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Motivation

▪ Long-standing call for statistics on the sources of growth
  ▪ Solow (1957), Denison (1967), Griliches and Jorgenson (1967)
  ▪ Postwar Recovery, Big Slump, IT Boom, the Great Recession
  ▪ “... differences between the BEA and BLS estimates have led many researchers to construct their own measures ...”

▪ The Advisory Committee on Measuring Innovation in the 21\textsuperscript{st} Century: A Report to the Secretary of Commerce (January 2008)
  ▪ “Develop annual, industry-level measures of total factor productivity ...”
Productivity statistics integrated with GDP

- This project: Incorporates comprehensive revision of U.S. National Accounts
  - R&D and entertainment originals capital

- Results on sources of growth 1998-2012:
  - R&D capital contributed about ½ as much as software capital over the 1998-2012 period
  - Much of the contribution of R&D capital comes from R&D intensive industries
  - Including R&D and entertainment originals reduces growth rate of MFP from 0.51% to 0.44% per year
Analysis of the ongoing recovery

- The smaller contribution of capital input relative to the pre-crisis period more than accounts for the slower growth during the recovery

- Non-college labor contributes positively in contrast to negative contributions in the pre-crisis and crisis periods
Aggregate results: VA growth decomposition 1998-2012

Real Value Added Contributions by Sector

Sources of Real Value Added Growth

- Other
- FIRE
- Prof. and Business Services
- Trade
- Information
- Manufacturing
- MFP
- College Labor
- Other Capital
- R&D
- Software
- IT Equipment
- Non-College Labor
Aggregate results: Sources of growth by sub period

- IT Equip and Software Capital
- Other Capital
- College Labor
- NonCollege Labor
- MFP
From aggregate to Industry sources of growth analysis

- Requires an industry-level production account
  - Industry-level outputs and inputs in current and constant prices
    \[ Y_Q = K_Q K_P + L_Q L_P + X_Q X_P = VA_Q VA_P + X_Q X_P \]
  - Symmetric treatment of outputs, intermediate inputs, and primary inputs

- Consistent with aggregate GDP constructed within an Input-Output Framework
  - Gross output, intermediate input, value added: BEA
  - Capital input: BLS, based on BEA Fixed Assets
  - Labor input: Hours from BLS, Composition from BEA
Industry origins of aggregate growth

- From industry to aggregate:
  - Direct aggregation of industries (Jorgenson, Ho, Samuels, Stiroh, 2007)
    - Contributions of industries to aggregate value added growth
    - Contributions of industries to the aggregate contribution of capital and labor inputs
    - Contributions of industries to aggregate MFP growth
  - Compare industry sources of growth over the recovery period to the pre-crisis period
Contributions to aggregate Capital by industry


- Farms
- Federal
- Mining, except oil and gas
- Oil and gas extraction
- Support activities for mining
- Chemical products
- Data processing, internet publishing, and other information services
- Food and beverage and tobacco products
- Primary metals
- Machinery
- Other transportation equipment
- Rail transportation
- Food services and drinking places
- Forestry, fishing, and related activities
- Waste management and remediation services
- Pipeline transportation
- Hospitals and Nursing and residential care
- Textile mills and textile product mills
- Apparel and leather and allied products
- Paper products
- Water transportation
- Motion picture and sound recording industries
- Educational services
- Electrical equipment, appliances, and components
- Performing arts, spectator sports, museums, and related activities
- Petroleum and coal products
- Social assistance
- Computer systems design and related services
- Wood products
- Fabricated metal products
- Ambulatory health care services
- Utilities
- Furniture and related products
- Management of companies and enterprises
- Printing and related support activities
- Transit and ground passenger transportation
- Miscellaneous manufacturing
- Nonmetallic mineral products
- Warehousing and storage
- Amusements, gambling, and recreation industries
- Plastics and rubber products
- Other transportation and support services
- Securities, commodity contracts, and investments
- Air transportation
- Truck transportation
- Motor vehicles, bodies and trailers, and parts
- Funds, trusts, and other financial vehicles
- Accommodation
- Computer and electronic products
- Other services, except government
- Administrative and support services
- Publishing industries, except internet (includes software)
- Legal services
- Broadcasting and telecommunications
- Miscellaneous professional, scientific, and technical services
- State and local government
- Insurance carriers and related activities
- Construction
- Wholesale trade
- Rental and leasing services and lessors of intangible assets
- Retail trade
- Federal Reserve banks, credit intermediation, and related activities
- Real estate
- IT Equip. and Software
- Other
Contributions to aggregate Labor by industry


- Computer and electronic products
- Machinery
- Administrative and support services
- Fabricated metal products
- Motor vehicles, bodies, and trailers, and parts
- Retail trade
- Computer systems design and related services
- Ambulatory health care services
- Primary metals
- Support activities for mining
- Insurance carriers and related activities
- Wholesale trade
- Management of companies and enterprises
- Apparel and leather and allied products
- Electrical equipment, appliances, and components
- Food services and drinking places
- Truck transportation
- Chemical products
- Oil and gas extraction
- Plastics and rubber products
- Other transportation and support activities
- Miscellaneous manufacturing
- Air transportation
- Food and beverage and tobacco products
- Federal
- Textile mills and textile product mills
- Rail transportation
- Paper products
- Motion picture and sound recording industries
- Mining, except oil and gas
- Accommodation
- Publishing industries, except internet (includes software)
- Other transportation equipment
- Wood products
- Printing and related support activities
- Waste management and remediation services
- Nonmetallic mineral products
- Pipeline transportation
- Furniture and related products
- Warehousing and storage
- Funds, trusts, and other financial vehicles
- Amusements, gambling, and recreation industries
- Water transportation
- Petroleum and coal products
- Forestry, fishing, and related activities
- Performing arts, spectator sports, museums, and related activities
- Farms
- Utilities
- Social assistance
- Rental and leasing services and lessors of intangible assets
- Other services, except government
- Hospitals and Nursing and residential care
- Legal services
- Educational services
- Real estate
- Broadcasting and telecommunications
- Securities, commodity contracts, and investments
- Miscellaneous professional, scientific, and technical services
- Construction
- State and local

College Labor  Non-College Labor

Average annual percentage point
Contributions to aggregate MFP by industry


Diagram showing contributions to aggregate MFP growth by industry from 2009-2012 compared to 1998-2007.
Computers and electronic products account for about 65% of aggregate MFP growth!
Conclusions and next steps

▪ Findings:
  ▪ Between 1998-2012 R&D capital services contributed about half as much as software capital services to GDP growth
  ▪ Comparing ongoing recovery to 1998-2007: major difference is contribution of capital input, concentrated in housing, trade, banking
    ▪ and contribution of Noncollege labor has picked up

▪ Update plans ...
  ▪ Explore alternative data sources for labor composition
  ▪ Incorporate methods into BEA systems
  ▪ Plan for regular updates, along with annual revisions
  ▪ Extend historical time series following JHS (2014)
Account details 1: Labor input

- Control totals from BLS
- Hours worked cross classified by:
  - Sex (2)
  - Class (2) (employee; self-employed)
  - Age (8) (<16, 16-17, 18-24, 25-34, 35-44, 45-54, 55-64, 65+)
  - Education (6) (grade 0-8, 9-12 no diploma, hs graduate, some college, BA, >BA)
  - Industry (63)
- 12096 workers by year
- Data source: decennial census, CPS
- Labor input is an index number with $/hr as the price.
Account details 2: Capital input

- Productive stock and capital services from BLS
- Capital input is index number of productive stocks by asset for each industry
- Key concept: capital services prices are the imputed Jorgensonian user cost
- 86 asset types for fixed business equipment and software, structures, inventories, and land
Industry-level output and intermediate input

- **Source:** BEA GDP-by-industry data 1998-2012

**Top 5 and Bottom 5 VA Growth Differences: 2009-2012 less 1998-2007**

- Motor vehicles, bodies and trailers, and parts
- Primary metals
- Apparel and leather and allied products
- Machinery
- Pipeline transportation
- Funds, trusts, and other financial vehicles
- Securities, commodity contracts, and investments
- Computer and electronic products
- Water transportation
- Petroleum and coal products

Average annual percent per year
Industry-level capital input

- **K services: BLS, based on BEA Fixed Assets**


  - Support activities for mining
  - Mining, except oil and gas
  - Farms
  - Oil and gas extraction
  - Pipeline transportation
  - Funds, trusts, and other financial vehicles
  - Real estate
  - Legal services
  - Federal Reserve banks, credit intermediation, and related activities
  - Rental and leasing services and lessors of intangible assets

  [Bar chart showing average annual percent per year]
Industry-level capital input


- Support activities for mining
- Mining, except oil and gas
- Farms
- Oil and gas extraction
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- Real estate
- Legal services
- Federal Reserve banks, credit intermediation, and related activities
- Rental and leasing services and lessors of intangible assets

Average annual percent per year

www.bea.gov
Industry-level labor input

- Labor hours: BLS, based on BLS survey data
- Labor composition: BEA


- Support activities for mining
- Apparel and leather and allied products
- Data processing, internet publishing, and other information services
- Machinery
- Rail transportation
- Securities, commodity contracts, and investments
- Social assistance
- State and local
- Educational services
- Construction

Average annual percent per year
Industry-level labor input


- Support activities for mining
- Apparel and leather and allied products
- Data processing, internet publishing, and other information services
- Machinery
- Rail transportation
- Securities, commodity contracts, and investments
- Social assistance
- State and local
- Educational services
- Construction

College | NonCollege

Average annual percent per year
MFP growth by industry


Motor vehicles, bodies and trailers, and parts
Pipeline transportation
Rental and leasing services and lessors of intangible assets
Motion picture and sound recording industries
Management of companies and enterprises
Rail transportation
Securities, commodity contracts, and investments
Water transportation
Petroleum and coal products
Computer and electronic products

Average annual percent per year