Research Output Before and During the Pandemic

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D.C. Area Economist

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The analysis and conclusions set forth are those of the author and do not represent the views of my employer.
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**Big picture:** Should the negative productivity findings based on call center and data entry workers be generalized and extended to the entire knowledge workforce?
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**Big picture:** Should the negative productivity findings based on call center and data entry workers be generalized and extended to the entire knowledge workforce?

- Instead, what are the productivity outcomes of **fully remote work** for individuals that tend to be **highly motivated with advanced degrees**?
Big Picture

My goal today is to convince BBD to tweak the narrative about fully remote work.
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Ask yourself or any economist...

What is the likely effect of fully remote work on productivity?
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  The effect on productivity of fully remote work is .... heterogeneous.
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Ask yourself or any economist...

What is the likely effect of fully remote work on productivity?

- **The number one answer:** It depends. It depends on the individual.

  The effect on productivity of fully remote work is ... heterogeneous.

For some, the effects may be negative, while for others, the effects may be positive.

- Call center, data entry workers: Negative
- Highly motivated w/ advanced degrees: ????
Literature about **fully remote** has documented objective (not self-assessed) positive outcomes for decades.

- **Geisler (1978):** 26% higher productivity for key coders working at home vs in-office for Blue Cross Blue Shield South Carolina.

- **Phelps (1980):** 48% higher productivity for course development managers at Mountain Bell in Denver.

- **Newman (1989):** 20% higher productivity for programmers at Travelers Insurance Company.

- **Dubrin (1991):** 29.9% higher productivity for data entry workers at NPD Group in New York.

- **Loy et al (2003):** 150.1% higher productivity for call center workers at Kentucky American Water Company.

- **Collins (2005):** 23% higher productivity for insurance techs at Lloyd's Insurance in the UK.
Big Picture

Again, goal is to convince you that...

The effects of **fully remote work** on productivity are potentially **heterogeneous**.

Two other studies speak to the potential heterogeneity.

- Dutcher (2012) provides experimental evidence that
  - Remote work for **simple, repetitive** tasks was associated with 10 percent **lower productivity**.
  - Remote work for tasks requiring **critical thinking and creativity** associated with 20 percent **higher productivity**.
  - Remote work had **negative productivity** association with firms primarily employing **low-skilled workers**.
  - In contrast, remote work had significantly **positive productivity** effects for firms that undertake **research and development** (R&D) activities.
Do the findings associated w/ fully remote call center and data entry workers more broadly apply to all knowledge workers? What about researchers or academics?
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This question has already received considerable interest surrounding the pandemic:

Barber et al (2021, Journal of Finance) document a self-reported decline in research productivity during the pandemic. In contrast, Kruger et al. (2022, Review of Financial Studies) finds that among the top 50 schools, there was a 35% increase in productivity as measured by SSRN paper postings. Largest gains accrued to top 10 schools. However, Jiang et. al (2022) look at top 1,000 schools and find an overall decline in productivity, with increased inequality. Extra time spent on teaching had an important negative effect. Federal Reserve System economists were explicitly excluded from these studies and did not face these teaching costs.
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Research Questions

During the pandemic, the Federal Reserve System adopted fully remote policies.

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- Was there any effect on inequality among economists?
- Can a general equilibrium model rationalize any of the findings?
- What would be the macroeconomic effects?
  - Important because increases in productivity tend to reduce inflation.
What Data Did We Use & Why?

- We examined working paper output from the 12 Federal Reserve System regional banks as well as a richer measure of output for Board authors.
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- Working papers are a consistent and relatively parsimonious measure which persists across all regional banks.
  - Avoids issues associated with lag times related to publication process.

- We use quarterly output per author as our measure of interest and construct a time series for each author.
Caveats to Using Working Papers

- Working papers are obviously just one dimension of output.
  - For the 12 regional banks, we do not include publications, revisions, book chapters, notes, and other research contributions.

- Output related to policy work is not included yet also important.

- Some economists use SSRN to release new papers, which we are not tracking.
Caveats to Using Pandemic

Pandemic was a unique time period, one perspective on results coming from the Pandemic...

- A land-grab of papers on COVID
- More demand for papers on COVID
- Short-run/long-run trade-off
  - Less time on conferences,
  - Less lunch with colleagues
  - More just pumping out papers

As robustness checks,
- We can exclude Covid papers
- We can exclude 2020.
  - Vaccine was widely available in 2021 i.e. more in-person activities.
- We can check 2008 financial crisis, another land-grab event.
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- 437 Authors, 1,541 working papers from the regional banks
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- 437 Authors, 1,541 working papers from the regional banks

- 507 Authors, 2,400 research pieces from the Board
Results: Summary Statistics Visualized

Percent Change Output Per Author Per Quarter: Pre vs Post Covid

Takeaway: Entire system had about 25% increase in output.
Results: Regression Specifications

Previous results were just summary statistics.

- Regressions provide for more formal analysis and controls.

Given that we are using count data, which is zero-bounded and right-skewed, we use Poisson regressions in addition to linear regressions.

- Cohn, Liu, and Wardlaw (2022) show Poisson regressions are more appropriate for this type of data.

Poisson regressions assume dependent variable follows a Poisson distribution and assumes the log of its expected value is linearly related to the independent variables.

We also control for author fixed effects.
### Main Regression Results: Quarterly Output per Author

<table>
<thead>
<tr>
<th>Panel A: Federal Reserve Regional Banks</th>
<th>Linear</th>
<th>Poisson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covid</td>
<td>0.041***</td>
<td>0.170***</td>
</tr>
<tr>
<td></td>
<td>(3.29)</td>
<td>(3.33)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.223***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(37.83)</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>6369</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: Board of Governors</th>
<th>Linear</th>
<th>Poisson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covid</td>
<td>0.091***</td>
<td>0.282***</td>
</tr>
<tr>
<td></td>
<td>(6.32)</td>
<td>(6.39)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.276***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(42.61)</td>
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</tr>
<tr>
<td>Observations</td>
<td>7559</td>
<td></td>
</tr>
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<th>Panel C: Combined</th>
<th>Linear</th>
<th>Poisson</th>
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<tbody>
<tr>
<td>Covid</td>
<td>0.068***</td>
<td>0.239***</td>
</tr>
<tr>
<td></td>
<td>(7.03)</td>
<td>(7.13)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.252***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(56.32)</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>13928</td>
<td></td>
</tr>
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**Constant:** $0.252 \times 4 \approx$ about 1 working paper per year per economist for pre-Covid.

Regional Banks had $17.0\%$, Board had $28.2\%$, and Combined $23.9\%$ increases.

**Takeaway:** Large significant gains across entire system during pandemic.
Quarterly Output per Author: Top Half of Distribution

We split the sample up into the top and bottom half based on Pre-Covid production.

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<td>(12.87)</td>
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</tr>
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<td>(24.30)</td>
</tr>
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<td>Covid x Top Half</td>
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</tr>
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</tr>
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<td>(18.69)</td>
<td>(−44.15)</td>
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**Pre-Covid**

Constant: **0.094** ≈ about 0.5 papers per year for bottom half of distribution Pre-Covid.

Top Half: **0.308** → **0.308 + 0.094** ≈ about 1.5 papers per year for top half.
Quarterly Output per Author: Top Half of Distribution

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Top Half: 0.308 \( \implies \) 0.308 + 0.094 \( \approx \) about 1.5 papers per year for top half.

**During Covid**

Covid: 0.130 bottom half of distribution nearly doubled its output (0.130 + 0.094).

Covid x Top Half: -0.125 + 0.130 = 0.005 \( \implies \) top half remained productive but unchanged.

**Takeaway:** Gains in output were driven by bottom half of distribution. Inequality declined.
Quarterly Output per Author: Female effect

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</tr>
<tr>
<td></td>
<td>(6.00)</td>
<td>(6.06)</td>
</tr>
<tr>
<td>Female</td>
<td>−0.009</td>
<td>−0.037</td>
</tr>
<tr>
<td></td>
<td>(−0.63)</td>
<td>(−0.62)</td>
</tr>
<tr>
<td>Covid × Female</td>
<td>−0.011</td>
<td>−0.029</td>
</tr>
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<td>(−0.49)</td>
<td>(−0.35)</td>
</tr>
<tr>
<td>Constant</td>
<td><strong>0.255</strong>*</td>
<td>−1.367***</td>
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<td></td>
<td>(35.41)</td>
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Pre-Covid

Constant: $0.255 \approx$ about 1 paper per year for males Pre-Covid.

Female: $-0.009 + 0.255 \implies$ insignificant difference for Pre-Covid ($T$-stat $= -0.63$).
# Quarterly Output per Author: Female effect

## Pre-Covid

**Constant:** \(0.255\) \(\approx\) about 1 paper per year for males Pre-Covid.

**Female:** \(-0.009 + 0.255\) \(\implies\) insignificant difference for Pre-Covid (T-stat = -0.63).

## During Covid

**Covid:** \(0.240\) \(\implies\) males increased output by 24%.

**Covid x Female:** \(-0.029 + 0.240\) \(\implies\) females increased by 21%, insig. diff. (T-stat = -0.35).

**Takeaway:** No significant difference between males and females (pre and during Covid).

Contrasts with evidence from university professors, which found significant difference.

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Quarterly Output per Author: Years since PhD effect

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<th>8 to 22 years</th>
<th>Over 22 years</th>
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<td>0.340***</td>
<td>0.205***</td>
</tr>
<tr>
<td></td>
<td>(5.25)</td>
<td>(6.50)</td>
<td>(5.11)</td>
</tr>
<tr>
<td>Age group</td>
<td>−0.051</td>
<td>0.428***</td>
<td>−0.476***</td>
</tr>
<tr>
<td></td>
<td>(−0.74)</td>
<td>(8.50)</td>
<td>(−8.38)</td>
</tr>
<tr>
<td>Covid x Age group</td>
<td>0.160*</td>
<td>−0.176**</td>
<td>0.084</td>
</tr>
<tr>
<td></td>
<td>(1.75)</td>
<td>(−2.52)</td>
<td>(1.07)</td>
</tr>
<tr>
<td>exp(Constant)</td>
<td>0.255***</td>
<td>0.199***</td>
<td>0.291***</td>
</tr>
<tr>
<td></td>
<td>(3.93)</td>
<td>(3.72)</td>
<td>(3.77)</td>
</tr>
</tbody>
</table>

Under 8 Years Since PhD

Covid x Age Group: 0.160 $\Rightarrow$ 16% more output than rest during Covid.

Covid + Covid x Age Group : 0.202 + 0.160 = 36.2% more output compared to Pre-Covid.

Takeaway: Youngest cohort gained most during the pandemic.

This goes against the view that youngest do poorly under fully remote.
Quarterly Output per Author: Years since PhD effect

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Under 8 years</th>
<th>8 to 22 years</th>
<th>Over 22 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covid</td>
<td>0.202***</td>
<td>0.340***</td>
<td>0.205***</td>
</tr>
<tr>
<td></td>
<td>(5.25)</td>
<td>(6.50)</td>
<td>(5.11)</td>
</tr>
<tr>
<td>Age group</td>
<td>-0.051</td>
<td>0.428***</td>
<td>-0.476***</td>
</tr>
<tr>
<td></td>
<td>(-0.74)</td>
<td>(8.50)</td>
<td>(-8.38)</td>
</tr>
<tr>
<td>Covid x Age group</td>
<td>0.160*</td>
<td>-0.176**</td>
<td>0.084</td>
</tr>
<tr>
<td></td>
<td>(1.75)</td>
<td>(-2.52)</td>
<td>(1.07)</td>
</tr>
<tr>
<td>exp(Constant)</td>
<td>0.255***</td>
<td>0.199***</td>
<td>0.291***</td>
</tr>
<tr>
<td></td>
<td>(3.93)</td>
<td>(3.72)</td>
<td>(3.77)</td>
</tr>
</tbody>
</table>

8 to 22 Years Since PhD

Covid x Age Group: -0.176 \( \implies \) 17% less relative output than everyone else during Covid.

Covid + Covid x Age Group : 0.340 - 0.176 = 16.4% more output compared to Pre-Covid.

Takeaway: Although gains were not as large as other age groups, still significantly positive.
## Quarterly Output per Author: Years since PhD effect

<table>
<thead>
<tr>
<th></th>
<th>Under 8 years</th>
<th>8 to 22 years</th>
<th>Over 22 years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel C: Combined Poisson</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covid</td>
<td>0.202***</td>
<td>0.340***</td>
<td>0.205***</td>
</tr>
<tr>
<td></td>
<td>(5.25)</td>
<td>(6.50)</td>
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<tr>
<td>Age group</td>
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</tr>
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<td></td>
<td>(1.75)</td>
<td>(−2.52)</td>
<td>(1.07)</td>
</tr>
<tr>
<td>exp(Constant)</td>
<td>0.255***</td>
<td>0.199***</td>
<td>0.291***</td>
</tr>
<tr>
<td></td>
<td>(3.93)</td>
<td>(3.72)</td>
<td>(3.77)</td>
</tr>
</tbody>
</table>

More than 22 Years Since PhD

Covid x Age Group: 0.084 $\implies$ 8% more output than others during Covid.

Covid + Covid x Age Group: 0.205 + 0.084 = 28.9% more output compared to Pre-Covid.

**Takeaway:** Gains relative to other cohorts were positive but insignificant.
Did we see similar increase around financial crisis?

- Gains could be driven by presence of new research ideas and not fully remote.
  - This view rests on the assumption that the constraining factor on researchers prior to Covid was not time, but limited number of research ideas.
- The Global Financial Crisis is another time period in which there was a new shock to do research on.
- Yet there were no changes in WFH policies over this time period.
- Could possibly serve as a good period for comparison.
Compare number of working papers from 2005 to 2008 vs 2009 to 2010.

- Board working papers declined 18% during financial crisis.
- System-wide including Board, average papers declined from 397 to 394.5 on annual basis.

Takeaway: Didn’t see large increase in research output around GFC, in contrast to Covid.
Quarterly Output per Author: Excluding 2020

<table>
<thead>
<tr>
<th></th>
<th>Poisson</th>
<th>Linear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covid</td>
<td>0.127***</td>
<td>0.037***</td>
</tr>
<tr>
<td></td>
<td>(3.03)</td>
<td>(2.98)</td>
</tr>
<tr>
<td></td>
<td>0.109***</td>
<td>0.032***</td>
</tr>
<tr>
<td></td>
<td>(2.68)</td>
<td>(2.65)</td>
</tr>
<tr>
<td>Constant</td>
<td>−1.296***</td>
<td>0.274***</td>
</tr>
<tr>
<td></td>
<td>(−49.32)</td>
<td>(38.05)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.275***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(65.84)</td>
</tr>
</tbody>
</table>

- Covid: **10.9%** significant increase.

**Takeaway:** Excluding 2020, effect remains economically large and significant.
### Quarterly Output per Author: Excluding Covid Papers

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Poisson</th>
<th>Linear</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Combined</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covid</td>
<td>0.102***</td>
<td>0.109***</td>
</tr>
<tr>
<td></td>
<td>(2.84)</td>
<td>(3.12)</td>
</tr>
<tr>
<td>Constant</td>
<td>−1.377***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(−55.51)</td>
<td></td>
</tr>
</tbody>
</table>

**Takeaway:** Excluding "Covid" or "Pandemic" papers, still significant positive.
Authors per Paper: Collaboration

**Table: Collaboration: Authors per Paper**

<table>
<thead>
<tr>
<th></th>
<th>Poisson</th>
<th>Linear</th>
<th>Poisson</th>
<th>Linear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covid</td>
<td>0.0713***</td>
<td>0.224***</td>
<td>0.105***</td>
<td>0.331***</td>
</tr>
<tr>
<td></td>
<td>(4.07)</td>
<td>(4.04)</td>
<td>(3.92)</td>
<td>(3.93)</td>
</tr>
<tr>
<td>Trend Effect</td>
<td></td>
<td></td>
<td>−0.0184</td>
<td>−0.0573</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(−1.56)</td>
<td>(−1.56)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.111***</td>
<td>3.038***</td>
<td>1.126***</td>
<td>3.083***</td>
</tr>
<tr>
<td></td>
<td>(97.51)</td>
<td>(87.74)</td>
<td>(73.99)</td>
<td>(65.40)</td>
</tr>
</tbody>
</table>

- **Constant:** 3.083 \( \approx \) 3 authors per paper for pre-Covid.
- **10.5\%** increase in authors per paper during Covid.

**Takeaway:** Significant increase in collaboration across the system (even when controlling for trend).
Some reasons WFH may increase output

The following items listed in Bloom et al (2022):

- Average U.S. employee saves about 70 minutes a day by avoiding having to commute and prepare for work, which is split into both additional work and leisure.
- Home working is often better for individual focused activities like coding or writing as it is usually quieter.
- Allows for greater time flexibility.

Choudhury et al (2021)

- WFH allows workers to control ambient workspace such as clothing, layout, ventilation, etc.
- Theorizes that those that self-select into WFH will experience greater satisfaction and utility, and will exert greater productivity-enhancing effort in appreciation of this nonpecuniary benefit.
General Equilibrium Model

We use a standard New-Keynesian model with endogenous growth.

- Endogenous growth allows for potential effects on productivity.

Given Bloom et al. (2022) finds 70 minutes a day in savings....

We simulate a 1% exogenous increase in the time endowment.

- Given typical model has households working a third of the time, the total endowment is typically 120 hours a week, 40 of which are devoted to labor.
- A one percent increase is roughly an additional hour per week, consistent with the findings of Aksoy et al. (2023).
Time endowment persistently rises (lower right).
Labor supply rises by about 0.35% and leisure rises 0.65% (top row).
Increased labor supply translates to higher output and consumption growth.
Also associated with higher R&D investment and idea accumulation.
Higher idea accumulation spills over to aggregate productivity (third row).
Higher labor supply is associated with lower real wages and lower inflation.
The lower inflation leads to lower risk-free rate which causes the 10y-3month spread to rise.
Aggregate productivity jumped well above trend and then came back to trend.
Rise in productivity and recent decline are consistent with model implications based on increase in time endowment and decrease associated with RTO.
Conclusion

- We find that research output significantly increased during fully remote.
- The bottom half of the distribution was responsible for the large gains.
- In addition, the increase was driven by under 35 and 50 plus.
- There was no significant difference between males and females.
- Collaboration as measured by authors per paper significantly increased.
- Findings can be rationalized in GE model with exogenous increase in time endowment.
- Caveat: This study is just about productivity, there’s other important aspects.
There exists a scenario that combines positive aspects of **fully remote** and **hybrid**:
Final Thought

- There exists a scenario that combines positive aspects of fully remote and hybrid: Cluster Hybrid
There exists a scenario that combines positive aspects of **fully remote** and **hybrid**: Cluster Hybrid

Cluster Hybrid brings everyone together for 4-5 days every 6 or so weeks.

Many of the benefits of fully remote work.

- Cost savings. Nationwide talent search. People can live where they want.
There exists a scenario that combines positive aspects of **fully remote** and **hybrid**: **Cluster Hybrid**

- Cluster Hybrid brings everyone together for 4-5 days every 6 or so weeks.
  - Many of the benefits of fully remote work.
    - Cost savings. Nationwide talent search. People can live where they want.
  - Also have the in-person culture building of hybrid.