2</sup> Department of Pharmacology and Therapeutics, Trinity Centre for Health Sciences, St James Hospital, Dublin 8, Ireland.

*Acknowledgements:* We would like to gratefully acknowledge the contributions made to this paper by Denis Conniffe, Hannah McGee and Emer Shelly as well as participants in seminars held at the ESRI and RCSI.

ESRI working papers represent un-refereed work-in-progress by members who are solely responsible for the content and any views expressed therein. Any comments on these papers will be welcome and should be sent to the author(s) by email. Papers may be downloaded for personal use only.

# Explaining Structural Change in Cardiovascular Mortality in Ireland 1995-2005: A Time Series Analysis

## 1. INTRODUCTION

As elsewhere in the EU15, all cause death rates have been falling steadily in Ireland since the 1970s but the rate of improvement has been particularly pronounced since the turn of the 21<sup>st</sup> century. Between 1996 and 1999 all cause death rates in Ireland fell by 5.2%, but by 26.2% between 2000 and 2004. The trend change can largely be explained by lower death rates from circulatory and respiratory causes (Layte et al 2007). Death rates from circulatory causes fell by 29.6% between 2000 and 2005 and deaths from respiratory causes by 29.1%. Research (Bennett et al 2006) suggests that the long term downward trend in circulatory death rates prior to 2000 in Ireland can be explained by changes in lifestyle and diet in combination with improved secondary prevention. No research to date has explained the acceleration in the trend in circulatory deaths since 2000 but trends in lifestyle factors since 2000 are challenging and cannot explain the change. Although the steep fall in respiratory death rates may also be related to the processes discussed in this paper<sup>1</sup> we confine our analyses here to trends in circulatory deaths rates and leave trends in respiratory deaths to a future paper.

Previous analyses (Walsh 2007) have shown that a significant proportion of the fall in mortality rates can be explained by a decrease in the extent of excess winter deaths, that is, the size of the increase in mortality in winter months over summer months each year (Wilmhurst, 1994, Healy 2000, Healy 2003). Together, the extent of the fall in deaths after 1999 and the fall in seasonality from that point would suggest that there has been a structural break in Irish mortality trends but to date no explanation has been put forward for either the timing or nature of the change.

---

<sup>1</sup> The extent of comorbidity between COPD and cardiovascular disease may mean that deaths attributed to respiratory disease may have their origin in cardiovascular events. Mascarenhas et al (2008) found that almost 40% of patients who were post AMI also had a diagnosis of COPD. Given this, better control of the symptoms of heart failure would reduce respiratory mortality as well as circulatory mortality.

The change in the seasonality of deaths could suggest that meteorological factors in the form of warmer winter weather, perhaps associated with global warming trends may play a role. An alternative explanation could be the change which occurred in patterns of prescribing for cardiovascular disease in the late 1990s in Ireland in combination with an increase in access to care which occurred after 2001. ‘Building Healthier Hearts’ (BHH), the report of the Irish cardiovascular health strategy group was published in 1999 (DOHC 1999). This recommended a set of priorities including a structured approach to the primary and secondary prevention of cardiovascular disease. The recommendations were widely adopted within Irish general practice but were also accompanied by increased investment in cardiology manpower in the Irish hospital sector, an increase in the volume of CABG and PTCA surgery<sup>2</sup> carried out and the establishment of a ‘shared care’ system between GPs and out patient departments for heart failure. Within primary care BHH recommended the adoption of the guidelines of European task force on coronary prevention and this was formalised in one fifth of GP practices who participated in the ‘Heart Watch’ programme which established a system of secondary prevention. Together these developments may have contributed to a steep increase in the volume of cardiovascular drugs prescribed after 1999. Between the summer of 1999 and end of 2003 prescribing rates of beta blockers increased by 109%, ace inhibitors by 89% and statins by 206%.

The increase in the volume of drugs prescribed was aided by the change in eligibility rules for medical cards in the third quarter of 2001. GP visits and associated prescribing is free to roughly 30% of the population in Ireland who have a medical card<sup>3</sup>. Until July 2001 only those eligible on the basis of a means test or involvement in specific government training scheme had access to a medical card. From July 2001 on however, all those aged 70 or over were given access to free primary care and pharmaceuticals<sup>4</sup>. The timing of the change in prescribing practices and the fact that the medications may well interact with other drivers of cardiovascular mortality such

---

<sup>2</sup> Coronary artery bypass graft and percutaneous transluminal coronary angioplasty.

<sup>3</sup> GP fees per visit vary widely but average 60EURO. Charges for prescribed medications are capped at 110 euro per month for the whole population through the Drug Payment Scheme.

<sup>4</sup> Non-medical card holders are entitled to free in patient and out patient care on the same basis as medical card holders except for the payment of a relatively small per diem charge for inpatient care.

as season and temperature could mean that this development was responsible for the fall in circulatory mortality and seasonality which was observed after 1999.

A review of clinical trials of cardiovascular drug efficacy during the period from 1970 (Weisfeldt and Zieman 2007) concluded that pharmaceutical agents played a major role in the prevention of atherosclerosis and its consequences and that the introduction of new classes of cardiovascular drugs often has positive population health consequences. A series of papers by Lichtenberg (2006; 2007; 2009) has also shown that the introduction of new classes of cardiovascular medication reduce other types of medical expenditure, hospital expenditure and, most importantly in the context of this paper, death rates from circulatory causes. As far as we are aware no research to date has examined the role of cardiovascular prescribing on the seasonality of death rates although it is reasonable to expect that specific classes of drugs may lessen the probability of thrombotic disease, the major cause of excess winter mortality alongside respiratory disease (Donaldson and Keatinge 2002).

There is also now a well developed literature examining the composition of change in cardiovascular mortality using the IMPACT CHD mortality model (Unal et al 2004; Capewell et al 1999; Capewell et al 2007) including a paper applying this model to the Irish context (Bennett et al 2006). Irish IMPACT models suggest that approximately 44% of the decline in CHD deaths between 1985 and 2000 can be attributed to improvements in the uptake of treatments, particularly secondary prevention (18%) and treatments of chronic angina (8.4%). This model also attributes 30% of the fall in CHD mortality to reductions in population cholesterol, probably as a result of changes in diet. Bennett (et al) also estimate that reductions in smoking contributed 26% of the reduction in cardiovascular deaths over the same period whilst population trends in physical activity, obesity and diabetes all contributed to worsening trends. It is interesting to note that all the main population risk factors for cardiovascular disease - smoking, physical activity, obesity, diabetes and population

blood pressure, have all worsened in Ireland since 2000 with the exception of population cholesterol<sup>5</sup> (Morgan et al 2008).

The IMPACT CHD mortality model does not attempt to directly test whether changing treatments and lowered population cholesterol explain the timing and extent of the trend in CHD deaths. Instead it uses international evidence on the impact of different treatments and risk factors combined with demographic data to decompose the observed falls in cardiovascular mortality over the approximate time period under examination. In this paper we adopt a more direct approach and use time series analysis to test whether the increased levels of prescribing of CHD medications can account for the timing and extent of the change in CHD mortality.

The paper is structured as followed. The next section details the various data sources that will be used in the paper whilst the third section of the paper discusses the methodology used in the paper. The fourth section describes our results including a descriptive analysis of mortality trends, weather patterns and cardiovascular prescribing in Ireland 1995-2005. The section then goes onto test whether a structural break in mortality trends occurred in Ireland before examining our hypotheses about cardiovascular prescribing using grouped logit models. In the fifth section we discuss the results of the analyses and their limitations before outlining possible future directions.

## **2. DATA**

Ideally we would test the role of cardiovascular drug prescribing by regressing individual risk of death from cardiovascular causes against prescriptions of cardiovascular medications controlling for confounding factors at the individual level. Unfortunately such data are not available in the Irish context. Our only option is to use aggregated data on deaths disaggregated by cause, sex and age group. Our data on mortality are death registrations in the Republic of Ireland from 1995 to 2005 supplied by the Irish Central Statistics Office (CSO). Deaths from 1995 to 2005 were grouped

---

<sup>5</sup> There is a high likelihood that the increased prescribing of lipid lowering medications since 1999 may well have contributed to this fall in population cholesterol.

by quarter (44), sex, cause of death (circulatory [ICD-9-CM codes 390-459] and three age groups (65 to 74, 75 to 84 and 85+ and an all 65+ group) for analysis. As previously commented upon we focus on those aged 65 or more for whom the change after 1999 was most pronounced. Population totals for each age and sex group were also obtained from the CSO and used to calculate the death rate per 1000 population.

A change in weather patterns in the form of warmer winter temperatures is also a possibility that we need to examine and control for. Temperature data were obtained from Met Eireann, the Irish Meteorological Service. Although it would be possible to get temperature readings from different locations, the use of aggregate data in this paper means that only a single measure of temperature can be used. Different formulations of temperature at Dublin Airport, Ireland (average temperature in quarter, average minimum temperature in quarter and overall minimum temperature in quarter) by quarter between January 1995 and December 2005 were obtained for analysis.

The main hypothesis examined is that the impact of changing prescribing practices on mortality rates. Information on prescribed cardiovascular medicines for the period from January 1995 to December 2005 were obtained from the Health Care Executive Primary Care Reimbursement Service (HSE-PCRS). The HSE-PCRS collates data on medicines prescribed under the three Community Drugs Schemes – the General Medical Services Scheme (GMS), the Drugs Payment Scheme (DPS) and the Long Term Illness Scheme (LTI). The GMS is by far the largest of these schemes and accounts for almost 75% of publicly funded prescriptions. Those eligible for a medical card receive free primary care and prescribing via an income means test, through particular health needs, or participation in an approved Government training and employment scheme (Primary Care Reimbursement Service, 2007). In 1998 67% of those aged 65 or more were holders of a medical card or had access to one via a close relative. With effect from July of 2001 all those aged 70 or more became entitled to a medical card and this saw the proportion in receipt of a card increase to almost 87%. Although contemporary HSE-PCRS data cover prescriptions received free under the GMS as well as the DPS and LTI schemes, available longitudinal data do not include prescriptions under DPS and LTI schemes. Due to changes in coding procedures only data for the Eastern Region Health Authority (ERHA) are available

for the observation period used in this paper. The ERHA region covers approximately one-third of the Irish population (The Health Board regions were superseded by the Health Services Executive Regions in 2005). Nonetheless trends in this region should be representative of trends in the Republic of Ireland overall. Data supplied by the PCRS in relation to cardiovascular drug prescriptions for persons within the ERHA aged 65 and over were adjusted to rates per 1,000 of the population.

### 3. METHODS

We assess the relationship between aggregate data on mortality, temperature, respiratory discharges and cardiovascular prescribing through time series analysis of 44 quarterly observations. The simplest model for this is:

$$y_t = \alpha + \beta_1 T_t + \beta_2 D_t + \varepsilon$$

where the death rate at time  $t$  ( $Y_t$ ) is a function of temperature ( $T$ ) and rate of cardiovascular drug use in the population ( $D$ ) all at time  $t$ , plus error ( $\varepsilon$ ). This could be estimated using ordinary least squares (OLS) or weighted least squares (WLS) methods. However OLS or WLS will produce predictions  $<0$  for some values of the independent variables. Instead we use grouped logit methods which are more appropriate:

$$Z = \log(p/(1-p))$$

We thus estimate the log of the number dying from a circulatory cause in quarter  $t$  divided by the proportion not dying from this cause in the quarter, As we are using grouped data we assume that all cases at  $t$  have the same values of the explanatory variables at  $t$ .

A central issue in time series analysis is the extent to which the data auto-correlated, that is, a process:

$$Y_t = rY_{(t-1)} + u_t$$

is said to be autocorrelated for where  $r$  is equal or greater than 1. A Durbin-Watson (DW) test varies between 0.38 and 0.84 for male circulatory deaths (depending on age) suggesting strong autocorrelation. However, controlling for the long term



downward trend in circulatory deaths and the seasonal nature of deaths produces a DW of between 1.96 to 2.4, a more acceptable result. Examination of autocorrelation and partial correlation plots for an OLS model of circulatory death rates for men aged 65 or more controlling for the trend in deaths and the seasonal variation shows relatively low and random autocorrelation and minimal partial correlation suggesting that our models are stationary. Dickey-Fuller unit root tests were negative.

### **Modelling Strategy**

The analysis strategy we adopt is to first establish whether and at which point there is a structural break in the death rate from circulatory causes in Irish death rates by sex and age group. We do this by fitting 128 ordinary least squares (OLS) models of circulatory deaths which use alternative break points between the first quarter of 1998 and the last quarter of 2001 by each age/sex group (16 possible break points x 4 age groups x 2 sexes) which include the overall trend in deaths (a linear representing each year quarter 1995 to 2005 running from 1 to 44), three variables representing year quarter (omitting quarter one), a term for the interaction of the structural break point and the overall trend and three other terms interacting the year quarter with the structural break point (see Appendix Table 1 for definitions of variables used). We use OLS models rather than grouped logit models in this instance to facilitate the comparison of non-nested models<sup>6</sup>. We select the break point for each age/sex combination by choosing the point at which the explained variance is highest as measured by an  $R^2$  statistic.

Having established the break point, we then fit a variable representing each drug to the basic model of death rate trend, seasonal pattern and break point whilst also controlling for temperature fitted as the lowest temperature at  $t$ . If the quantitative variable expressing the cardiovascular drug effect can render the variable representing the structural change, or break point in death rates insignificant and reduce its coefficient we then take this as giving support to the hypothesis that the new trend pattern can be explained to an extent by cardiovascular prescribing trends.

---

<sup>6</sup> Use of grouped logit models would necessitate the use of an information criterion approach such as the Bayesian or Akaike Information Criterion. There is still some debate about the efficacy of such approaches (Bernham and Anderson 2002).

## 4. RESULTS

### Trends in Circulatory Death Rates

Figures 1 and 2 show male and female circulatory death rates between 1995 and 2005 for four age categories: 65-74 years, 75-84 years and 85+ years plus all 65+ years. These show that mortality from circulatory disease in Ireland displays a strong seasonal pattern, with the highest mortality rates occurring in quarter one, and the lowest in quarter three. In relation to cardiovascular deaths, male mortality is generally higher than female mortality across all age groups. For both sexes, in addition to the higher amplitude of fluctuations, the rate is highest amongst the oldest age group aged 85 and over. The first quarter of 1999 exhibited the highest rates of mortality in this group, with males recording 34.3 deaths per 1,000 of the population aged 85 and over, compared to slightly lower 28.1 deaths per 1,000 of the female population aged 85 and over. The figures below,

FIGURES 1 and 2 ABOUT HERE

These mortality figures indicate that post 2000, the seasonal pattern has modified, with less amplitude in the differences between quarter one and quarter three. Previous research (Walsh, 2007) commented on the strong seasonality effects in circulatory mortality in Ireland. This is also strongly evident in our graphs which plot the quarterly death rates over the period 1995-2005.

Appendix Table 2 gives the adjusted  $R^2$  associated with each of the break points and shows that among men the break point which explains the most variance in the mortality data occurs in Q4 1999 for those aged 64 to 74 and 85+ (as well as all 65+), whilst for those aged 75-84, a break point in the last quarter of 2000 explains more of the variance in the data. For women the break point occurs around a year later in the third and fourth quarters of 2000. These break points are adopted in the main analysis of our variables of interest.

TABLE 1 ABOUT HERE

Table 1 shows the results for grouped logit models of circulatory deaths by sex and age group. This shows that for men aged 65 to 84 there is a significant structural break in the time trend plus a structural break in the seasonality trend for those aged 75 to

84. For men aged 85+ on the other hand there is evidence only of a structural break in the seasonality accounting for the overall decrease in mortality rates for circulatory disease. Table 1 shows the significant downward trend in death rates for all age and sex groups plus the strong seasonality in deaths with Q3 each year having the lowest rate of deaths and Q1 the highest. Transformed, the results for men aged 65+ show a 0.82% fall in deaths/000 per quarter 1995-2005, increasing by 0.5% per quarter after Q4 1999. They also show a strong seasonal variation with 25% less deaths/000 in Q3 than Q1<sup>7</sup>. There is a 9% reduction in Q3 seasonality post Q4 1999. For women the structural break in the main time trend is significant for all age groups whereas there is evidence for the break in seasonality only for women aged 75 to 84. Transformation of the results in Table 1 for women aged 65+ suggest a 0.53% fall in deaths/000 per quarter 1995-2005, increasing by 0.48% after Q1 2000. Seasonality among women is just as pronounced as among men with 25.2% less deaths in Q3 than Q1 although there is a smaller reduction in this proportion after Q1 2000 of 6.8% relative to 9% among men.

Among the oldest age groups (85+) the over downward trend was stronger with a 0.68% reduction among men per quarter and 0.54% among women, a fall which decreases by 0.37% among men and 0.26% among women after the break point. Seasonal variation is higher among the oldest age group with men experiencing 29.3% fewer deaths in Q3 compared to Q1 and women 24.7%. These seasonal fluctuations decrease by 10.6% among men and 4.2% among women after the break point.

## **Temperature**

Figure 3 shows the Met Eireann data on the average minimum temperature, minimum temperature and mean temperature which were recorded in each of the quarterly time periods from 1995-2005.

FIGURE 3 ABOUT HERE

The differences across seasons fluctuate between lows in quarter one, to highs in quarter three, for the average minimum temperature and mean temperature. The

---

<sup>7</sup> Healy (2003) found a 21% increase in winter mortality for Ireland using data from 1988 to 1997 using a slightly different measure, the coefficient of seasonal variation in mortality (CVSM).

lowest minimum temperature was often lowest in quarter four. The greatest fluctuation between season one and season three occurred in 1995 for mean temperature when the temperature fluctuated between a minimum of 5.7 degrees in season one to a maximum of 16.2 degrees in quarter three. The lowest temperature was recorded in the first quarter of 2001 when temperature fell to a mean low of 4.7 degrees which was also the quarter when the lowest minimum temperature was recorded (-8.0 degrees Celsius).

The suggestion that milder winters (Walsh, 2007) may have had an effect on the fall in death rates, the temperature data does not reflect the decline that was witnessed in mortality post 2000. Fitting each of these variables (average minimum temperature, mean temperature and minimum temperature) into our model, alongside the trend, and structural break variables yields mainly insignificant results across all age groups and disease categories. Where there were significant results, they were negative, for example, after fitting minimum temperature into the model, the effects for males aged 65 and over in the circulatory disease group fell by 0.2 per cent.

### **Cardiovascular Drug Prescribing**

Figures 4 and 5 show the prescribing rates for different CHD medications for the period 1995 to 2005 for men and women. Across almost all the medications there is a gradual increase from the beginning of the series followed by a steepening increase after 1999 followed by a pronounced change in the prescribing trend post 2001. This coincides with the timing of the provision of medical cards to all those aged 70 years and over in the third quarter of 2001, irrespective of means.

FIGURES 4 AND 5 ABOUT HERE

### **Modelling the Impact of CHD Prescribing**

Table 2 shows that the introduction of the variables representing cardiovascular prescribing (controlling for temperature) has an important impact, both in terms of the effects of the drugs themselves and their impact on the significance and coefficient for the terms representing the trend-break point in the time series. However, the impact of the cardiovascular drugs varies considerably both by type and between the sexes. The impact of the drug variables is highest among men with the drug terms for beta-blocker, ace inhibitor and aspirin rendering the trend-break variable insignificant

across all age groupings. Diuretic, statin, calcium channel blocker and nitrates fail to explain the trend-break for men aged 75 to 84.

Among women, beta-blocker, aspirin and calcium channel blocker explain the trend-break terms for all age groups. Ace inhibitor and statin fail to explain the trend break for those aged 65-74 and diuretic and nitrates fail to explain the trend in any age group.

The impact of the drug effects on the trend-break coefficient varied by drug and sex. For men, aspirin and beta blocker produced the largest fall in the trend-break coefficient at 82% followed by statin (77%). Diuretic, calcium channel blocker and nitrate medications reduced the trend-break coefficient by 62%, 63% and 58% respectively. The variable representing rates of ace inhibitor use produced the lowest fall in the coefficient at 25% largely because of its lack of impact for the 65 to 74 year age group among men. Among men aged 75 to 84 ace inhibitor produced a 45% fall in the trend-break coefficient, rising to 78% among men aged 85+. The mean reduction in the trend-break coefficient masks substantial variation between age groups. The mean fall in the coefficient for men aged 65 to 74 and 75 to 84 is 50% and 49% respectively but this rises to 92% among men aged 85+.

Among women the medication variables produce substantially smaller falls in the female trend-break variables with statin producing the largest fall at 47% followed by ace inhibitor (42%), beta blocker (41%), aspirin (38%), calcium channel blocker (23%), nitrate (12%) and diuretic (8%). As with the male results, the female results vary by age group with the largest fall occurring among women aged 75 to 84 at 63% followed by women aged 85+ at 28%. This proportion falls to less than 1% among women aged 65 to 74.

The coefficients for the effect of the drugs on mortality vary also with beta blocker, ace inhibitor and calcium channel blocker reducing the odds of death from circulatory causes by 0.3% for each increase rate per thousand prescribed the medications. Statin, diuretic and aspirin have impacts on the probability of death of roughly half this size at 0.15% per rate point increase. Nitrate results prove to be positive, i.e. increase the probability of death (0.49% per rate point increase). Among women coefficients are larger for calcium channel blocker (0.42%) and beta blocker (0.37%), but smaller for ace inhibitor (0.25%). As among men, aspirin (0.16%) and diuretic (0.18%) have a

lower impact. Nitrate and diuretic appear to have a positive effect on deaths among women with the nitrate effect particularly large at 1.6% per rate point increase.

## **5. DISCUSSION**

This paper was motivated by the pronounced fall in mortality from circulatory and respiratory causes observed around the turn of the last century in Ireland. Our estimates suggest that male deaths from circulatory causes were already falling by 3.3% a year until the fourth quarter of 1999 at which point the rate proportionate fall increased to 5.3% a year. Among women the extent of change was not as large but the first quarter of the year 2000 saw the yearly fall in circulatory deaths essentially double from 2.1% to 4%. Similar pronounced and sudden changes were observed in the seasonality of circulatory deaths. Before the fourth quarter of 1999/first quarter 2000 circulatory deaths in the third quarter of the year were typically 25.2% lower than in the first quarter among both men and women. After this point however, the peak summer fall in mortality dropped to 18.4% among men and 20.2% among women. This change in mortality has attracted much comment in Ireland and further afield but up to this point attempts to explain the change in trend have been few in number and met with limited success (Walsh 2008). This paper has shown that the structural break in the trend can be explained by changes in the pattern of cardiovascular drug prescribing in Ireland after 1998. Our analyses show that variables representing the trend break across different age/sex groups can be rendered insignificant, and a high proportion of their coefficient explained by quantitative variables measuring the increase in prescribing of cardiovascular drugs between 1995 and 2005. Variations in this effect across the sexes and between drugs deserves some comment.

Just as the fall in circulatory deaths was largest among men, our models also showed that the impact of circulatory drugs was also more significant among men with drug variables both more likely to render the trend-break variable insignificant and reducing its coefficient by a larger amount. Whilst there is no evidence to show that the cardiovascular medications examined in this paper are less effective among women there is some evidence internationally to suggest that women may be prescribed such medications at a lower level of risk than among men (Stocks et al

2004). If replicated among our Irish sample such over prescribing would lead to the slope coefficient for cardiovascular prescribing among women to be reduced.

Our analyses also showed differential impacts among the different medications. Among men, beta blocker, aspirin and ace inhibitor medications were most effective at explaining the structural break in the mortality trends and reducing its effect. Among women, all drug variables failed to completely explain the trend break across all age groups. The rather small effect for statin in this context is difficult to understand given its efficacy in randomised control trials. Once again however, it may be that overprescribing of statin to individuals at a lower level of risk may lead to lower levels of effect than would be expected from trials.

Our research clearly had a number of drawbacks. Ideally, longitudinal data on circulatory mortality alongside individual specific data on prescribing would be used for this analysis. Unfortunately this is not available for Ireland at present. In its absence we are forced to use aggregate data and time series methods within which we have a limited number of degrees of freedom to examine the hypotheses at issue. First and foremost this means that our estimates of the effects of the cardiovascular medications are not as precise as we would like. But it also means that we cannot test for the independent effects of different medications and combinations thereof without experiencing unacceptable levels of autocorrelation.

Secondly, our data are not as representative of the population as we would like. Our data on cardiovascular medications measure prescribing patterns only for medical card holders over the age of 64. This partial coverage is not as problematic as it would be among the younger population as 67% of those over the age of 64 had access to a medical card in the late 1990s rising to 87% after 2001 with 100% coverage of those over 70. Nonetheless this partial coverage introduces error into the analysis of the probability of death from cardiovascular causes which is based on national data. Ideally data on prescribing for the total population would be used although this is not available at present.

A factor which we have not examined in this paper but which it is possible played a role in the change in mortality trends may have been the wider availability of influenza vaccine after 1998. Campaigns to increase levels of flu vaccination in winter

months among older Irish people began in 1998 and were accompanied by free flu vaccine for all those aged over 65. The timing of this policy initiative fits well with the observed time trend in death rates as does the fact that influenza infection has been shown to be a contributing factor to increased death rates from thrombotic and respiratory disease (Donaldson and Keating 2002). The fall in the seasonality of deaths from respiratory and circulatory disease also suggests that this hypothesis has promise since influenza and other respiratory infections are more common from December to February. Data on the extent of take up of vaccine among older age groups is not available from the Primary Care Reimbursement Service at present but it would be important to be able to control for this factor in future analyses.

## 6. REFERENCES

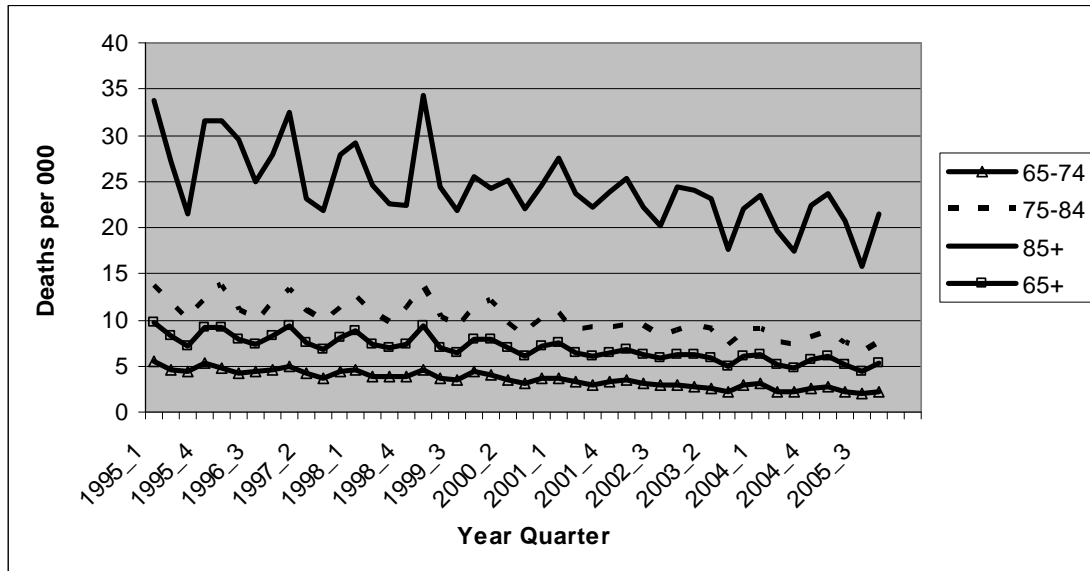
- Ayanian JZ, Epstein AM. Differences In The Use Of Procedures Between Women And Men Hospitalized For Coronary Heart Disease. *N Engl J Med.* 1991;325:221–225.
- Bennett, Kathleen, Kabir, Zubair, Unal, Belgin, Shelley, Emer, Critchley, Julia, Perry, Ivan, Feely, John, Capewell, Simon, “Explaining The Recent Decrease In Coronary Heart Disease Mortality Rates In Ireland, 1985-2000” *Journal Epidemiology and Community Health* 2006 60: 322-32.
- Burnham, K. P., and D. R. Anderson, 2002. Model Selection and Multimodel Inference: A Practical-Theoretic Approach, 2nd ed. Springer-Verlag.
- Clancy, L., Goodman, P., Sinclair, H., and Dockery, D.W., “Effects Of Air Pollution Control On Death Rtes In Dublin: An Intervention Study”, *The Lancet* Vol. 360, Issue 9341, 19<sup>th</sup> October 2002, pp. 1210-1214.
- Clinch, J.P., Healy, J.D., “Housing Standards And Excess Winter Mortality” *Journal of Epidemiology Community Health* 2000;54:719-720.
- Department of Health and Children. Building Healthier Hearts. National Cardiovascular Health Strategy. 1999, Dublin: Stationery Office.
- Donaldson, G.C., and Keatinge, W.R., Observational study “Excess Winter Mortality” *BMJ* 2002;324;89-90.
- Healy J.D., “Excess Winter Mortality In Europe: A Cross Country Analysis Identifying Key Risk Factors”, *J Epidemiology Community Health*, October 1, 2003; 57(10): 784 – 789.



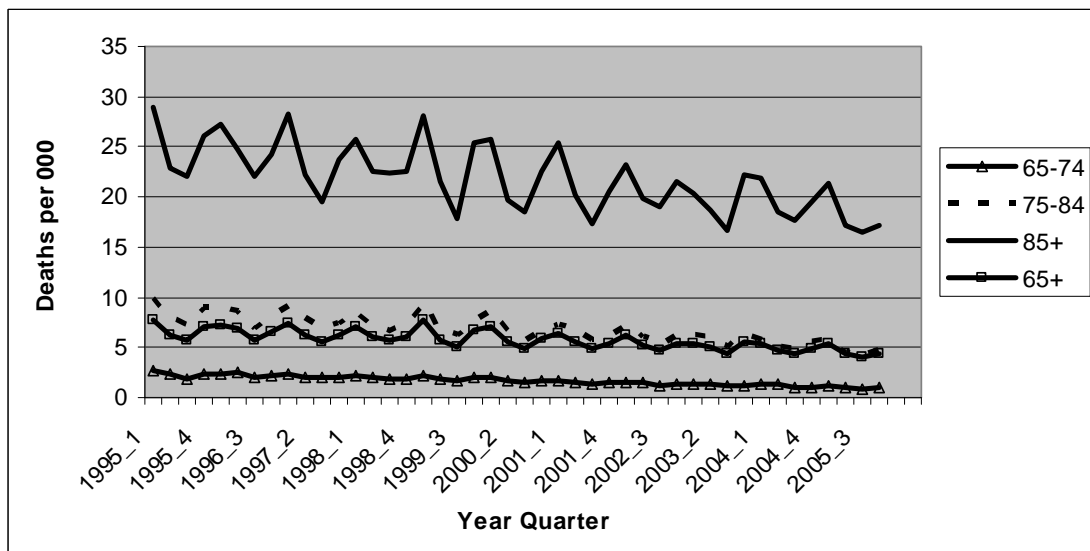
- Jaglal SB, Goel V, Naylor CD. Sex Differences In The Use Of Invasive Coronary Procedures In Ontario. *Can J Cardiol.* 1994;10:239 –244.
- Mascarenhas J, Lourenco P., Lopes R., Azevedo, A. and Bettencourt, P., (2008) Chronic Obstructive Pulmonary Disease In Heart Failure. Prevalence, Therapeutic and Prognostic Implications, *American Heart Journal*, vol. 155, 521 – 525.
- Stocks, N.P, Ryan, P., Elroy, H.J., McAllan, J.A (2004) Statin prescribing in Australia: socioeconomic and sex differences - A Cross-Sectional Study, *Medical Journal of Australia*, 2004; 180 (5):229-231.
- Walsh, B. 'Recent Trends In Mortality And Morbidity In Ireland: Annual Symposium - Wealthier And Healthier: Ireland's Demographic Catch-Up'. - Dublin: *Journal of the Statistical and Social Inquiry Society of Ireland*, Vol.37, 2007/8 , pp.95-112.
- Weisfeldt, M.L., and Zieman, S.J., “Advances In the Prevention And Treatment Of Cardiovascular Disease” *Health Affairs*, January/February 2007; 26(1): 25-37.
- Wilmshurst, P. “Temperature and Cardiovascular Mortality”, *BMJ* 1994;309:1029-1030.

## Figures and Tables

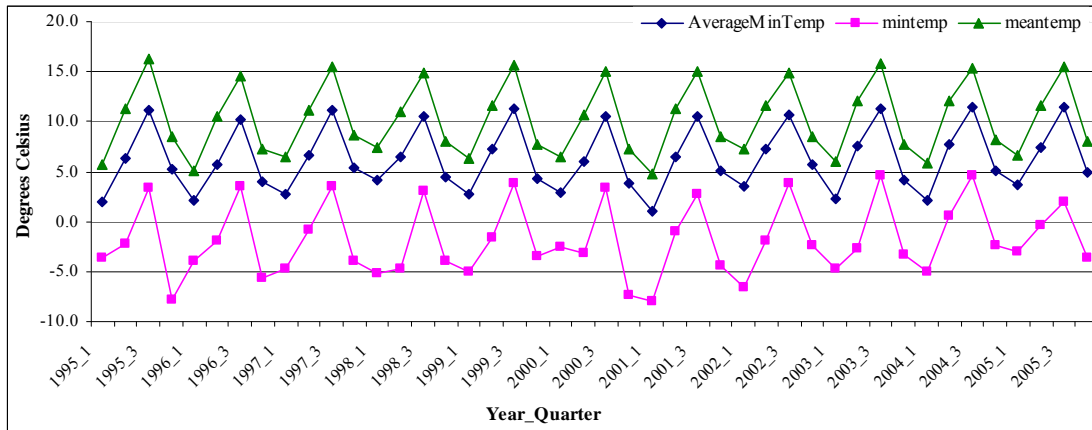
**Figure 1: Male Circulatory Death Rates by Age Group, Year and Quarter 1995-2005**



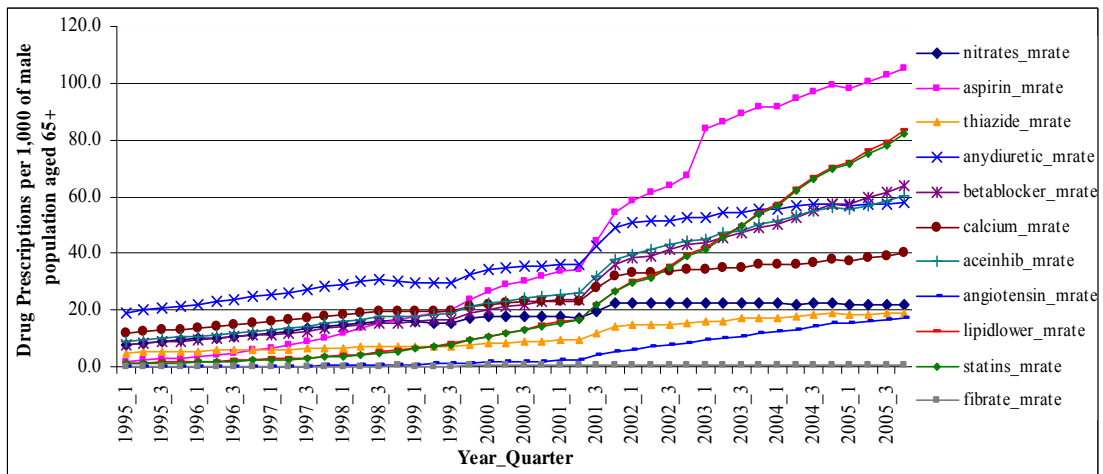
**Figure 2: Female Circulatory Death Rates by Age Group, Year and Quarter 1995-2005**



**Figure 3: Average Minimum, Minimum Temperature and Mean Temperature at Dublin Airport by Quarter 1995-2005**

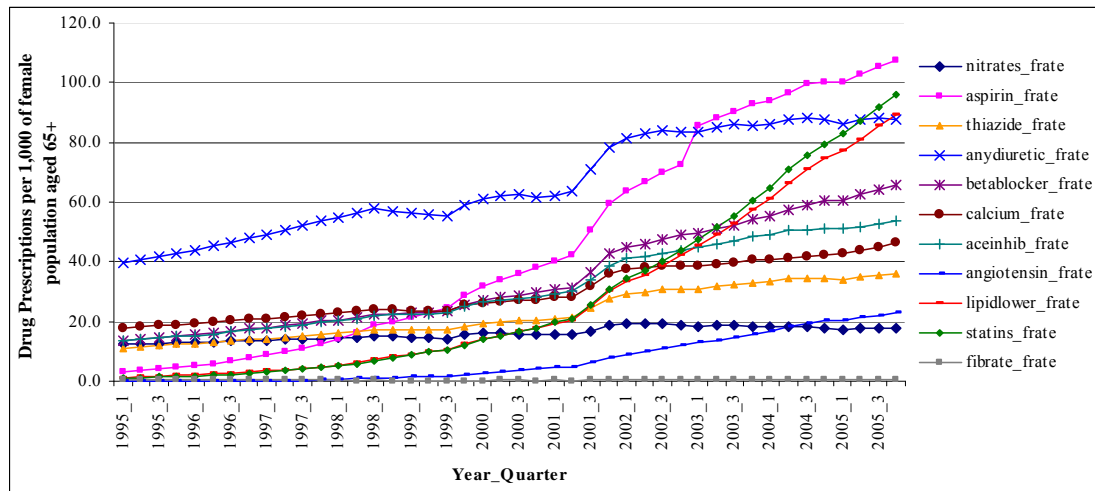


**Figure 4: Cardiovascular Prescribing for Males Aged 65+ per 1,000 Male Population**



Source: Primary Care Reimbursement Service, Eastern Region Health Area Data

**Figure 5: Cardiovascular Prescribing for Females Aged 65+ per 1,000 Female Population**



Source: Primary Care Reimbursement Service, Eastern Region Health Area Data

**Table 1: Grouped Logit Model of Male Circulatory Deaths by Age Group 1995-2005**

Male								
	Aged 65-74		Aged 75-84		Aged 85+		Aged 65+	
	$\beta$	Sig.	$\beta$	Sig.	$\beta$	Sig.	$\beta$	Sig.
Trend	-0.015	***	-0.007	***	-0.007	**	-0.008	***
Q2	-0.174	***	-0.200	***	-0.221	***	-0.199	***
Q3	-0.215	***	-0.314	***	-0.347	***	-0.290	***
Q4	-0.053	n.s	-0.124	***	-0.161	***	-0.115	***
Trend_Int	-0.004	*	-0.005	***	-0.004	n.s	-0.005	***
Q2_Int	0.071	n.s	0.089	*	0.125	**	0.089	***
Q3_Int	0.045	n.s	0.130	***	0.101	*	0.086	***
Q4_Int	0.036	n.s	0.046	n.s	0.120	*	0.063	**
Constant	-5.163	***	-4.228	***	-3.345	***	-4.587	***
Psuedo R <sup>2</sup>	0.0047		0.0030		0.0026		0.003	
N	5071600		2581600		523200		8176400	
Female								
	Aged 65-74		Aged 75-84		Aged 85+		Aged 65+	
	$\beta$	Sig.	$\beta$	Sig.	$\beta$	Sig.	$\beta$	Sig.
Trend	-0.015	***	-0.009	***	-0.005	***	-0.005	***
Q2	-0.093	**	-0.205	***	-0.196	***	-0.186	***
Q3	-0.215	***	-0.323	***	-0.284	***	-0.290	***
Q4	-0.067	n.s	-0.149	***	-0.112	***	-0.132	***
Trend_Int	-0.005	**	-0.005	***	-0.003	*	-0.005	***
Q2_Int	0.026	n.s	0.102	**	0.020	n.s	0.063	**
Q3_Int	0.015	n.s	0.107	**	0.041	n.s	0.066	**
Q4_Int	-0.042	n.s	0.088	**	0.032	n.s	0.061	**
Constant	-5.915	***	-4.578	***	-3.510	***	-4.835	***
Psuedo R <sup>2</sup>	0.0051		0.0034		0.0022		0.0021	
N	5680800		384 0400		1204400		10725600	

Note: See Appendix Table 1 for variable definitions & section 4 for year/quarter of each structural break point.

Sig Key: n.s – Not Significant; \*= $P < 0.05$ ; \*\*= $P < 0.01$ ; \*\*\*= $P < 0.001$

**Table 2: Grouped Logit Model of Circulatory Death Rates By Age Group and Sex (Controlling for Minimum Temperature in Quarter)**

		Male				Female			
		65-74	75-84	85+	65+	65-74	75-84	85+	65+
a. Beta-Blocker	B	-0.0055	-0.003	-0.0006	-0.0037	-0.0016	-0.0059	-0.0001	-0.0037
	Sig.	**	n.s	n.s	***	n.s	*	n.s	**
b. Trend_int	B	-0.0005	-0.0019	-0.0002	-0.0015	-0.004	-0.0004	-0.0019	-0.002
	Sig.	n.s	n.s	n.s	n.s	n.s	n.s	n.s	*
a. Ace-Inhibitor	B	-0.0058	-0.0029	-0.0008	-0.004	-0.0017	-0.0039	-0.0015	-0.0025
	Sig.	**	n.s	n.s	**	n.s	n.s	n.s	n.s
b. Trend_int	B	-0.0005	-0.0021	-0.0002	-0.0015	-0.0052	-0.0017	-0.0023	-0.0027
	Sig.	n.s	n.s	n.s	n.s	*	n.s	n.s	**
a. Diuretic	B	-0.0031	-0.0004	-0.0013	-0.0028	0.0036	0.0016	0.0013	0.001
	Sig.	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
b. Trend_int	B	-0.002	-0.0032	-0.0001	-0.0023	-0.0055	-0.0031	-0.0022	-0.0036
	Sig.	n.s	**	n.s	**	***	**	*	***
a. Statin	B	-0.0029	-0.0014	-0.0003	-0.0018	-0.0015	-0.0027	-0.0005	-0.0018
	Sig.	**	n.s	n.s	***	n.s	***	n.s	***
b. Trend_int	B	-0.0009	-0.0022	-0.0002	-0.0018	-0.0035	-0.0006	-0.0016	-0.002
	Sig.	n.s	*	n.s	*	*	n.s	n.s	**
a. Aspirin	B	-0.0029	-0.001	-0.0006	-0.0019	-0.0008	-0.002	-0.0002	-0.0016
	Sig.	**	n.s.	n.s.	***	n.s	n.s.	n.s.	n.s.
b. Trend_int	B	-0.0003	-0.0024	0	-0.0014	-0.004	-0.0011	-0.0018	-0.002
	Sig.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*
a. Calcium	B	-0.0064	-0.0012	-0.0018	-0.0051	0.0021	-0.0059	-0.0001	-0.0042
	Sig.	n.s.	n.s.	n.s.	*	n.s	n.s.	n.s.	n.s.
b. Trend_int	B	-0.0019	-0.0031	-0.0002	-0.0023	-0.0052	-0.0016	-0.0019	-0.0026
	Sig.	n.s.	**	n.s.	**	n.s.	n.s.	n.s.	**
a. Nitrates	B	0.0113	0.006	-0.0027	0.0057	0.0196	0.0191	0.0095	0.0163
	Sig.	*	n.s.	n.s.	n.s.	n.s.	**	n.s.	**
b. Trend_int	B	-0.0021	-0.0031	-0.0005	-0.0026	-0.005	-0.0031	-0.0022	-0.0038
	Sig.	n.s.	***	n.s.	***	***	**	*	***

NOTE: a – Cardiovascular medication coefficient and significance

b – Trend-break point interaction coefficient and significance controlling for cardiovascular medication a.

## Appendix

**Appendix Table 1: Variable Description**

Variable	Description
Trend	=Integer from 1 to 44 identifying Year/Quarter 1995-2005
Q2	=1 if 2 <sup>nd</sup> Quarter of Year
Q3	=1 if 3 <sup>rd</sup> Quarter of Year
Q4	=1 if 4 <sup>th</sup> Quarter of Year
Trend_Int	= Trend * post break point period
Q2_Int	=2 <sup>nd</sup> Quarter * post break point period
Q3_Int	=3 <sup>rd</sup> Quarter * post break point period
Q4_Int	=4 <sup>th</sup> Quarter * post break point period
Mintemp	=Minimum temperature measured in quarter t
β-Blocker	=Sex specific rate of prescribing of β-Blocker in quarter t
Ace Inhibitor	=Sex specific rate of prescribing of Ace Inhibitor in quarter t
Diuretic	=Sex specific rate of prescribing of any Diuretic in quarter t
Statin	=Sex specific rate of prescribing of Statin in quarter t
Aspirin	=Sex specific rate of prescribing of Aspirin in quarter t
Calcium	=Sex specific rate of prescribing of Calcium Channel Blocker in quarter t
Nitrates	=Sex specific rate of prescribing of Nitrates in quarter t

**Appendix Table 2: Model Fit (Adjusted R<sup>2</sup>) Statistics for Different Structural Break Points**

	Males				Females			
	65-74	75-84	85+	65+	65-74	75-84	85+	65+
98_1	0.9548	0.9284	0.8038	0.9498	0.9513	0.9120	0.8646	0.9119
98_2	0.9552	0.9278	0.8083	0.9500	0.9511	0.9142	0.8626	0.9121
98_3	0.9534	0.9267	0.8052	0.9477	0.9504	0.9123	0.8579	0.9062
98_4	0.9545	0.9266	0.8157	0.9490	0.9507	0.9143	0.8618	0.9092
99_1	0.9553	0.9492	0.8233	0.9620	0.9526	0.9240	0.8697	0.9224
99_2	0.9565	0.9484	0.8268	0.9626	0.9521	0.9257	0.8693	0.9219
99_3	0.9575	0.9504	0.8272	0.9641	0.9525	0.9268	0.8711	0.9238
99_4	<b>0.9578</b>	0.9545	<b>0.8296</b>	<b>0.9656</b>	0.9559	0.9260	0.8678	0.9235
00_1	0.9574	0.9585	0.8144	0.9604	0.9587	0.9382	0.8698	<b>0.9356</b>
00_2	0.9570	0.9572	0.8068	0.9603	0.9581	0.9382	0.8692	0.9343
00_3	0.9575	0.9604	0.8011	0.9614	0.9581	<b>0.9403</b>	0.8718	0.9348
00_4	0.9576	<b>0.9606</b>	0.8030	0.9614	<b>0.9601</b>	0.9399	<b>0.8718</b>	0.9339
01_1	0.9550	0.9309	0.8144	0.9500	0.9540	0.9158	0.8618	0.9143
01_2	0.9547	0.9272	0.8057	0.9483	0.9523	0.9169	0.8650	0.9161
01_3	0.9549	0.9383	0.8006	0.9523	0.9534	0.9218	0.8657	0.9178
01_4	0.9548	0.9316	0.8016	0.9491	0.9553	0.9206	0.8639	0.9132

Year	Number	Title/Author(s) ESRI Authors/Co-authors <i>Italicised</i>
<b>2009</b>		
	299	EU Climate Change Policy 2013-2020: Using the Clean Development Mechanism More Effectively <i>Paul K Gorecki, Seán Lyons and Richard S.J. Tol</i>
	298	Irish Public Capital Spending in a Recession <i>Edgar Morgenroth</i>
	297	Exporting and Ownership Contributions to Irish Manufacturing Productivity Growth <i>Anne Marie Gleeson, Frances Ruane</i>
	296	Eligibility for Free Primary Care and Avoidable Hospitalisations in Ireland <i>Anne Nolan</i>
	295	Managing Household Waste in Ireland: Behavioural Parameters and Policy Options <i>John Curtis, Seán Lyons and Abigail O'Callaghan-Platt</i>
	294	Labour Market Mismatch Among UK Graduates; An Analysis Using REFLEX Data <i>Seamus McGuinness and Peter J. Sloane</i>
	293	Towards Regional Environmental Accounts for Ireland <i>Richard S.J. Tol, Nicola Commins, Niamh Crilly, Sean Lyons and Edgar Morgenroth</i>
	292	EU Climate Change Policy 2013-2020: Thoughts on Property Rights and Market Choices <i>Paul K. Gorecki, Sean Lyons and Richard S.J. Tol</i>
	291	Measuring House Price Change <i>David Duffy<sup>F</sup></i>
	290	Intra-and Extra-Union Flexibility in Meeting the European Union's Emission Reduction Targets <i>Richard S.J. Tol</i>
	289	The Determinants and Effects of Training at Work: Bringing the Workplace Back In <i>Philip J. O'Connell and Delma Byrne</i>
	288	Climate Feedbacks on the Terrestrial Biosphere and the Economics of Climate Policy: An Application of <i>FUND</i> <i>Richard S.J. Tol</i>

- 287 The Behaviour of the Irish Economy: Insights from the HERMES macro-economic model  
*Adele Bergin, Thomas Conefrey, John FitzGerald and Ide Kearney*
- 286 Mapping Patterns of Multiple Deprivation Using Self-Organising Maps: An Application to EU-SILC Data for Ireland  
*Maurizio Pisati, Christopher T. Whelan, Mario Lucchini and Bertrand Maitre*
- 285 The Feasibility of Low Concentration Targets: An Application of FUND  
*Richard S.J. Tol*
- 284 Policy Options to Reduce Ireland's GHG Emissions  
Instrument choice: the pros and cons of alternative policy instruments  
*Thomas Legge and Sue Scott*
- 283 Accounting for Taste: An Examination of Socioeconomic Gradients in Attendance at Arts Events  
*Pete Lunn and Elish Kelly*
- 282 The Economic Impact of Ocean Acidification on Coral Reefs  
*Luke M. Brander, Katrin Rehdanz, Richard S.J. Tol, and Pieter J.H. van Beukering*
- 281 Assessing the impact of biodiversity on tourism flows: A model for tourist behaviour and its policy implications  
*Giulia Macagno, Maria Loureiro, Paulo A.L.D. Nunes and Richard S.J. Tol*
- 280 Advertising to boost energy efficiency: the Power of One campaign and natural gas consumption  
*Seán Diffney, Seán Lyons and Laura Malaguzzi Valeri*
- 279 International Transmission of Business Cycles Between Ireland and its Trading Partners  
*Jean Goggin and Iulia Siedschlag*
- 278 Optimal Global Dynamic Carbon Taxation  
*David Anthoff*
- 277 Energy Use and Appliance Ownership in Ireland  
*Eimear Leahy and Seán Lyons*
- 276 Discounting for Climate Change  
*David Anthoff, Richard S.J. Tol and Gary W. Yohe*



2008

- 275 Projecting the Future Numbers of Migrant Workers in the Health and Social Care Sectors in Ireland  
*Alan Barrett and Anna Rust*
- 274 Economic Costs of Extratropical Storms under Climate Change: An application of FUND  
*Daiju Narita, Richard S.J. Tol, David Anthoff*
- 273 The Macro-Economic Impact of Changing the Rate of Corporation Tax  
*Thomas Conefrey and John D. Fitz Gerald*
- 272 The Games We Used to Play  
An Application of Survival Analysis to the Sporting Life-course  
*Pete Lunn*
- 271 Exploring the Economic Geography of Ireland  
*Edgar Morgenroth*
- 270 Benchmarking, Social Partnership and Higher Remuneration: Wage Settling Institutions and the Public-Private Sector Wage Gap in Ireland  
*Elish Kelly, Seamus McGuinness, Philip O'Connell*
- 269 A Dynamic Analysis of Household Car Ownership in Ireland  
*Anne Nolan*
- 268 The Determinants of Mode of Transport to Work in the Greater Dublin Area  
*Nicola Commins and Anne Nolan*
- 267 Resonances from *Economic Development* for Current Economic Policymaking  
*Frances Ruane*
- 266 The Impact of Wage Bargaining Regime on Firm-Level Competitiveness and Wage Inequality: The Case of Ireland  
*Seamus McGuinness, Elish Kelly and Philip O'Connell*
- 265 Poverty in Ireland in Comparative European Perspective  
*Christopher T. Whelan and Bertrand Maitre*
- 264 A Hedonic Analysis of the Value of Rail Transport in the Greater Dublin Area  
*Karen Mayor, Seán Lyons, David Duffy and Richard S.J. Tol*

- 263 Comparing Poverty Indicators in an Enlarged EU  
*Christopher T. Whelan and Bertrand Maitre*
- 262 Fuel Poverty in Ireland: Extent,  
Affected Groups and Policy Issues  
*Sue Scott, Seán Lyons, Claire Keane, Donal McCarthy  
and Richard S.J. Tol*
- 261 The Misperception of Inflation by Irish Consumers  
*David Duffy and Pete Lunn*
- 260 The Direct Impact of Climate Change on Regional  
Labour Productivity  
Tord Kjellstrom, R Sari Kovats, Simon J. Lloyd, Tom  
Holt, *Richard S.J. Tol*
- 259 Damage Costs of Climate Change through Intensification  
of Tropical Cyclone Activities:  
An Application of FUND  
Daiju Narita, *Richard S. J. Tol* and *David Anthoff*
- 258 Are Over-educated People Insiders or Outsiders?  
A Case of Job Search Methods and Over-education in UK  
Aleksander Kucel, *Delma Byrne*
- 257 Metrics for Aggregating the Climate Effect of Different  
Emissions: A Unifying Framework  
*Richard S.J. Tol*, Terje K. Berntsen, Brian C. O'Neill, Jan  
S. Fuglestedt, Keith P. Shine, Yves Balkanski and Laszlo  
Makra
- 256 Intra-Union Flexibility of Non-ETS Emission Reduction  
Obligations in the European Union  
*Richard S.J. Tol*
- 255 The Economic Impact of Climate Change  
*Richard S.J. Tol*
- 254 Measuring International Inequity Aversion  
*Richard S.J. Tol*
- 253 Using a Census to Assess the Reliability of a National  
Household Survey for Migration Research: The Case of  
Ireland  
*Alan Barrett and Elish Kelly*
- 252 Risk Aversion, Time Preference, and the Social Cost of  
Carbon  
*David Anthoff, Richard S.J. Tol* and Gary W. Yohe
- 251 The Impact of a Carbon Tax on Economic Growth and  
Carbon Dioxide Emissions in Ireland

*Thomas Conefrey, John D. Fitz Gerald, Laura Malaguzzi Valeri and Richard S.J. Tol*

- 250 The Distributional Implications of a Carbon Tax in Ireland  
*Tim Callan, Sean Lyons, Susan Scott, Richard S.J. Tol and Stefano Verde*
- 249 Measuring Material Deprivation in the Enlarged EU  
*Christopher T. Whelan, Brian Nolan and Bertrand Maitre*
- 248 Marginal Abatement Costs on Carbon-Dioxide Emissions: A Meta-Analysis  
Onno Kuik, Luke Brander and *Richard S.J. Tol*
- 247 Incorporating GHG Emission Costs in the Economic Appraisal of Projects Supported by State Development Agencies  
*Richard S.J. Tol and Seán Lyons*
- 246 A Carbon Tax for Ireland  
*Richard S.J. Tol, Tim Callan, Thomas Conefrey, John D. Fitz Gerald, Seán Lyons, Laura Malaguzzi Valeri and Susan Scott*
- 245 Non-cash Benefits and the Distribution of Economic Welfare  
*Tim Callan and Claire Keane*
- 244 Scenarios of Carbon Dioxide Emissions from Aviation  
*Karen Mayor and Richard S.J. Tol*
- 243 The Effect of the Euro on Export Patterns: Empirical Evidence from Industry Data  
*Gavin Murphy and Iulia Siedschlag*
- 242 The Economic Returns to Field of Study and Competencies Among Higher Education Graduates in Ireland  
*Elish Kelly, Philip O'Connell and Emer Smyth*
- 241 European Climate Policy and Aviation Emissions  
*Karen Mayor and Richard S.J. Tol*
- 240 Aviation and the Environment in the Context of the EU-US Open Skies Agreement  
*Karen Mayor and Richard S.J. Tol*
- 239 Yuppie Kvetch? Work-life Conflict and Social Class in Western Europe  
*Frances McGinnity and Emma Calvert*
- 238 Immigrants and Welfare Programmes: Exploring the

- Interactions between Immigrant Characteristics,  
Immigrant Welfare Dependence and Welfare Policy  
*Alan Barrett and Yvonne McCarthy*
- 237 How Local is Hospital Treatment? An Exploratory  
Analysis of Public/Private Variation in Location of  
Treatment in Irish Acute Public Hospitals  
*Jacqueline O'Reilly and Miriam M. Wiley*
- 236 The Immigrant Earnings Disadvantage Across the  
Earnings and Skills Distributions: The Case of  
Immigrants from the EU's New Member States in Ireland  
*Alan Barrett, Seamus McGuinness and Martin O'Brien*
- 235 Europeanisation of Inequality and European Reference  
Groups  
*Christopher T. Whelan and Bertrand Maitre*
- 234 Managing Capital Flows: Experiences from Central and  
Eastern Europe  
*Jürgen von Hagen and Iulia Siedschlag*
- 233 ICT Diffusion, Innovation Systems, Globalisation and  
Regional Economic Dynamics: Theory and Empirical  
Evidence  
*Charlie Karlsson, Gunther Maier, Michaela Trippel, Iulia  
Siedschlag, Robert Owen and Gavin Murphy*
- 232 Welfare and Competition Effects of Electricity  
Interconnection between Great Britain and Ireland  
*Laura Malaguzzi Valeri*
- 231 Is FDI into China Crowding Out the FDI into the  
European Union?  
*Laura Resmini and Iulia Siedschlag*
- 230 Estimating the Economic Cost of Disability in Ireland  
*John Cullinan, Brenda Gannon and Seán Lyons*
- 229 Controlling the Cost of Controlling the Climate: The Irish  
Government's Climate Change Strategy  
*Colm McCarthy, Sue Scott*
- 228 The Impact of Climate Change on the Balanced-Growth-  
Equivalent: An Application of *FUND*  
*David Anthoff, Richard S.J. Tol*
- 227 Changing Returns to Education During a Boom? The  
Case of Ireland  
*Seamus McGuinness, Frances McGinnity, Philip O'Connell*
- 226 'New' and 'Old' Social Risks: Life Cycle and Social Class

- Perspectives on Social Exclusion in Ireland  
*Christopher T. Whelan and Bertrand Maitre*
- 225 The Climate Preferences of Irish Tourists by Purpose of Travel  
*Seán Lyons, Karen Mayor and Richard S.J. Tol*
- 224 A Hirsch Measure for the Quality of Research Supervision, and an Illustration with Trade Economists  
*Frances P. Ruane and Richard S.J. Tol*
- 223 Environmental Accounts for the Republic of Ireland: 1990-2005  
*Seán Lyons, Karen Mayor and Richard S.J. Tol*
- 2007** 222 Assessing Vulnerability of Selected Sectors under Environmental Tax Reform: The issue of pricing power  
*J. Fitz Gerald, M. Keeney and S. Scott*
- 221 Climate Policy Versus Development Aid  
*Richard S.J. Tol*
- 220 Exports and Productivity – Comparable Evidence for 14 Countries  
*The International Study Group on Exports and Productivity*
- 219 Energy-Using Appliances and Energy-Saving Features: Determinants of Ownership in Ireland  
*Joe O'Doherty, Seán Lyons and Richard S.J. Tol*
- 218 The Public/Private Mix in Irish Acute Public Hospitals: Trends and Implications  
*Jacqueline O'Reilly and Miriam M. Wiley*
- 217 Regret About the Timing of First Sexual Intercourse: The Role of Age and Context  
*Richard Layte, Hannah McGee*
- 216 Determinants of Water Connection Type and Ownership of Water-Using Appliances in Ireland  
*Joe O'Doherty, Seán Lyons and Richard S.J. Tol*
- 215 Unemployment – Stage or Stigma? Being Unemployed During an Economic Boom  
*Emer Smyth*
- 214 The Value of Lost Load  
*Richard S.J. Tol*
- 213 Adolescents' Educational Attainment and School Experiences in Contemporary Ireland

*Merike Darmody, Selina McCoy, Emer Smyth*

- 212 Acting Up or Opting Out? Truancy in Irish Secondary Schools  
*Merike Darmody, Emer Smyth and Selina McCoy*
- 211 Where do MNEs Expand Production: Location Choices of the Pharmaceutical Industry in Europe after 1992  
*Frances P. Ruane, Xiaoheng Zhang*
- 210 Holiday Destinations: Understanding the Travel Choices of Irish Tourists  
*Seán Lyons, Karen Mayor and Richard S.J. Tol*
- 209 The Effectiveness of Competition Policy and the Price-Cost Margin: Evidence from Panel Data  
Patrick McCloughan, *Seán Lyons* and William Batt
- 208 Tax Structure and Female Labour Market Participation: Evidence from Ireland  
*Tim Callan, A. Van Soest, J.R. Walsh*
- 207 Distributional Effects of Public Education Transfers in Seven European Countries  
*Tim Callan, Tim Smeeding and Panos Tsakloglou*