Intangible Capital and U.S. Productivity Growth in 61 Industries

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SGE session on Productivity, ASSA meetings
January 9, 2022

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Outline of Paper

- Considers intangible capital and productivity in 61 industries in U.S. private business sector, 1987-2019.

- First, shows effect on output of three intangibles presently included in U.S. Accounts: R&D, Software, Artistic Originals.

- Second, considers advertising investment as intangible capital

- Third, looks at differences between returns to intangibles at the firm and industry levels. These differ because industry data reflect spillovers within an industry which extend beyond firm effects. Example of R&D.

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The R&D Literature

- BEA work on R&D mainly considers R&D returns to individual firms, which BEA measures well. In contrast, official BLS statistics measure productivity primarily at the industry level.

- BSVR (2013) show social returns to R&D, most presumably in the same industry, are two or three times greater than direct returns to firms undertaking R&D. Industry data contain these important spillovers between firms.

- This paper makes some estimates of spillover effects of intangibles using firm data from Compustat to determine differences between firm and industry effects.

The Impact of Intangibles

Contribution of an input *x* to growth is:

$$\alpha_x \ \dot{X}/X \qquad\qquad (1)$$

- where α_x is the cost share of input x

- Use logarithmic form in actual calculations.

- BLS capital data contain service (rental) prices as well as quantities, so we can measure factor shares as a proportion of value added.

A Key Advantage of BLS Data

- BLS obtains investment and investment price deflators from the Accounts. BLS computes stocks and service prices for each asset/year.

- Much work on intangibles does not have data on service prices, just quantities.

- BLS has prices and quantities of capital assets, so we can calculate factor shares (α_x) for each asset as a proportion of total cost.

Effects of Intangibles; R&D is crucial

Table 1: Contributions of each intangible asset to the growth of capital services for private business

Percentage point contributions

Period	Artistic Originals	R&D	Pre-Packaged Software	Custom Software	Own-Account Software	All-asset Growth
1990-2000	0.12	0.47	0.33	0 .20	0.09	4.5%
2000-2007	0.12	0.39	0.28	0.15	0.11	3.4%
2007-2019	0.06	0.36	0.26	0.17	0.07	2.3%
1987-2019	0.09	0.41	0.29	0.18	0.09	3.4%

- R&D is the category with the greatest impact on the growth of capital services. (We consider software below.)

- The table includes only private returns to individual firms. Bloom, Schankerman, and Van Reenen (2013) and other work show us that most returns to R&D occur through spillover effects. Therefore, the results in Table 1 understate the true importance of R&D.

Asset share of productive capital stock by sector, 2017

Sector	Artistic Originals	R&D	Pre-Packaged Software	Custom Software	Own-Account Software	Other Assets	Advertising
Manufacturing	0.0%	25.9%	0.5%	0.8%	0.2%	72.2%	0.3%
Other Goods	0.0%	0.3%	0.2%	0.1%	0.0%	99.3%	0.1%
Trade	0.0%	1.2%	0.7%	0.8%	0.4%	94.5%	2.3%
Finance	0.0%	1.8%	4.8%	3.7%	1.1%	86.9%	1.7%
Other Services	3.9%	3.3%	0.8%	1.5%	0.7%	88.8%	1.0%

"Other goods" represent agriculture, mining, and construction.
"Other services" are those other than trade and finance. Table 9 in the text.

- R&D constitutes a substantial share of the total capital stock in manufacturing. R&D is also relatively important in many of the services.

Intangible share of capital stock by major sector, 2017

Sector	Intangible Stock ($millions)	Tangible Stock ($millions)	% Intangible
Other Goods	65,749	9,319,058	1%
Manufacturing	1,734,320	4,511,265	28%
Trade	282,552	4,900,574	5%
Other Services	1,949,448	15,466,035	11%
Finance	259,786	1,718,178	13%

- This table indicates that intangible assets in manufacturing, which consist mainly of R&D, account for a large proportion of the total stock of intangibles in the private business economy.

Contribution of Software

Table 1: Contributions of each intangible asset to the growth of capital services for private business, Percentage point contributions

Period	Artistic Originals	R&D	Pre-Packaged Software	Custom Software	Own-Account Software	All-asset growth
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- Artistic Originals have much less impact on growth than R&D and software do.

- Software all together is even more important than the (direct) effects of R&D.

- Some literature suggests Custom + Own-Account Software are more important than Pre-Packaged Software (Bessen et al., 2020). In our national income-based data, Pre-Packaged Software has more impact on capital services growth. Leased software is counted as Pre-Packaged (as Bart Van Ark has commented), which is probably why it is so important.

Role of Intangibles in Total Growth

Contribution of each factor of production to growth in private business output, as percentage of total growth, Percent, average annual growth (Table 2 in text)

Period	Intangibles	ICT	All other assets	Labor	TFP	Private Industry Value-Added Output Growth
1990-2000	10%	13%	15%	36%	25%	3.90
2000-2007	14%	14%	18%	10%	43%	2.60
2007-2019	19%	12%	17%	31%	20%	1.80
1987-2019	14%	13%	16%	31%	26%	2.80

- Contribution of intangibles as a share of total growth increases over time
- Effect of intangibles is roughly equivalent to ICT (information and communications technology)
- Intangibles are still less important than TFP or labor input growth.

Advertising, a Further Intangible?

- Now we add Advertising as further intangible asset
  - Firms invest in advertising so potential consumers have their products in mind so ads becomes capital

- Develop measures of Advertising from Input-Output tables at national and industry levels.

- The Advertising data are consistent with national income concepts. (Just like R&D, Software, and Artistic Originals.)

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Advertising Investment

- We deflate measures of advertising by standard output price deflators.

- We assume 60 percent of advertising is investment, and annual depreciation is also 60 percent, following Corrado, Hulten, Sichel (2009).

- We change output to treat ads as Investment, and calculate new service prices in every industry and year.

Advertising Services Growth

- Advertising services increased less than GDP growth, so including advertising as an intangible actually lowers the growth rate.

- Our work assumes current price deflators for advertising are accurate. Michael Mandel suggests that advertising prices have declined.

- For R&D, spillovers are clearly positive, but spillovers in advertising could be negative if ads cancel out competitors' ads.

Firm Production Functions

- Value-added production function for firms:

- $$V_{i,t} = \mathrm{a} K_{i,t-1}^{\alpha} L_{i,t-1}^{\beta} RD_{i,t-1}^{\gamma} \qquad (2)$$

- Inputs are as of beginning-of-year to avoid simultaneity. (BSVR, 2013)

- Estimated for 2-digit NIPA industries. Since equation (2) is Cobb-Douglas, we obtain estimates of factor shares from it.

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Firm Data With Spillovers

■ Firms in the same 4-digit NAICS industry are most similar and are likely to be the strongest source of relevant R&D spillovers.

■ $V_{i,t} = \mathrm{a} K_{i,t-1}^{\alpha} L_{i,t-1}^{\beta} RD_{i,t-1}^{\gamma} RDSPILL_{i,t-1}^{\delta}$ (2a)

■ where *RDSPILL* is the R&D stock of all other firms in the same 4-digit NAICS industry.

■ Firm advertising stocks are calculated as in Peters & Taylor (2017). We show OLS estimates of δ for R&D and advertising in the next two slides.

Spillovers for R&D and Advertising

NIPA Industry	R&D	Advertising
Primary metals	-.006	.007**
Machinery	.059**	.025**
Computers	.065**	.055**
Electrical Equipment	.038**	-.010
Motor Vehicles	-.010	-.007
Other Transport Eqpmt	.034**	-.041
Chemicals	.038**	.014**
Wholesale Trade	.040**	.006**

** indicates elasticities are significantly greater than 0 at the 95% level

Spillovers: R&D and Advert, cont'd

NIPA Industry	R&D	Advertising
Retail Trade	.020**	.014**
Broad/Telecom	-.019	.013**
Data, Internet	.060**	.073**
Insurance	-.124	.096**

➔ R&D spillover effects are positive in 8 of the 12 industries -- positive effects of firm R&D stocks on other firms in their 4-digit NAICS industry.

In 9 of the 12 industries, advertising spillovers are also positive. E.g., ads remind potential buyers of the advantages and features of the product category.

Firm and Industry Returns

- Previous work used the median value of the (intangible stock/output) ratio to evaluate private and spillover returns. The gross rate of return to R&D is then: $rr_{RD} = \gamma_{RD}(\frac{V}{RD})$, where γ_{RD} is estimated in a firm production regression.

- Problem: In our firm data, the median value of this ratio for R&D and for advertising is frequently zero.

- We will have to look at returns to individual firms more carefully.

Conclusions

- We analyze intangible capital in 61 U.S. industries, 1987-2019

    - R&D is the most important intangible, followed by Software and Artistic Originals.

    - Within software, pre-packaged affects growth the most

    - We construct advertising capital stocks, but including advertising as investment in the Accounts has little effect on implied GDP growth

- We make some progress on the crucial issue of relating firm and industry returns to intangibles. Positive spillovers are likely, which implies that returns will be higher in industry data.

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Intangible Capital and US Productivity Growth in 61 Industries

Discussion by Rachel Soloveichik

Virtual ASSA Conference, January 2022

Praise for Worthy Paper

- I'm always happy to see papers that use BEA and BLS data to show interesting things
    - I really liked the careful documentation of data sources and methodology
    - I was especially impressed by their section on advertising, which cleverly re-used existing data to study something worthwhile

- This paper had very clear empirical results
    - The tables scattered throughout the paper were very helpful
    - The discussion also helped me understand the issues better

- Despite the high quality of the paper, my discussion will focus on suggestions for future research
    - The authors are very dedicated, and they explicitly asked me to talk about suggestions rather than simply praise a worthy paper

Data Suggestion 1:
Own-Account Advertising

- Own-account advertising is similar to purchased advertising, so it should be tracked consistently
  - Previous research (Nakamura, Samuels, and Soloveichik 2018) has shown that own-account advertising is large and growing rapidly

- Capitalizing advertising has different direct effects on each sector studied
  - For-profit businesses: GDP↑ by the newly recognized investment
  - Government and non-profits: GDP↑ by the newly recognized consumption of fixed capital (CFC)
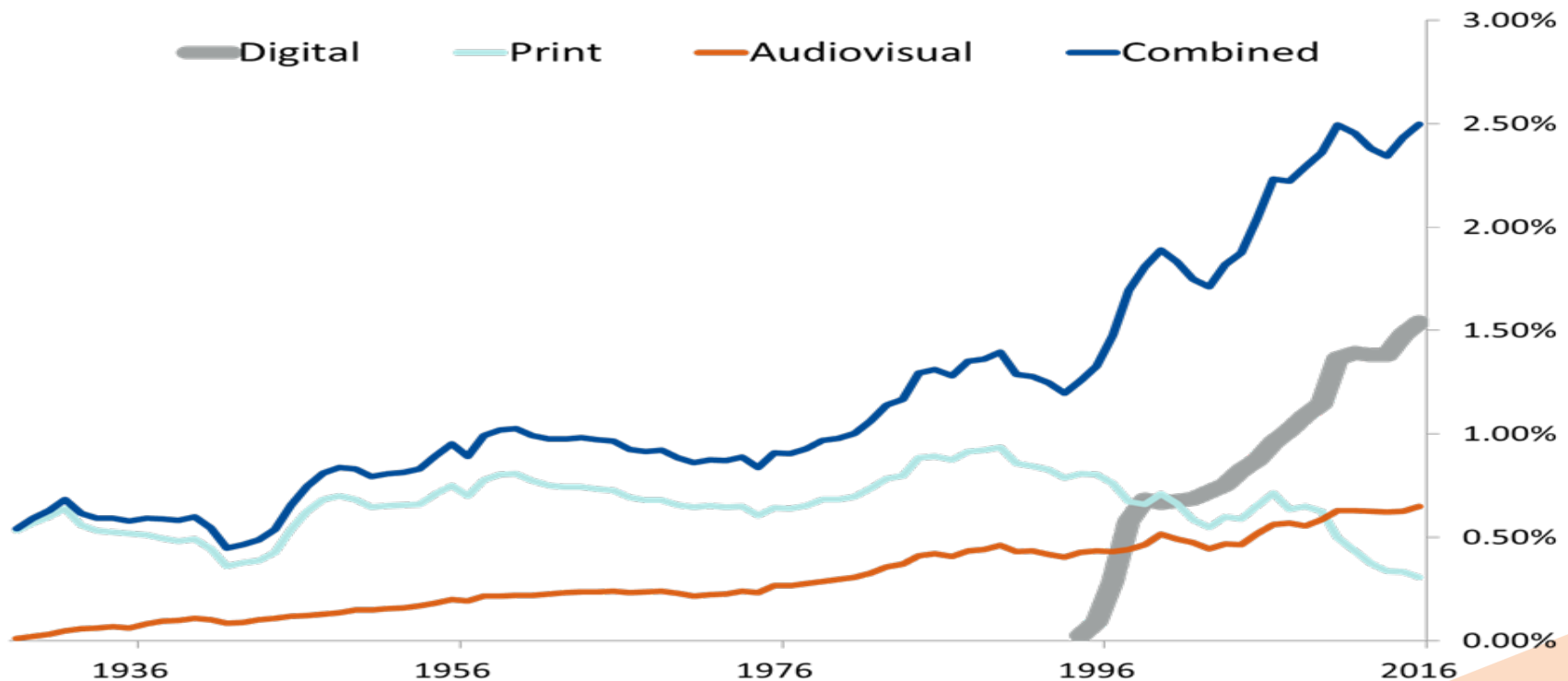
- Capitalizing advertising may also have indirect effects on governments and non-profits
  - By construction, capitalizing advertising changes measured inputs
  - National accountants often use inputs to proxy to output, so measured output could change noticeably

- The authors should track advertising separately for each sector studied
 - This might require original data collection

- **The line between the two assets can be fuzzy**
  - Most modern equipment contains a lot of intangible software
  - The structure category 'mining exploration, shafts, and wells' is at least partially an intangible asset
  - Real estate agents provide a mostly intangible service, and so therefore their commissions could be viewed as an intangible asset

- **Intangibles are often bundled with equipment**
  - For example, a smartphone user might pay $500 for the physical phone – but nothing for the intangible operating system
  - Holding the total bundle price fixed, both buyers and sellers are indifferent to the list prices for each component

- **Even if the authors can't solve this data issue, they might still benefit from discussing it**

- Migrants prefer childhood brands for decades
  - Figure 3 from Bronnenberg, Dube, and Getzkow 2010
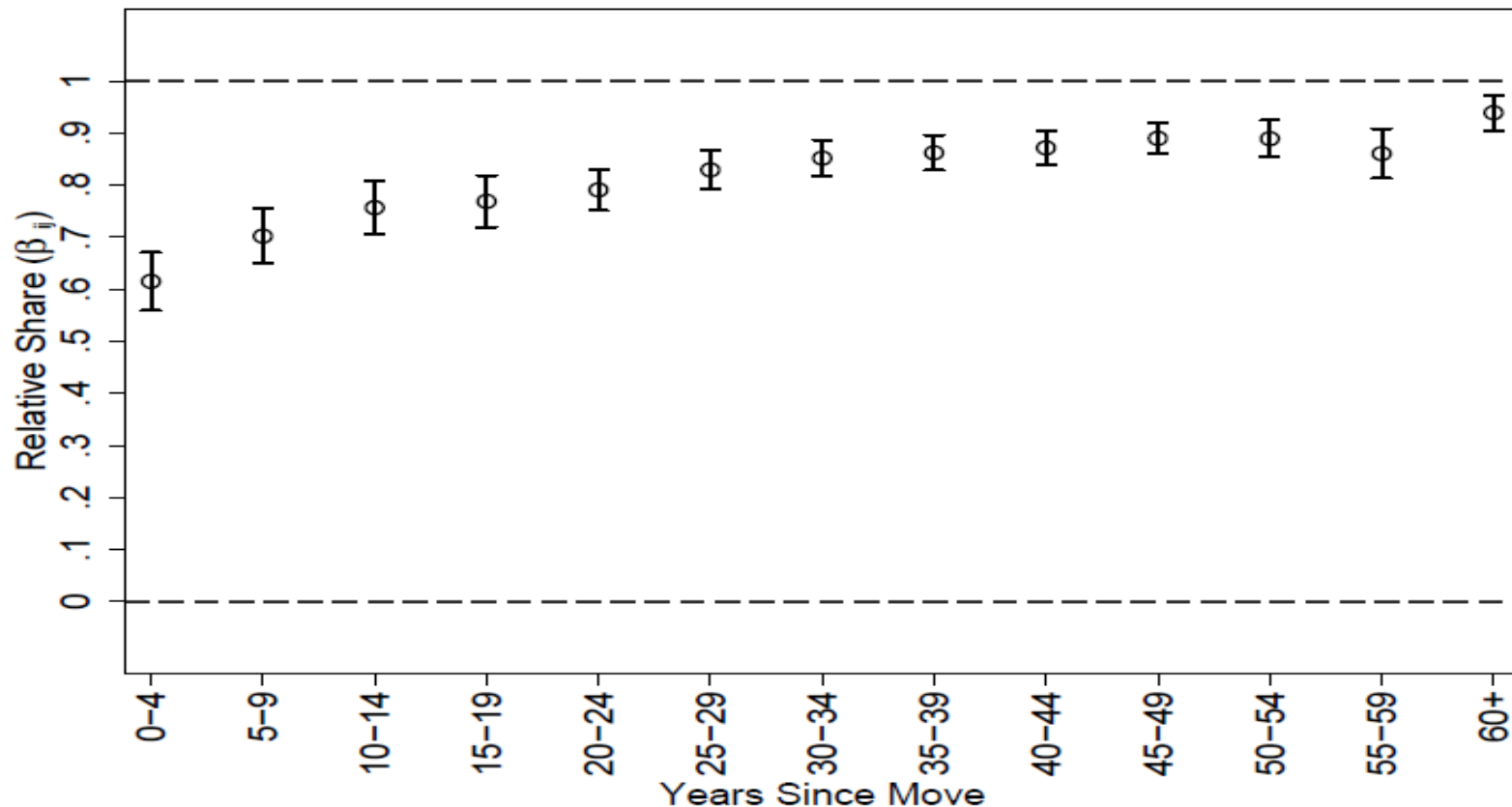
# Methodology Suggestion 2:
Model R&D Spillovers Carefully

- Case 1: firms are voluntarily sharing R&D at conference, through joint ventures, etc.

- Case 2: employees are taking R&D with them when they change jobs
  – Assuming a competitive market, the wage for new employees probably includes a payment for transferred R&D

- Case 3: firms are required to share R&D publicly
  – For example, pharmaceutical companies are typically required to report clinical trial results and drug side-effects publicly

- Case 4: R&D transfers between firms without any action by firms, employees, or government

Methodology Suggestion 3:
Natural Resource Exploration as an Intangible Asset

- Property owners combine produced exploration capital with non-produced natural resources
  - For example, a utility might explore the watershed to find a clean aquifer

Conclusion
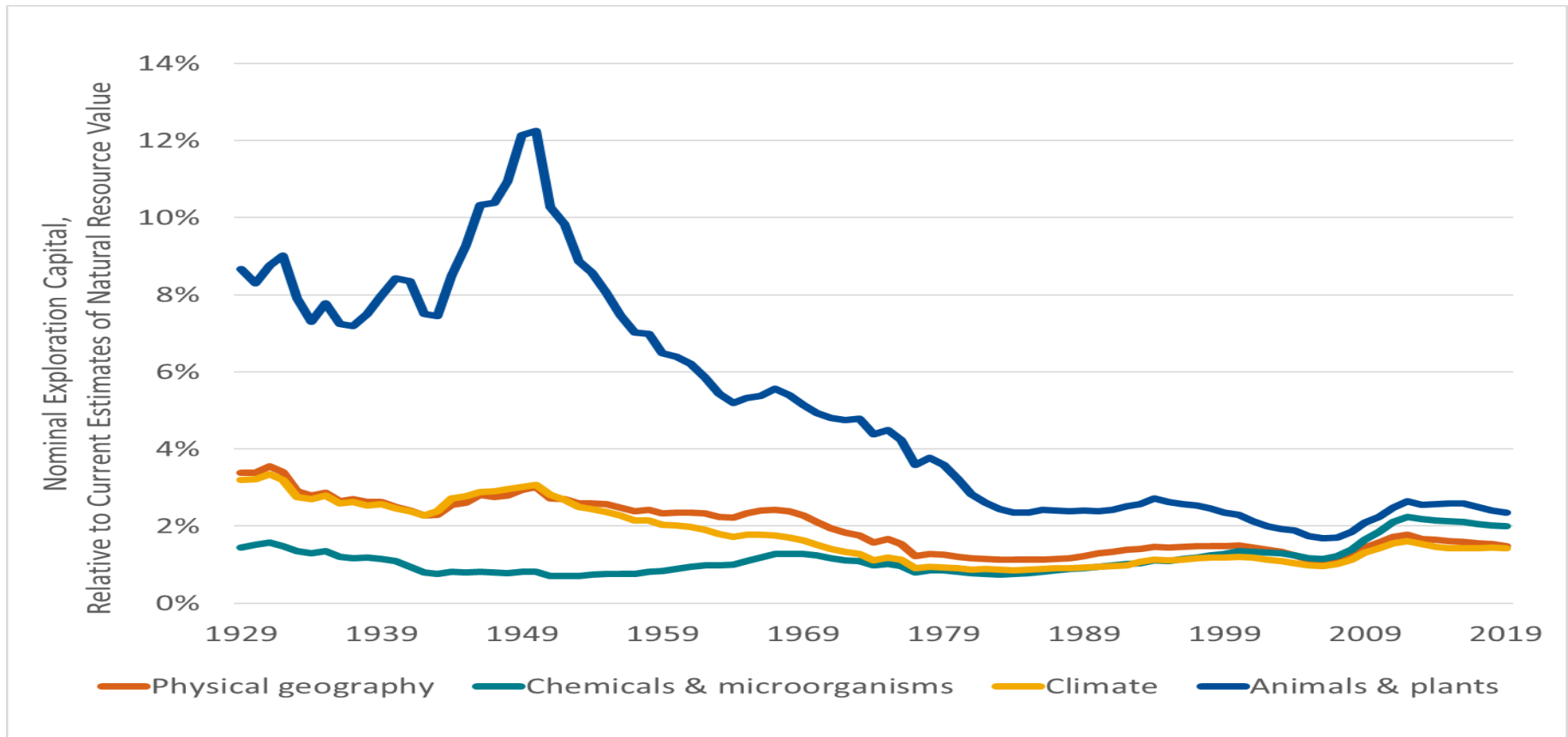
- This was an interesting paper with useful results

  - Capitalizing intangible assets raises measured GDP growth a small amount – but doesn't change economic history dramatically

  - The discussion really helps readers understand what types of intangible assets and what industries are being studied

- Productivity researchers may be especially interested in this paper

  - This paper documents assumptions that other authors gloss over

- My discussion focused on suggestions because the authors asked me to talk about my doubts