The impact of pharmaceutical innovation on longevity, quality of life, and medical expenditure

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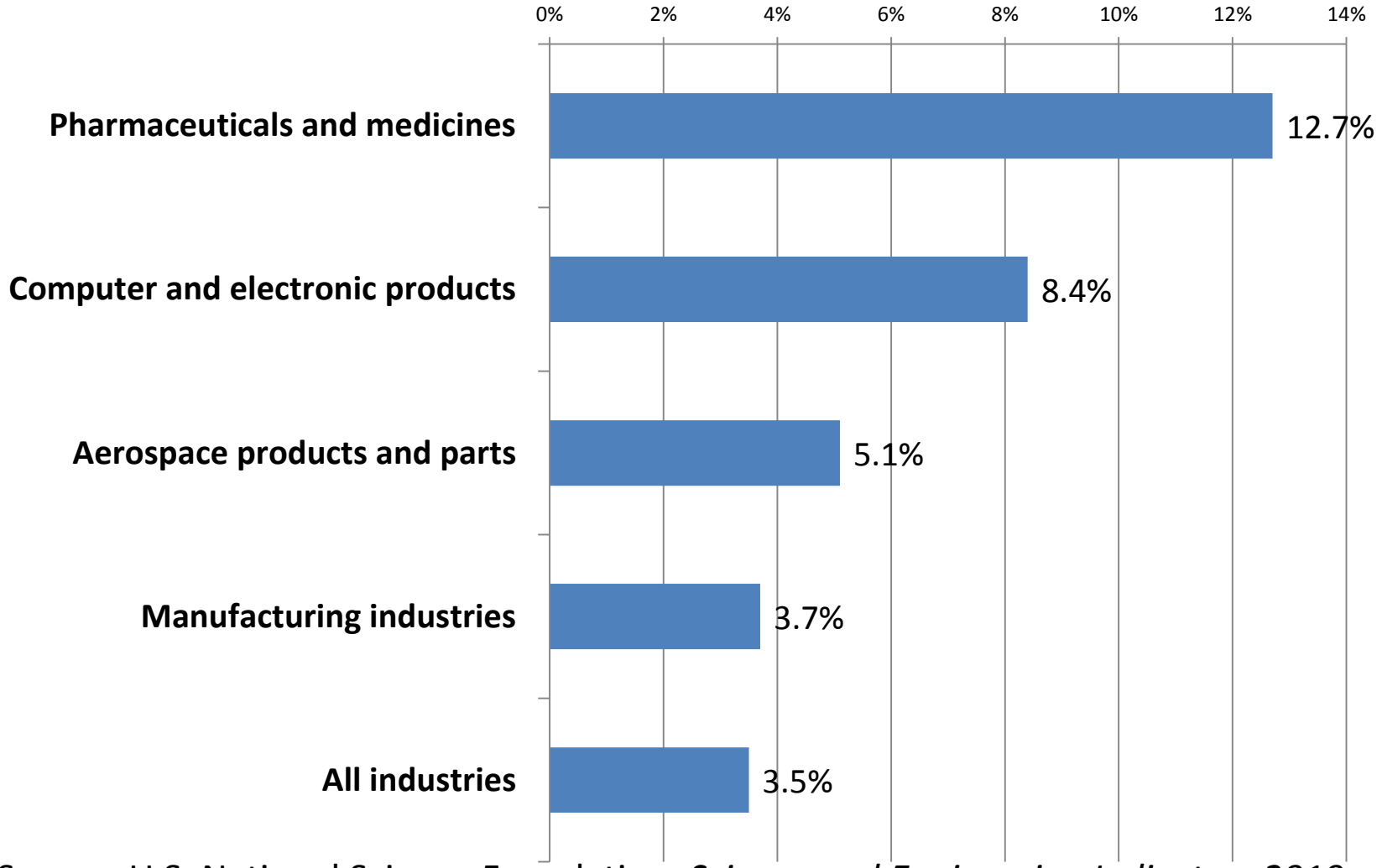
Hypothesis

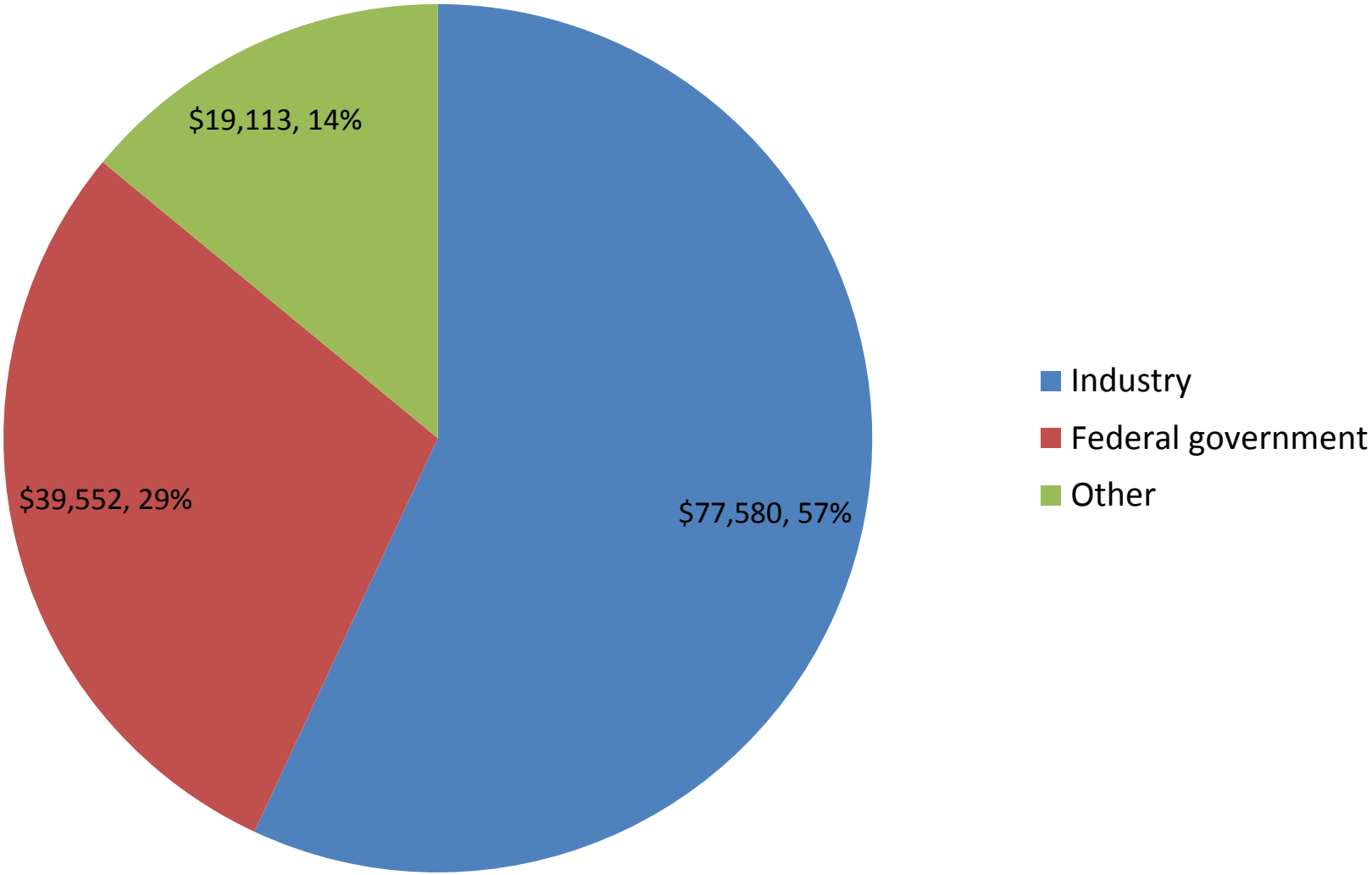
- I have performed numerous studies that have investigated the hypothesis that **the health and longevity of a population depends on how technologically advanced the medical goods (including drugs) and services its members use are.**
- Furthermore, how technologically advanced a medical good or service is depends on its *vintage*, defined as its year of invention or first use.
  - Wine: older (earlier vintage) products are of higher quality
  - Drugs: newer (later vintage) products are of higher quality
- Nobel laureate Robert Solow introduced the concept of vintage into economic analysis. Solow's basic idea was that technical progress (which results from R&D investment) is "built into" machines and other goods and that this must be taken into account when making empirical measurements of their roles in production.

Company-funded R&D expenditure as % of sales, U.S., 2007

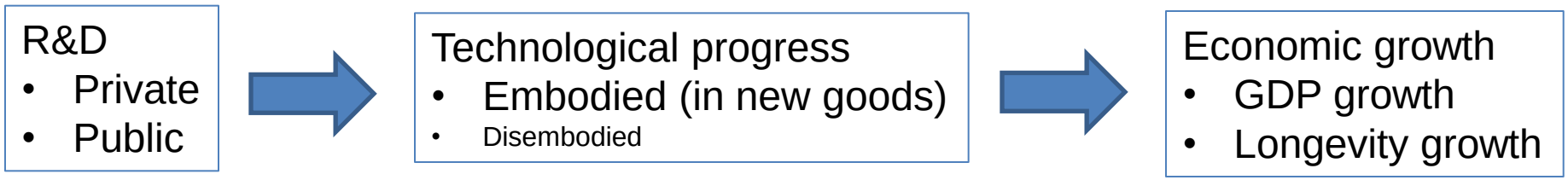


Source: U.S. National Science Foundation, *Science and Engineering Indicators 2010*, appendix table 4-14

2011 U.S. Biomedical and Health R&D Spending (millions of dollars)



R&D, technological progress, and economic growth



Has medical innovation reduced cancer mortality?

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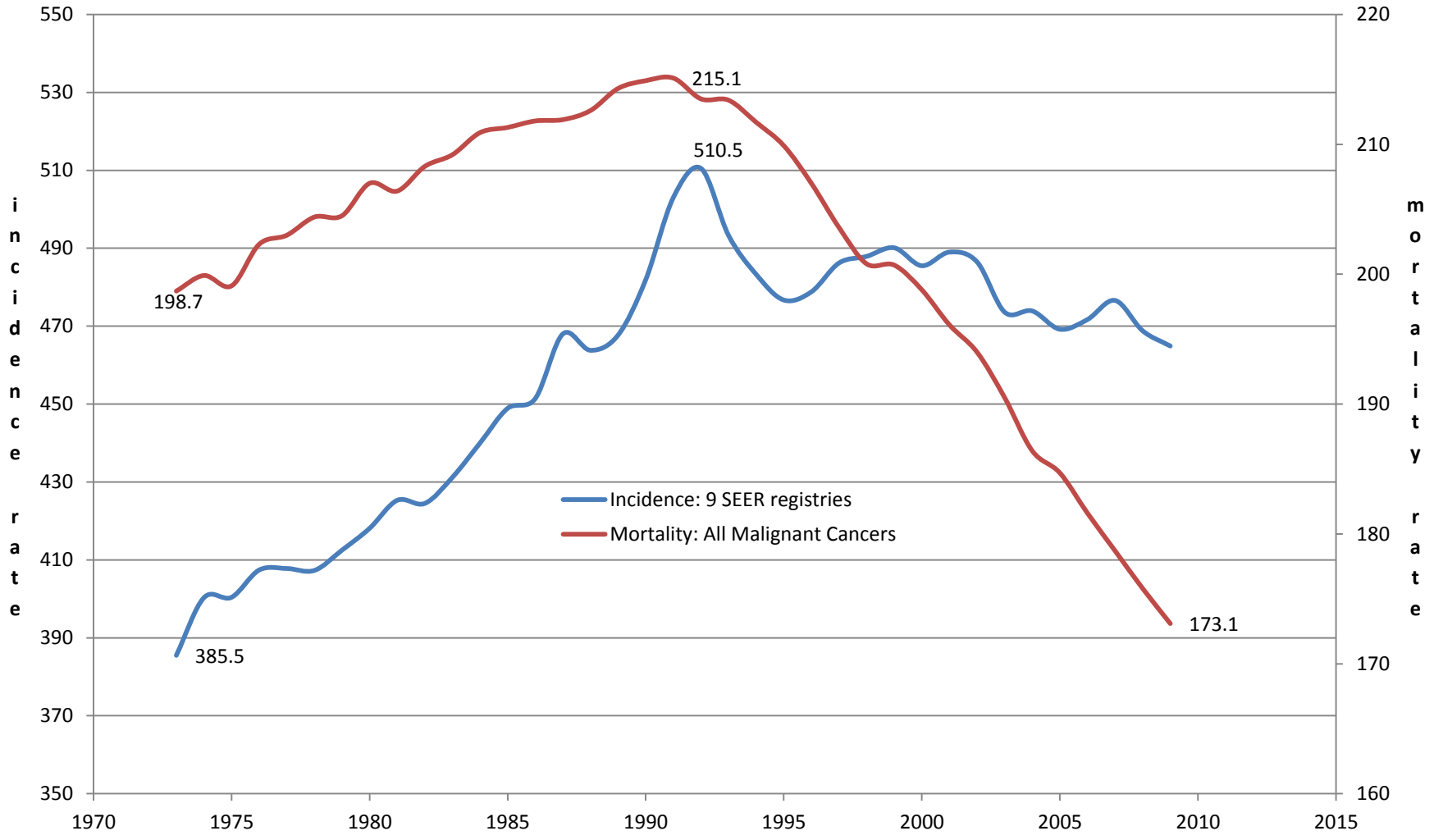
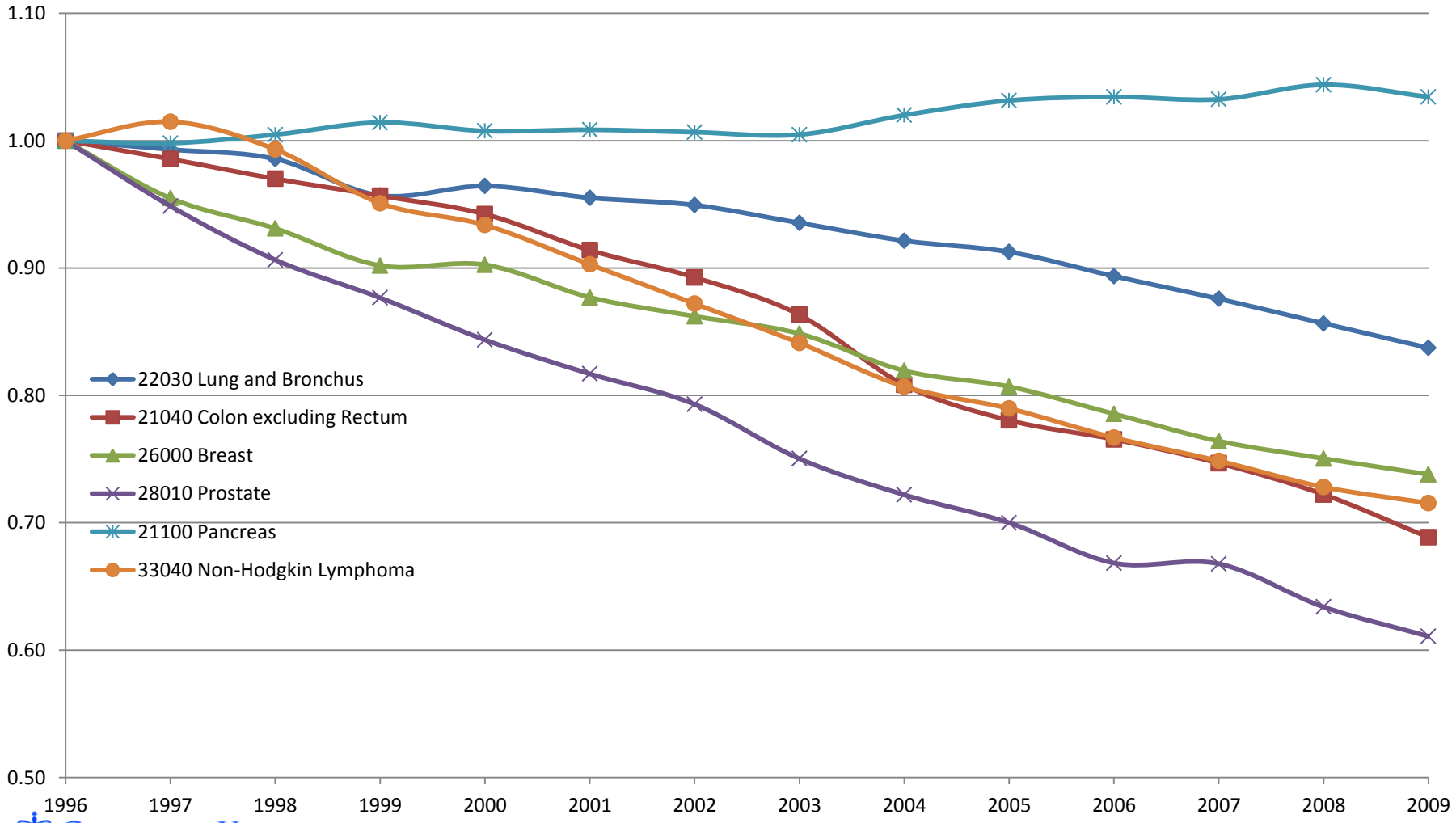
Age-adjusted U.S. cancer incidence and mortality rates, 1973-2009

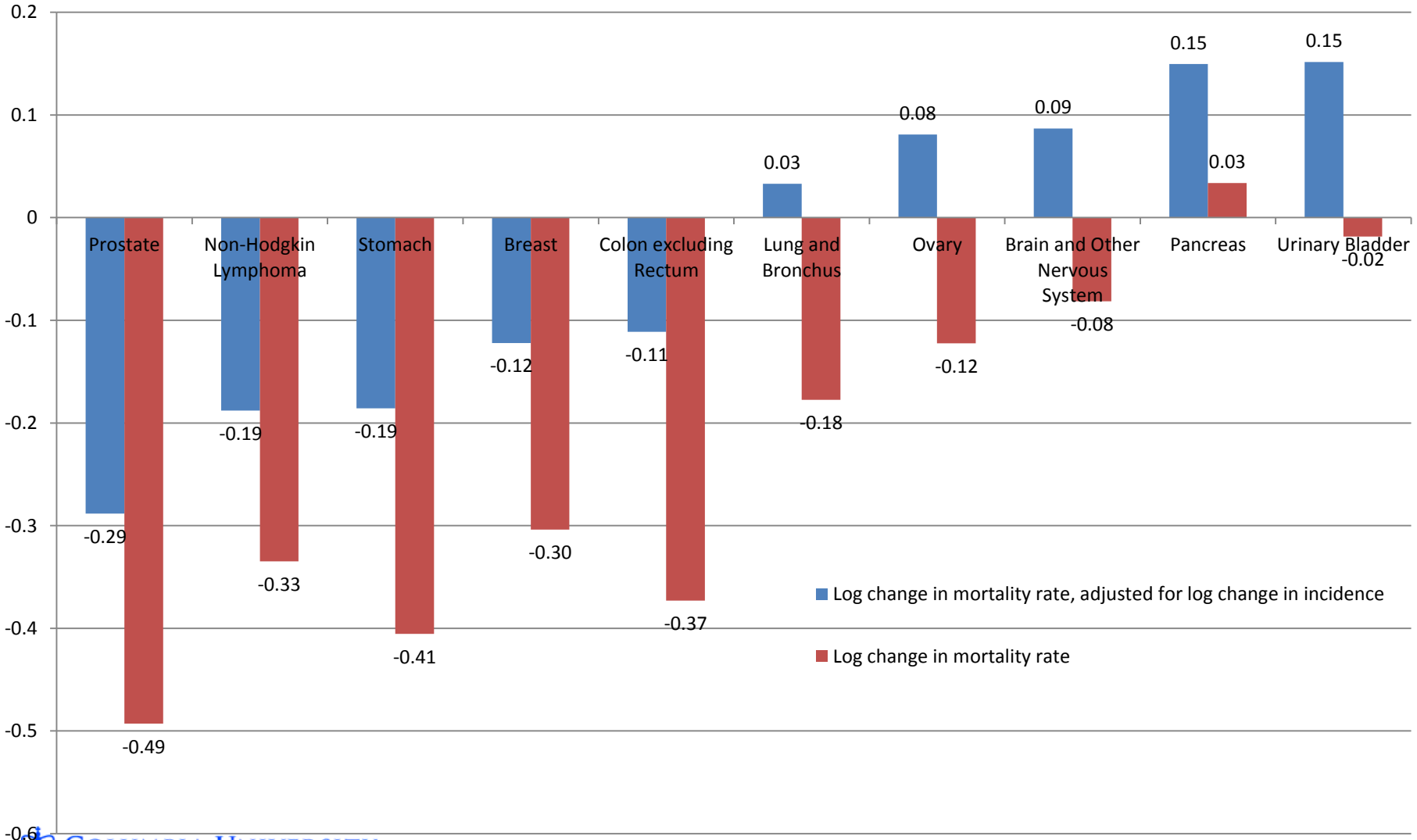


During the period I studied (1996-2009), the age-adjusted cancer mortality rate declined 19%; the age-adjusted cancer incidence rate declined by only 4%.

Age-adjusted mortality rate, six major cancer sites, 1996-2009 (index: 1996 = 1.00)



Log change in age-adjusted mortality rate, 1996-2009, top 10 cancer sites (ranked by average mortality rate)

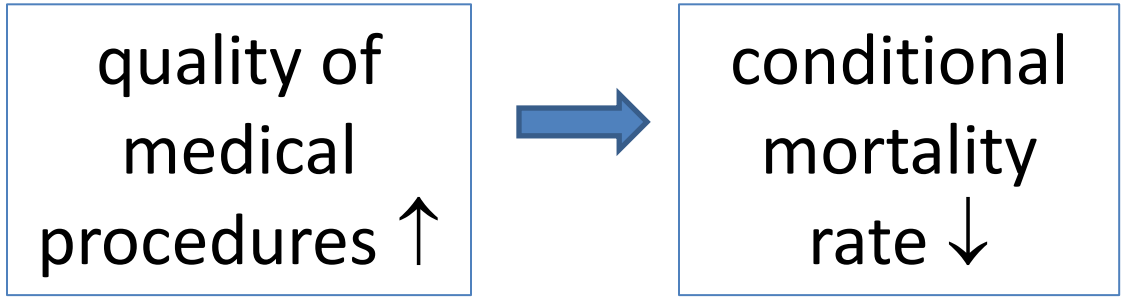


Key hypothesis:

Mortality rates declined more for cancer sites that were subject to more treatment innovation,

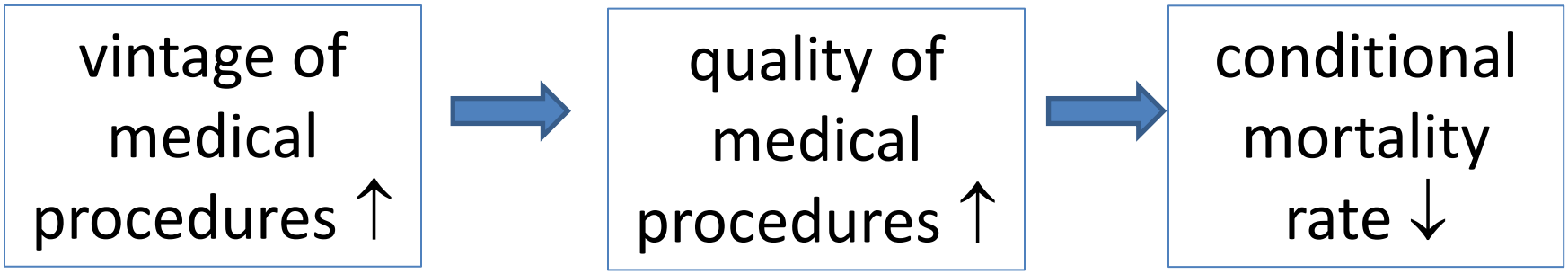
controlling for change in incidence, etc.

Hypothesis: the conditional mortality rate (P(death from cancer | cancer diagnosis)) is inversely related to the average (current and lagged) *quality* of medical procedures



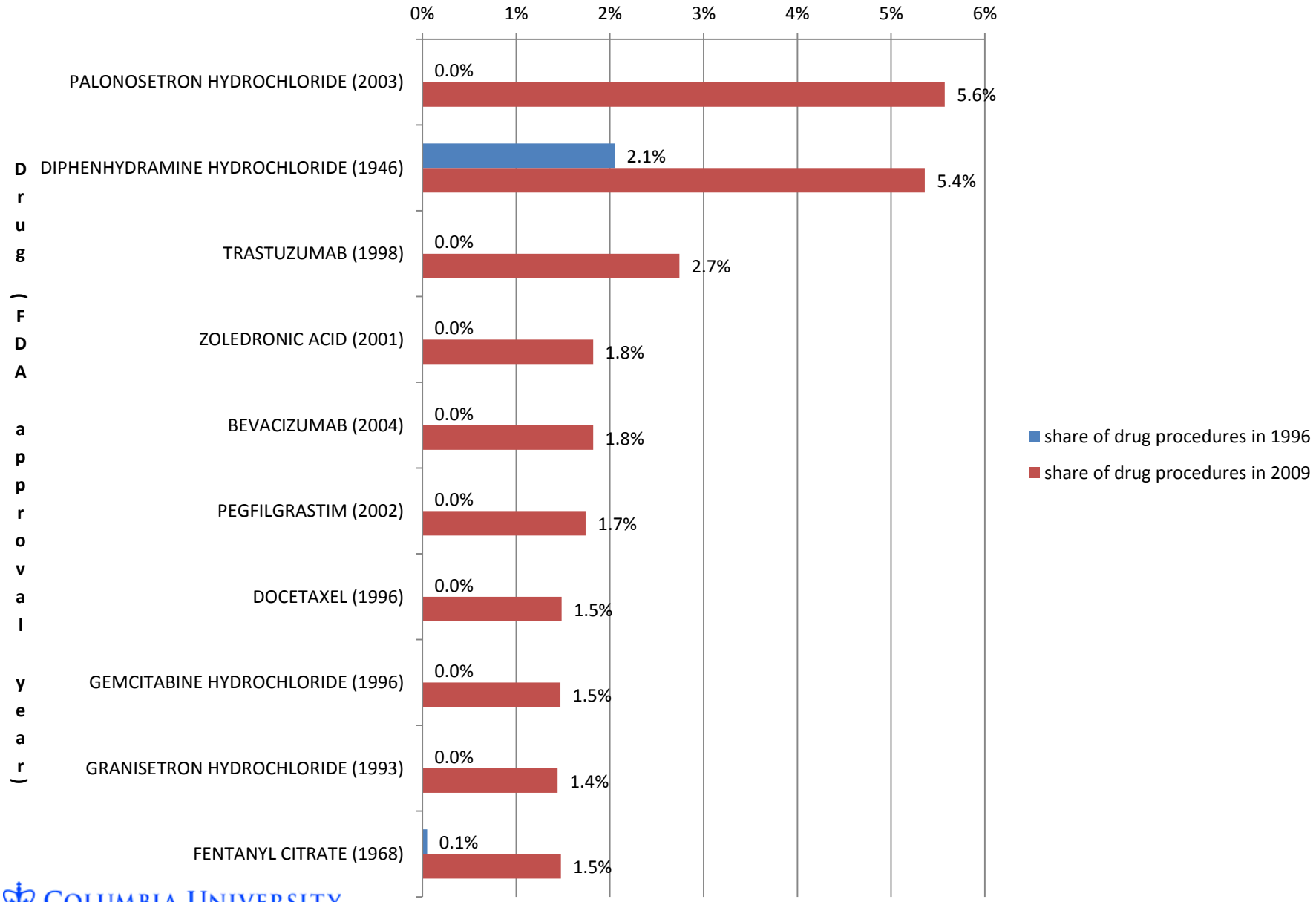
Quality of medical procedures is not directly observable, but…

Hypothesis: treatment quality is directly related to treatment vintage



Drug vintage is defined as the original FDA approval year of the drug's active ingredient(s)

Ten drugs with the largest 1996-2009 increase in share of all cancer drug procedures



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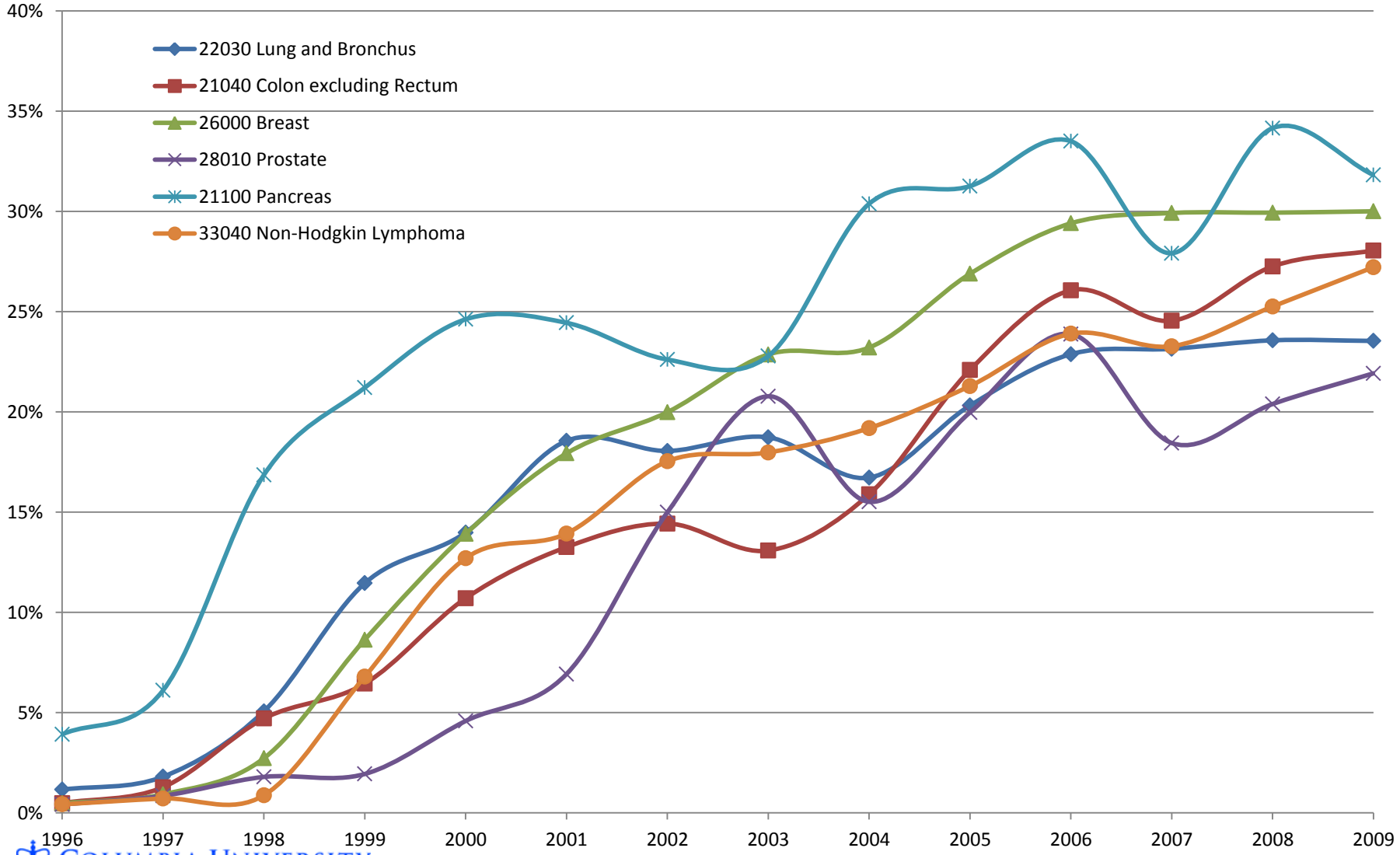
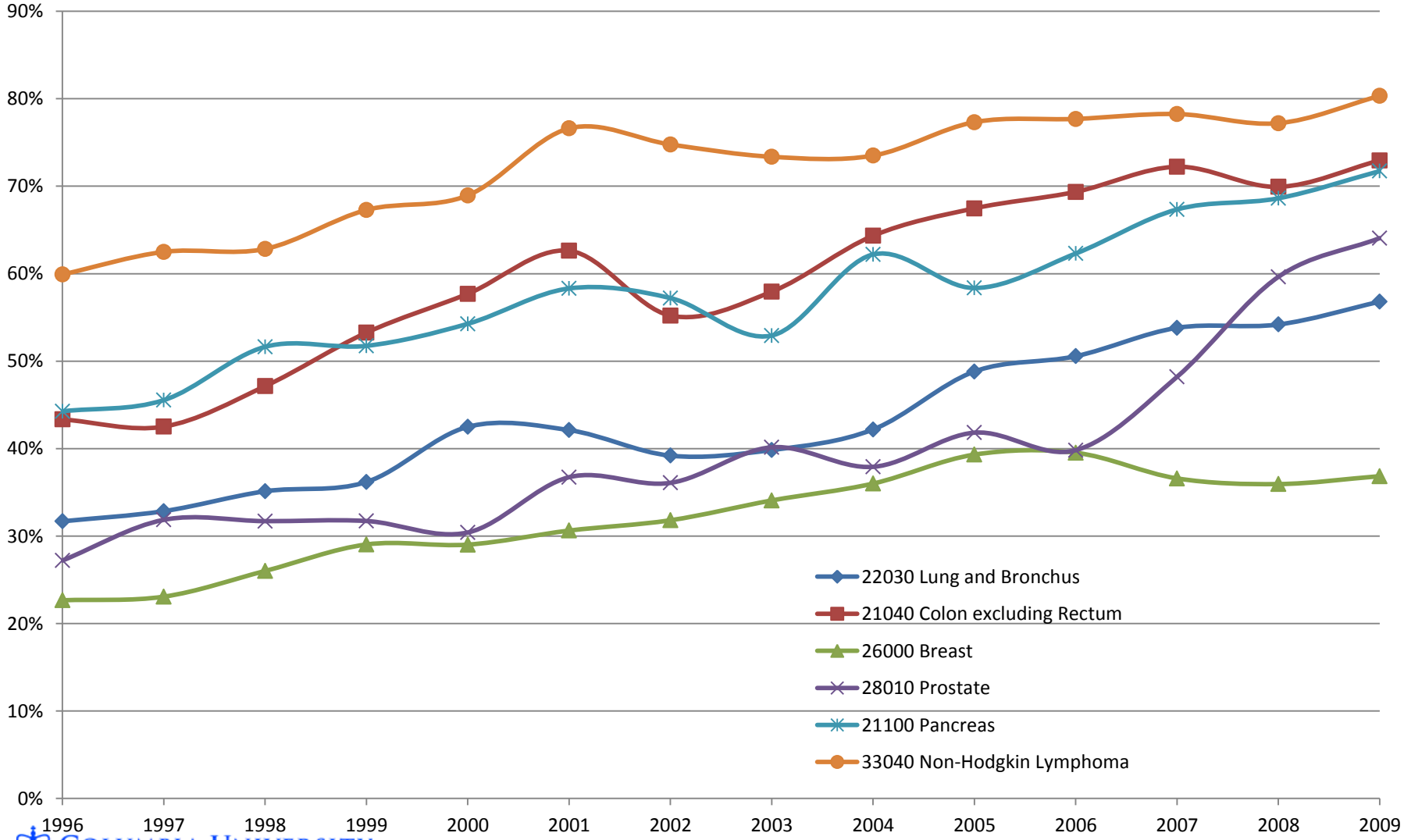
Fraction of drug procedures that were post-1995 drug procedures , 6 major cancer sites, 1996-2009



Fraction of imaging procedures that were advanced imaging procedures, 6 major cancer sites, 1996-2009



3 major reasons for the 13.8% decline in the cancer mortality rate during 2000-2009

- **Drug innovation reduced the cancer mortality rate by 8.0%.**
- Imaging innovation reduced the cancer mortality rate by 4.0%.
- The 3% decline in the cancer incidence rate is estimated to have reduced the cancer mortality rate by just 1.2%.
- Estimates of the effects of radiation and surgical innovation were not significant, but these types of innovation are more difficult to measure than drug and imaging innovation.

Benefits vs. costs of innovation

- Murphy and Topel (2006) estimated that a "1 percent reduction in [U.S.] cancer mortality would be worth nearly $500 billion."
- This implies that the value of the mortality reduction resulting from cancer drug innovation was $4.0 trillion (= 8.0 * $500 billion).
- Data from IMS Health indicate that total U.S. expenditure on "new" (post-1995) cancer drugs in 2009 was $31.0 billion
- If Murphy and Topel's and my calculations are correct, **the cost of new cancer drugs is less than 1% of the value of the mortality reduction they yielded.**

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

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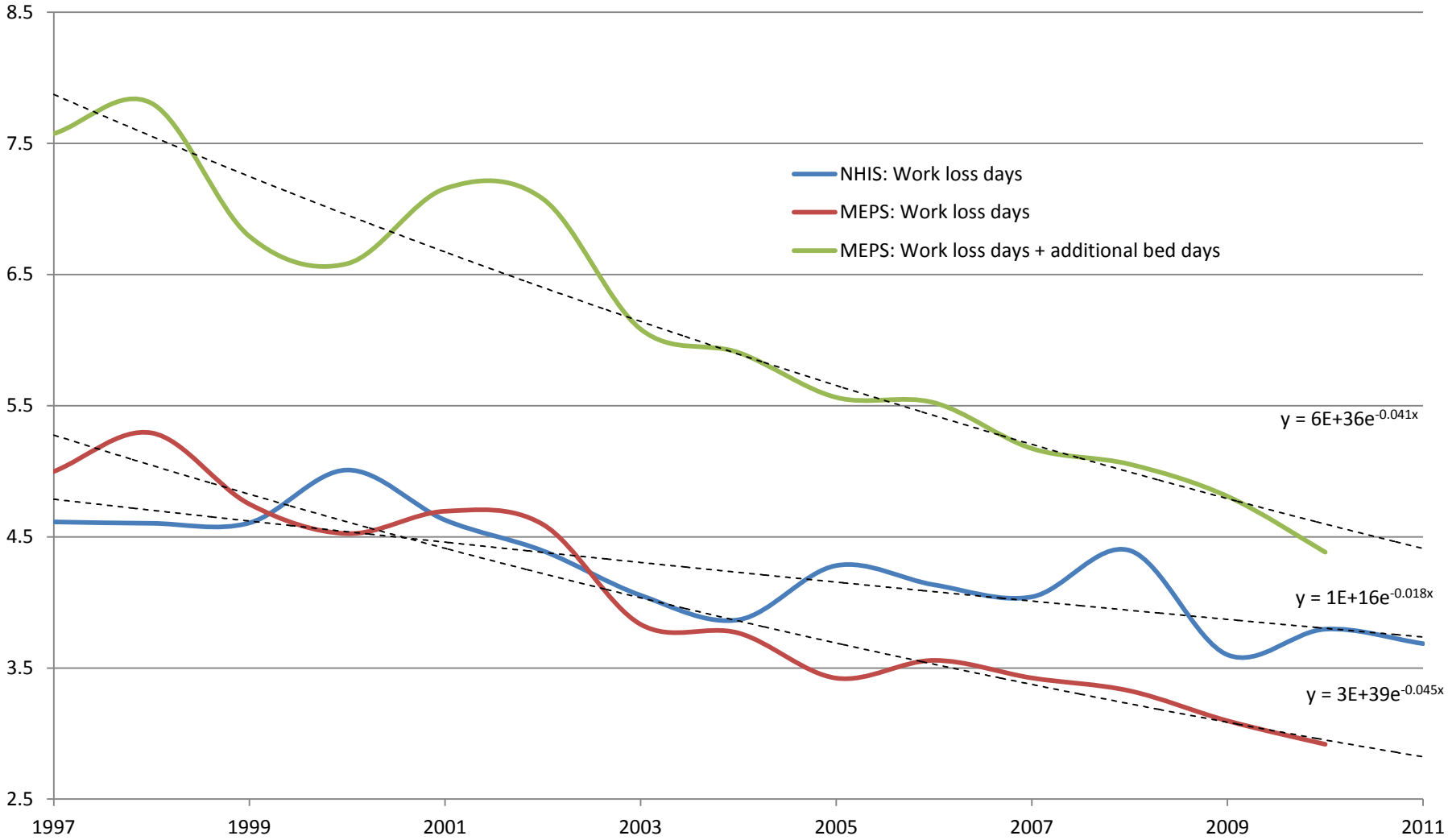
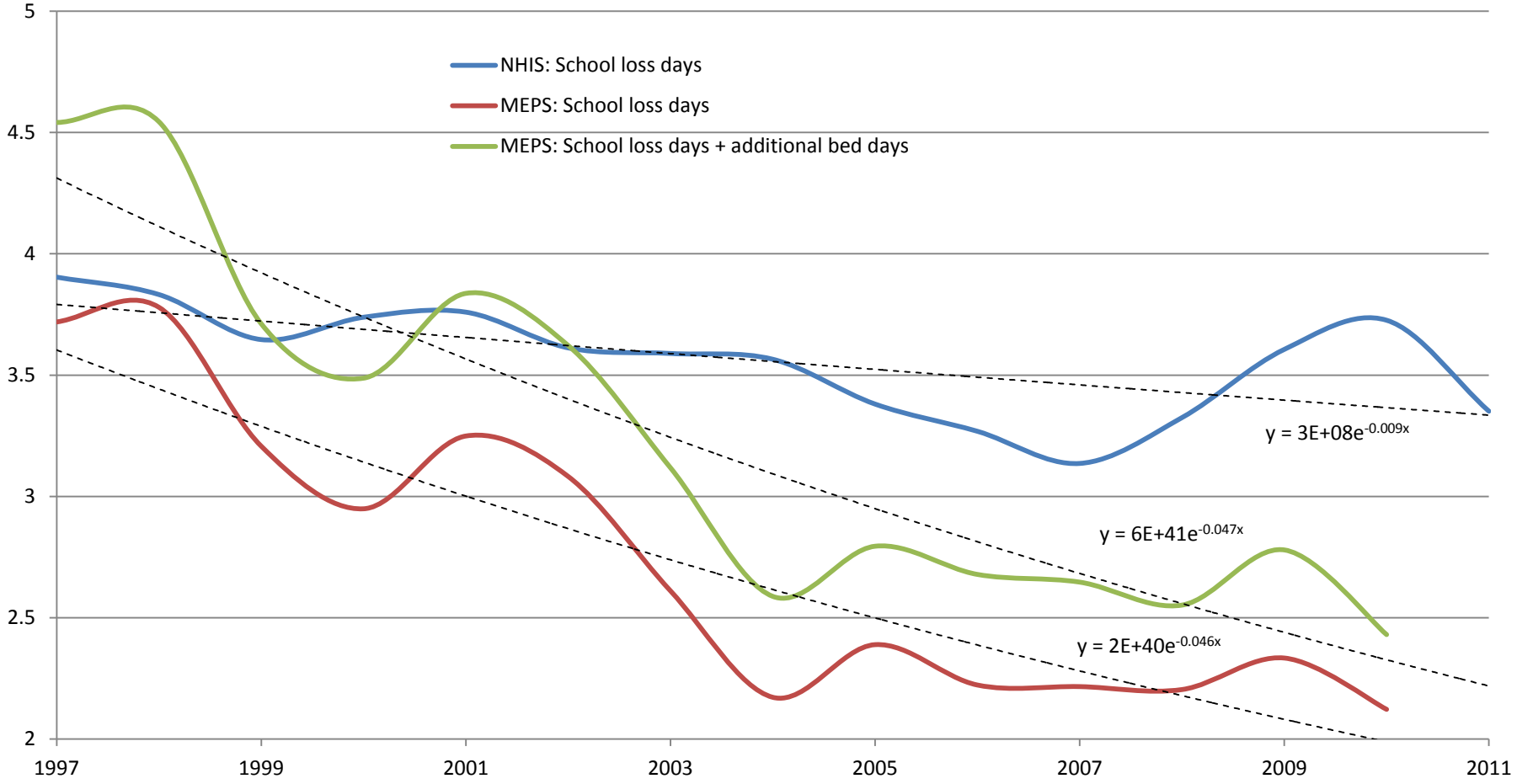
Mean number of work-loss days per year, employed persons 18 years of age and older



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)

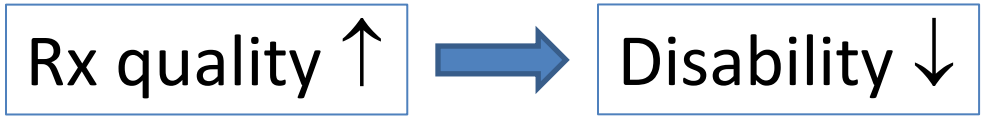
Mean number of school days missed per year because of illness or injury for children aged 5–17



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)

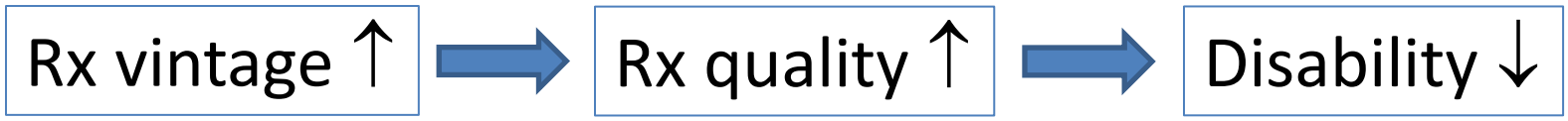
Hypothesis: medical innovation—especially pharmaceutical innovation—has played an important role in reducing disability days

Hypothesis: disability is inversely related to Rx quality



Rx quality is not directly observable, but…

Hypothesis: Rx quality is directly related to Rx vintage



Rx vintage is defined as the original FDA approval year of the drug's active ingredient(s)

Other medical innovation

- The **number of people exposed** to pharmaceutical innovation tends to be much larger than the number of people exposed to other types of medical innovation: for example, in 2007, 62% of Americans consumed prescription drugs, while only 8% of Americans were admitted to hospitals.
- **Pharmaceuticals are more research-intensive** than other types of medical care: in 2007, prescription drugs accounted for 10% of U.S. health expenditure, but more than half of U.S. funding for biomedical research came from pharmaceutical and biotechnology firms. Much of the rest came from the federal government (i.e. the NIH), and new drugs often build on upstream government research (Sampat and Lichtenberg, 2011).
- Evidence presented in Lichtenberg (2013) suggests that the rate of pharmaceutical innovation is uncorrelated across diseases with rates of innovation in imaging and other procedures.

Econometric model to assess the impact of pharmaceutical innovation on disability days and the use of medical services

$$\ln(Y_{ct}) = \pi\, RX\_VINTAGE_{ct} + \gamma\, Z_{ct} + \alpha_c + \delta_t + \varepsilon_{ct} \qquad (1)$$

Y_{ct}	= a measure of disability days or the use of medical services associated with medical condition c in period t
$RX\_VINTAGE_{ct}$	= a measure of the mean vintage of prescription drugs used to treat medical condition c in period t
Z_{ct}	= a measure of other attributes of medical condition c in period t
α_c	= a fixed effect for medical condition c
δ_t	= a fixed effect for period t

Estimates of disability-days and medical service use models

- Medical conditions that had larger increases in the number of post-1990 drugs per person tended to have larger declines in (per capita and total) disability days and use of almost all non-drug medical services.
- An increase in drug quality improves health more when the average quantity of drugs consumed is high.

Cost and benefits per medical condition in 2010 of new (post-1990) drugs

Cost of new (post-1990) drugs	**$42**
Benefits of new drugs	
• value of the reduction in the number of work loss days	$14
• value of the reduction in the number of other bed days	$10
• reduction in hospital expenditure	$39
• reduction in office-based expenditure	$10
• reduction in emergency room expenditure	$6
• reduction in home health expenditure	$5
• reduction in old (pre-1991) drug expenditure	$11
Total value of benefits	**$95**

Conclusions

- The cost of new cancer drugs is less than 1% of the value of the mortality reduction they yielded
- Pharmaceutical innovation has reduced work-loss and school-loss days
- Pharmaceutical innovation has reduced non-drug medical expenditure (e.g. hospital expenditure) more than it has increased drug expenditure
- **Good access to new drugs is needed to ensure that society enjoys the benefits of pharmaceutical innovation**