**Lecture 7 – Sales Pitches vs Real Estimates of Private and Social Returns From R&D**
**From Micro to Macro GDP accounts**
**I. Micro Claims vs Evidence**

"If we want to make the best products, we also have to invest in the best ideas. **Every dollar we invested to map the human genome returned $140 to our economy.** Today, our scientists are mapping the human brain to unlock the answers to Alzheimer's … Now is not the time to gut these job-creating investments in science and innovation. Now is the time to reach a level of research and development not seen since the height of the Space Race." President Obama State of the Union Feb 2013

**Obama announces $100M for brain mapping project** AP: April 2 WASHINGTON — President Barack Obama on Tuesday proposed an effort to map the brain's activity in unprecedented detail, as a step toward finding better ways to treat such conditions as Alzheimer's, autism, stroke and traumatic brain injuries. He asked Congress to spend $100 million next year to start a project that will explore details of the brain, which contains 100 billion cells and trillions of connections. That's a relatively small investment for the federal government — less than a fifth of what NASA spends every year just to study the sun — but it's too early to determine how Congress will react.

**President Obama's Proposal to Double Federal Funding for the BRAIN Initiative** March 11, 2014
Last week, President Obama announced his budget proposal to double the Federal investment in the BRAIN Initiative from about $100 million in Fy 2014 to approximately $200 million in FY 2015. Read the fact sheet to learn more about the proposed investments at various agencies to support groundbreaking research and meet the audacious goals of this initiative. Universities like to claim that their R&D brings great benefits to the locality in which they located.

Published online 11 May 2011 | Nature | doi:10.1038/news.2011.281

News

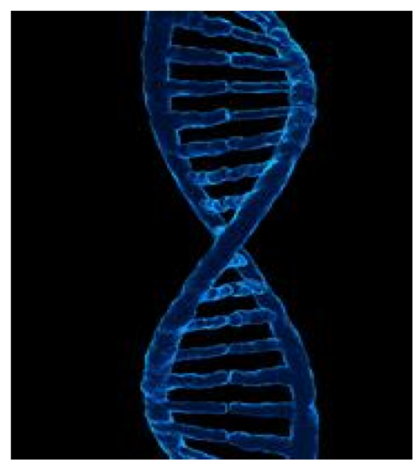
# What is the human genome worth?

**Economists sceptical over study's estimate of massive financial return.**

Nadia Drake

A high-profile claim that the Human Genome Project and associated research generated almost US$800 billion in economic benefits has been questioned by economists.

The estimate comes from the Battelle Memorial Institute, headquartered in Columbus, Ohio. A team of researchers used an 'input–output' economic model to calculate a 141-fold return on each dollar invested in the Human Genome Project. The team's report concludes that a $3.8-billion federal investment (equivalent to $5.6 billion in 2010 dollars) produced $796 billion in economic output between 1988 and 2010 and, in 2010 alone, supported 310,000 jobs.



The Human Genome Project has brought many benefits, but can we put a dollar value on them? *Purestock*

Critics of the report say that the methods used to calculate these numbers, despite being common practice in such studies, are flawed. For example, some of the costs of the project — such as the salaries of those working on it — are counted as benefits.

**Some Previous estimates and related claims**

2010: Nature Vol 465|10 June "What science is really worth?": Collins has recently cited a report by Families USA, a Washington DC-based health advocacy group, which found that every US$1 spent by the NIH typically generates $2.21 in additional economic output within 12 months. Hmm. Costs as benefits.


Would smart people in top universities engage in the same nonsense?.

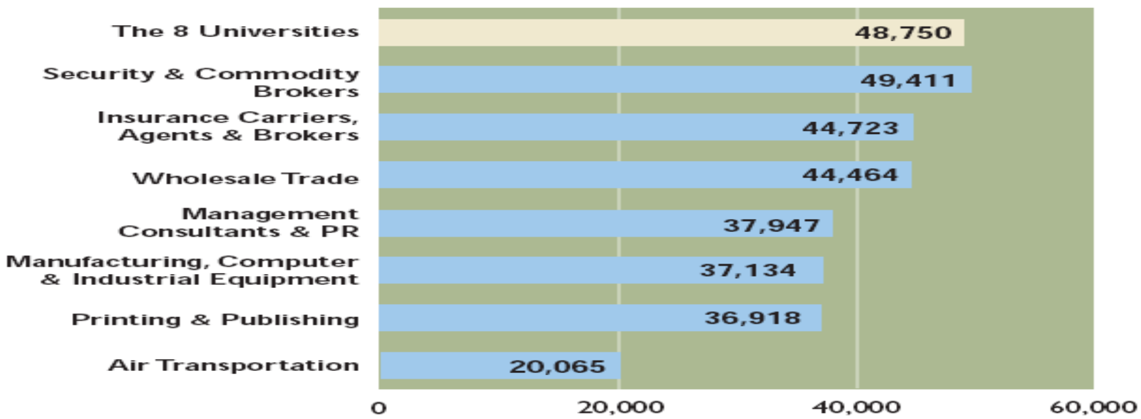
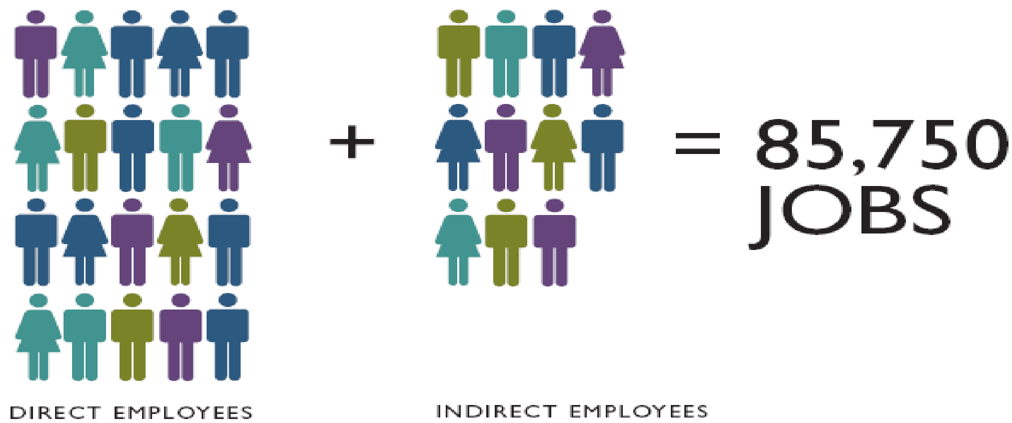



*Figure 4*
In 2000, the research universities collectively employed more people than a number of other leading industries in the Boston area, including banking, insurance, management consulting and computer manufacturing.

*Figure 5*
In addition to the 48,750 employees of the eight major universities in 2000, it is estimated that spending by the universities in their local communities support another 37,000 full-time equivalent jobs. This total does not include the people employed by the universities' affiliated hospitals and research centers.




The universities have also served as a magnet to a number of national and international companies that have located or are developing major research operations in the Boston area. Among them are Amgen, Cisco, Merck, Novartis, Pfizer and Sun Microsystems.

**Where do these numbers come from?**

From input-output "impact studies" based on Leontief's input-output tables that show the interrelationships of purchases and sales among sectors using fixed coefficient production relations. The BEA's Industry Economic Accounts prepares benchmark input-output (I-O) accounts for years ending in 2 and 7, using detailed data from quinquennial economic censuses. The benchmark accounts provide data on the flows of goods and services between some 500 or so industries who provide input to, and use output from, each other to produce gross domestic product.

NIH/GENOME/UNIVERSITY is a final user who buys Research Services. The purchase of services shows up as purchase of intermediate inputs and as Value Added in labor compensation. The producers of the intermediate inputs use other inputs, and those producers use other inputs.

Input-output equations are written as a square matrix of technical coefficients, A, where $a_{cr}$ measures the ratio of purchases that column industry c makes from the row industry r: how much of 1$ of construction output goes to services from transportation. Let X be a column of total outputs of each industry, and Y a column of final demand. Then **X=AX +Y** shows how the total-output-of-each-industry (X) is used as intermediate good in production or as final-demand (Y). Rewrite as (I—A)X=Y. Then solve for total output: $X=(I—A)^{-1}Y$, where $(I—A)^{-1}$ is the inverse of I-A. This equation determines the full output consistent with the sector A uses sector B uses sector A etc equation.

Given total output of a sector, you can derive the value added from labor and employment. This provides way to determine the total employment, outputs attributable to a given final demand – such as government spending for Human Genome, NIH research, etc.

An NIH study using the Department of Commerce' RIMS II model, projected that $26.6 billion in NIH extramural funding in 2010 directly and indirectly supported 487,900 jobs nationwide, leading to fifteen states experiencing job growth of 10,000 or more. The $23.7 billion spent by NIH... in 2011 directly and indirectly supported 432,094 job. NIH spending in 2011 alone produced $62.132 billion in new economic activity ( NIH'S ROLE IN SUSTAINING THE U.S. ECONOMY summary of May, 2011, United For Medical Research report entitled, "An Economic Engine: NIH Research, Employment, and the Future of the Medical Innovation Sector,")

# Economic Impact of the Human Genome Project

*How a $3.8 billion investment drove $796 billion in economic impact, created 310,000 jobs and launched the genomic revolution*

Battelle measured economic impact using an input/output model that differentiated three different impacts:

**Direct impact** means the specific expenditures, such as each year's NIH and DOE funding on genomics, or specific spending by a given economic sector such as pharmaceuticals on genomics-related research.

**Indirect impacts** are from suppliers to those industries, such as companies that provide services, reagents, equipment and so on.

**Induced impacts** are the follow-on effect of the suppliers and employees spending in the economy.

Battelle used IMPLAN, a software platform that is widely used for calculating economic impacts, and focused on six economic sectors that were mapped to the closest economic sectors in IMPLAN.

Figure ES-1: The Structure of Forward and Backward Linkage Impacts Sequencing

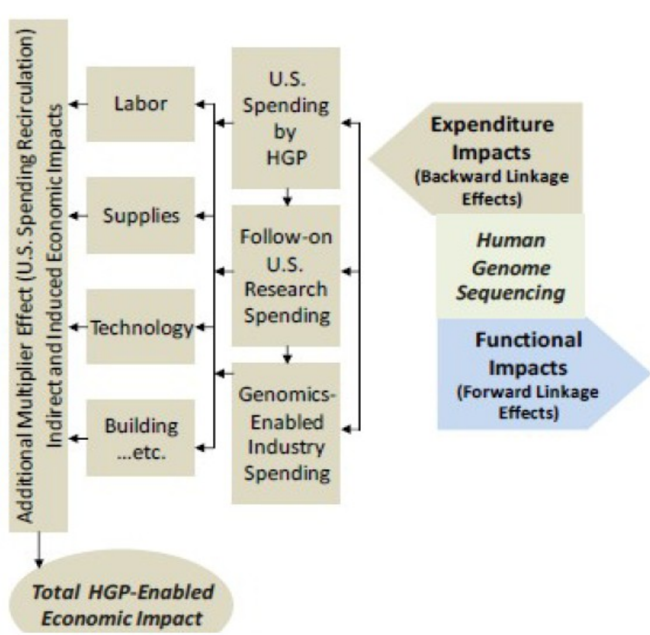
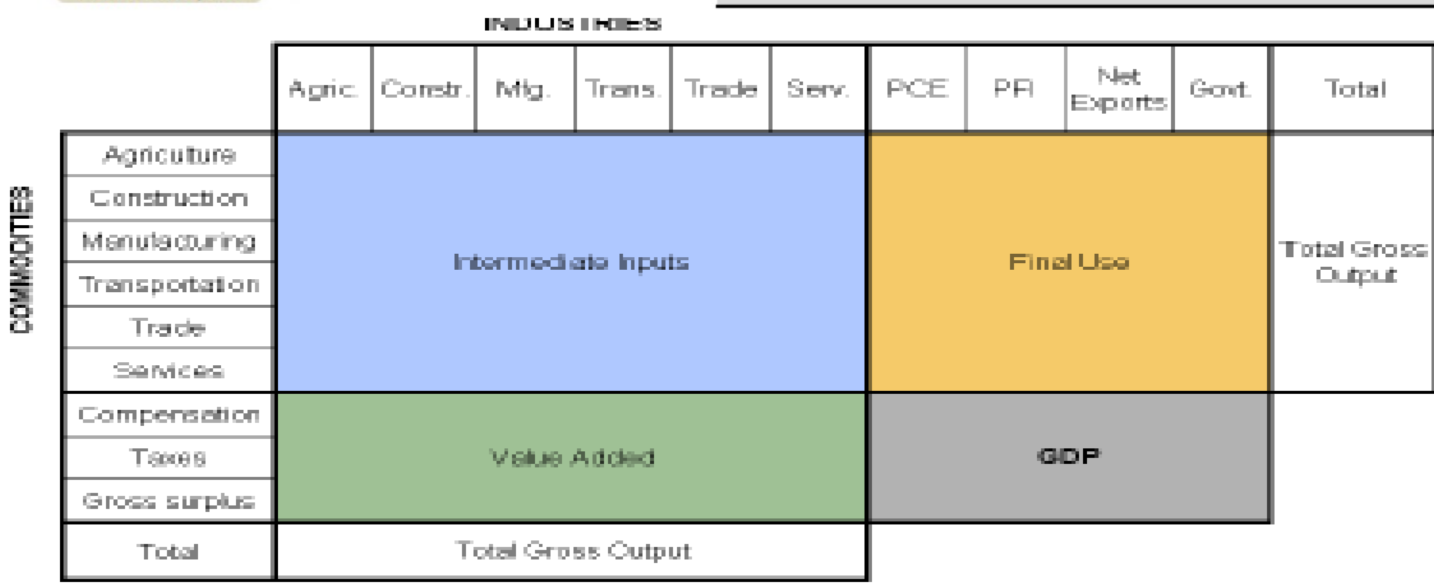



Table ES-1: Cumulative Economic Impact of Human Genome Sequencing, 1988–2010 (in Billions, 2010 $)

| Impact | Employment (Job-Years) | Personal Income | Output | State/Local Tax Revenue | Federal Tax Revenue |
|---|---|---|---|---|---|
| Direct Effect | 710,819 | 71.4 | 264.8 | 3.5 | 13.0 |
| Indirect Impacts | 1,298,216 | 89.2 | 265.8 | 10.8 | 18.0 |
| Induced Impacts | 1,818,459 | 83.3 | 265.7 | 15.2 | 17.9 |
| Total Impact | 3,827,495 | 243.9 | 796.3 | 29.5 | 48.9 |
| Impact Multiplier | 5.38 | 3.42 | 3.01 | 8.37 | 3.75 |



The model and accounting are valid as representation of flows of intermediate goods and services. But NOT to measure benefit-cost of policies.

**Table 9: Economic Impact of the Genomics-Enabled Industry, 2010 (in Millions, 2010 $)**

| Impact | Employment (Jobs) | Personal Income | Output | State/Local Tax Revenue | Federal Tax Revenue |
|---|---|---|---|---|---|
| Direct Effect | 44,372 | 4,889.0 | 21,401.3 | 266.4 | 924.4 |
| Indirect Impacts | 104,126 | 7,309.2 | 21,904.2 | 889.0 | 1,466.0 |
| Induced Impacts | 138,173 | 6,331.5 | 20,185.5 | 1,152.2 | 1,360.1 |
| Total Impact | 286,672 | 18,529.7 | 63,491.0 | 2,307.6 | 3,750.5 |
| Impact Multiplier | 6.46 | 3.79 | 2.97 | 8.66 | 4.06 |

1)**More people hired, resources used → bigger effects.** If hiring 710,819 leads to 4.38 times as many jobs, just hire another 700,000 and we will be at full employment with bigger GDP. Impact includes "cost of project", which in sensible only if resources are unemployed. If genome solved at once, estimated value would have fallen!

2)**Problem of counter factual**: where else might govt have spent money? If comes out of taxes, people reduce demand for something else... SHOULD BE NET CALCULATION. In general, all indirect and induced for given spending are of same order of magnitude so unlikely that any net would show great differences in types of spending

3)**Federal is much smaller than headline** … huge industry effect that is "due" to federal, but industry employment is not massive. It is industry induced and indirect. Not sure why that is so high.

4)**Missing is measure of "sales"/value of output – knowledge – say in terms of improved health.**

**"Real Payoffs" through:**

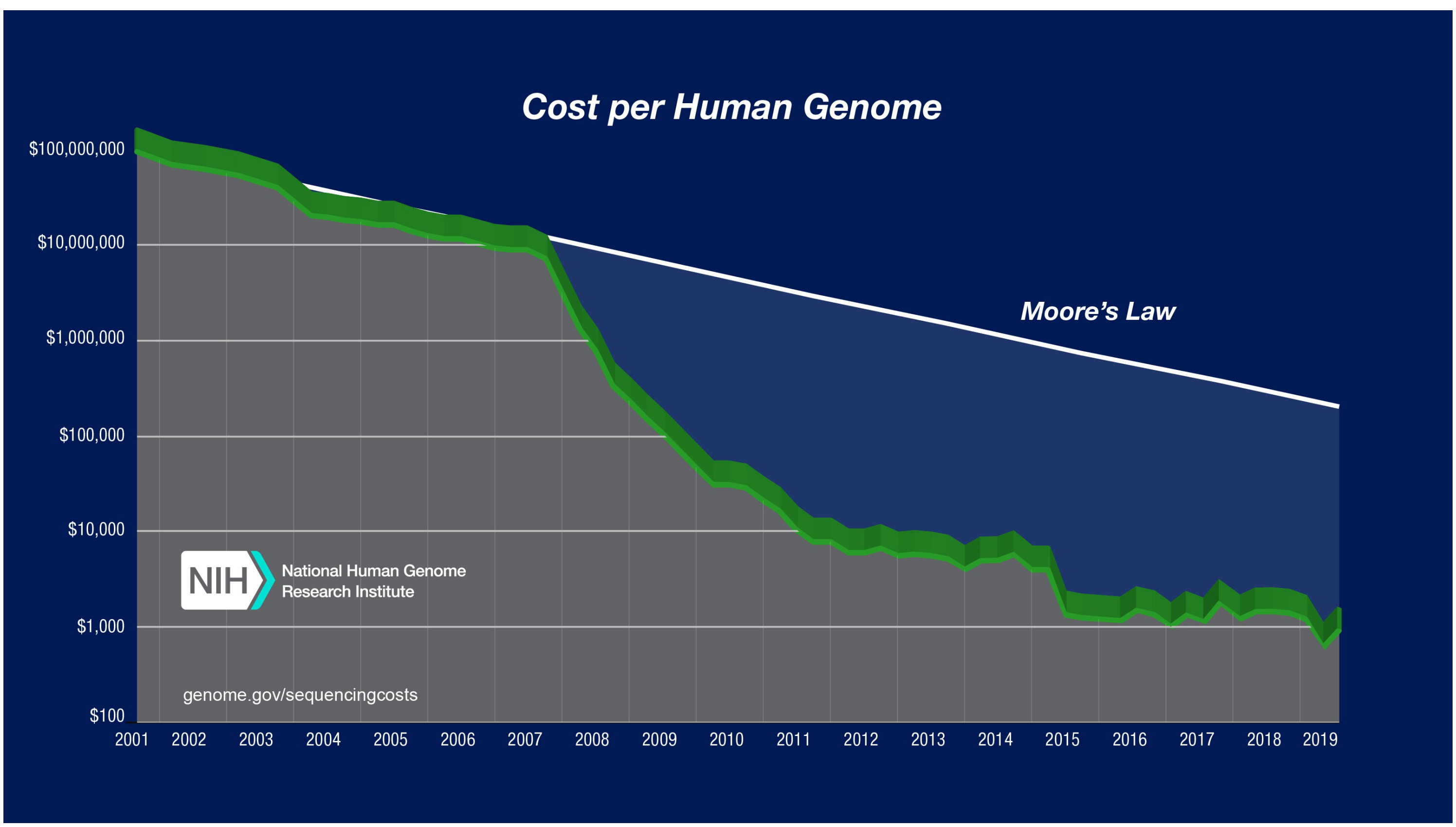
**1) Higher Productivity/ Reduced Cost/Price of Technology**

We measure technological change:

By improved productivity in production function – GDP' = aL' + bK' +c Other inputs' + d RDK'

By dual price change – P' =aW' + b Pc' + c Potherinputs' .

Take a major input into future medicine – cost of sequencing human genome. **YOUR FULL GENOME CAN BE ANALYZED FOR JUST $1,000 IT USED TO COST $100 MILLION JUST A FEW YEARS AGOB POPULAR SCIENCE** September 30, 2015 Veritas Genetics announced that it had reached a milestone: participants in its limited, but steadily expanding Personal Genetics Program can get their entire genome sequenced for just $1,000.



**Definition of the BRDPI**

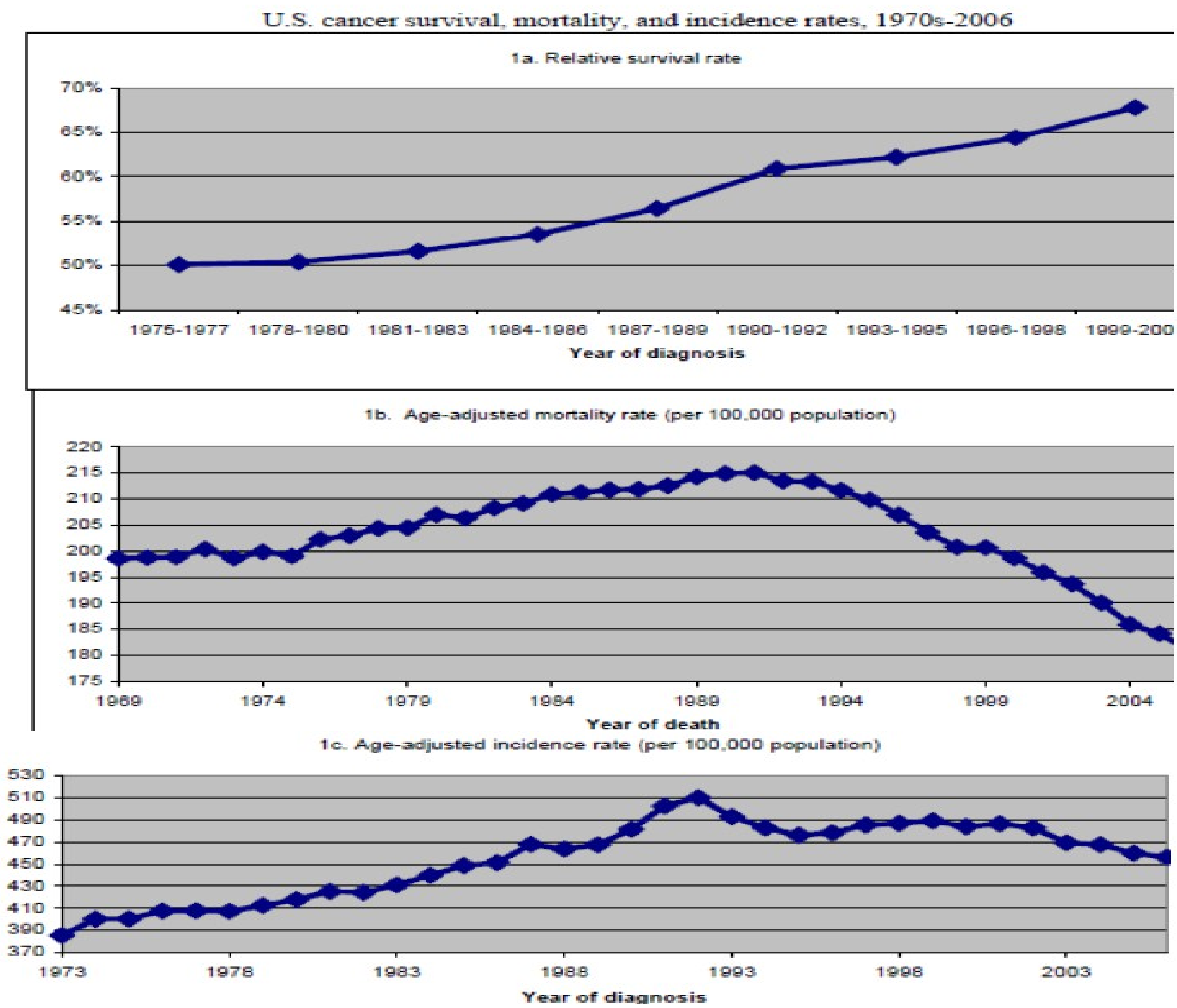
The BRDPI measures changes in the weighted average of the prices of all the inputs (e.g., personnel services, various supplies, and equipment) purchased with the NIH budget to support biomedical research. The weights used to construct the index reflect the actual pattern, or proportions, of total NIH expenditures on each of the types of inputs purchased. Theoretically, the annual change in the BRDPI indicates how much NIH expenditures would need to increase, without regard to efficiency gains or changes in government priorities, to maintain NIH-funded research activity at the previous year's level.

**TABLE A**

**HISTORICAL ANNUAL PERCENT CHANGES**

| Fiscal Year | GDP Price Index | BRDPI |
|---|---|---|
| Col. (1) | Col. (2) | Col. (3) |
| **2010** | 0.9% | 3.0% |
| **2011** | 2.0% | 2.9% |
| **2012** | 1.9% | 1.3% |
| **2013** | 1.8% | 1.9% |
| **2014** | 1.9% | 2.1% |
| **2015** | 1.2% | 2.0% |
| **2016** | 0.9% | 2.2% |
| **2017** | 1.8% | 2.6% |
| **2018** | 2.3% | 2.5% |
| **2019** | 1.9% | 2.1% |

**Through disease reduction:** Lichtenberg, "Has Medical Innovation Reduced Cancer Mortality?" NBER WP 15880
Outcomes: survival rate for people diagnosed with disease, mortality rate with disease as cause; incidence rate



Through Production Functions

**Table 5**

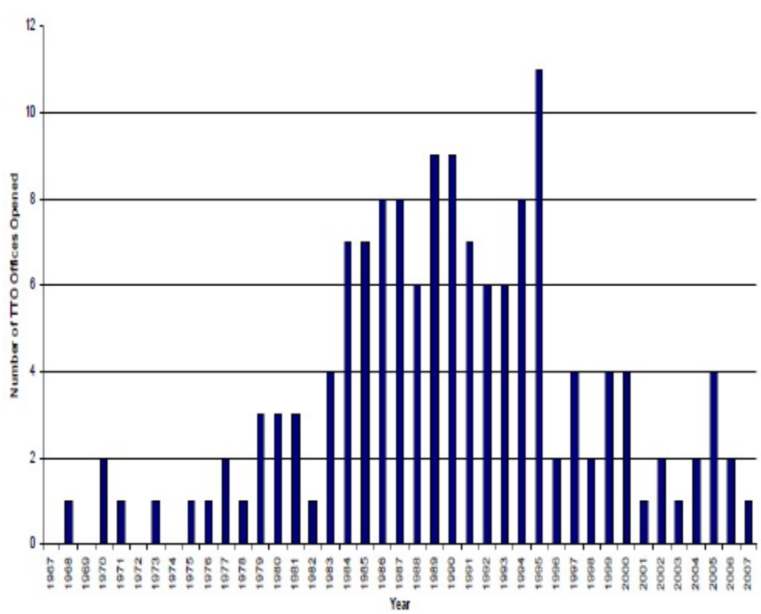
Market value regressions of knowledge assets and trademark stocks.

| Variables(Dependent variable: Tobin's $q$) | Model M0 | Model M1 | Model M2 | Model M3 | Model M4 | Model M5 |
|---|---|---|---|---|---|---|
| Log (assets) | −0.0107 | −0.0155* | −0.0126 | −0.0226** | −0.0121 | −0.0022 |
| | (0.0095) | (0.0094) | (0.0010) | (0.0096) | (0.0101) | (0.0103) |
| R&D stock/assets | | 0.6333*** | 0.6342*** | 0.5292*** | | 0.3188* |
| | | (0.1848) | (0.1847) | (0.1893) | | (0.1898) |
| Patent stock/R&D stock | | | 0.0006 | −0.0012 | | −0.0026 |
| | | | (0.0032) | (0.0034) | | (0.0044) |
| Citation stock/patent stock | | | | 0.1553*** | | 0.1485*** |
| | | | | (0.0286) | | (0.0284) |
| Trademark stock/marketing assets | | | | | 13.5040*** | 11.816*** |
| | | | | | (2.5929) | (2.6212) |
| Control variables | | | | | | |
| No R&D | | −0.0055 | −0.0200 | −0.0221 | | −0.0366 |
| | | (0.0355) | (0.0351) | (0.0355) | | (0.0346) |
| No patents | | | 0.0881 | 0.1337*** | | 0.1307*** |
| | | | (0.0432) | (0.0437) | | (0.0429) |

**Through Spillovers: Hausman** UNIVERSITY INNOVATION, LOCAL ECONOMIC GROWTH, AND ENTREPRENEURSHIP CES 12-10 June, 2012: identifies universities effect on economic activity using the interaction of a national shock to the spread of innovation from universities - the Bayh-Dole Act of 1980 - with pre-determined variation of university academic strengths and federal R&D. Using Census longitudinal establishment data, she finds that long run employment and payroll per worker around universities rise particularly rapidly after Bayh-Dole in industries closely related to local university innovative strengths with greater impact when closer geographic proximity to the university. Spillover studies credible because it is the other guys' R&D that benefits you, so there is less problem of endogeneity and you are counting the "knowledge magic" as opposed to measuring the normal flows.

FIGURE 1

Openings of University and Hospital Technology Transfer Offices 1967 - 2007




Source: Association of University Technology Managers (AUTM) Licensing Activity Survey, 2007.
Note: Bars represent the number of university technology transfer offices (among AUTM members) opened in each year from 1967 to 2007.

FIGURE 2

University Patents Granted by Year, 1976-1997

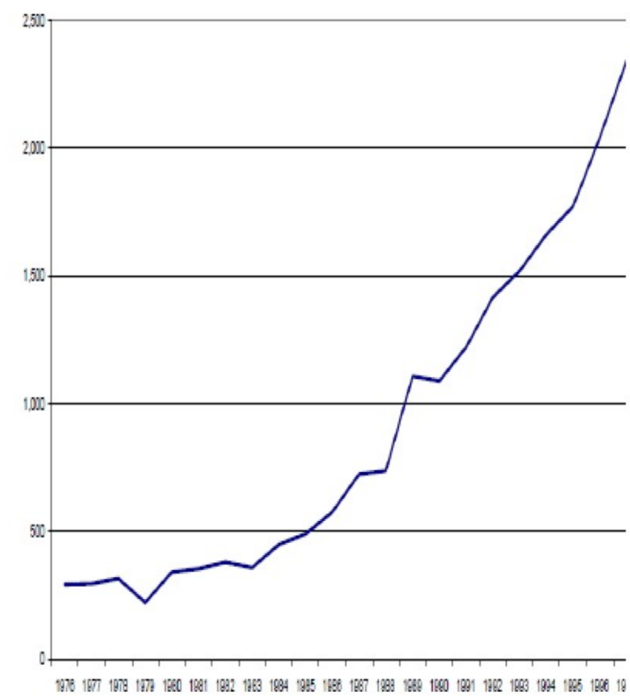
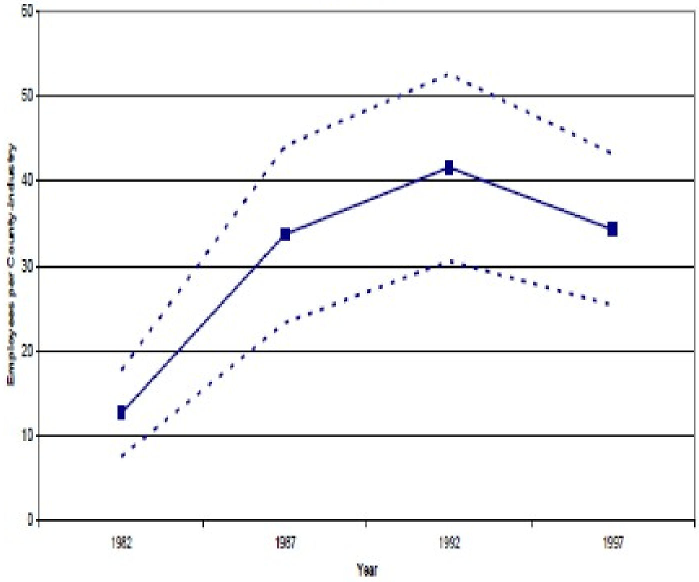


FIGURE 4
Employment Effects by Year After Bayh-Dole
1982 – 1997




Notes: Points represent coefficients on the interaction term of industry intesity and year indicators from a regression predicting total employment in a county-industry-year, with county and industry-by-year fixed effects. Estimates for this regression are shown in Table 4, column 2. Error bands represent the 95% confidence interval around these point estimates.

**TABLE 7**
**Effects of Federal University Research Funding on Industry Employment**

| Dependent Variable: Employment | (1) 5 Yr Sum: Total Funding | (2) 5 Yr Sum: DOD Funding | (3) 5 Yr Sum: NIH Funding |
|---|---|---|---|
| After Bayh-Dole * Fed Funding * univ cnty | 0.061 *** | 0.104 *** | 0.140 *** |
| | (0.012) | (0.032) | (0.027) |
| Industry * Year Fixed Effects | Yes | Yes | Yes |
| Observations | 4,814,860 | 4,814,860 | 4,814,860 |
| R-squared | 0.11 | 0.11 | 0.11 |

Notes:
1. Robust standard errors are clustered at the county level.
2. After Bayh-Dole is an indicator equal to 1 after 1980, and univ cnty is an indicator equal to 1 for counties near a university.
3. Federal funding is measured in millions of dollars. The 5 year sum of federal funding includes the years 1976-1980, inclusive. Col. 2 uses the 5 year sum of funding from the Department of Defense. Col. 3 uses the 5 year sum of funding from the National Institutes of Health.
4. In all columns, the dependent variable is total employment in the county-industry-year, while the measure of federal funding changes across columns.
4. Main effects of After Bayh-Dole * univ cnty and Fed Funding * univ cnty are included in all

## Stock Market and financial measures

**Tobin's Q** – stock market value/book value – If stock market values a firm more than estimated replacement value on books, this could reflect unmeasured contribution of knowledge, goodwill, technology and other intangible assets that a company may have but aren't recorded by accountants.

TABLE 2
THE STOCK MARKET'S RELATIVE VALUATION OF R & D AND PATENTS
DEPENDENT VARIABLE: LOG (Q)

| | | | |
|---|---|---|---|
| SP/A | 0.493 | 0.111 | 0.246 |
| | (0.165) | (0.094) | (0.082) |
| K/A | | 1.374 | 0.741 |
| | | (0.182) | (0.152) |
| NR/A | | | 11.99 |
| | | | (1.556) |
| $R^2$ | 0.027 | 0.125 | 0.258 |

*Source:* Cockburn and Griliches (1987), table 3.
V = market value of the firm.
A = total net assets at replacement cost.
Q = V/A.
K = "stock" of R & D using 15 percent depreciation rate.
NR = "news in R & D": current R & D less depreciation of the R & D stock.
SP = "stock" of patents using 30 percent depreciation rate.
$N$ = 722. Mean of the dependent variable = −0.272; standard deviation = 0.697.
Heteroscedasticity-consistent standard errors in parentheses.

All equations also contain an intercept term and the logarithm of assets, whose coefficients was small but consistently significant, on the order of −0.03 (0.01).

Sandnerc and Blocka "The market value of R&D, patents, and trademarks", Research Policy vol 40 2011

| Elasticities $\partial \log(V/A)/\partial \log X$ | | | | | |
|---|---|---|---|---|---|
| R&D stock/assets | 0.0594*** | 0.0595*** | 0.0469*** | | 0.0275*** |
| | (0.0163) | (0.0163) | (0.0160) | | (0.0156) |
| Patent stock/R&D stock | | 0.0001 | 0.0002 | | −0.0005 |
| | | (0.0006) | (0.0006) | | (0.0008) |
| Citation stock/patent stock | | | 0.0637*** | | 0.0591*** |
| | | | (0.0110) | | (0.0106) |
| Trademark stock/marketing assets | | | | 0.0628*** | 0.0506*** |
| | | | | (0.0113) | (0.0108) |

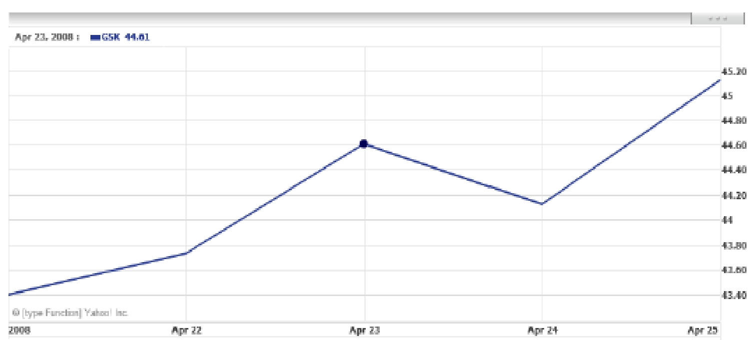
Notes: N = 6757 observations from N = 1216 companies. Estimation method: NLLS. Clustered standard errors in parentheses. Reference group for industry: 'electronics ar components'. Reference country: US. Reference year: 2002.

**Event Studies:** A firm announces it has increased its R&D spending or has bought a small R&D startup or has completed some R&D activity. The announcement is a surprise to the stock market. To the extent that the market makes a good assessment of the prospects of the firm, the increase in its value represents the best "informed judgment" of the likely future payoff from this R&D

**GlaxoSmithKline to acquire Sirtris Pharmaceuticals, a world leader in 'Sirtuin' R&D** – Tuesday 22 April 2008, London, UK, Philadelphia PA, Cambridge, MA – GlaxoSmithKline and Sirtris Pharmaceuticals Inc (Nasdaq: SIRT) announced today that they have entered into a definitive agreement pursuant to which GSK will acquire Sirtris Pharmaceuticals for approximately USD720 million (or approx. GBP362 million) through a cash tender offer of USD22.50 (or approx. GBP11.33) per share.

**What happened to the Glaxo share price?** With 2.54B shares outstanding a change in share of 2.8 cents would "pay for the purchase"

| | Adj | Close | Adj | Close |
|---|---|---|---|---|
| April 21 | 39.2 | 43.40 | | |
| April 22 | 39.5 | 43.73 | | |
| April 23 | 40.29 | 44.61 | 2.0% | +2.0% |
| April 24 | 39.85 | 44.12 | | |
| April 25 | 40.75 | 45.12 | | |




PAPER TOPIC: How responsive are the shares of big pharmaceuticals firms when they buy start-ups.

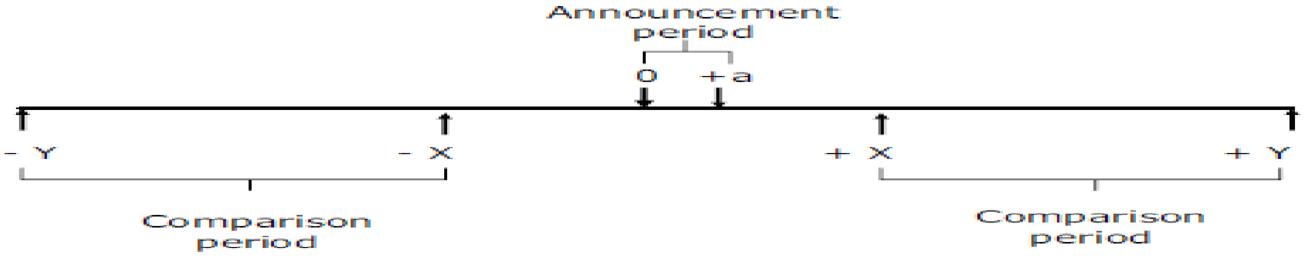
**The stock market methodology: event studies.**

In ideal event study, identification of effect of event (new R&D, purchase, whatever), about which people did not know beforehand, comes from narrow time period. The period is narrow so that other confounding factors do not operate, so no need to control for other factors as in standard regression models where many things change besides the factor you are studying. An event study is good if 1) Market rapidly reacts to news; 2) Properly identified and isolated event. This means that it critical to get the appropriate WINDOW during which information disseminated.

So what does a study do?

1- Finds announcement of event from some source (with recognition that could have been leakage of information beforehand. Before 1976 US firms did not have to disclose RD on their 10-K forms so an announcement would be disclosing "secret information". Studies use day 0 or day -1 as the announcement period, with the day-1 reflecting some belief that announcement itself leaked.

- Event studies — the measurement of an abnormal stock return




**Chan, Martin, Kensinger study, Journal of Financial Economics, 26, 1999, 255-276**

Category I. *Pure announcements of plans to increase corporate R & D expenditures, with no additional comtemporaneous information.*
*For example:* 'Varian Associates Inc. said it plans to increase its spending on research and development to $50 million for 1983, up 20% from $41 million' (*WSJ*, 2/25/83). This category also includes announcements of plans to build or expand R & D centers or facilities. *Also:* 'General Electric Co. announced plans for a $50 million expansion of its research and development center in Schenectady, New York' (*WSJ*, 11/20/79).

Category II. *R & D announcements that also release management's forecast of earnings.*
*For example:* 'Medtronic Inc.'s earnings and revenue growth in fiscal 1983, ending April 30 should be at or near 20%, Dale Olseth, chief executive, said after the annual meeting . . . . He added that the company plans to spend at least $35 million on research and development this year, up from $30 million last year' (*WSJ* and *DJNW*, 8/25/82).

Category III. *R & D announcements that also release quarterly earnings reports.*
*For example:* 'Esterline Corp. posted first quarter net earnings of 28 cents a share versus the prior period's net of 26 cents . . . . After the annual meeting, the president and chief executive also said research and development spending will rise to about $19 million from $16.4 million in the prior year' (*WSJ* and *DJNW*, 2/27/85).

Category IV. *R & D announcements that also report increases in capital expenditures.*
*For example:* 'Texas Instruments said it will increase its capital expenditures for 1982 to $390 million from $350 million in 1980 and will spend $244 million on research and development compared with $219 million last year' (*WSJ* and *DJNW*, 4/15/82).

Strategy: 1) Find announcements of increased research spending from Dow-Jones New Retrieval Service database, which covers Dow-Jones NewsWire, WSJ, and Barrons2) Go to CRSP (Center for Research in Security Prices) data base http://www.crsp.com/ for share prices and calculate:

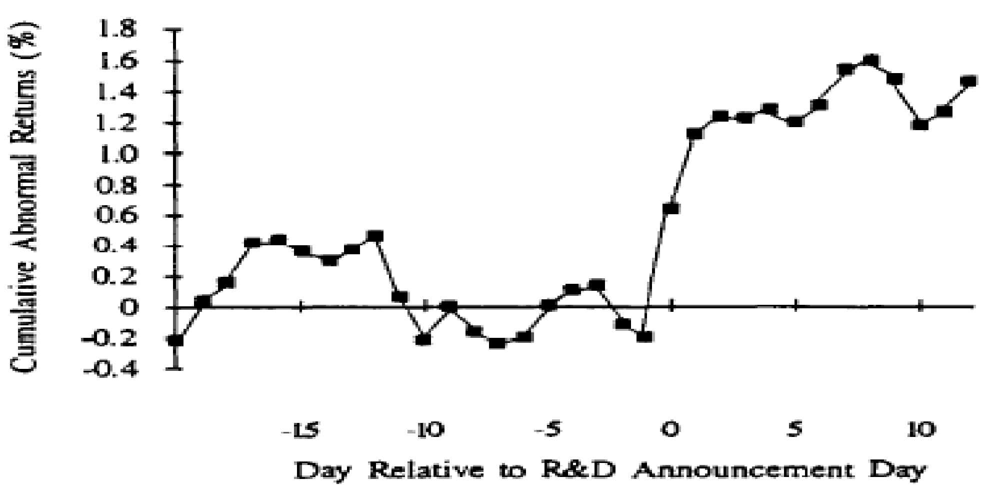



Fig. 1. Cumulative abnormal returns (%) in the period from 20 days before through 12 days after the 95 R & D spending increase announcements in the period 1979–1985.

(1) $R_{i,t} = (D_{i,t} + P_{i,t} - P_{i,t-1})/P_{i,t-1}$

where $D_{i,t}$ = dividend per share over day $t$ for security $i$ and $P_{i,t}$ = price (ex dividend) of security $i$ at the end of day $t$; and

(2) $R_{i,t} = \alpha_i + \beta_i R_{m,t} + AR_{i,t}$

(3) *ABNORMAL RETURN is Ari,t*

(4) *CUMULATED AVERAGED ABNORMAL RETURN. SUM THE ABNORMAL RETURNS OVER different periods and take an average:*

Table 4

Abnormal stock returns for 95 announcements of R&D spending increases by NYSE and AMEX firms in the period 1979–1985.

Panel A: Average and cumulative abnormal returns

| Day relative to R&D announcement | Average abnormal return (in percent) | Cumulative average abnormal return (in percent) | Percent of positive abnormal returns |
|---|---|---|---|
| −30 | 0.10 | 0.10 | 45.3 |
| −25 | 0.10 | −0.39 | 50.5 |
| −20 | −0.03 | −0.23 | 45.3 |
| −19 | 0.26 | 0.03 | 50.5 |
| −18 | 0.14 | 0.16 | 49.4 |
| −17 | 0.24 | 0.41 | 57.9 |
| −16 | 0.03 | 0.43 | 48.4 |
| −15 | −0.10 | 0.34 | 49.4 |
| −14 | −0.05 | 0.29 | 44.2 |
| −13 | 0.07 | 0.36 | 45.3 |
| −12 | 0.08 | 0.45 | 45.3 |
| −11 | −0.40[a] | 0.05 | 37.9 |
| −10 | −0.28[b] | −0.23 | 41.1 |
| −9 | 0.21 | −0.02 | 52.6 |
| −8 | −0.15 | −0.17 | 50.5 |
| −7 | −0.09 | −0.25 | 46.3 |
| −6 | 0.05 | −0.20 | 53.7 |
| −5 | 0.20 | −0.00 | 49.4 |
| −4 | 0.10 | 0.10 | 49.4 |
| −3 | 0.03 | 0.13 | 50.5 |
| −2 | −0.23 | −0.10 | 41.1 |
| −1 | −0.11 | −0.21 | 48.4 |
| 0 | 0.85[a] | 0.64 | 61.1 |
| 1 | 0.53[a] | 1.17 | 57.9 |
| 2 | 0.14 | 1.31 | 53.7 |
| 3 | −0.05 | 1.27 | 52.6 |
| 4 | 0.08 | 1.35 | 50.5 |
| 5 | −0.11 | 1.24 | 49.4 |
| 6 | 0.13 | 1.37 | 50.5 |
| 7 | 0.27 | 1.64 | 56.8 |
| 8 | 0.07 | 1.72 | 52.6 |
| 9 | −0.14 | 1.58 | 49.4 |
| 10 | −0.34[b] | 1.24 | 36.8 |
| 11 | 0.09 | 1.33 | 50.5 |
| 12 | 0.23 | 1.57 | 51.6 |

Panel B: Distribution of two-day announcement-period abnormal returns

| Magnitude of two-day abnormal returns for the day of and the day after the announcement (*CAR*) | Number of observed abnormal returns |
|---|---|
| 11.0% < *CAR* | 2 |
| 8.0% < *CAR* < = 11.0% | 3 |
| 6.0% < *CAR* < = 8.0% | 3 |

Additional concern: If announcement is really new information then firms that increased R&D might have done so because they expected positive response. Perhaps other firms that increased R&D did not do so because they expected negative response. Then the results would not indicate response to RD but response to RD announcement but firms that self-selected for positive analysis. They do some "selectivity correction" by creating matched set of firms that increased RD without announcements, using Business Week and

Surprisingly there is a lot of variability in the choice of a window and variation in when analysts find effects. Consider the labor area: Many studies that use the event study methodology find that the stock market evaluates labor events within the short window used to isolate those events. These studies include announcements of staff reductions and shutdowns (Abowd, Milkovich, and Hannon, 1990), announcements about work-family personnel policies (Arthur and Cook, 2004), news of anti-sweatshop corporate campaigns (Rock 2003) and news about union-initiated boycotts (Pruitt, et al 1988) that resemble in part the corporate campaign against Smithfield. In each case, the studies report that some labor event affected share prices in a short window when there was little time for anything else to impact the price.

But other studies have found that some labor events affect share prices over a longer period but not in a short event window (Abowd, 1990, Lee and Mas, 2008). Economists are uncertain about the reasons why announcements about some activities impact share prices immediately, per the classic event study, while other pieces of news do not have such an effect.

Initially labor analysts thought the problem was that stock market concern over labor issues is modest but there are also studies of non-labor events in which abnormal returns begin around the time of an event and increase over time and note that experts in financial markets view this pattern as "an open puzzle". It is a puzzle because it runs counter to what one expects in an efficient financial market.

## II.RD in GDP, new satellite account, Intangible knowledge

### 1.Macro-economics needs Stock of Useful Knowledge and Measures of Intangible Knowledge Capital.

Because otherwise we are as clueless as the physicists/cosmologists who need dark matter and dark energy to explain why the universe expands instead of contracts.

**NASA:** Dark Energy, Dark Matter (http://science.nasa.gov/astrophysics/focus-areas/what-is-dark-energy/). In the early 1990's, one thing was fairly certain about the expansion of the Universe... theoretically, the Universe had to slow. The Universe is full of matter and the attractive force of gravity pulls all matter together. Then came 1998 and the Hubble Space Telescope (HST) observations of very distant supernovae that showed that, a long time ago, the Universe was actually expanding more slowly than it is today. No one expected this, no one knew how to explain it. … but they have given the solution a name. It is called dark energy. … It turns out that roughly 70% of the Universe is dark energy. Dark matter makes up about 25%. The rest - everything on Earth, everything ever observed with all of our instruments, all normal matter - adds up to less than 5% of the Universe.

In economics the problem comes from the relation between tangible inputs such as capital and labor and education and GDP in economic growth. Growth accounting is comparable to accounting for the matter in the universe. On the one side, we have measured growth of GDP. On the other side, measured growth of inputs, labor and capital and, if we want, materials. We estimate the contribution of the measured growth of labor and capital to the growth of GDP and find that growth of output exceeds growth of labor and the growth of capital, appropriately weighted. We have "productivity growth" – the difference between the growth of output and the growth of labor and capital – aka the residual. Can reduce residual some by using education, the demographic composition of the work force, hours of work and of capital, and hedonic price indexes to deal with changes in the quality of capital, such as computers, the residual remains.

And even if we were to "explain" away the residual, would ask … why is quality of machines changing? And is college grad/engineer/medical scientist of today the same as one in say 1950. We know more today and the educated worker will use modern knowledge to solve problems that could not be similarly solved back then.

Growth accounting analysis starts with a linear homogeneous production function – constant returns to scale:

(1) $X = f(L,K)$. With constant returns, $X= f_1L + f_2K$ – product exhaustion. This is related to identity that output is divided between labor and capital ($X = wL + rK$). Totally differentiate (1) to get

2)$dX = f_1dL + f_2\, dK$

**Divide by $X= f_1L + f_2K$ and we get**

3)$dX/X = (f_1dL + f_2\, dK)/( f_1L + f_2K) = dL/L[ f_1L/( f_1L + f_2K)] + dK/K[f_2K /(f_1L + f_2K)]$

4)$X' = \alpha L' + (1- \alpha) K'$ , where X' is dlnX ~dX/X, and dittos for L and K and α is labor's share in GDP/cost.

This is the **fundamental equation in growth accounting:** the differential changes in growth is a weighted average of the differential changes in the inputs that enter the production function weighted by their shares of output

When firms profit maximize and pay factors their marginal products, $f_1$ = w/p and $f_2$ = r/p so that constant returns becomes pX + wL + rK, where p is price of output and we estimate α by the observed share of labor in GDP or cost.

But actual growth of output exceeds growth of measured inputs – creating a missing input problem (or measurement error in inputs or in outputs.

I've an idea! Let's call it technological change    It's the growth of knowledge!    I can see it!

**2.GDP Accounts--** Bureau of Economic Affairs – Commerce Dept agency that produces GDP and other statistics.

Gross Domestic Product (GDP) measures the total value of **final** goods and services

= consumption by households = all investment by businesses + purchases by the government, plus purchases made by foreigners minus purchases of things made abroad. Thus C+I+G+X-M

= income of factors = total wages paid + total profits + rent + interest + statistical adjustments (corporate income taxes, dividends, undistributed corporate profits

Gross investment = private domestic fixed investment, Δ private inventories + government gross investment.

Private fixed investment includes:Non-residential investment: Expenditures by firms on capital such as tools, machinery, and factories. Residential Investment: Expenditures on residential structures/equipment owned by landlords and rented to tenants.

"Net investment" deducts depreciation from gross investment. Net fixed investment is the value of the net increase in the capital stock per year. K= K(-1) – depreciation of K stock

Issues: It does not measure all of production. Limited to production via market so leaves out household production.
It does not measure all of output. Neglects negative/positive externality – impact on environment
Neglects some intangible investments and so understates total output
It does not measure growth/decline of capital per se – need net investment measure.
It does not measure intangibles – stock of useful knowledge

Where is R&D in this analysis? Although R&D is investment, until 2008 national accounts measured R&D as current period expenditures, purchase of intermediate good. **Why not?** 1) R&D expenditures not have easily measured assets bcs R&D capital is not generally sold for a market price, Measured on a cost basis 2) R&D return counted in returns to all fixed capital -- plant, equipment, 3)other private producers may benefit from the R&D as imitators or as buyers of the new product. Need deflators, service lives/depreciation, length of time before benefits from R&D are realized. **Satellite accounts** experiment with methods of estimating R&D capital and alternative scenarios of R&D returns to get a picture of the order of magnitude of the size and impact of R&D capital on GDP (Fraumeni and Okuba, 2004),

**BEA** satellite accounts showed that impact of R&D on the growth rate of real GDP depends on proper deflator for RD, which is missing because much of the R&D output is unobservable and the prices for the traded R&D output are not collected. BEA uses patents and/or employees to create quantity index and backs out price index. Then 2008 revision of the SNA recommended treating R&D as investment. "Treating R&D expenditures as investment in the NIPAs would make these expenditures fully comparable to expenditures on other intangibles, such as software, that are already considered investments." Changing treatment of R&D affects the production account where R&D expenditure would now be recorded as the production of an asset (I) instead of an expense and the capital account.

## How R&D Investment Affects GDP and GDI

Treating research and development (R&D) as an investment rather than as an expense in the calculation of gross domestic product (GDP) and gross domestic income (GDI) would result in important changes to both measures (see table below).

### Business sector

Currently, business spending on R&D is not included in the calculation of GDP, which is a measure of final demand. Rather, R&D expenditures are considered business expenses, that is, purchases of intermediate inputs that are used in the production process. Shifting business R&D expenditures out of expenses and into investment would lead to an increase in GDP equal to the value of R&D investment.

Recognizing R&D as investment would also affect GDI via two components: Business income and depreciation (consumption of fixed capital).

Because R&D would no longer be considered an expense, it would no longer be deducted from gross business income (corporate profits and proprietors' income). So business income would increase.

Depreciation would also increase because R&D investment adds to the capital stock, which is subject to a decline in value over time. The net effect on business income would be that it increases by the amount of R&D investment less depreciation.

However, because depreciation of the capital stock is also a component of GDI, the depreciation of R&D investment would be added to the total measure of depreciation. So the net effect on GDI would be an increase equal to R&D investment, maintaining the accounting identity between GDP and GDI.

### Nonprofits and general government

In these two sectors, R&D expenditures would be reclassified from consumption to investment. Because consumption is already part of GDP, this shift alone would not change the measure of GDP.

However, recognizing R&D spending as investment by nonprofit institutions serving households (household sector) and governments would also require an estimate of the capital services generated by R&D investment. Capital services measure the value of a capital asset's use in production. Conceptually, that value is the amount a producer would be willing to pay to rent the asset for a given period. Because most capital assets are owned by the same entity that uses them, capital services must be estimated indirectly.

In the R&D satellite account, capital services are defined as the sum of depreciation and the net returns on R&D investment. The inclusion in the R&D account of net returns to nonprofits and general government is a departure from BEA's current calculation of GDI, which includes only depreciation, a partial measure of capital services. The BEA R&D account, however, allows for exploratory approaches, and returns on R&D investment seem to have been significant. Also, accounting for net returns is roughly parallel with the treatment in the business sector. In that sector, net returns are assumed to be included in business income.

For nonprofits and government, output is generally not sold at market prices, so the value of output must be measured indirectly, based on the costs or expenses incurred in production. For nonprofits, PCE for services would rise by an amount equal to capital services. Government consumption would rise by the same amount.

**Treating R&D as Investment: Effect on GDP and GDI**

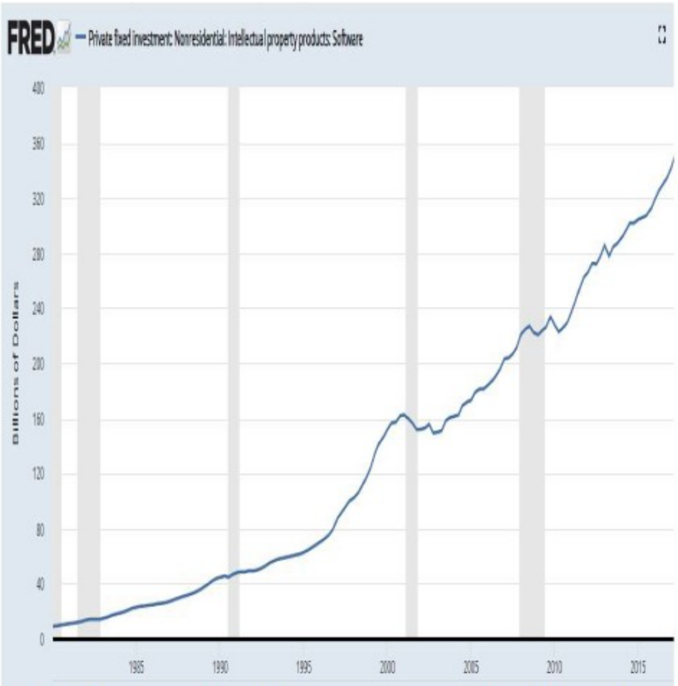
| | Gross domestic product (GDP) | | | Gross domestic income (GDI) | |
|---|---|---|---|---|---|
| Sector | Current treatment in GDP | Adjusted GDP [1] | Change to GDP | Adjusted GDI [2] | Change to GDI |
| Business | Expenses | R&D spending reclassified to investment | Increase equals the value of R&D investment | 1. Increase in business income equal to R&D investment less CFC<br>2. Increase in CFC | Increases by value of R&D investment |
| Nonprofit institutions serving households (part of the household sector) | PCE | 1. R&D spending reclassified to investment<br>2. PCE for services boosted | 1. No change from reclassification<br>2. PCE services increase equal to capital services (CFC plus net returns) | 1. Returns to R&D capital added [3]<br>2. CFC boosted | Increases by value of capital services (net returns plus depreciation) |
| General government | Government consumption | 1. R&D spending reclassified to investment<br>2. Government spending on services boosted | 1. No change from reclassification<br>2. Government spending on services increase equal to capital services (CFC plus net returns) | 1. Returns to R&D capital added [3]<br>2. CFC boosted | Increases by value of capital services (net returns plus depreciation) |

1. Adjusted GDP incorporates the impact of treating R&D as investment.
2. Adjusted GDI incorporates the impact of treating R&D as investment.
3. Currently, GDI does not include a measure of returns on government or nonprofit investment.

CFC Consumption of fixed capital
PCE Personal consumption expenditures

*Sumiye Okubo*

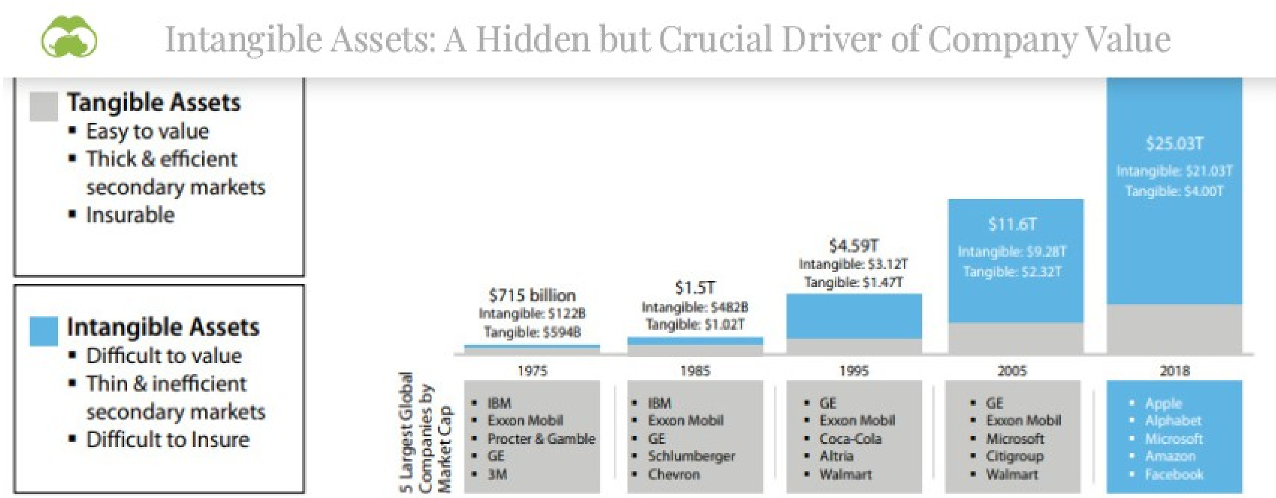
R&D accounts has gotten most attention bu there are other variables that analysts use to assess intangible capital … patents, which we will examine in detail 2-3 weeks from now and software. Biggest change in US investment in recent years has been huge increase in software.




| | Q2 1980 | Q2 2019 |
|---|---|---|
| Private Nonresidential Fixed Investment in current $ | 395.0 | 2890.0 |
| | | |
| Type of Investment as Share of total | | |
| Structures | 33.7% | 21.9% |
| Equipment | 52.9 | 43.4 |
| Information Processing | 13.2 | 14.5 |
| Computer and Peripheral | 5.8 | 4.4 |
| **Intellectual Property** | **13.7** | **34.7** |
| **Software (excludes spending as intermediate)** | **2.5** | **14.2** |
| Research and Development | 8.6 | 17.3 |
| | | |
| Ratio of Software Investment to Other Investments | | |
| **Software Investment/Equipment** | **0.05** | **0.33** |
| **Software Investment/ Research and Development** | **0.29** | **0.82** |

NB: By excluding noncapitalized spending, the software figures excludes 47% of software expenditures (2013 ICT survey). Shift to Cloud and SaaS likely makes 47% underestimate)

If we add software that firms report as intermediate expenditures – say by monthly leases – Software would be greater than business R&D in 2019 And note that move in software producers to sell on basis of leases will bias downward investment figures. – You purchase lease for new software and do not list it as investment but that is solely a shift in accounting.
Intangibles include R&D based knowledge, software, … Estimated to be bulk of enterprise value.




Source: Aon

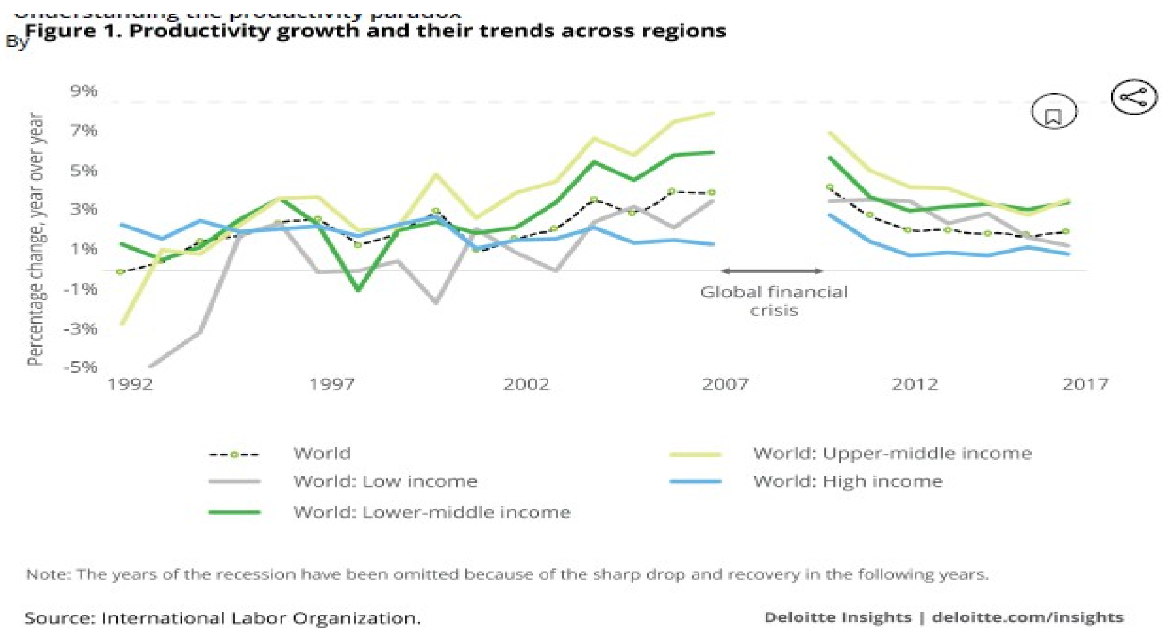
In just 43 years, intangibles have evolved from a supporting asset into a major consideration for investors – today, they make up 84% of all enterprise value on the S&P 500, a massive increase from just 17% in 1975.

## Intangible Assets: A Hidden but Crucial Driver of Company Value

| | | | | |
|---|---|---|---|---|
| 1 | Microsoft | Internet & Software | $904B | 90% |
| 2 | Amazon | Internet & Software | $839B | 93% |
| 3 | Apple | Technology & IT | $675B | 77% |
| 4 | Alphabet | Internet & Software | $521B | 65% |
| 5 | Facebook | Internet & Software | $409B | 79% |
| 6 | AT&T | Telecoms | $371B | 84% |
| 7 | Tencent | Internet & Software | $365B | 88% |
| 8 | Johnson & Johnson | Pharma | $361B | 101% |
| 9 | Visa | Banking | $348B | 100% |
| 10 | Alibaba | Internet & Software | $344B | 86% |

But if  we gave massively increased intangible assets, have more R&D and scientists and engineers and more scientific papers, and patents, and … there is a new puzzle.

The question is no longer how to explain output/productivity growth greatly exceeding  growth of inputs-- but how to explain SLUGGISH output and productivity growth given huge increase in knowledge investment.

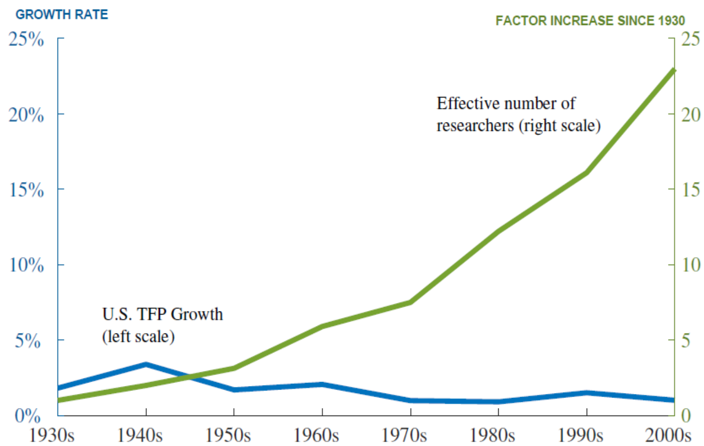


(https://www2.deloitte.com/content/dam/insights/us/articles/3779_BtN_Oct2017/fgures/3779_fig1.png)

**Paper to Read:  ARE IDEAS GETTING HARDER TO FIND?**
Nicholas Bloom Charles I. Jones John Van Reenen Michael Webb
NBER Working Paper 23782

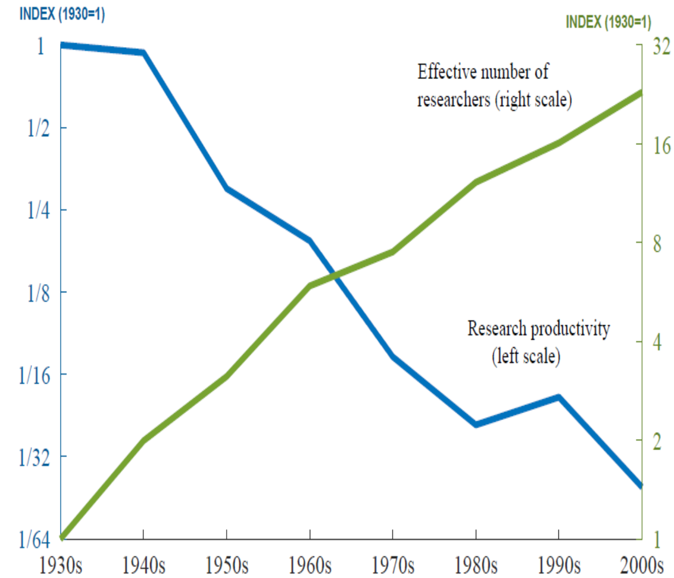
**In many growth models, economic growth arises from people creating ideas, and the long-run** growth rate is the product of two terms: the effective number of researchers and their research productivity. We present a wide range of evidence from various industries, products, and firms showing that research effort is rising substantially while research productivity is declining sharply. A good example is Moore's Law. The number of researchers required today to achieve the famous doubling every two years of the density of computer chips is more than 18 times larger than the number required in the early 1970s. Across a broad range of case studies at various levels of (dis)aggregation, we find that ideas — and in particular the exponential growth they imply — are getting harder and harder to find. Exponential growth results from the large increases in research effort that offset its declining productivity.

Figure 1: Aggregate Data on Growth and Research Effort




Note: The idea output measure is TFP growth, by decade (and for 2000-2014 for the latest observation). For the years since 1950, this measure is the BLS Private Business Sector multifactor productivity growth series, adding back in the contributions from R&D and IPP. For the 1930s and 1940s, we use the measure from Robert Gordon (2016). The idea input measure is gross domestic investment in intellectual property products from the National Income and Product Accounts, deflated by a measure of the nominal wage for high-skilled workers.

Figure 2: Aggregate Evidence on Research Productivity




Note: Research productivity is the ratio of idea output, measured as TFP growth, to research effort. See notes to Figure 1 and the online data appendix. Both research productivity and research effort are normalized to the value of 1 in the 1930s.

Note the scaling of the units: TFP growth is output measure and RD is number of researchers. Which connects to the production function linking output to a researcher – assumed in growth rate that one researcher who raises TFP by say 1% does so regardless of whether economy is small – say 100 units or large say 1000 units.

But why not have the production of knowledge be linear functional form. If output measure is not percentage growth of output but change in output, much of puzzle is resolved.

One researcher can create and implement idea that raises output by 5 units when output is 100 or when output is 1000. It is not so much the new idea but implementing it at lots of different work sites. So every firm that uses new technology needs say a scientist-engineer to get it to work. Then to get output grow at 5% need one researcher in small economy with 100 output but need 10 researchers to produce the 50 extra outputs in the larger economy with 1000 output – each 100 output firm needs its scientist-engineer-researcher to get the idea up and working.

The evidence crudely supports this view: Growth rate of GDP is roughly same 5% over time and TFP is roughly same 2.5% over time but Output that it applies to in 2019 is roughly 20 times the output in, say, 1930 before Depression hit GDP hard. What is the growth of RD? About 20 times in figure 1 and 2. What about fall in research productivity? Figure 2 shows drop of research productivity to about 1/32$^{th}$ of 1930s level so sort of fits if you need 20 times as many people to spread technology around 20 times bigger economy. Drop in this case would 1/3$^{rd}$ of true productivity.

Implication is impact of ideas is not the "you use stock of useful knowledge" freely but have to invest in people/implementation. Suggests greater emphasis on STEM workers who do not do R&D but do other stuff. Which is the majority of them. And most R&D money is D, with basic R, which presumably is ideas that are freely movable, being only a small part of the funding. In 2017 US RD was $548B of which $400B was business which was not spreading knowledge freely, 91B was basic and 109 Applied with bulk being experimental development.

ideas harder to find
ideas harder to implement in bigger economy – small GDP just need one person; bigger GDP needs more ….

Class project: Find best fit for link of "research workers" or RD spending to GDP or **level** of total factor productivity. Will best fit be a function with %growth rate or with $$growth to RD variable? What is best functional form for linking the two parts of puzzle – RD input and measure of output? How would you instruct machine to find best form?