The impact of pharmaceutical innovation on longevity, productivity, and medical expenditure

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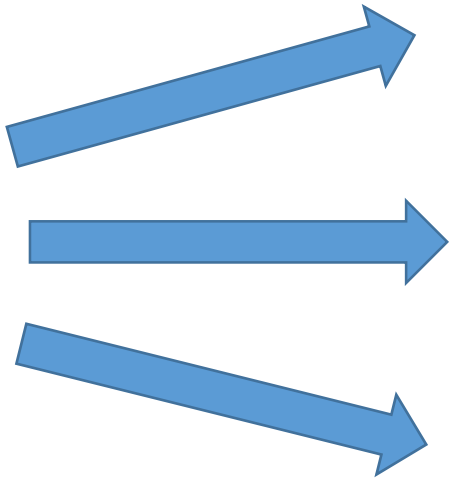
Happiness Doesn't Bring Good Health, Study Finds

A study published in The Lancet, following one million middle-aged women in Britain for 10 years, finds that the widely held view that happiness enhances health and longevity is unfounded.

"Happiness and related measures of well-being do not appear to have any direct effect on mortality," the researchers concluded.

Benefits of pharmaceutical innovation

Pharmaceutical innovation
(introduction and use of new drugs)



Longevity ↑
(premature mortality ↓)

Hospital expenditure ↓
other medical expenditure ↓

Ability to work ↑
school attendance ↑

Pharmaceutical innovation and longevity growth in 30 developing and high-income countries, 2000-2009

Lichtenberg FR (2014). Pharmaceutical Innovation and Longevity Growth in 30 Developing and High-income Countries, 2000-2009 *Health Policy and Technology* 3(1): 36-58, March.

Health Policy and Technology (2014) 3, 36–58

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Pharmaceutical innovation and longevity growth in 30 developing and high-income countries, 2000–2009

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KEYWORDS
Longevity;
Pharmaceuticals;
Innovation;
Mortality

Abstract
I examine the impact of pharmaceutical innovation, as measured by the vintage (world launch year) of prescription drugs used, on longevity using longitudinal, country-level data on 30 developing and high-income countries during the period 2000–2009. I control for fixed country and year effects, real per capita income, the unemployment rate, mean years of schooling, the urbanization rate, real per capita health expenditure (public and private), the DPT immunization rate among children ages 12–23 months, HIV prevalence and tuberculosis incidence.
The estimates indicate that life expectancy at all ages and survival rates above age 25 increased faster in countries with larger increases in drug vintage (measured in three different ways), ceteris paribus, and that the increase in life expectancy at birth due to the increase in the fraction of drugs consumed that were launched after 1990 was 1.27 years—73% of the actual increase in life expectancy at birth.
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Introduction

Longevity increase is increasingly recognized by economists to be an important part of economic growth and development.[1] Economists also recognize that, in the long run, the rate of economic "growth…is driven by technological change that arises from intentional [research and development (R&D)] investment decisions made by profit-maximizing agents" [32].

According to the National Science Foundation [30], the medical devices and substances industries are the most research intensive industries in the economy. In 1997, "medical substances and devices firms had by far the highest combined R&D intensity at 11.8 percent,…well above the 4.2-percent average for all 500 top 1997 R&D spenders combined. The information and electronics sector ranked second in intensity at 7.0 percent."

In principle, technological change could be either disembodied or embodied in new goods. Solow [36] hypothesized that most technological change is embodied: to benefit from technological progress, one must use newer, or later vintage, goods and services. Bresnahan and Gordon [4] argued that "new goods are at the heart of economic progress," and Hercowitz [16], p. 223 also reached the "conclusion…that 'embodiment' is the main transmission mechanism of technological progress to economic growth."

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[1] See e.g. Nordhaus [31] and Murphy and Topel [29]. Murphy and Topel estimated that, over the 20th century, cumulative gains in U.S. life expectancy were worth over $1.2 million per person for both men and women. Between 1970 and 2000, increased U.S. longevity added about $3.2 trillion per year to national wealth, an uncounted value equal to about half of average annual GDP over the period.

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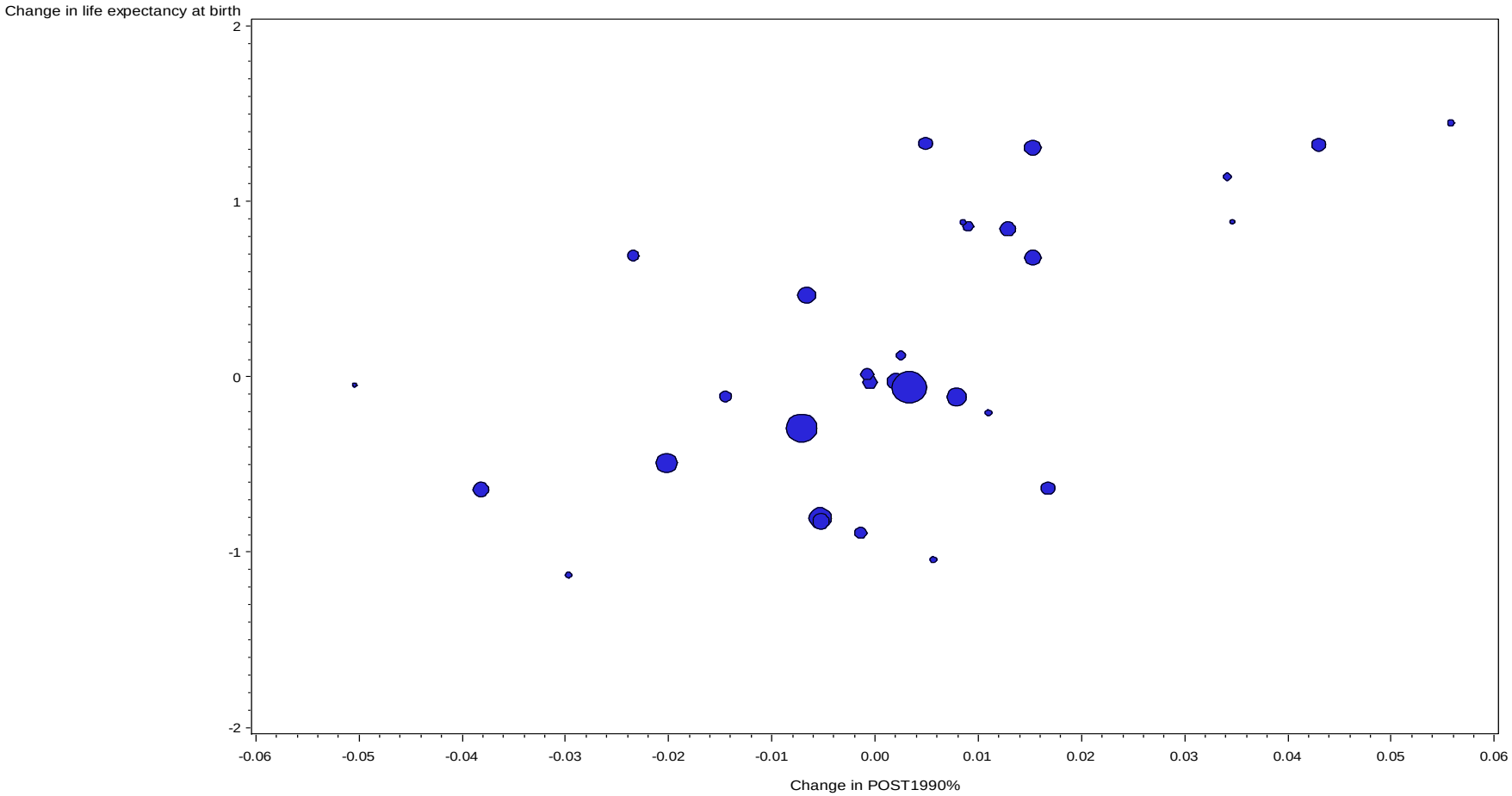
http://dx.doi.org/10.1016/j.hlpt.2013.09.005

Correlation across countries between 2000-2009 change in life expectancy at birth and change in drug vintage (POST1990%),

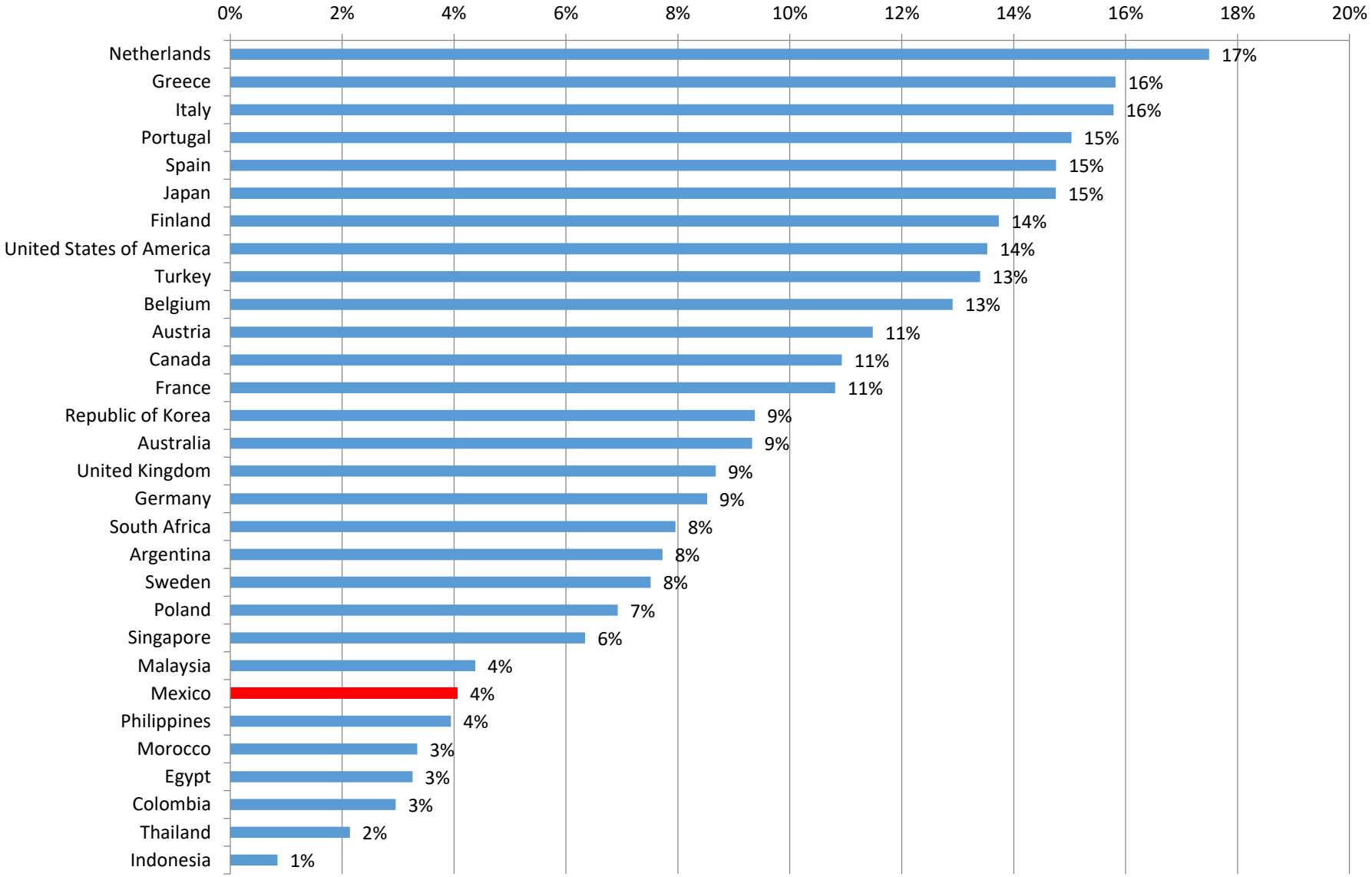
controlling for changes in income, unemployment rate, education, urbanization, health expenditure, immunization rate, HIV prevalence and tuberculosis incidence

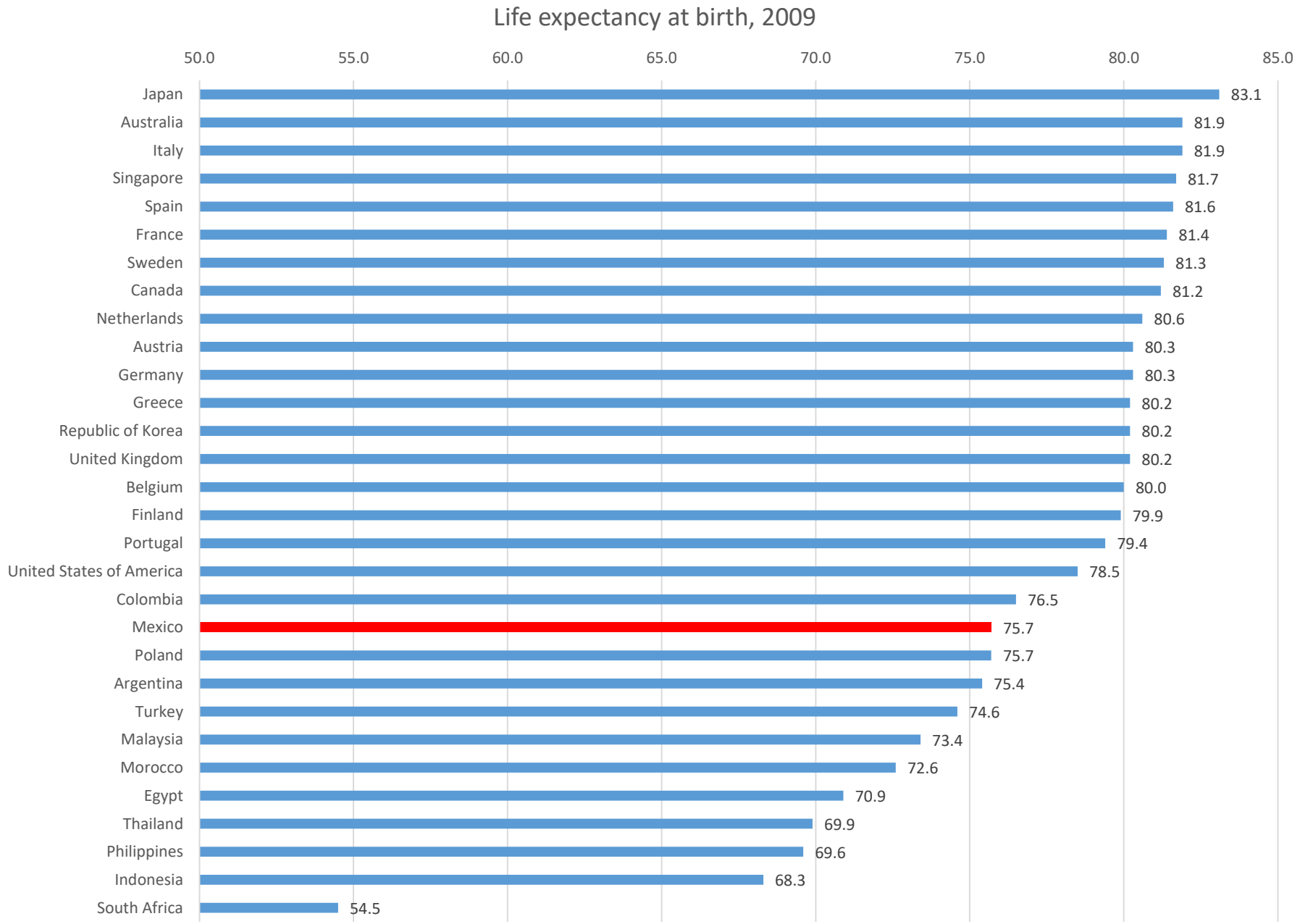


Note: size of bubble is proportional to country population.

The increase in life expectancy at birth due to the increase in the fraction of drugs consumed that were launched after 1990 was 1.27 years—73% of the actual increase in life expectancy at birth.

Quantity-weighted-mean fraction of products sold in 2009 that were launched after 1990 (POST1990%) , by country




Life expectancy at birth, 2009
50.0
55.0
60.0
65.0
70.0
75.0
80.0
85.0
Japan 83.1
Australia 81.9
Italy 81.9
Singapore 81.7
Spain 81.6
France 81.4
Sweden 81.3
Canada 81.2
Netherlands 80.6
Austria 80.3
Germany 80.3
Greece 80.2
Republic of Korea 80.2
United Kingdom 80.2
Belgium 80.0
Finland 79.9
Portugal 79.4
United States of America 78.5
Colombia 76.5
Mexico 75.7
Poland 75.7
Argentina 75.4
Turkey 74.6
Malaysia 73.4
Morocco 72.6
Egypt 70.9
Thailand 69.9
Philippines 69.6
Indonesia 68.3
South Africa 54.5

The impact of pharmaceutical innovation on premature cancer mortality in Canada, 2000-2011

Lichtenberg FR (2015). The Impact of Pharmaceutical Innovation on Premature Cancer Mortality in Canada, 2000-2011, *International Journal of Health Economics and Management* 15(3):339-359, June.

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RESEARCH ARTICLE

The impact of pharmaceutical innovation on premature cancer mortality in Canada, 2000–2011

Frank R. Lichtenberg[1,2]

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Abstract The premature cancer mortality rate has been declining in Canada, but there has been considerable variation in the rate of decline across cancer sites. I analyze the effect that pharmaceutical innovation had on premature cancer mortality in Canada during the period 2000–2011, by investigating whether the cancer sites that experienced more pharmaceutical innovation had larger declines in the premature mortality rate, controlling for changes in the incidence rate. Premature mortality before age 75 is significantly inversely related to the cumulative number of drugs registered at least 10 years earlier. Since mean utilization of drugs that have been marketed for less than 10 years is only one-sixth as great as mean utilization of drugs that have been marketed for at least a decade, it is not surprising that premature mortality is strongly inversely related only to the cumulative number of drugs that had been registered at least ten years earlier. Premature mortality before age 65 and 55 is also strongly inversely related to the cumulative number of drugs that had been registered at least ten years earlier. None of the estimates of the effect of incidence on mortality are statistically significant. Controlling for the cumulative number of drugs, the cumulative number of chemical subgroups does not have a statistically significant effect on premature mortality. This suggests that drugs (chemical substances) within the same class (chemical subgroup) are not therapeutically equivalent. During the period 2000–2011, the premature (before age 75) cancer mortality rate declined by about 9 %. The estimates imply that, in the absence of pharmaceutical innovation during the period 1985–1996, the premature cancer mortality rate would have increased about 12 % during the period 2000–2011. A substantial decline in the "competing risk" of death from cardiovascular disease could account for this. The estimates imply that pharmaceutical innovation during the period 1985–1996 reduced the number of years of potential life lost to cancer before age 75 in 2011 by 105,366. The cost

Electronic supplementary material The online version of this article (doi:10.1007/s10754-015-9172-2) contains supplementary material, which is available to authorized users.

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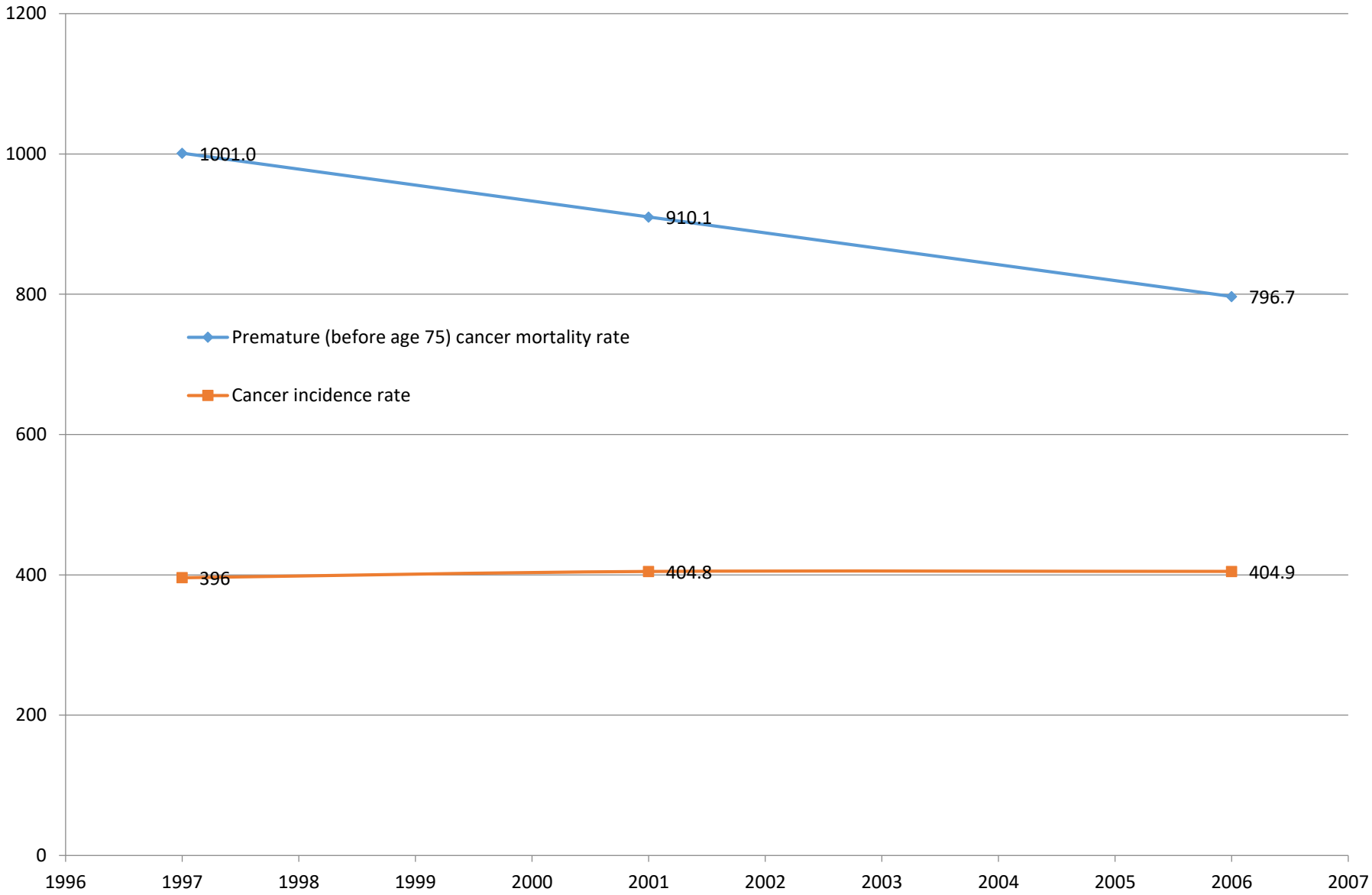
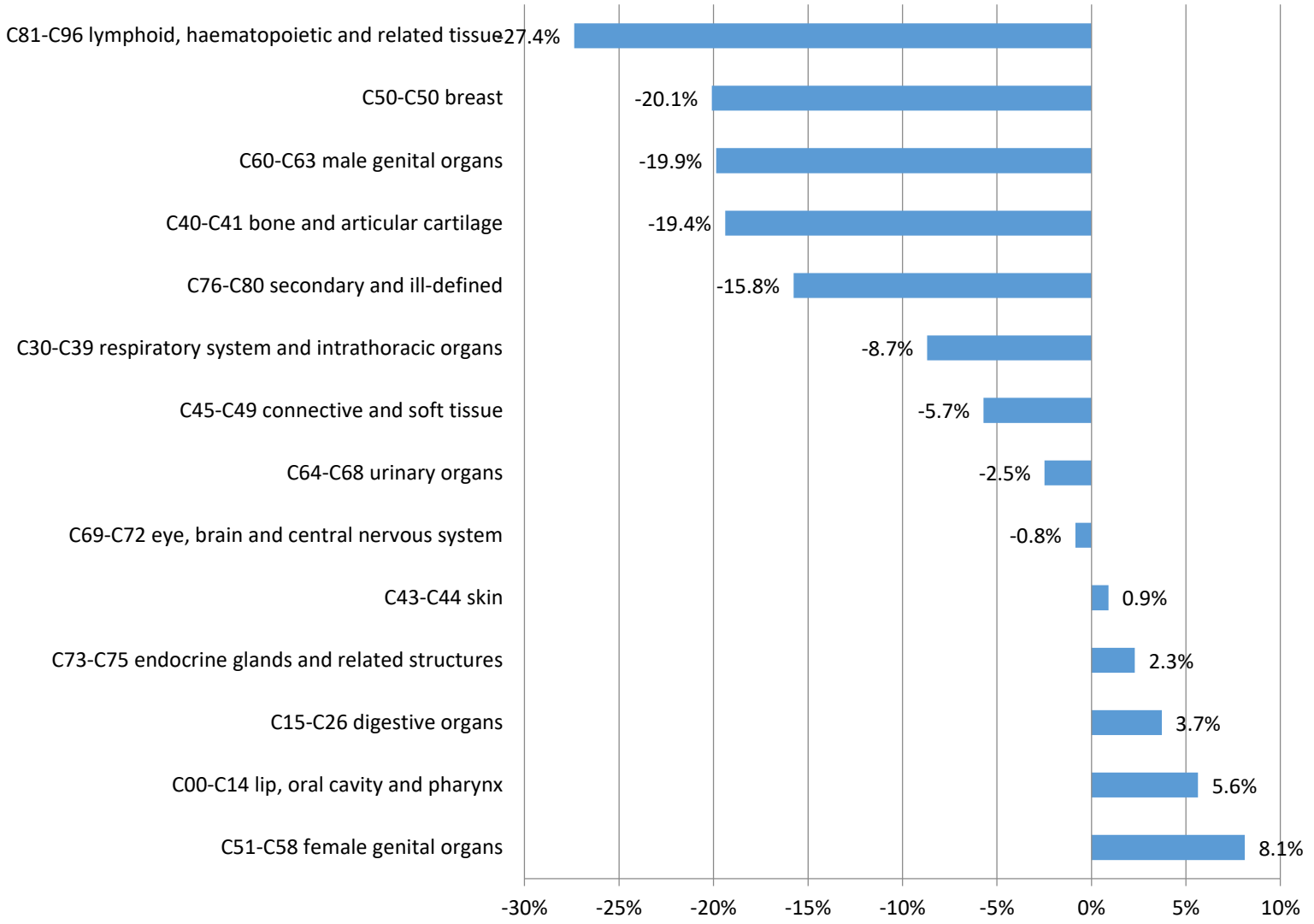
Trends in premature cancer mortality and cancer incidence, Canada, 1997-2006

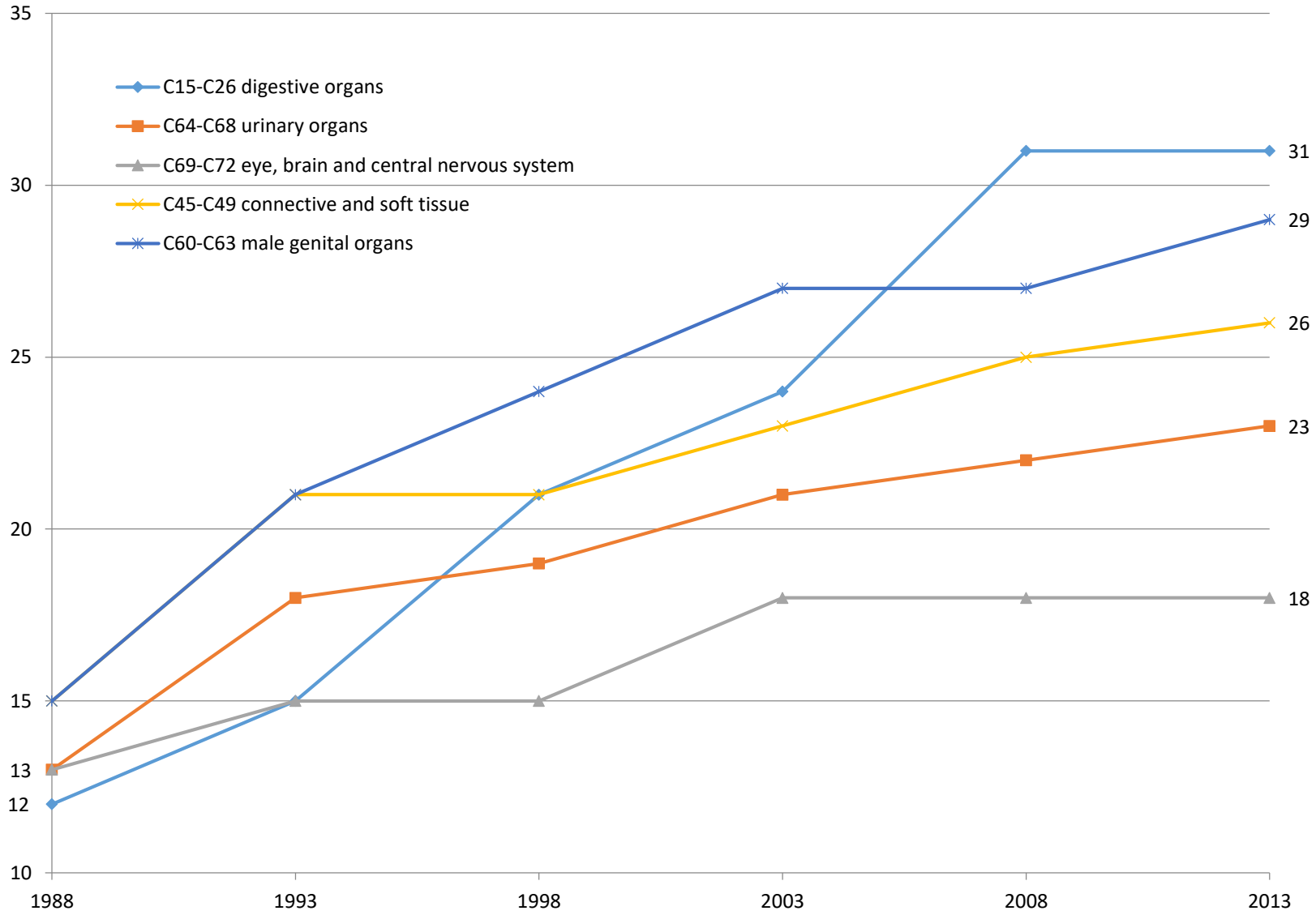


Log change from 2000 to 2011 in the premature mortality rate, by type of cancer, Canada



The premature mortality rate is the number of potential years of life lost before age 75 per 100,000 population age 0-74.

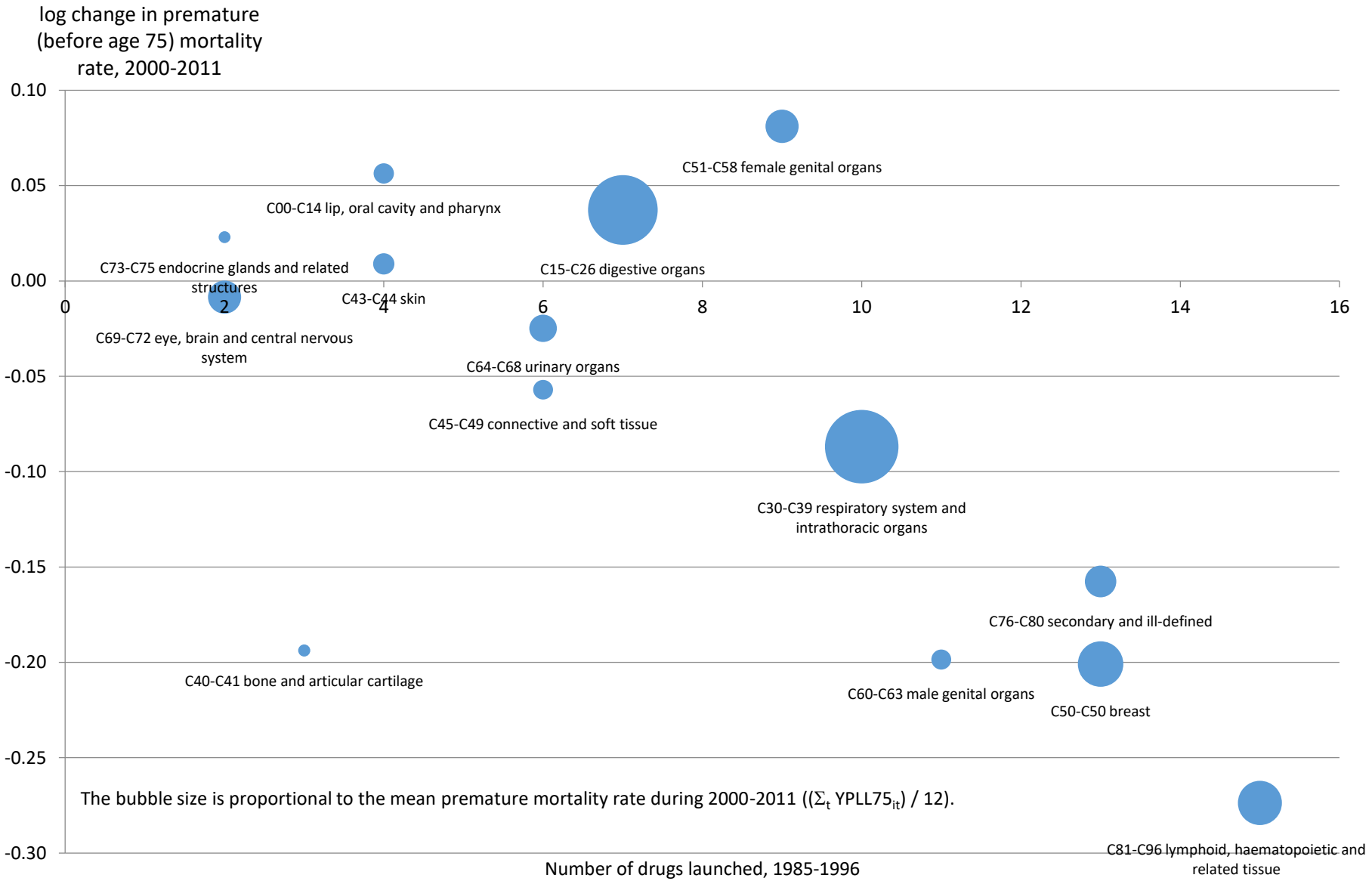
Cumulative number of drugs registered in Canada for 5 types of cancer, 5-year intervals, 1988-2013



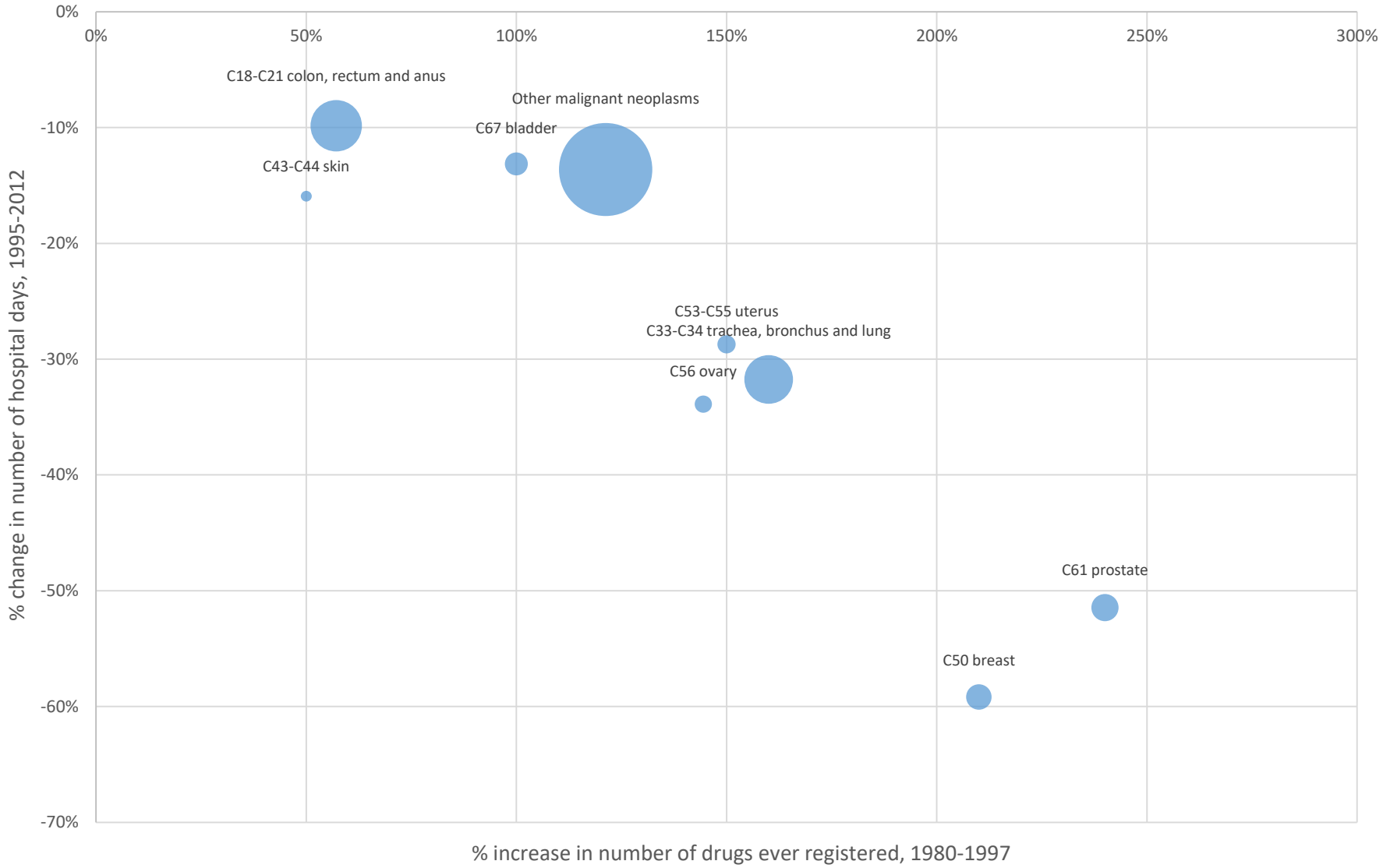
Decline in premature mortality due to pharmaceutical innovation

- Pharmaceutical innovation during the period 1985–1996 reduced the number of years of potential life lost to cancer before age 75 in 2011 by 105,366.
- The cost per life-year before age 75 gained from previous pharmaceutical innovation is estimated to have been 2730 USD, a figure well below even the lowest estimates of the value of a life-year gained.
- The largest reductions in premature mortality occur at least a decade after drugs are registered, when their utilization increases significantly. This suggests that, if Canada is to obtain substantial additional reductions in premature cancer mortality in the future (a decade or more from now) at a modest cost, pharmaceutical innovation (registration of new drugs) is needed today.

Relationship across cancer sites between the number of drugs launched during 1985-1996 and the 2000-2011 log change in the premature (before age 75) mortality rate



Relationship across cancer sites between the % increase in the number of drugs ever registered, 1980-1997, and the % change in the number of **hospital days, Canada, 1995-2012**



Pharmaceutical innovation, longevity, and medical expenditure in Greece, 1995-2010

Lichtenberg FR (2015). Pharmaceutical innovation, longevity, and medical expenditure in Greece, 1995-2010 *International Journal of the Economics of Business* 22(2): 277-299.

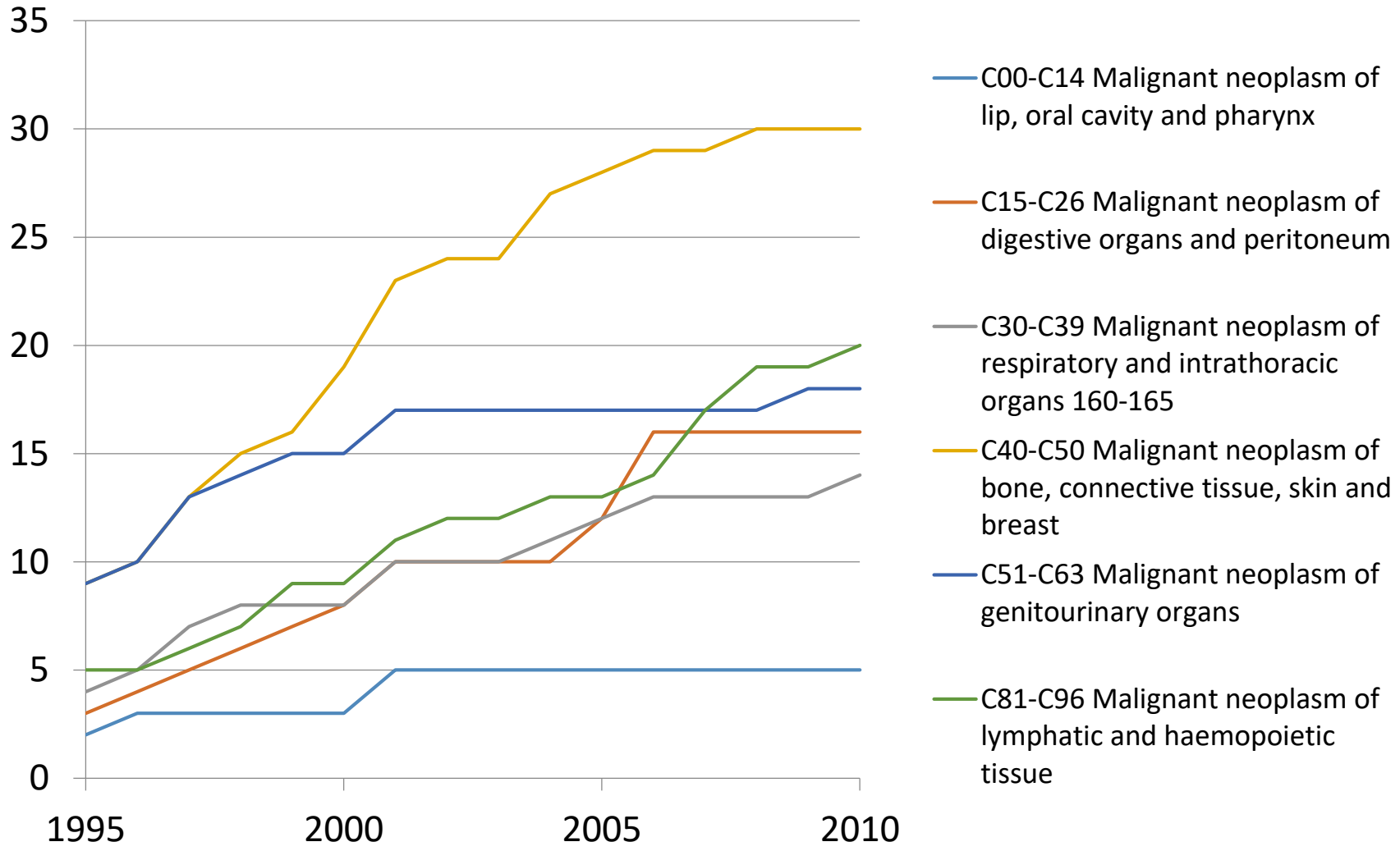
C15-C26 Malignant neoplasm of digestive organs and peritoneum

atc	year_world	year_greece
L01DB03 Epirubicin	1984	1985
H01CB02 Octreotide	1988	1990
J02AC01 Fluconazole	1988	1991
L01CD02 Docetaxel	1995	1996
L01BC05 Gemcitabine	1995	1997
L01XX19 Irinotecan	1994	1998
L01BC06 Capecitabine	1998	1999
L01XC03 Trastuzumab	1998	2000
B03XA02 Darbepoetin alfa	2001	2001
M05BA08 Zoledronic acid	2000	2001
L01XA03 Oxaliplatin	1996	2005
L01XC07 Bevacizumab	2004	2005
L01XC06 Cetuximab	2003	2006
L01XE03 Erlotinib	2004	2006
L01XE04 Sunitinib	2006	2006
L01XE05 Sorafenib	2005	2006

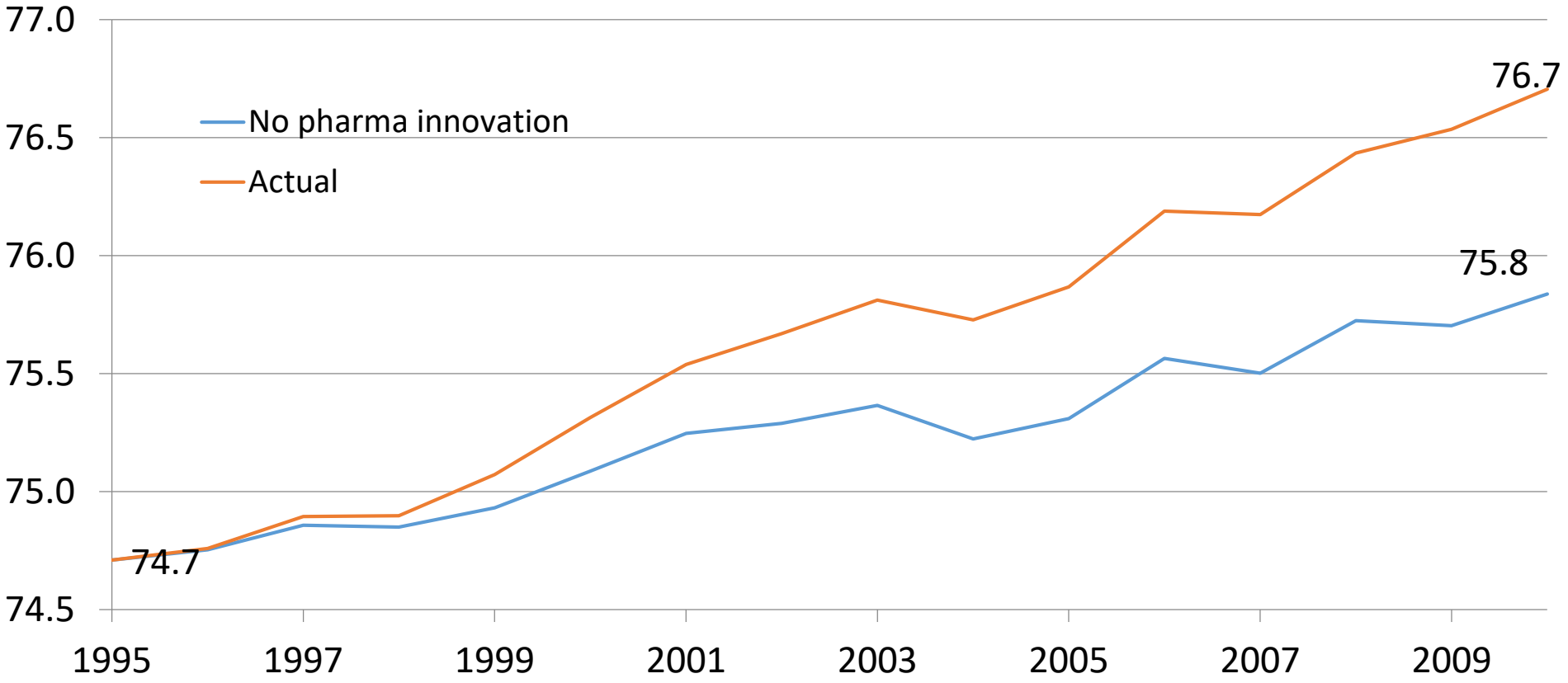
C40-C50 Malignant neoplasm of bone, connective tissue, skin and breast

atc	year_world	year_greece
L01DB03 Epirubicin	1984	1985
L01DB07 Mitoxantrone	1984	1987
L03AB05 Interferon alfa-2b	1985	1988
L02AE02 Leuprorelin	1984	1990
L03AB04 Interferon alfa-2a	1986	1990
J02AC01 Fluconazole	1988	1991
L02AE03 Goserelin	1987	1991
L01CD01 Paclitaxel	1992	1994
L02BG02 Formestane	1993	1995
L01CD02 Docetaxel	1995	1996
L01BC05 Gemcitabine	1995	1997
L01CA04 Vinorelbine	1989	1997
L02BA02 Toremifene	1989	1997
L02BG03 Anastrozole	1995	1998
L02BG04 Letrozole	1996	1998
L01BC06 Capecitabine	1998	1999
L01AD05 Fotemustine	1989	2000
L01XC03 Trastuzumab	1998	2000
M05BA06 Ibandronic acid	1996	2000
B03XA02 Darbepoetin alfa	2001	2001
D06BB10 Imiquimod	1997	2001
L02BG06 Exemestane	1999	2001
M05BA08 Zoledronic acid	2000	2001
L01XE01 Imatinib	2001	2002
L01BA04 Pemetrexed	2004	2004
L01XX22 Alitretinoin	1999	2004
L02BA03 Fulvestrant	2002	2004
L01XC07 Bevacizumab	2004	2005
L01XC06 Cetuximab	2003	2006
L01XE07 Lapatinib	2007	2008

Cumulative number of post-1982 new chemical entities that had previously been launched in Greece, 6 types of cancer, 1995-2010

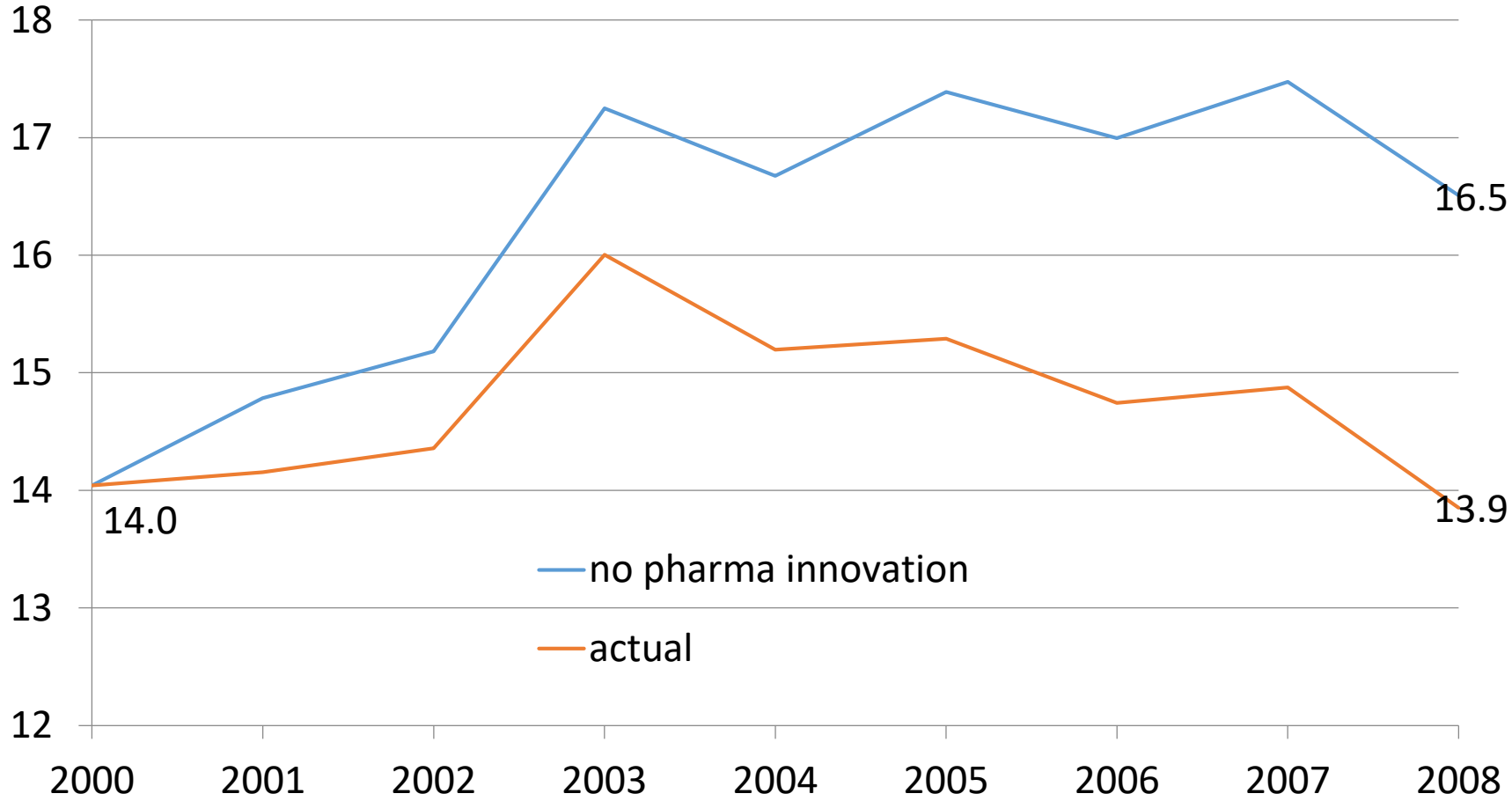


Mean age at death, Greece, 1995-2010



During the period 1995-2010, longevity (mean age at death) increased exactly 2.00 years in Greece. The estimates indicate that **44% of the 1995-2010 increase in longevity was due to the introduction of new drugs during the period 1992-2007.** In other words, pharmaceutical innovation increased longevity in Greece by .87 years during the period 1995-2010.

Millions of hospital days in Greece, 2000-2008:
actual vs. estimated, in absence of previous pharma innovation



Previous pharmaceutical innovation reduced the number of hospital days in 2008 by 2.6 million (16%).

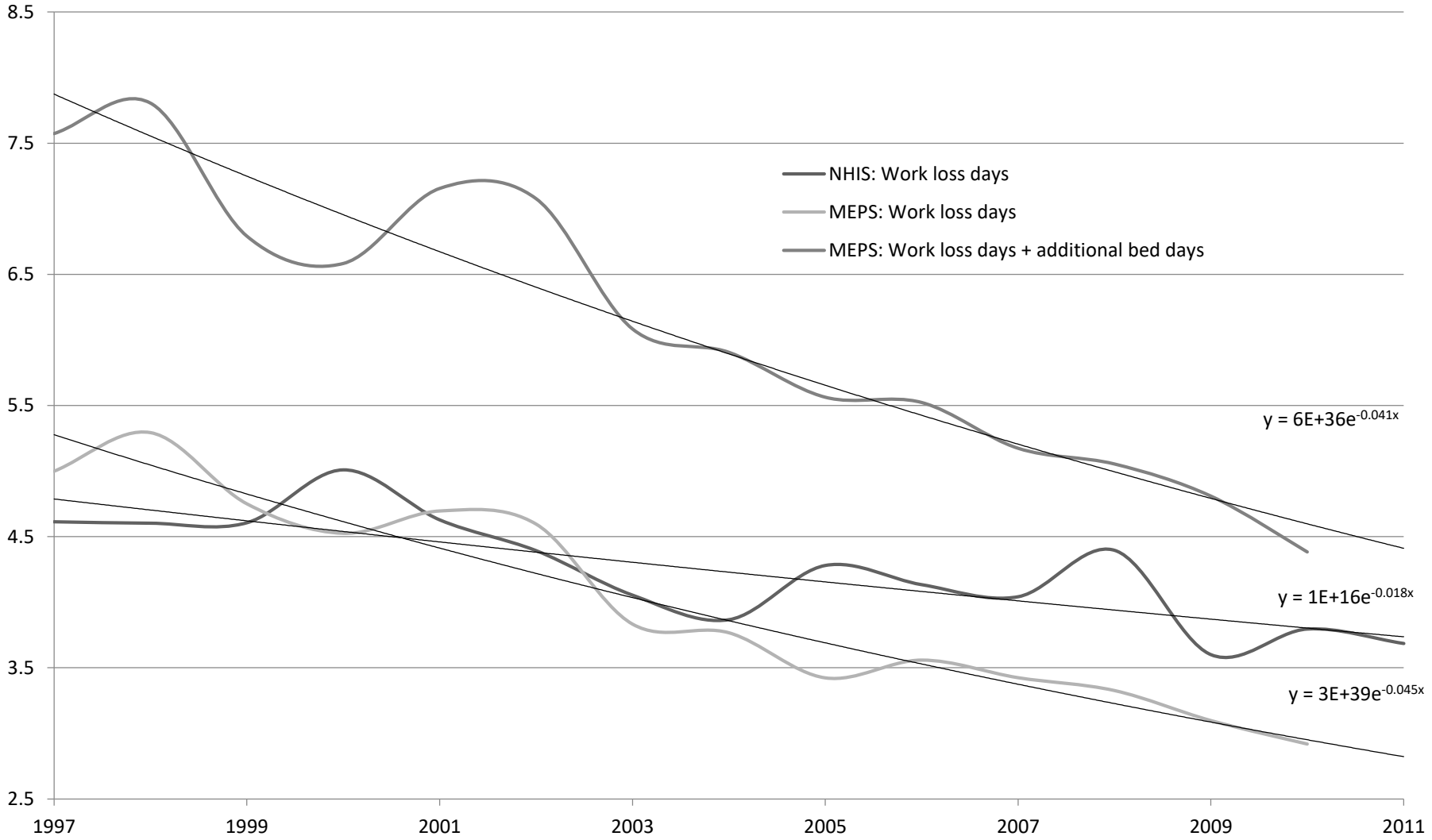
Pharmaceutical innovation has also significantly reduced utilization of nursing homes by elderly Americans

- Diseases with more rapid rates of pharmaceutical innovation had larger declines in the nursing home residence rate during the period 1985–1999.
- Pharmaceutical innovation is estimated to have accounted for almost three-quarters of the decline in the age-adjusted nursing home residence rate of people 65 and over, and 56% of the decline in the rate of people age 80 and over.
- I estimate that 55% of expenditure on new drugs by people age 65 and over was offset by reduced expenditures on nursing home care and that among people age 80 and over, the reduction in expenditure on nursing home care due to the use of new drugs exceeded expenditure on new drugs by 26 per cent.
- Lichtenberg FR (2009). "Home, or nursing home? The effect of medical innovation on the demand for long-term care," in J. Costa i Font, A. McGuire and C. Courbage (eds), *The Economics of New Health Technologies: Incentives, Organisation and Financing*, Oxford University Press.

The impact of pharmaceutical innovation on disability days and the use of medical services in the United States, 1997-2010

Lichtenberg FR (2014). "The impact of pharmaceutical innovation on disability days and the use of medical services in the United States, 1997-2010," *Journal of Human Capital* 8(4): 432-480.

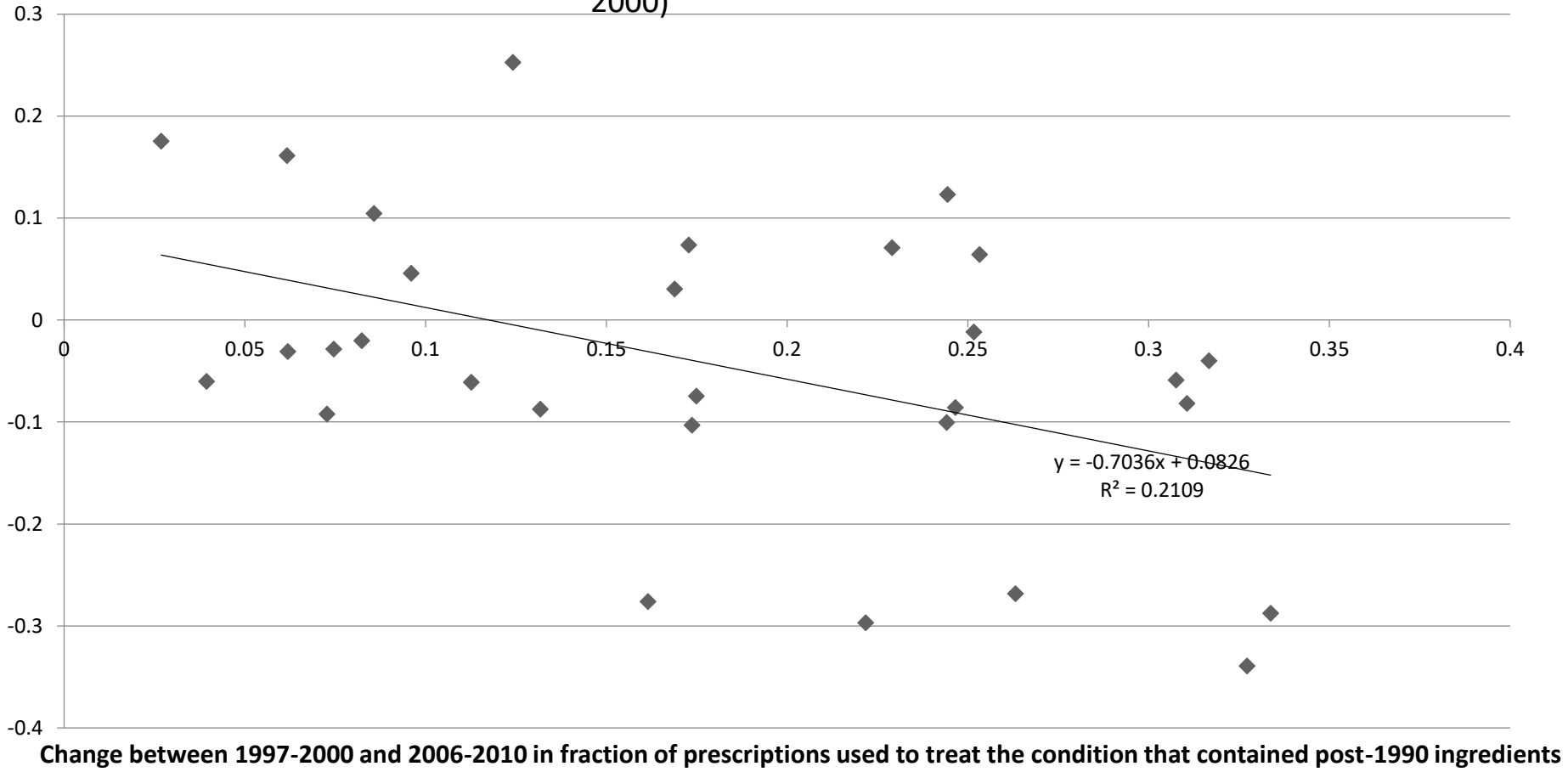
Mean number of work-loss days per year, employed persons 18 years of age and older



Source: author's calculations based on (1) NHIS data from Minnesota Population Center and State Health Access Data Assistance Center, Integrated Health Interview Series: Version 4.0. Minneapolis: University of Minnesota, 2011, and (2) MEPS Supplemental Public Use Files (1997-1998) and full-year consolidated data files (1996-2010)

Correlation across medical conditions between pharmaceutical innovation and change in probability of work-loss,

top 30 conditions (ranked by number of employed persons who missed work because of the condition during 1997-2000)



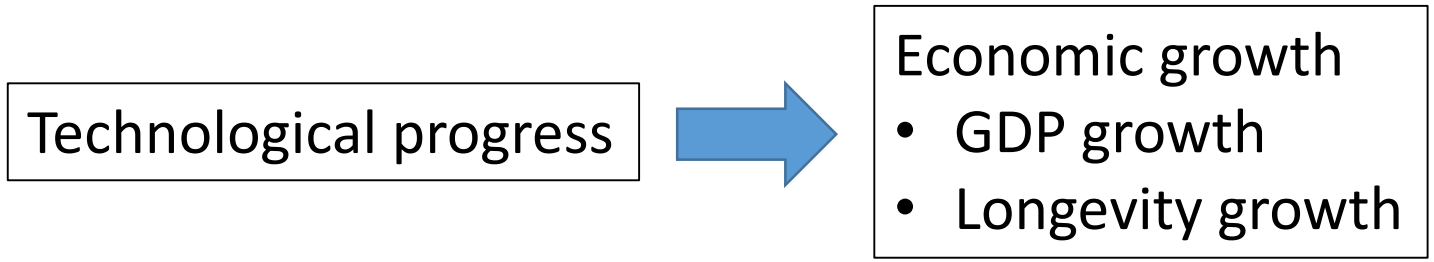
The increase in use of new drugs reduced the mean number of work loss days per employed person by about 0.6 percent per year—about one-third of the average annual rate of decline of work loss days.

Two (roughly equal) components of economic growth

Economic growth
- GDP growth
- Longevity growth

‘‘To a first approximation, the economic value of increases in longevity over the twentieth century is about as large as the value of measured growth in non-health goods and services.’’
Nordhaus WD. *The health of nations: the contribution of improved health to living standards*. In: Murphy KM, Topel RH, editors. *Measuring the gains from medical research: an economic approach*. Chicago (IL): University of Chicago Press, 2003: 9-40

Economic growth is due to technological progress

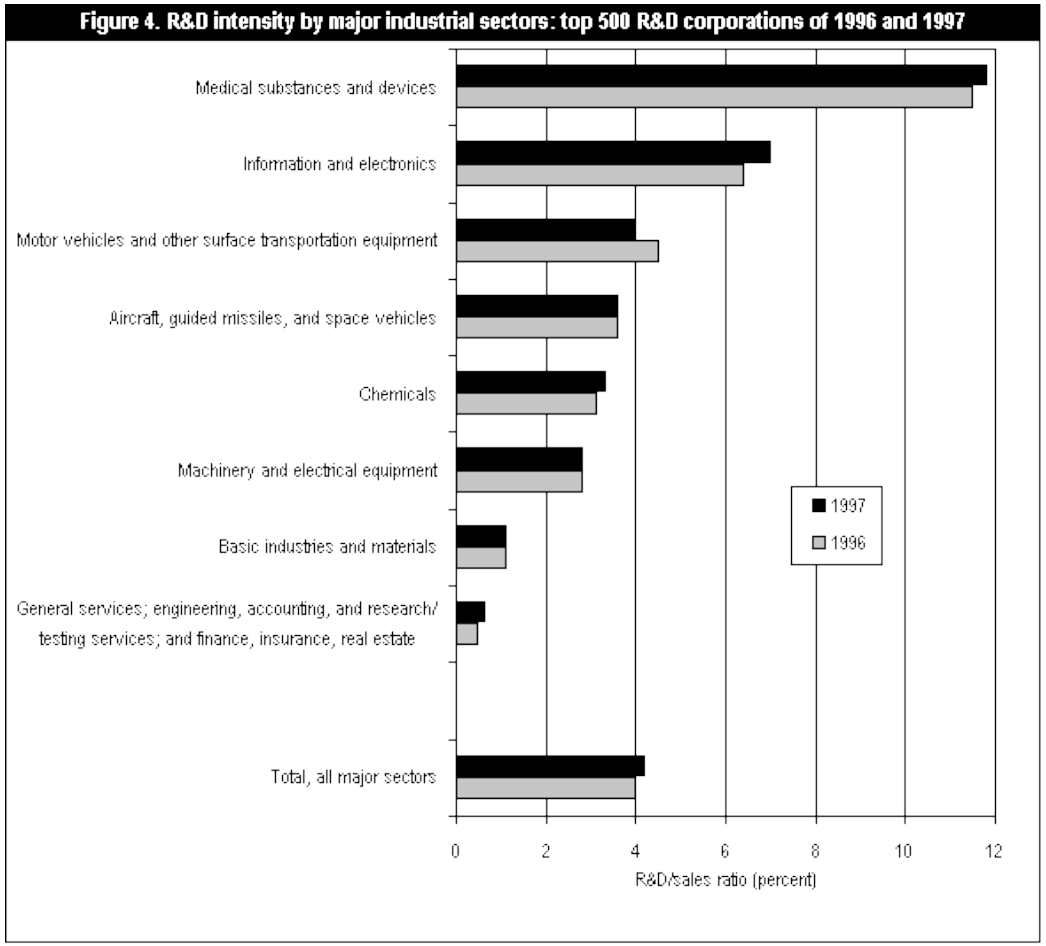


‘‘Technological progress [is] the ultimate driving force behind sustained economic growth.’’
Jones C. *Introduction to economic growth*. New York: Norton, 1998

Technological progress results from R&D investment

‘‘Technological progress is driven by research and development (R&D) in the advanced world.’’
Jones C. *Introduction to economic growth*. New York: Norton, 1998

Medical substances and devices industry is the most R&D-intensive



In 1997, medical substances and devices firms had by far the highest combined R&D intensity at 11.8 percent…well above the 4.2-percent average for all 500 top 1997 R&D spenders combined. The information and electronics sector ranked second in intensity at 7.0 percent. Source: National Science Foundation, Corporate R&D: Volume 1: Top 500 Firms in R&D by Industry Category, http://www.nsf.gov/statistics/nsf00301/expendit.htm#intensity