The value and determinants of biopharmaceutical innovation

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Two major points about biopharmaceutical innovation

- Biopharmaceutical innovation has been extremely valuable in the U.S. and globally. It has:
  - Increased longevity
  - Reduced disability
  - Reduced the average cost of health care episodes
- Financial incentives influence the amount of biopharmaceutical innovation

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The effect of pharmaceutical innovation on longevity: Evidence from the U. S. and 26 high-income countries

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ABSTRACT

This study examines the impact that pharmaceutical innovation, which accounts for most private biomedical research expenditure, has had on longevity. We perform two types of two-way fixed-effects analyses, which control for the effects of many potentially confounding variables. First, we analyze long-run (2006–2018) *changes* in longevity associated with different diseases in a single country: the U.S. Then, we analyze relative longevity *levels* associated with different diseases in 26 high-income countries during a single time period (2006–2016). The measure of longevity we analyze, mean age at time of death, is strongly positively correlated across countries with life expectancy at birth. The measure of pharmaceutical innovation we use is the mean vintage (year of initial world launch) of the drugs used to treat each disease in each country. Changes in the vintage distribution of drugs are due to both entry of new drugs and exit of old drugs. Our analysis of U.S. data indicates that the diseases for which there were larger increases in drug vintage tended to have larger increases in the longevity of Americans of all races and both sexes. In other words, the lower the mean age of the drugs, the higher the mean age at death. We test, and are unable to reject, the "parallel trends" hypothesis. We estimate that the 2006–2018 increase in drug vintage increased the mean age at death of Americans by about 6 months (66% of the observed increase). Controlling for sex, race, and education has only a small effect on the estimate of the vintage coefficient. The estimates indicate that drug vintage did not have a significant effect on the mean age at death of decedents with less than 9 years of education. Drug vintage had a positive and significant effect on the mean age at death of decedents with at least 9 years of education, and a larger effect on the mean age at death of decedents with at least 13 years of education. The finding that pharmaceutical innovation has a larger effect on the longevity of people with more education is consistent with previous evidence that more educated people are more likely to use newer drugs. Our analysis of data on 26 high-income countries indicates that the higher the vintage of drugs available to treat a disease in a country, the higher mean age at death was, controlling for fixed disease and country effects. The increase in drug vintage is estimated to have increased mean age at death in the 26 countries by 1.23 years between 2006 and 2016—73% of the observed increase. We obtain estimates of the cost of pharmaceutical innovation—its impact on drug expenditure—as well as estimates of an important benefit of pharmaceutical innovation—the number of life-years gained from it—and of their ratio, i.e., the incremental cost-effectiveness ratio. Estimates of the cost per life-year gained for the U.S. and the 26 countries are $35,817 and $13,904, respectively. Both figures are well below per capita GDP in the respective regions, suggesting that, overall, pharmaceutical innovation was highly cost-effective.

1. Introduction

Longevity increase is a very important part of economic growth, broadly defined. Nordhaus (2005) argued that "improvements in health status have been a major contributor to economic welfare over the twentieth century. To a first approximation, the economic value of increases in longevity in the last hundred years is about as large as the value of measured growth in non-health goods and services." Murphy and Topel (2006) estimated that cumulative gains in life expectancy after 1900 were worth over $1.2 million to the representative American in 2000, whereas post-1970 gains added about $3.2 trillion per year to national wealth, equal to about half of GDP. The United Nations' Human Development Index, which is used to rank countries into four tiers of human development, is a composite statistic of life expectancy, income per capita, and education (United Nations Development Program, 2022).

There is a consensus among macroeconomists that technological progress is the principal source of GDP growth. Romer, (1990) (p. S71) argued that "growth…is driven by technological change that arises from intentional investment decisions made by profit-maximizing agents."

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2006-2018 increase in U.S. longevity (mean age at death) attributable to increase in drug vintage

- I estimated that the 2006-2018 increase in drug vintage:
  - increased the mean age at death of all races by 0.79 years (103% of the observed increase)
  - increased the mean age at death of Black Americans by 0.88 years (54% of the observed increase).

Findings: longevity levels in 26 countries

- **Biopharmaceutical innovation (the increase in drug vintage) is estimated to have increased mean age at death in 26 countries by 1.50 years between 2006 and 2016.**
- This increase is almost twice as large as my maximum estimate of the 2006-2018 increase in mean age at death in the U.S. attributable to the increase in drug vintage (0.79 years).
- However, longevity increased much more throughout the world than it did in the U.S., so **the increase in drug vintage accounted for 36% of the overall increase in mean age at death in 26 countries.**

Article

Frank R. Lichtenberg*

The Impact of Biopharmaceutical Innovation on Disability, Social Security Recipiency, and Use of Medical Care of U.S. Community Residents, 1998–2015

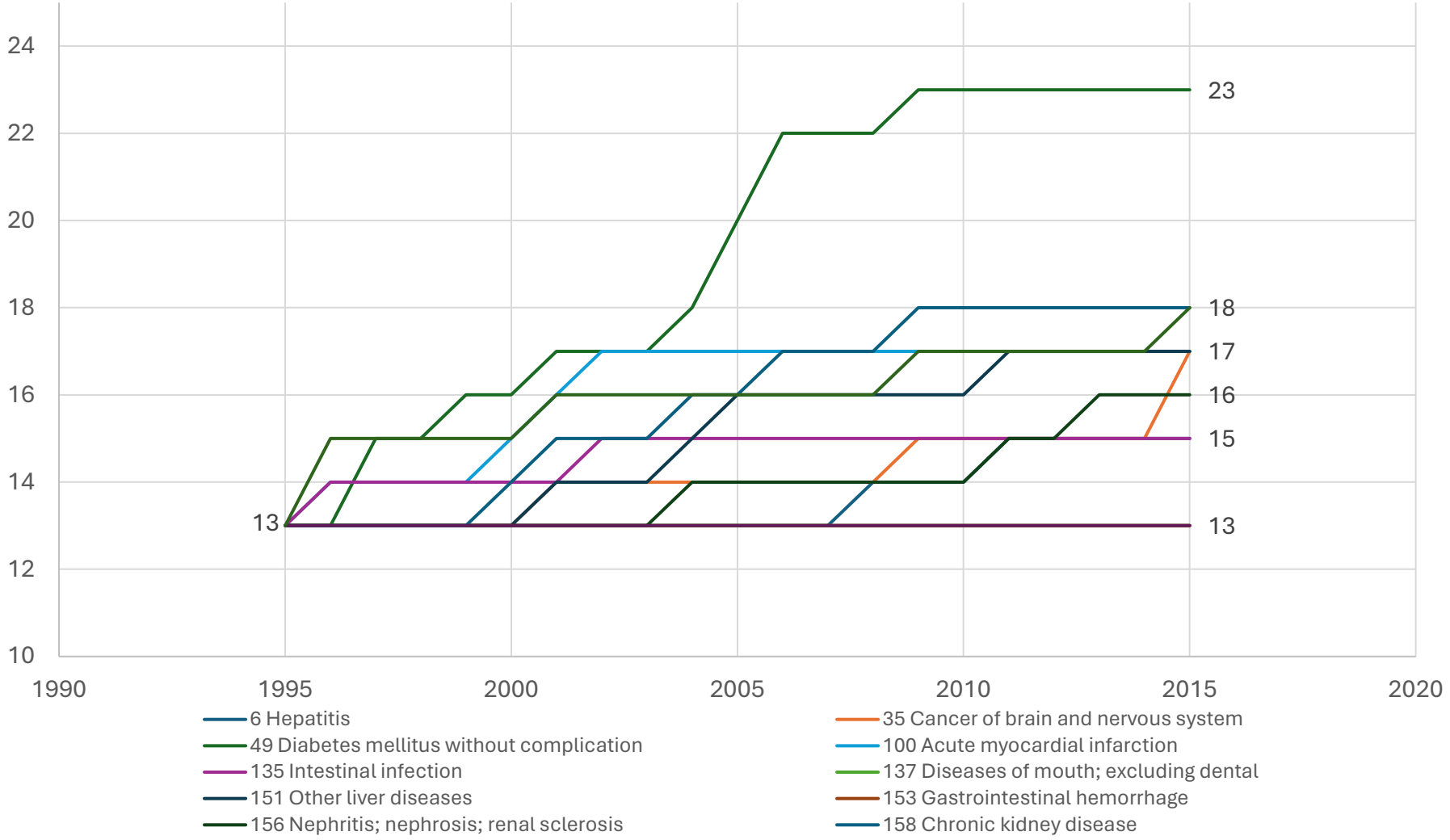
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Abstract: This study seeks to analyze the overall impact that biopharmaceutical innovation had on disability, Social Security recipiency, and the use of medical services of U.S. community residents during the period 1998–2015. We test the hypothesis that the probability of disability, Social Security recipiency, and medical care utilization associated with a medical condition is inversely related to the number of drug classes previously approved for that condition. We use data from the 1998–2015 waves of the Medical Expenditure Panel Survey and other sources to estimate probit models of an individual's probability of disability, Social Security recipiency, and medical care utilization. The effect of biopharmaceutical innovation is identified by differences across over 200 medical conditions in the growth in the lagged number of drug classes ever approved. 18 years of previous biopharmaceutical innovation is estimated to have reduced: the number of people who were completely unable to work at a job, do housework, or go to school in 2015 by 4.5%; the number of people with cognitive limitations by 3.2%; the number of people receiving SSI in 2015 by 247 thousand (3.1%); and the number of people receiving Social Security by 984 thousand (2.0%). Previous innovation is also estimated to have caused reductions in home health visits (9.2%), inpatient events (5.7%), missed school days (5.1%), and outpatient events (4.1%). The estimated value in 2015 of some of the reductions in disability, Social Security recipiency, and use of medical care attributable to previous biopharmaceutical innovation ($115 billion) is fairly close to 2015 expenditure on drug classes that were first approved by the FDA during 1989–2006 ($127 billion). However, for a number of reasons, the costs are likely to be lower, and the benefits are likely to be larger, than these figures.

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The impact of biopharmaceutical innovation on disability, Social Security recipiency, and use of medical care of U.S. community residents, 1998-2015. *Forum for Health Economics & Policy* 24(1): 35-74, 2022 Aug 30.

Number of WHO ATC4 chemical subgroups ever FDA-approved for 12 diseases, 1995-2015



Findings

- The estimates indicate that **the probability of disability, Social Security recipiency, and medical care utilization is inversely related to the number of drug classes previously approved.**
- The **length of the estimated lag is generally 6-9 years**, which is not surprising, due to the gradual diffusion of new drug classes.
  - Due to this lag, the number of current drug class approvals may be useful **predictors** of future disability, Social Security recipiency, and medical care use.

Estimated reductions in disability, Social Security recipiency, and use of medical care

- Previous innovation is estimated to have reduced:
  - the number of people who were completely unable to work at a job, do housework, or go to school in 2015 by 4.5%
  - the number of people with cognitive limitations by 3.2%
  - the number of people receiving SSI in 2015 by 247 thousand (3.1%)
  - the number of people receiving Social Security by 984 thousand (2.0%)
  - the number of home health visits by 9.2%
  - the number of inpatient events by 5.7%

Estimated value in 2015 of some reductions in disability, Social Security recipiency, and use of medical care attributable to previous pharmaceutical innovation

outcome	% reduction	estimated value (millions of dollars)
unable to work?	3.9%	$27,124
receives SSI?	3.1%	$2,287
receives Social Security?	2.0%	$13,990
any emergency room visits?	2.3%	$1,542
any inpatient events?	5.7%	$56,136
any home health visits?	9.2%	$8,234
any outpatient events?	4.1%	$5,482
TOTAL		$114,794

- The total value ($115 billion) is fairly close to 2015 expenditure on drug classes that were first approved by the FDA during 1989-2006 ($127 billion).
- However, for a number of reasons, the costs are likely to be lower, and the benefits are likely to be larger, than these figures.

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RESEARCH ARTICLE

Has pharmaceutical innovation reduced the average cost of U.S. health care episodes?

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Abstract
A number of authors have argued that technological innovation has increased U.S. health care spending. We investigate the impact that pharmaceutical innovation had on the average cost of U.S. health care episodes during the period 2000–2014, using data from the Bureau of Economic Analysis' Health Care Satellite Account and other sources. We analyze the relationship across approximately 200 diseases between the growth in the number of drugs that have been approved to treat the disease and the subsequent growth in the mean amount spent per episode of care, controlling for the growth in the number of episodes and other factors. Our estimates indicate that mean episode cost is not significantly related to the number of drugs ever approved 0–4 years before, but it is significantly inversely related to the number of drugs ever approved 5–20 years before. This delay is consistent with the fact (which we document) that utilization of a drug is relatively low during the first few years after it was approved, and that some drugs may have to be consumed for several years to have their maximum impact on treatment cost. Our estimates of the effect of pharmaceutical innovation on the average cost of health care episodes are quite insensitive to the weights used and to whether we control for 3 covariates. Our most conservative estimates imply that the drugs approved during 1986–1999 reduced mean episode cost by 4.7%, and that the drugs approved during 1996–2009 reduced mean episode cost by 2.1%. If drug approvals did not affect the number of episodes, the drugs approved during 1986–1999 would have reduced 2014 medical expenditure by about $93 billion. However, drug approvals may have affected the number, as well as the average cost, of episodes. We also estimate models of hospital utilization. The number of hospital days is significantly inversely related to the number of drugs ever approved 10–19 years before, controlling for the number of disease episodes. Our estimates imply that the drugs approved during 1984–1997 reduced the number of hospital days by 10.5%. The hospital cost reduction was larger than expenditure on the drugs.

Keywords Health care cost · Innovation · Pharmaceutical

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Extended author information available on the last page of the article

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Estimated reduction in cost_per_case

- **My most conservative estimates imply that the drugs approved during 1986-1999 reduced cost_per_case by 4.7%, and that the drugs approved during 1996-2009 reduced cost_per_case by 2.1%.**
- According to the BEA, aggregate expenditure on medical services by disease was $2005 billion in 2014. Therefore, **if drug approvals did not affect the *number* of episodes, the drugs approved during 1986-1999 would have reduced 2014 medical expenditure by about $93 billion (= 4.7% * $2005 billion).**

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IMPORTATION AND INNOVATION

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Importation of drugs into the US may soon become legal. Since prices of drugs are lower in most other countries than they are in the US, importation would result in a decline in US drug prices. The purpose of this paper is to assess the consequences of importation for new drug development.

First, the author presents a simple theoretical model of drug development which suggests that the elasticity of innovation with respect to the expected price of drugs should be at least as great as the elasticity of innovation with respect to expected market size (disease incidence). Then, the cross-sectional relationship between pharmaceutical innovation and market size among a set of diseases (different types of cancer) exhibiting substantial exogenous variation in expected market size is examined. Two different measures of pharmaceutical innovation are analysed: the number of distinct chemotherapy regimens for treating a cancer site and the number of articles published in scientific journals pertaining to drug therapy for that cancer site.

Both analyses indicate that the amount of pharmaceutical innovation increases with disease incidence. The elasticity of the number of chemotherapy regimens with respect to the number of cases is 0.53. The elasticity of MEDLINE drug cites with respect to cancer incidence throughout the world is 0.60. In the long run, a 10% decline in drug prices would therefore be likely to cause at least a 5–6% decline in pharmaceutical innovation. Evidence suggests that pharmaceutical industry employment would also decline (by at least 3.5–4%) in response to an exogenous 10% decline in drug prices.

Keywords: Pharmaceuticals; Importation; Innovation; Cancer; Chemotherapy; Employment

1 INTRODUCTION

Importation of drugs into the US may soon become legal. Since prices of drugs are lower in most other countries than they are in the US, importation would result in a decline in US drug prices. The price decline would benefit US consumers in the short run. However, importation may have two other effects that could reduce the welfare of US consumers. First, importation could reduce the quality, or safety, of drugs purchased by Americans and increase the number of adverse drug events. Second, importation could reduce the number of new drugs developed in the future by reducing the expected profitability of new drug development. In previous papers (Lichtenberg, 2005a, b, c), I have shown that the introduction of new drugs has increased the longevity and ability to work and reduced the utilization of hospitals and nursing homes.

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Importation and innovation, *Economics of Innovation and New Technology*, 2007, Vol. 16(6), September, pp. 403–417

IMPORTATION AND INNOVATION

- Two analyses indicated that the amount of pharmaceutical innovation increases with disease incidence (market size).
- In the long run, a 10% decline in drug prices would therefore be likely to cause at least a 5–6% decline in pharmaceutical innovation.
- Evidence suggests that pharmaceutical industry employment would also decline (by at least 3.5–4%) in response to an exogenous 10%decline in drug prices.