

THE CONFERENCE BOARD



**Intangibles, Productivity, and Growth:
Current Projects Potpourri**

Carol Corrado, Senior Advisor
and Research Director
The Conference Board

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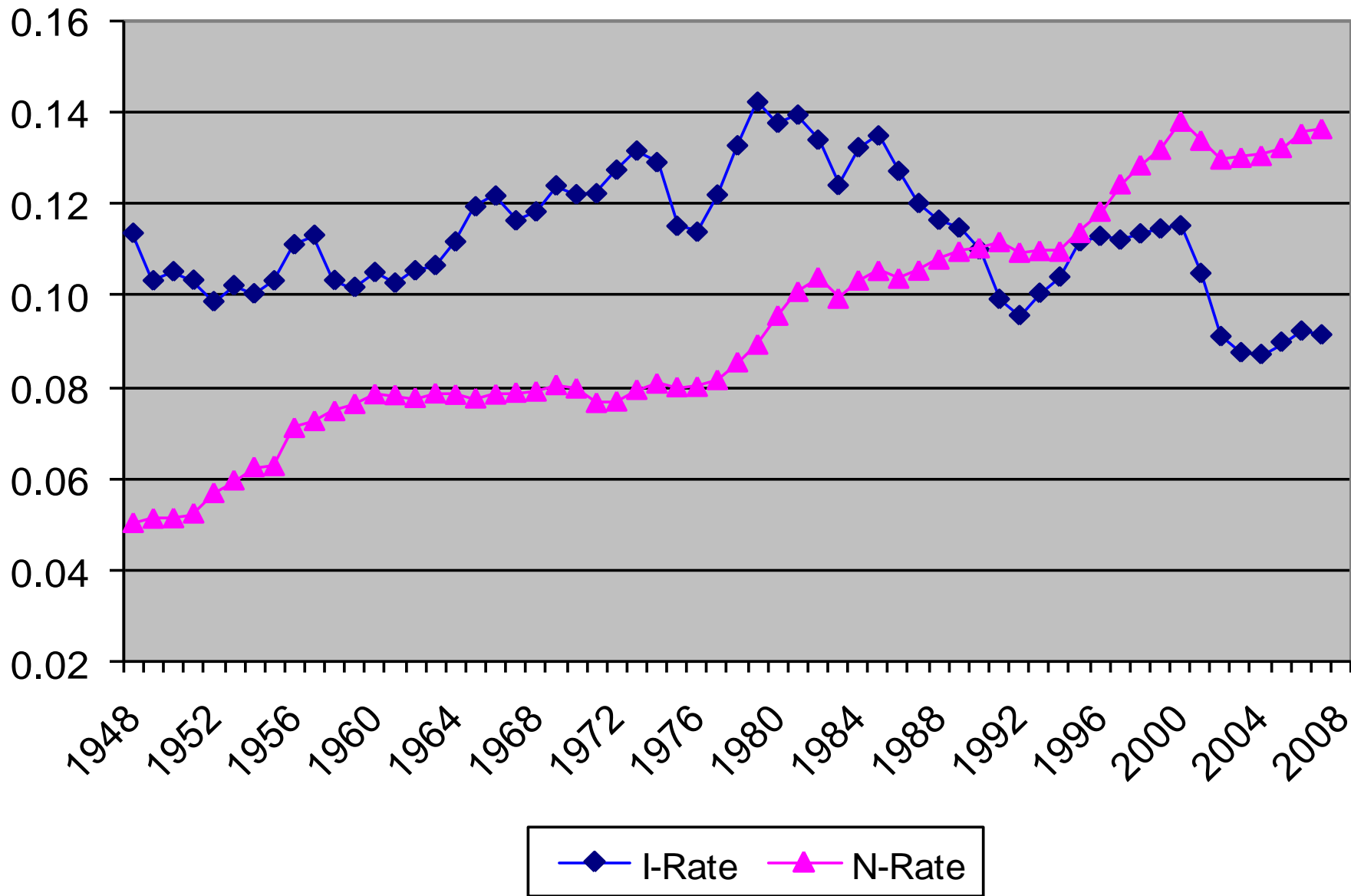
Current projects

- Updated macroeconomic estimates of productivity and growth with intangibles (aspects in NAS volume, and forthcoming Atlanta ASSA paper with Hulten)
- Exploiting occupation and wage structure data: Improving estimates of intangible investment by the financial sector (funded by NSF, with Hao)
- What keeps national accountants up at night: Prices for R&D and other intangibles (COINVEST project, with Haskel)

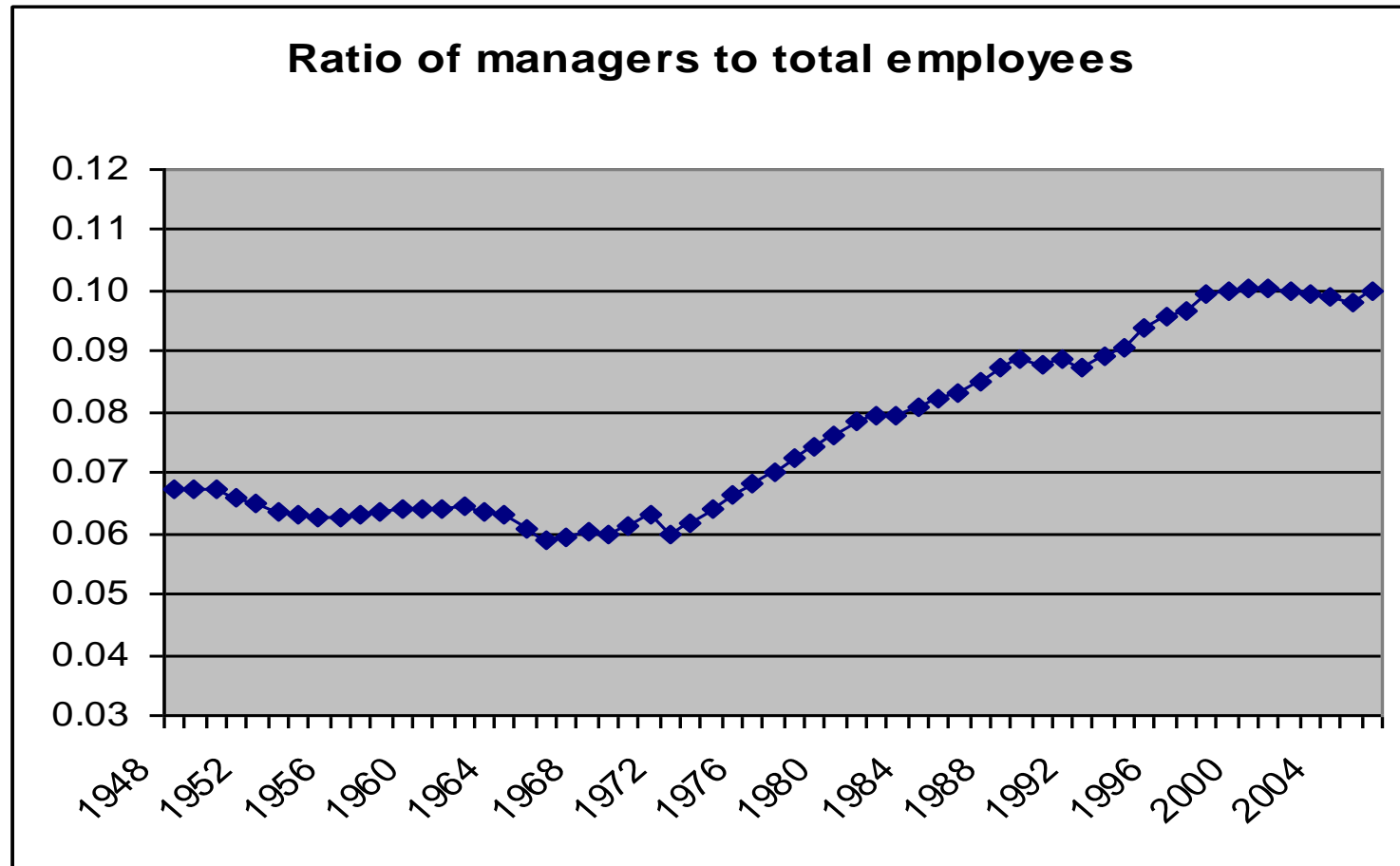
Intangibles are important.....

- Earlier work found that U.S. intangible business investment was **more than \$1 trillion in the late 1990s.**
- **Updated:** In the **first 7 years of this decade,**
 - Intangible business investment was **45 percent** larger than tangible investment in the U.S.
 - Nonfarm business (NFB) output would be **12 percent** higher if new CHS intangibles were included.
- The saving rate would be higher; more capital accumulation. Capital stock would be higher (by nearly \$4 trillion in 2006).

Investment rate: Tangible (I) and Intangible (N)



Based on refined estimates of trends derived from data with major changes in classification systems...

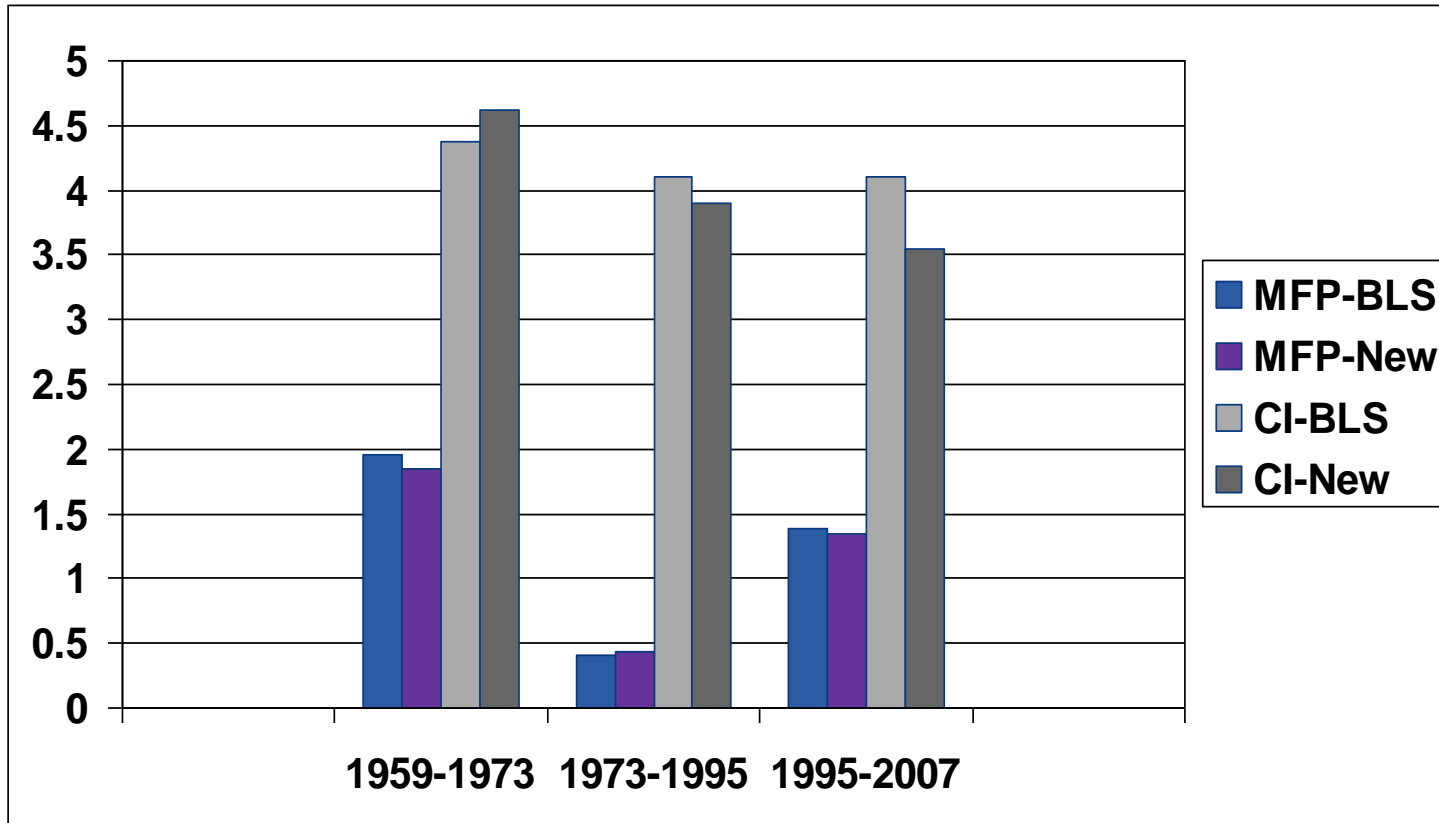


Source: Estimates based on data from the Current Population Survey and Decennial Census. Excludes farm managers.

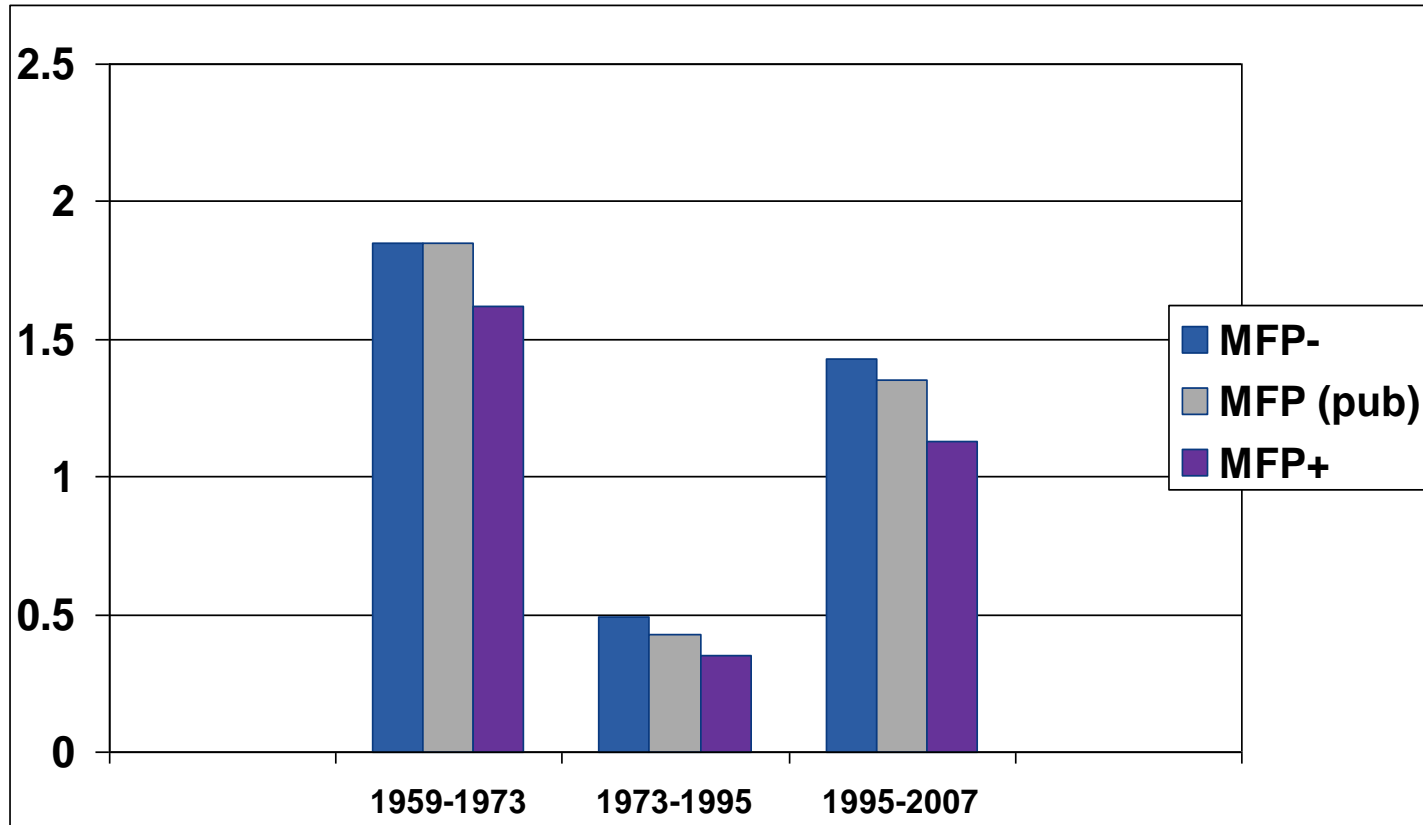
Update of productivity and growth results

- Based on consistently-calculated, current estimates of productivity and capital from **1959 to 2007** for nonfarm business sector
- Built from
 - BEA investment data for detailed fixed assets and inventories
 - BEA depreciation model (geometric rather than beta-decay)
 - BLS land estimates
 - BLS labor input data (hours, “composition” index)
- Jorgenson, Ho, Samuels, and Stiroh (2007) quantified:
 - Labor and capital input industry reallocation effects in MFP residual
 - Found effects “wash” out over business cycle/long time periods.

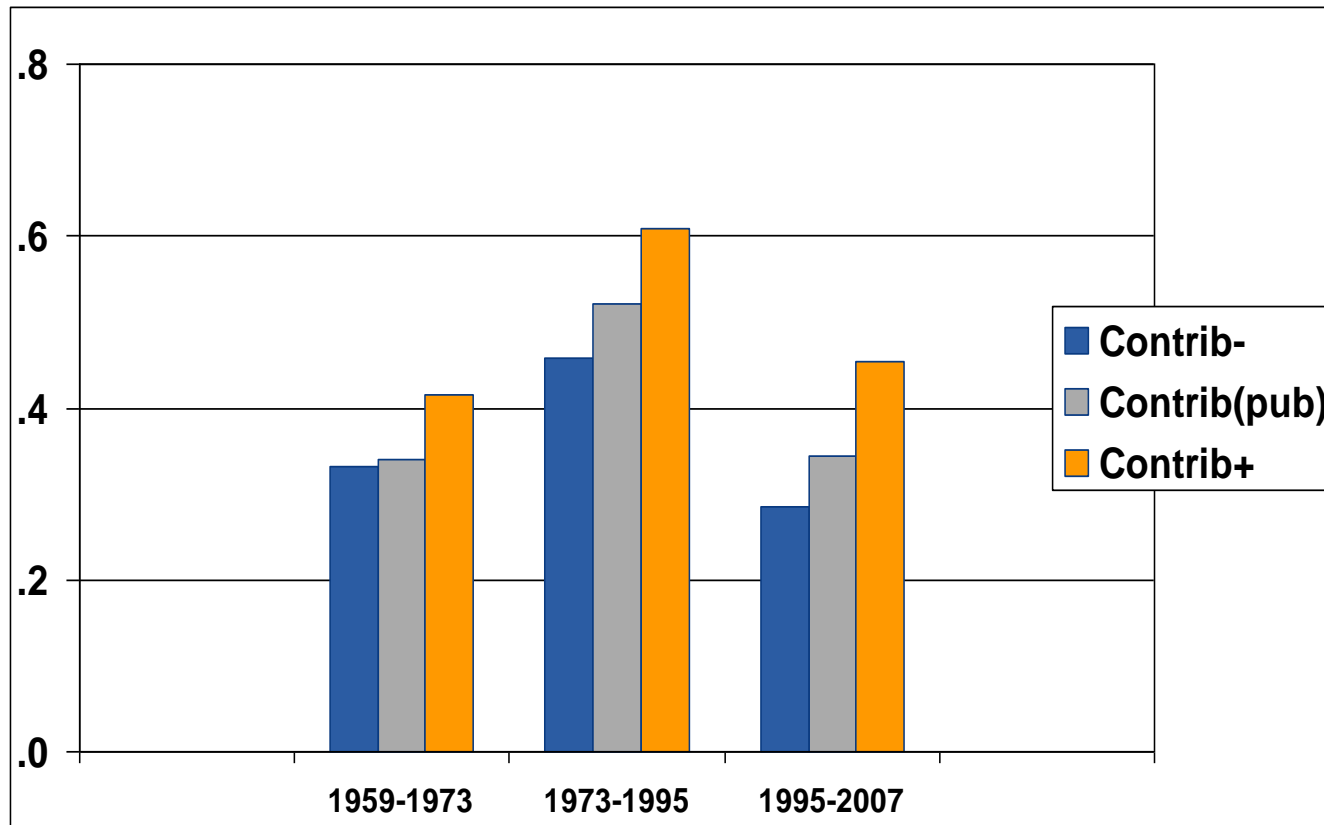
NFB Labor Productivity, percent change annual rate, BLS versus New Results



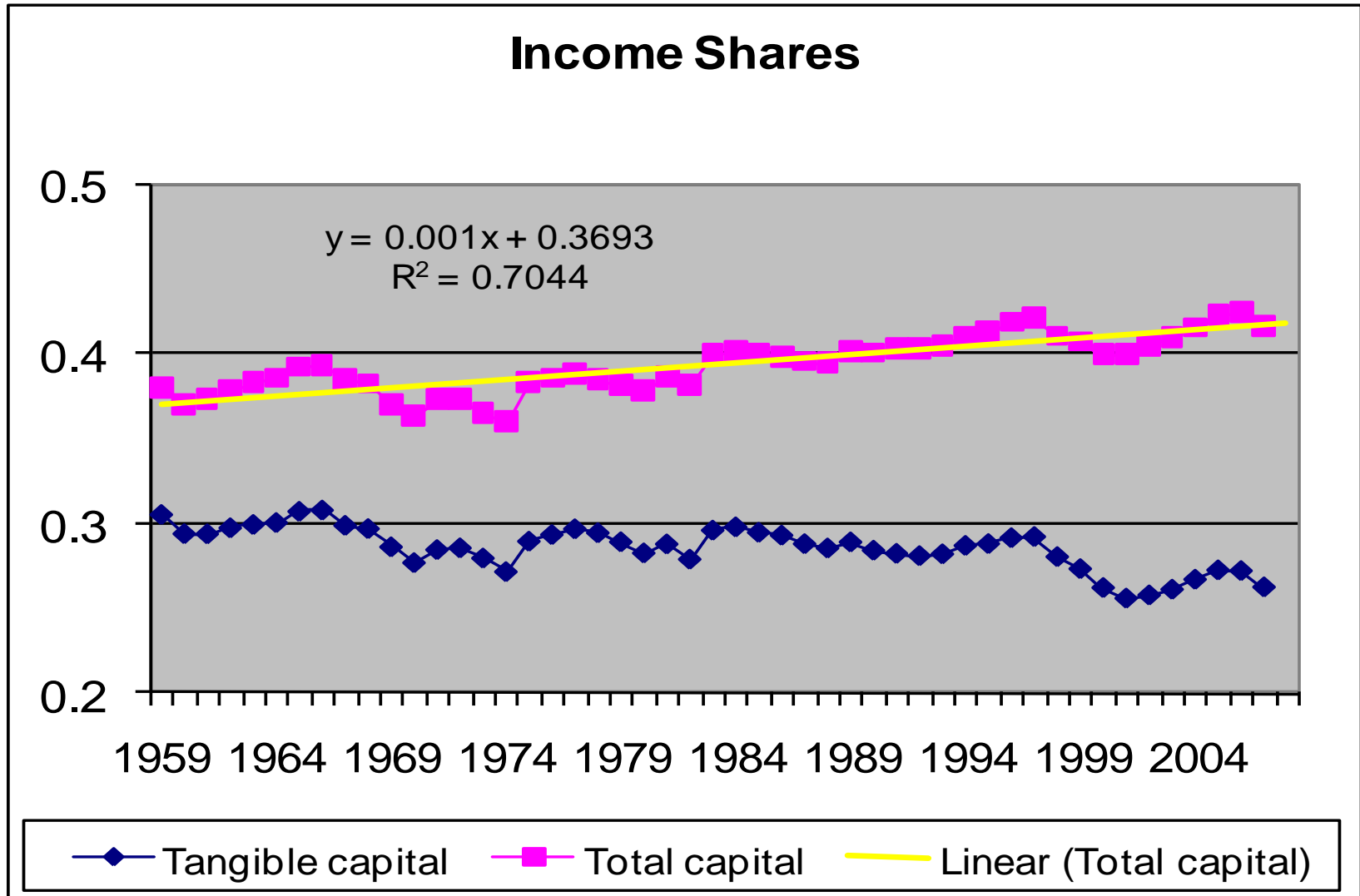
NFB Multifactor Productivity, with (+) and without (-) Intangibles, percent change, annual rate



Percent of OPH explained by capital deepening, with (+) and without (-) Intangibles



A new stylized fact? Probably not, rather a transition



Reason

- The inclusion or omission of a type of capital does not affect the dynamics of **steady-state** growth (Jorgenson 1966).
- But a steady state growth model is not well suited to the task of describing the shift from one technological era to another.
- Dynamics **are** being affected b/c in early stages of a transition, the growth in new I typically outstrips the growth of K.

Potential for paradigm shift

- The U.S. ICT sector is increasingly composed of “knowledge” workers
 - Modularity in production emerged in the 1990s (Berger, et. al)
 - Globalization tends to leave S&E, marketing and management in the home country.
- Although such trends would seem to imply, at the extreme, endogenous growth.....more realistically, **the emerging role of intangible capital, like IT capital, is a composition story**
- Suggests examining the occupational structure of industries for clues to business models in other sectors of the economy

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* COINVEST project

** funded by the NSF

Finance is a technology

Objective is to measure resources devoted to the development of new products and new business models in the financial services industry, an activity we will call **finance R&D**.

- Traditional R&D spending captures the cost of the “work done” by scientists and engineers because scientific inventions are well understood to originate in a laboratory.
- But where do financial innovations, such as electronic payment systems, ATMs, and the like, originate?
- And what about leverage, derivatives/securitization, and hedging?

Usage of terms “R&D” and “Innovation”

We employ the term R&D broadly (as in CHS 2005, 2006) to include all human knowledge inputs to the creation of intellectual and innovative property in private business.

For innovation, we employ the Schumpeterian definition adopted by the Commerce Dept:

“The design, invention, development and/or implementation of new or altered products, services, processes, systems, organizational structures, or business models for the purpose of creating new value for customers and financial returns for the firm.”

U.S. Department of Commerce (2008)

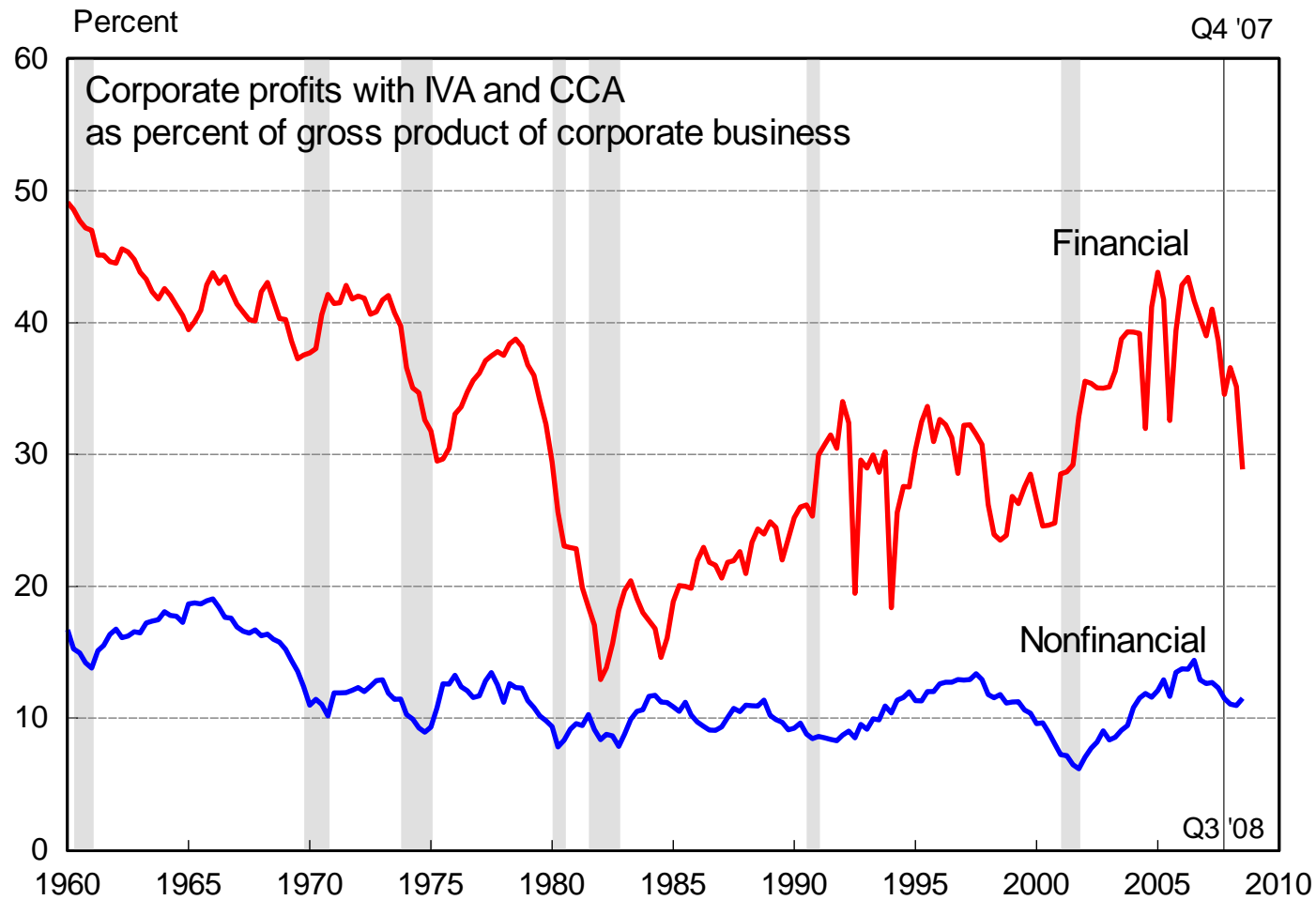
Research Strategy

- Exploit employer-based data on employment and wages by detailed occupation and industry (OES data) along with traditional source data for analysis of employment by occupation (CPS)



- Use the resulting estimates to enhance the Corrado, Hulten, and Sichel (2006) macroeconomic estimates of the contribution of intangible capital to U.S. economic growth.
- Why finance R&D:
 - Finance R&D was imprecisely estimated in CHS.
 - The sector is large and growing. It accounted for about 1/3 of U.S. productivity gains from 2000-05.

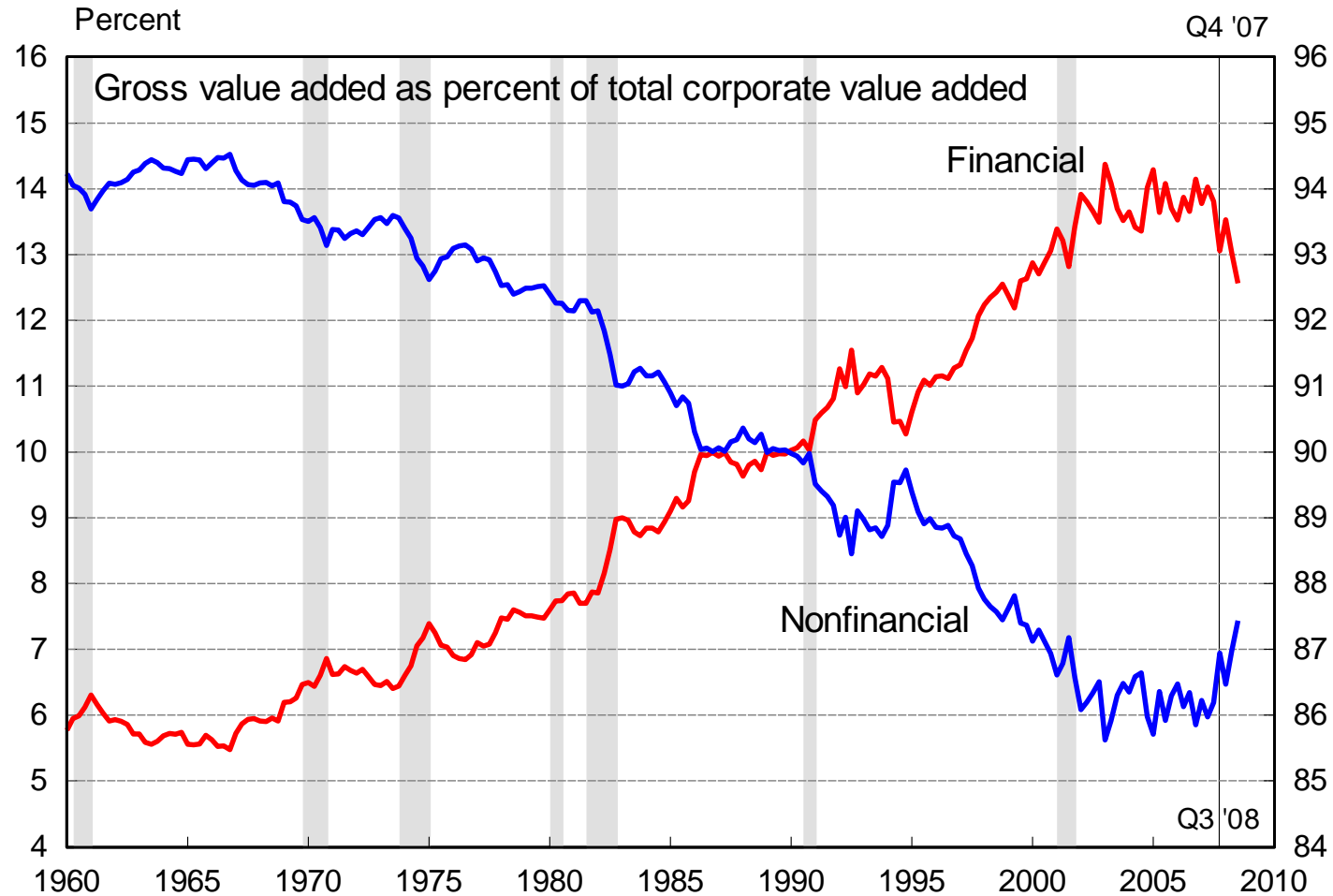
The profitability of the financial sector has outpaced the nonfinancial sector for some time...



Note: Shaded areas represent U.S. recessions

Sources: BEA, The Conference Board

... and resources increasingly have been allocated to the sector



Note: Shaded areas represent U.S. recessions

Sources: BEA, The Conference Board

Hurdles

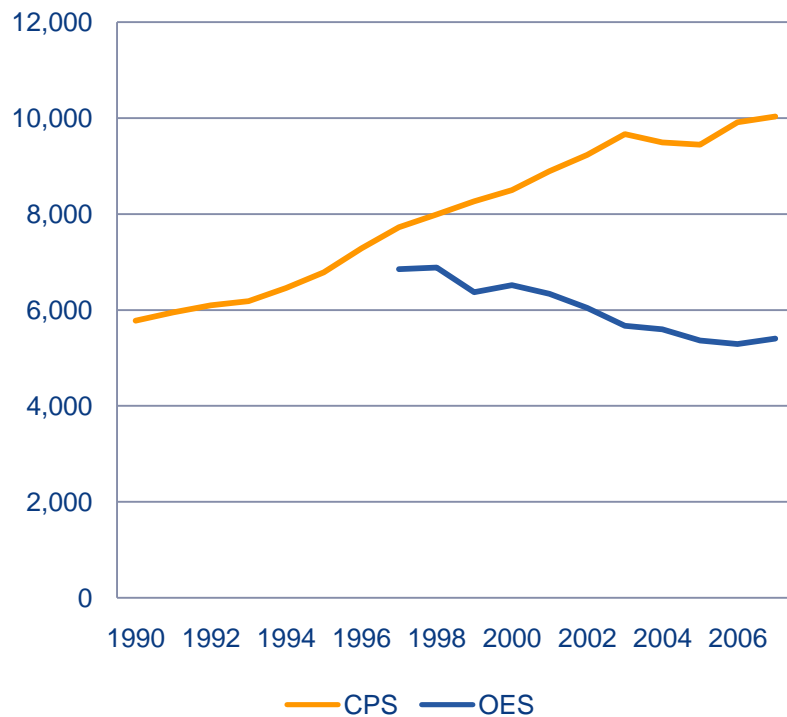
- No comprehensive time series data on employment and wages by industry and occupation:
 - BLS states on its website that it “does not use or encourage the use of OES data for time series analysis.”
 - The data contain myriad industry and occupation classification systems (5 changes since 1996!).
 - Abraham and Spletzer (2008) uncover significant changes in OES coding of management occupations beginning in 1999.
- With the advent of the financial crisis,
 - ...we put off starting the formal interviews although we now have completed a few, with strong results

Data challenge is to reconcile

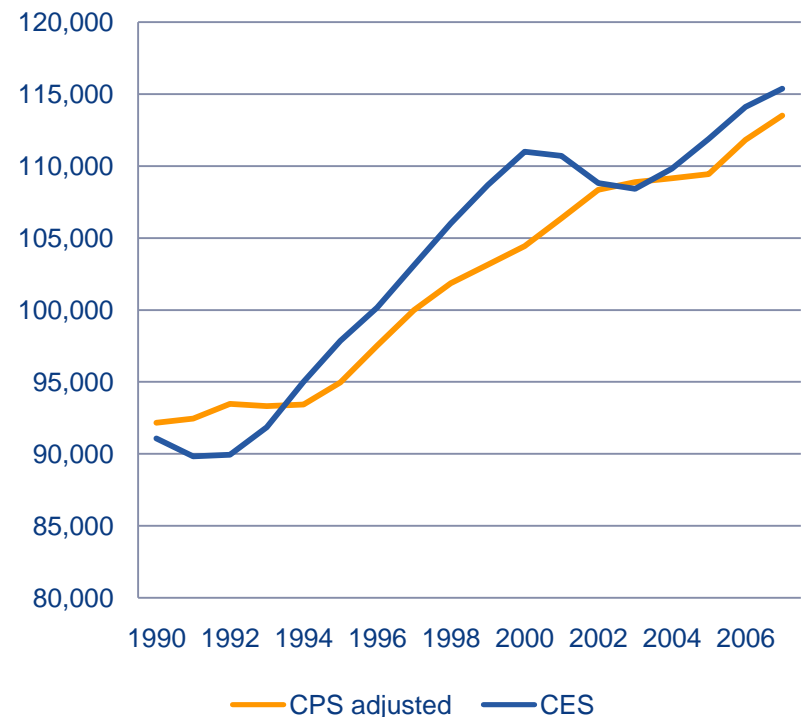
Puzzling discrepancies in source data for certain occupational trends....

along with familiar ones....

Managers



Total private employment

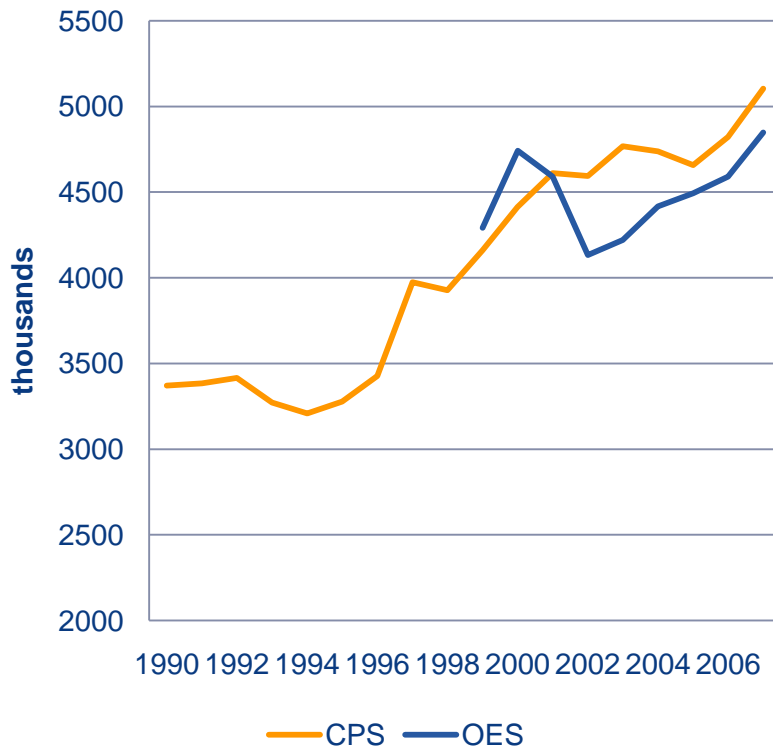


Additional perspectives...

S&E professionals*

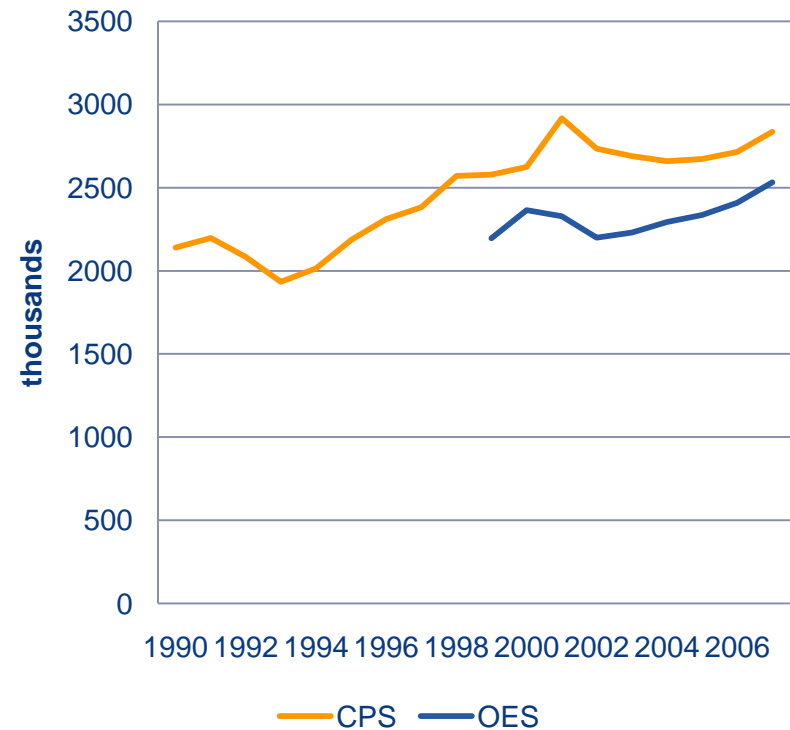
*includes managers, advanced professionals and technicians

STEM



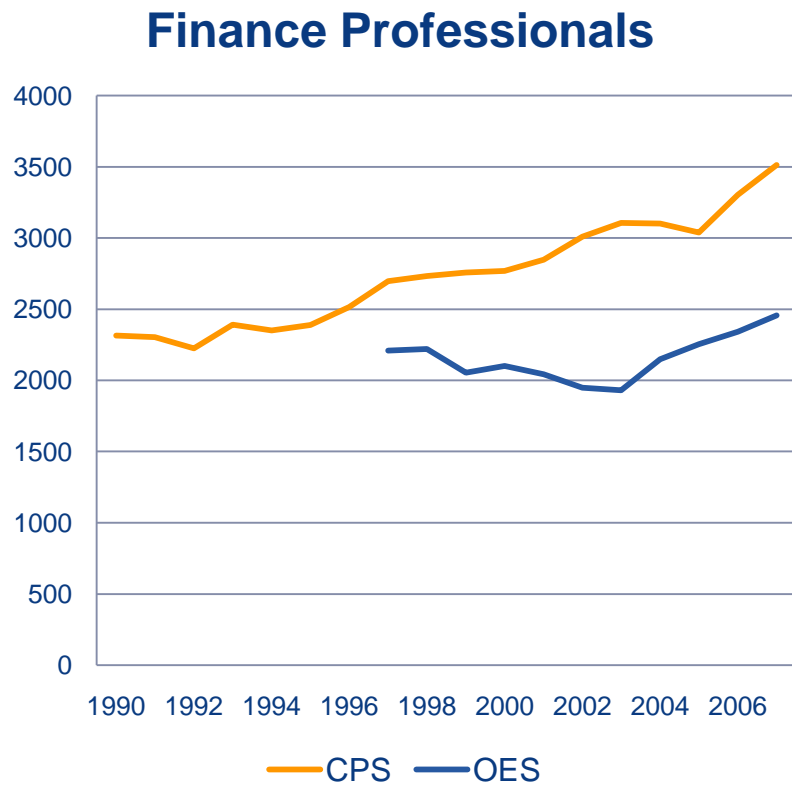
Design, marketing, and social science professionals

Other research & design occupations



And another

Relatively large discrepancy



- All told, OES estimates of employment in management and finance occupations are considerably lower than the CPS.
- Same pattern holds for research and design occupations (ie, S&E plus broader group), but to a much lesser extent.

Employment discrepancies are resolved by bi-proportional balancing, aka “RASing”

(a form of maximization under linear constraints)

- Columns are industries (detail on finance, others grouped into a few major sectors)
- Rows are selected groupings of occupations (detail on research and certain professions, others in major groups)
- column controls are CES data, which are paramount
- row controls are CPS data, pre-adjusted for key CES-CPS reconciling items (eg., self-employed)
- the OES are initial values for cells:
=> solution is dependent on initial conditions.

Wage distribution by industry and occupation

- ...taken from the OES
- ... and converted to compensation by proportionately adjusting each cell so that the **industry total** matches time-series figures published in the national accounts
- ...yielding compensation-weighted employment by occupation and industry

■ **Details:**

Undocumented changes to the OES in 1998/1999 forced us to apply the 1999 distribution backward in time; still working to resolve but may need to resort to CPS.

Estimates are generated from 1990 to 2007.

The intent is to combine the RAS'd data with information obtained from interviews

- That is, combine point-in-time estimates of finance R&D obtained from semi-structured interviews with time series estimates of compensation by occupation and industry.

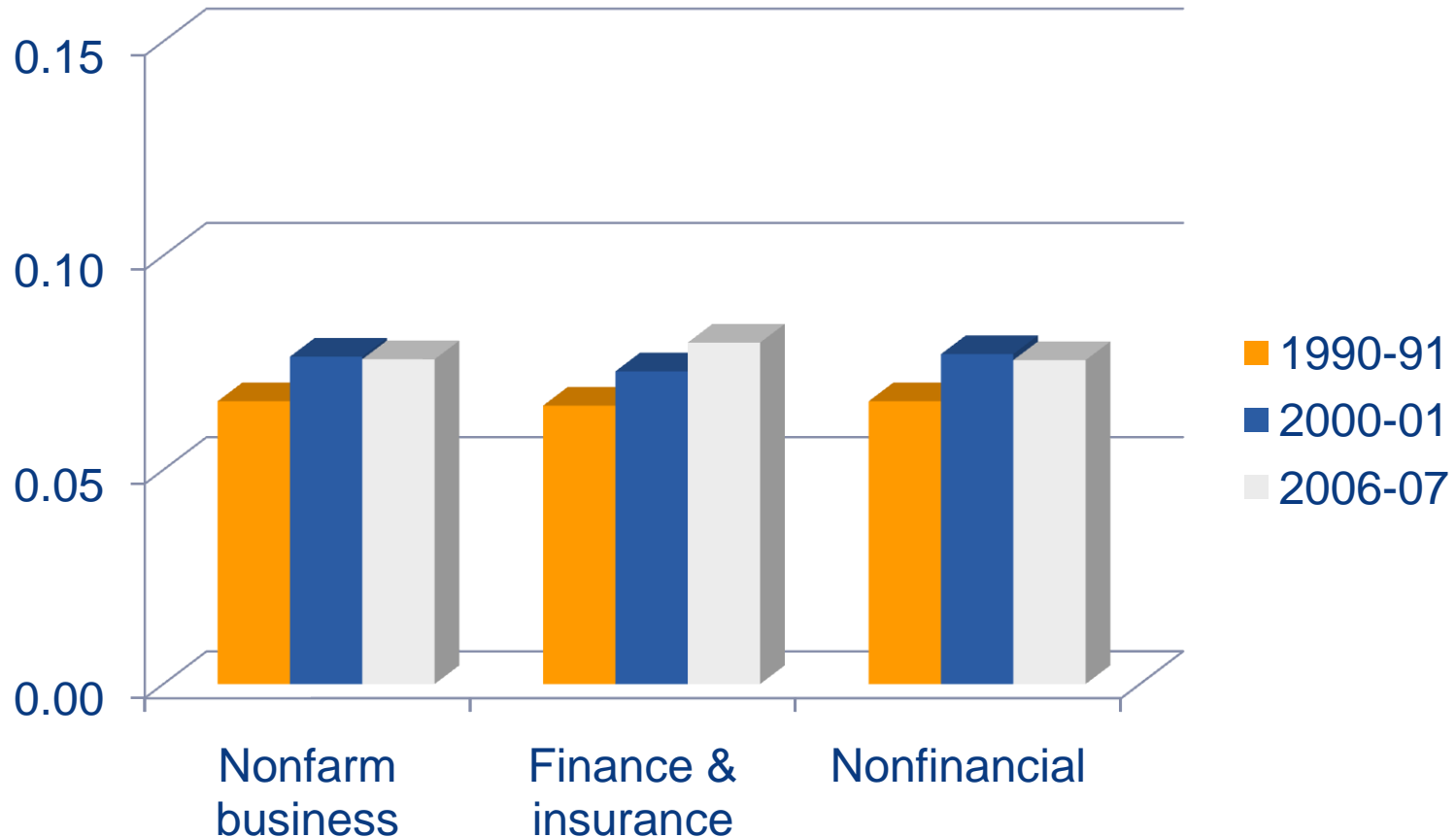
- We plan to calculate finance R&D in period t as

$$\sum_{sj} w(s,j,t)*e(s,j,t)*\lambda(s,j) + \sum_s m(s,t)*\gamma(s)$$

- $w(s,j)$ = compensation/employee of the j-th occ in sector s.
 - $e(s,j)$ = employment of the j-th occ in sector s
 - $\lambda(s,j)$ = scalar adjustment to control to an available point-in-time estimate of finance R&D for occupation j in sector s
 - $m(s)$ = purchased inputs to innovation in sector s
 - $\gamma(s)$ = scalar adjustment to control to an available point-in-time estimate of purchased inputs to innovation in sector s
- Integrity of our estimates depends on the time series for $e(s,j,t)$ and the distribution of $w(s,j)$

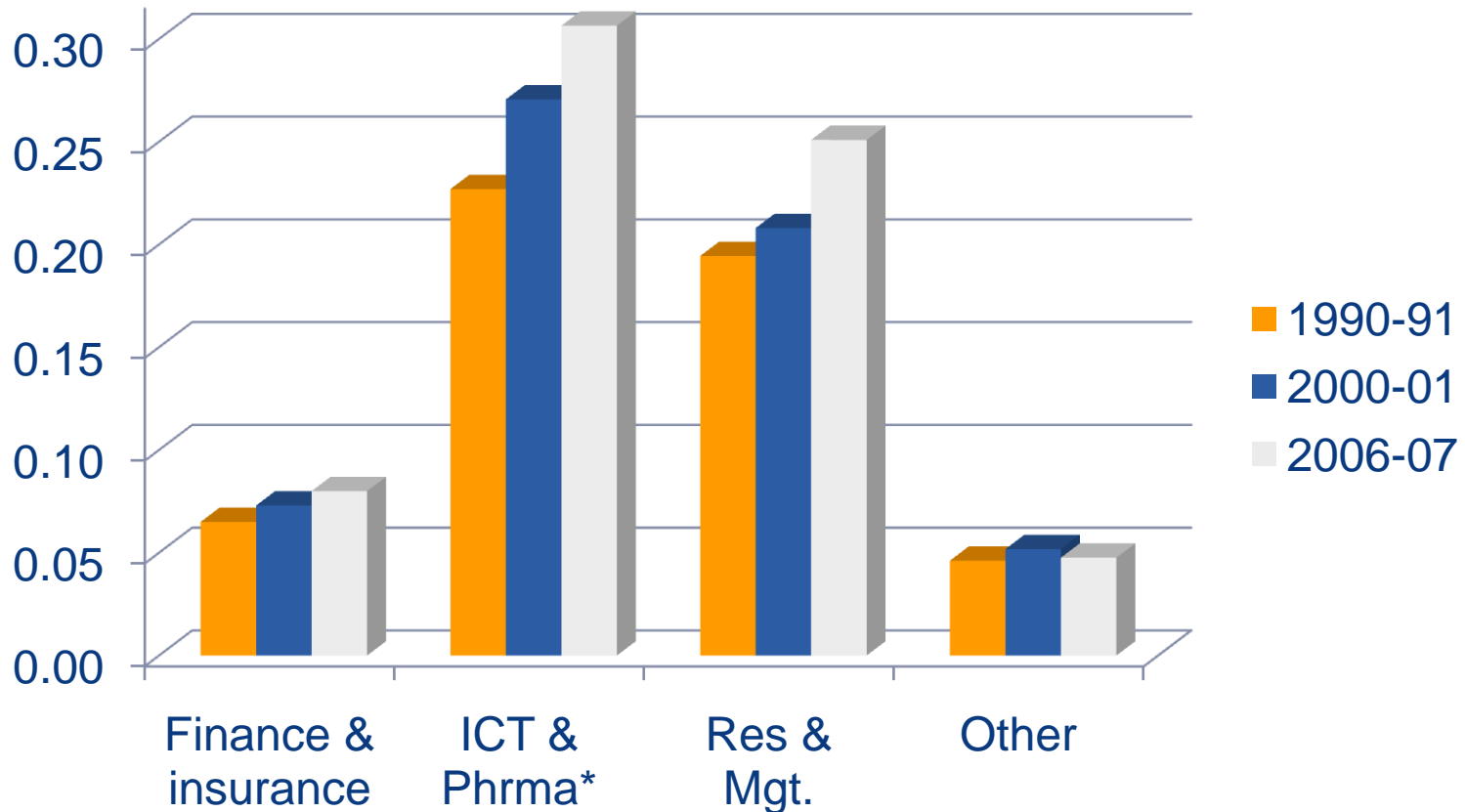
RAS results: Research and design intensity of nonfarm business employment

(research occupations include S&E + social science and design)



Research and design intensity of employment in business, by selected sectors

(research occupations include S&E + social science and design)



* includes mfg and services.

A few comments on research employment (though somewhat off-target) ...

The results just shown...

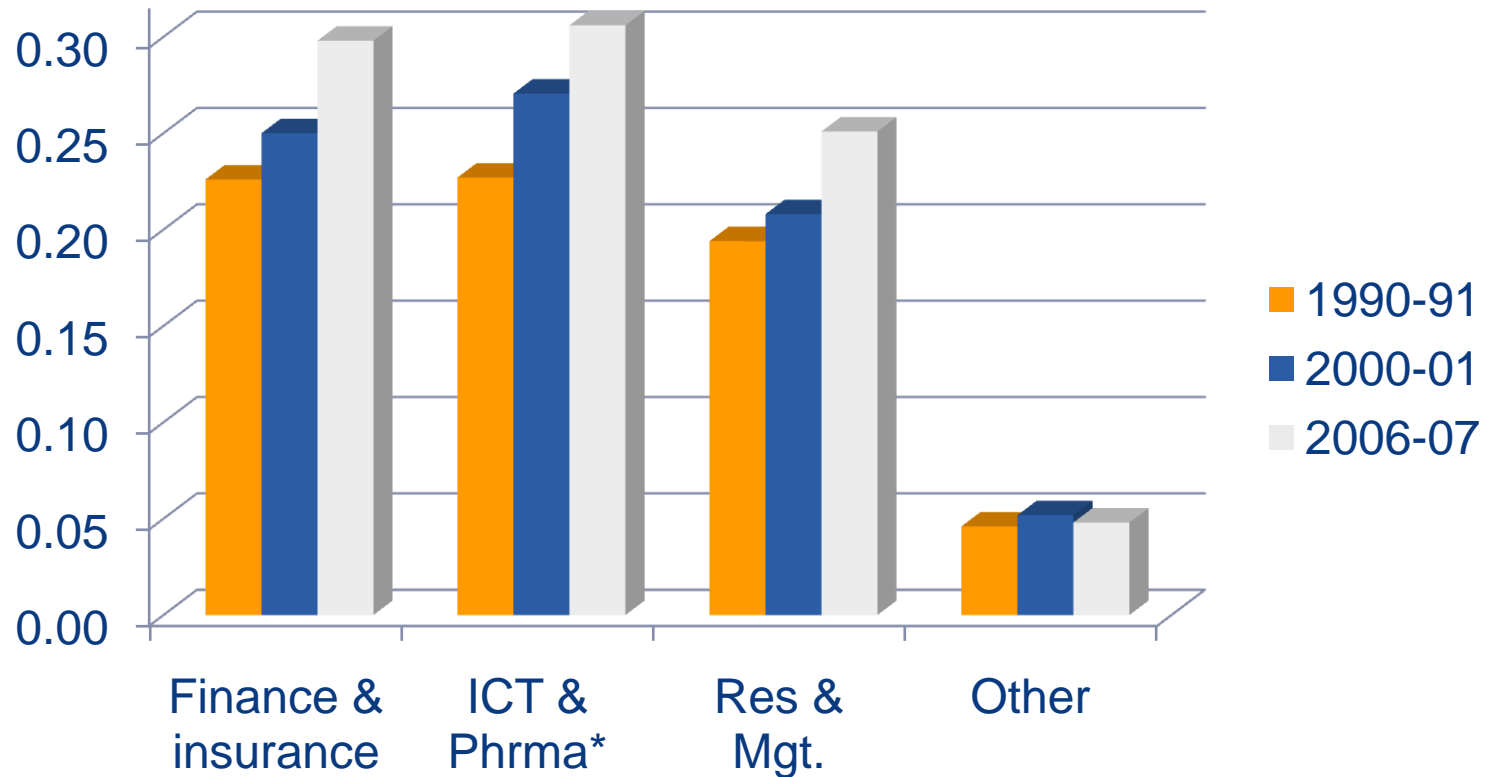
- Contain offsetting “within” and “between” results for research and design employment (NB: changes in shares not shown).
- “Stabilization” occurs not b/c research-intensive industries engaging in less research....
- Rather, less-research-intensive sectors have gained more in employment thus far this decade (compared with 1990s).

but what about finance?

- Preliminary information from informal interviews and consultants’ reports suggests **finance professionals and management strategists** conduct research/new product development in the financial services industry.
- Looking at research and design employment (**expanded to include finance professionals working in finance**) ...next chart... the within/between distinction shows through **more strongly**.



Research (science and finance) and design intensity of employment in selected sectors



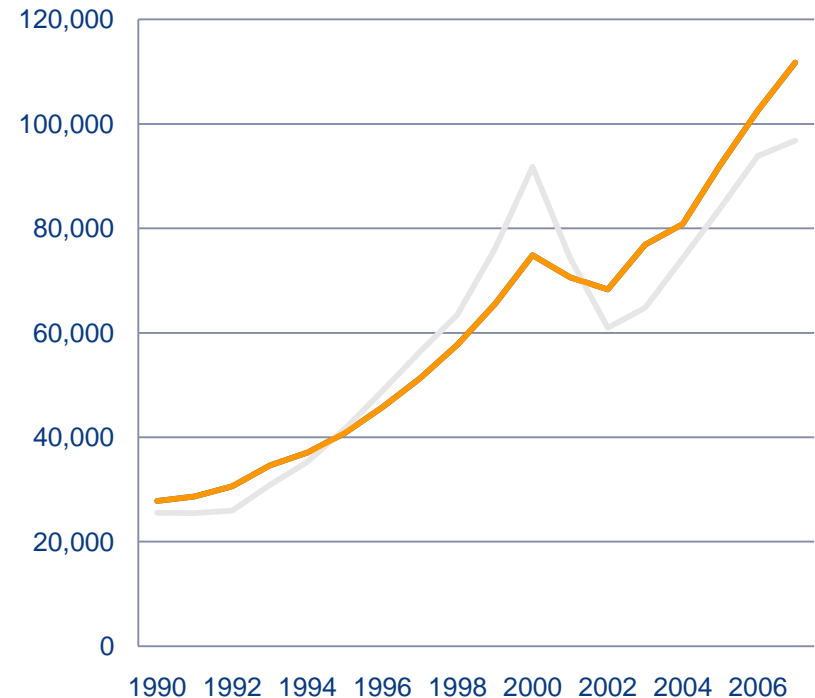
* includes mfg and services.

Back to main message: Employment trends are combined with compensation trends to obtain compensation-weighted labor inputs

Assume...

- 50% of the labor costs of research professionals is R&D
- 20% of the labor costs of finance professionals is R&D
- 8% of total purchased inputs is purchased R&D

Finance & Insurance R&D
(millions of dollars)



Final comments

- Estimates on previous chart, though crude and for illustrative purposes only, are very close to the time series embedded in the original work of CHS.
 - But we have yet to complete our interviews, exploit the occupation dispersion within the broad occupation groupings, and obtain a reliable source for purchased R&D --- stay tuned.
- We learned (from confidential reports) that firms in finance and insurance manage compensation very carefully, even on the basis of time-use surveys of employee activity.
 - The 50/20 percentages used in the previous chart were adapted from one such report – we do not know the representativeness, however.
- We gleaned (preliminarily, case-study style) that the R&D/GTM process in finance/insurance is increasingly like that in manufacturing, but with shorter gestations.

We therefore expect the interview/survey stage of our work to pin down these notions in a more scientific fashion....

- George Stigler famously quipped, “data are the plural of anecdote.”
- The learning and discovery described in
“R&D comes to Services: Bank of America’s Pathbreaking Experiments” by Stefan Thomke, *Harvard Business Review*, April 2003.
“Can a Hybrid 401(k) Save Retirement?”, by Amy Feldman, *Business Week*, 2/5/2009.
-suggests the innovation process in financial services has much in common with the scientific R&D process in manufacturing.

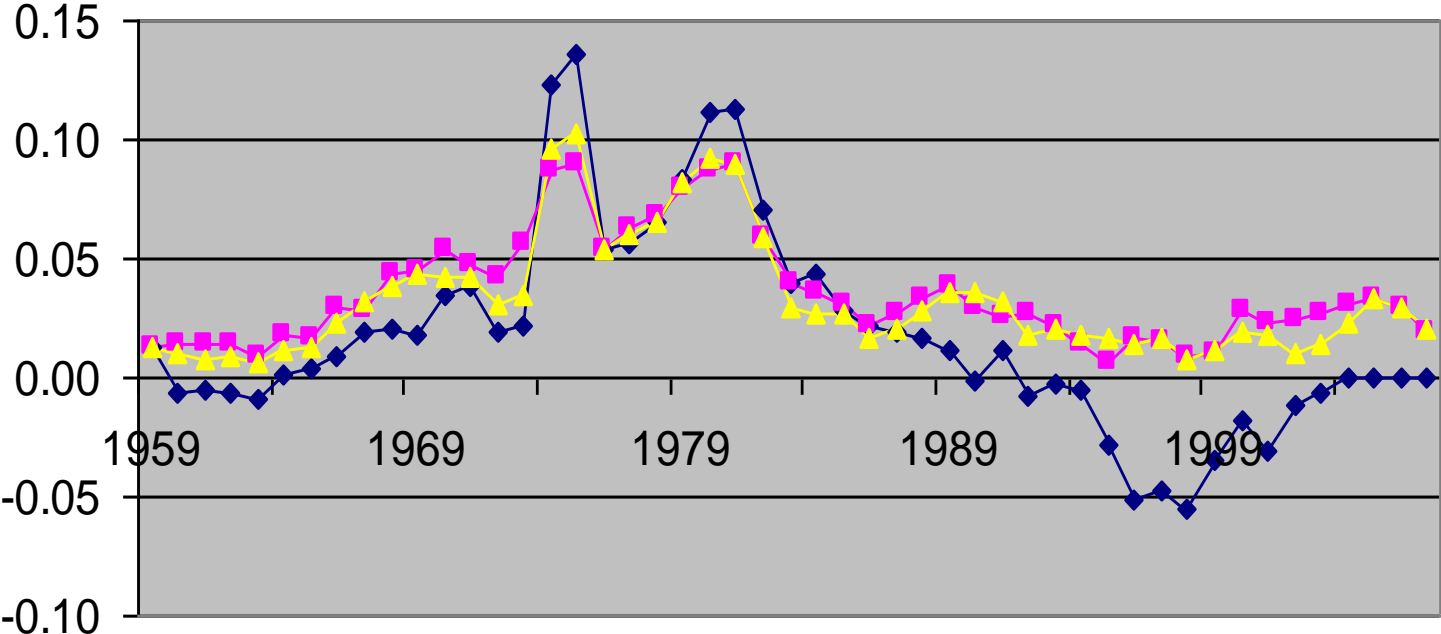
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Rate of change in R&D deflators (smoothed)

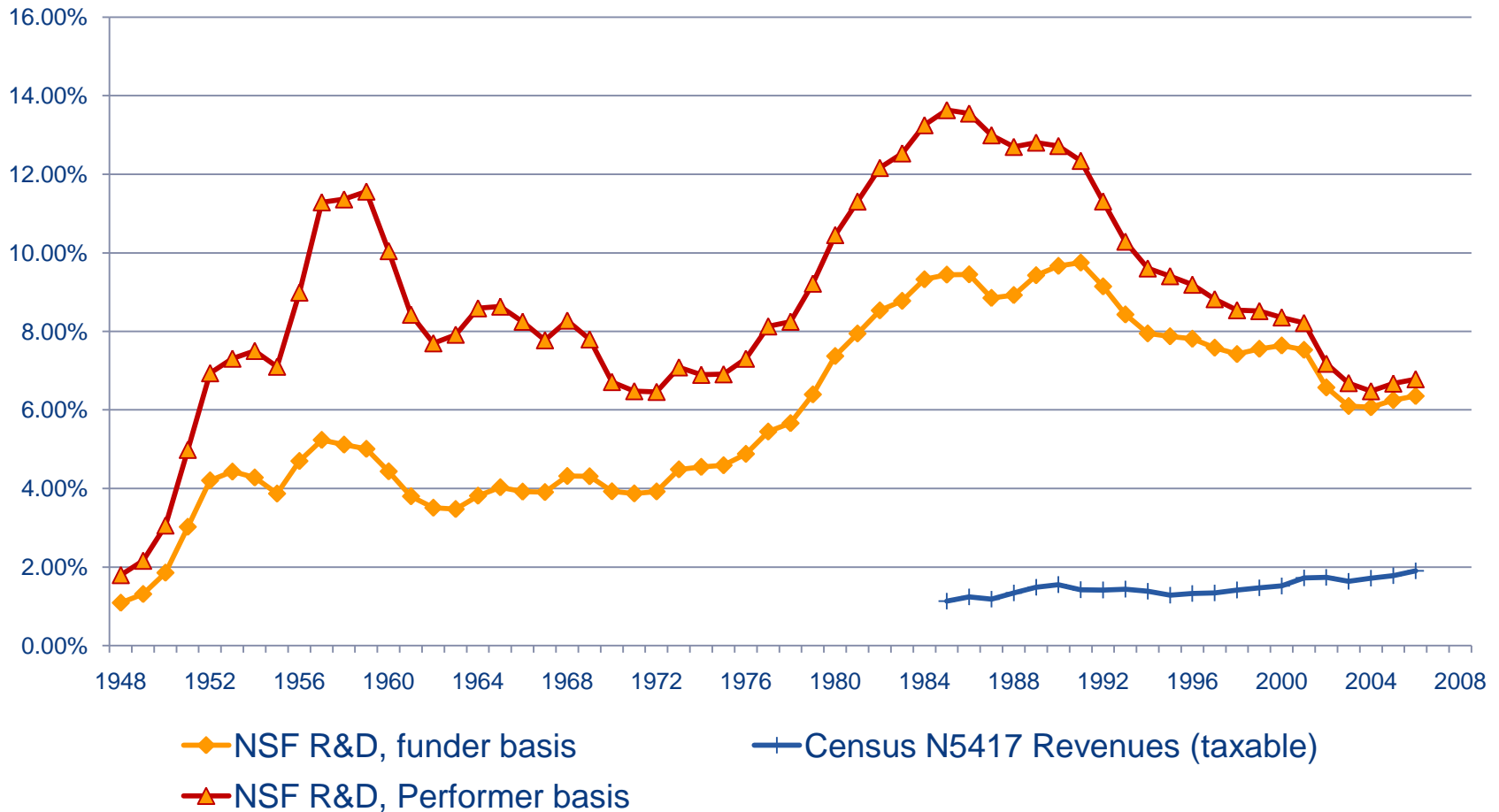


◆ BEA output deflator ■ BEA input deflator ▲ PNFB output deflator

A recent BEA paper has taken a new approach to measuring prices for R&D

- Latest effort to go beyond input cost indexes to obtain an R&D output price index.
- Key idea: exploit revenues in the R&D marketplace, proxied by BEA's gross output figures for NAICS industry 5417.
 - According to BEA's estimates, private for-profit business R&D is 70% self-produced, 30% purchased (of which N5417 is a growing part).
- But they obtain a puzzling result: **Prices rise faster than input costs.**

NSF Industrial R&D and Census 5417 Revenue (percent of Nonfarm business output)



How can that be?

- The result implies the R&D process is getting less and less efficient year in and year out:

$$\begin{aligned} N &= \text{real value of R\&D} \\ &= Z B(L, K, R), \end{aligned}$$

where $R = N + \delta R_{-1}$, $Z =$ R&D productivity, B is c.r.s.

$\Delta \ln P_N =$ share-wtd change in input costs less $\Delta \ln Z$

- An ideal measure of P_N would account for Z :
“The real measure of success is the number of experiments that can be crowded into 24 hours.”
--- Thomas Edison

R&D productivity hasn't received much attention from economists, despite.....

- Beginning 20 years ago, high tech-enabled combinatorial chemistry drastically lowered costs of experimentation in pharma labs.*
- IT enabled shorter design times for semiconductors (MGI, 2001), early testing of new car designs now uses “virtual” software, etc...
- BiZ school is full of it, eg., “The three R’s of design innovation: Rough, rapid, and right” to emphasize importance of early experimentation and efficiency.
 - Many references possible.

* Example of an exception: Furman, J.L., M.K. Kyle, I. Cockburn, and R. Henderson. 2004. "Public and Private Spillovers, Location, and the Productivity of Pharmaceutical Research." Mimeo. Duke University.

Problem is lack of data and models

- Innovation as “inspiration” or defining innovation as an “idea” reinforces the view that technical change is essentially costless.
- The view that human knowledge enters the production function via the augmentation of labor input also reinforces this view.
- In other words, $N = Z F(L)$ as the fundamental model of innovation is a problem.
- A key conceptual underpinning of the move to capitalize R&D in national accounts is the model (as before):

$$N = Z F(L, K, R) \text{ with } R = N + \delta R_{-1}$$

is that research builds upon research, and that business appropriates knowledge.

Entrepreneurial model, a variant of the more general CHS model

- Aggregate output represented by 2 sectors: innovation/research sector and operations/producing sector
- Called “entrepreneurial” model b/c especially relevant when you have entrepreneurs and independent labs as producers of innovation

$$O = A F(L_o, K_o, Nu) \quad , \quad N = Z B(L_n, K_n, R), \quad R = N - Nu$$

- We examine the price duals, exploit recursive nature of the model to highlight role of costs in prices, eg. (after a few assumptions):

$$\Delta \ln P_N = \Delta \ln FC_N - \Delta \ln Z / (1-s_R)$$

- Following Hausman, we consider pricing concepts under imperfect competition to derive insights from the demand side.

Lack of data also a serious impediment to estimating both P_N and δ_R

- Before measurement, need to ask, What is the unit of analysis?
 - With regard to broader issue of measuring innovation, a group of experts conjectured the unit of analysis should be the “project” or “initiative” (Corrado 2008).
- In a recent paper on measuring “nonmarket” prices, Diewert (2008) shows:
 - Data on input costs for units such as “procedures” (he was using the example of health) can yield price measures that incorporate productivity effects (a la Edison).
- Project level data on outcomes as well as inputs would enable the computation of rates of return...
-and enable the study of determinants of R&D productivity and innovation success.