Internet Access and its Implications for Productivity, Inequality, and Resilience

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Federal Communications Commission

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1. Working from home (WFH) will account for one-fifth or more of paid workdays in the post-pandemic economy.

2. Universal access to reliable, high-speed home internet service would raise (earnings-weighted) labor productivity by an estimated 1.1% in the post-pandemic economy.

3. The implied output gains are about $160 billion per year, or $4 trillion when capitalized at a 4% annual rate.

4. Flow output payoffs to universal access are nearly 3X as large in COVID-like disaster states (because of much more WFH).

5. Subjective well-being was higher during the pandemic for people with better home internet service conditional on age, employment status, earnings, working arrangements, and other controls.
Table 1: Working from home before, during, and after the Covid-19 pandemic

<table>
<thead>
<tr>
<th></th>
<th>Percent of full paid days worked from home</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-COVID</td>
<td>During COVID</td>
<td>Post-COVID</td>
</tr>
<tr>
<td>Equal-weighted</td>
<td>4.8</td>
<td>47.4</td>
<td>(0.3)</td>
</tr>
<tr>
<td>Earnings-weighted</td>
<td>--</td>
<td>54.4</td>
<td>(0.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27.7</td>
<td>(0.3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Percent of full paid days worked from home</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Education</td>
</tr>
<tr>
<td>Less than high school</td>
<td>24.6</td>
</tr>
<tr>
<td>High school</td>
<td>32.0</td>
</tr>
<tr>
<td>1 to 3 years of college</td>
<td>40.4</td>
</tr>
<tr>
<td>4-year college degree</td>
<td>57.9</td>
</tr>
<tr>
<td>Graduate degree</td>
<td>63.4</td>
</tr>
</tbody>
</table>

“Pre-COVID” data from 2017-18 ATUS. “During COVID” data are from May 2020 to May 2021 SWAA. “Post-COVID” data from December 2020 to May 2021 SWAA.
Survey of Working Arrangements and Attitudes

~60,000 respondents, fifteen survey waves to date
  • Fielded monthly since May 2021, ongoing

US residents aged 20-64, earning $20K+ in 2019
  • After dropping “speeders,” we re-weight to match the CPS distribution of workers by age-sex-education-earnings distribution.

40-55 questions per wave
  • Demographics, earnings, hours worked, living arrangements
  • Extent of WFH during COVID and desires/plans after COVID
  • Experience, perspectives on WFH, contagion fears, vaccines, etc.
  • Home and workplace locations, commuting time, spending, etc.
  • WFH efficiency: Relative to worksite productivity and to expectations
  • Relative effectiveness of remote and in-person meeting
  • Who wants to WFH, and why?
6. After COVID, in 2022 and later, how often is your employer planning for you to work full days at home?

- Never
- About once or twice per month
- 1 day per week
- 2 days per week
- 3 days per week
- 4 days per week
- 5+ days per week
- My employer has not discussed this matter with me or announced a policy about it
- I have no employer
Why the big shift to WFH will (partly) stick

1. Mass experimentation and learning → re-optimization of working arrangements
2. Investments (in time, equipment, systems, and processes) by workers and firms that enable WFH
3. Attitudinal shifts:
   • Stigma around WFH has plummeted
   • Lingering fears of infection risks
4. A surge in innovation that supports WFH
5. Long COVID pandemic entrenches the shift to WFH

Deutsche Bank says it will let staff work from home 3 days a week when offices open

Deutsche Bank plans to adopt a hybrid working model as its employees return to work.

Staff would be able to work up to three days a week from home, Deutsche Bank said.

CFO James von Moltke told Bloomberg it would be "up to the employee, but in a structured way with the manager."

Deutsche Bank plans to let staff work from home for up to three days a week, in a move towards more flexible working.

James von Moltke, Deutsche Bank’s chief financial officer, told Bloomberg Wednesday that "it’s a range of 40 to 60 percent, we think, of flexibility."

"It will really be up to the employee, but in a structured way with the manager so we know when people are expected to come to the office," he said.
The Pandemic Has Endured and May Become Endemic – Further Entrenching Recent Shifts in Working Arrangements

Reproduced from the Washington Post on 19 September 2021.
Questions on Relative Productivity of WFH

How does your efficiency working from home during the COVID-19 pandemic compare to your efficiency working on business premises before the pandemic?

- Better—I am more efficient at home than I was working on business premises
- About the same—I'm equally efficient in both places
- Worse—I am less efficient at home than I was working on business premises

For those who respond “Better” [“Worse”], we follow up with:

How much more [less] efficient have you been working from home during the COVID-19 pandemic than on business premises before the COVID-19 pandemic?

Response options are: Under 5% more [less] efficient; 5 to 10% more [less] efficient; 10 to 15% more [less] efficient; 15 to 25% more [less] efficient; 25 to 35% more [less] efficient; and Over 35% more [less] efficient.
Figure 1: Efficiency of WFH vs. working on business premises

- Much more efficient, >30%: 14.4%
- Substantially more efficient, 15: 9.5%
- More efficient, <15%: 17.7%
- About the same: 43.9%
- Less efficient, <15%: 5.4%
- Substantially less efficient, 1: 3.5%
- Much less efficient, >35%: 5.6%

Percent of respondents
Figure 2: Distribution of internet quality among SWAA respondents

- Perfect, works 100% of time: 40.9%
- Good, works 90% of time: 42.9%
- Moderate, works 70%-80% of time: 11.9%
- Poor, works <70% of time: 1.8%
- No internet connection at home: 2.5%

Percent of respondents
Figure 3: Self-assessed efficiency while WFH by reported internet quality

Sample: Respondents with WFH experience during COVID
How We Project the Productivity Effects of Universal Access

1. Combine individual-level data on the planned extent of WFH in the post-pandemic economy with individual-level estimates for the productivity effect of moving to reliable, high-speed home internet.

2. Two approaches to individual-level productivity effects:
   a) Ask workers how reliable, high-speed home internet access would affect their productivity (if at all) when WFH
   b) Fit regression models that relate the productivity of WFH to internet access quality in the cross section.

3. Aggregate over workers in an earnings-weighted manner to get aggregate labor productivity effect.
“How much would your efficiency working from home increase if you had perfect high-speed internet?”

A. All Respondents with WFH Experience

- None, my internet is fast enough: 74.9%
- A little, about 5% increase: 10.2%
- Somewhat, about 10% increase: 8.8%
- Substantially, about 20% increase: 5.2%
- Massively, 30% or more: 0.9%

B. Only Those with Imperfect Reliability

- None, my internet is fast enough: 19.8%
- A little, about 5% increase: 32.7%
- Somewhat, about 10% increase: 28.0%
- Substantially, about 20% increase: 16.7%
- Massively, 30% or more: 2.8%

Note: Efficiency gain imputed to ‘None’ if the respondent reports perfect internet quality. Some respondents with <100% reliable internet report zero potential gains.

Sample: Only respondents who report <100% reliable internet.

Source: Responses to the following questions in the Survey of Working Arrangements and Attitudes:

“How reliable is your internet connection?”

“How much would your efficiency working from home increase if you had perfect high-speed internet?”
Table 3: Earnings-weighted productivity effects of internet access quality

<table>
<thead>
<tr>
<th>Approach to Estimating the Individual-Level Productivity Effects of Universal Access</th>
<th>(1) Productivity Shortfall During COVID</th>
<th>(2) Post-COVID Gains from Universal Access</th>
<th>(3) And adjusted for WFH rise induced by universal access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression-imputed (simple)</td>
<td>-0.8</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Regression-imputed (controls)</td>
<td>-0.7</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Self-assessed causal effect</td>
<td>-3.0</td>
<td>1.1</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Figure 5: How the incidence of WFH relates to internet access quality conditional on industry and earnings

Notes: Coef during COVID = 0.08 (0.03). Coef post-COVID = 0.08 (0.02) N = 24890. Controls for industry, survey wave FE, and 2019 earnings. 7/2020 and later survey waves.
Table 5: Extra WFH induced by universal access during and after the COVID-19 pandemic

<table>
<thead>
<tr>
<th>Increase in percent of full paid days WFH induced by universal access to perfect high-speed internet</th>
<th>During COVID</th>
<th>After COVID</th>
<th>Increase in percent of full paid days WFH induced by universal access to perfect high-speed internet</th>
<th>During COVID</th>
<th>After COVID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.7</td>
<td>0.7</td>
<td>Ann. Earnings of $20 to $50K</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Women</td>
<td>0.7</td>
<td>0.8</td>
<td>Ann. Earnings of $50 to $100K</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Men</td>
<td>0.6</td>
<td>0.7</td>
<td>Ann. Earnings of $100 to $150K</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ann. Earnings over $150K</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Age 20 to 29</td>
<td>0.7</td>
<td>0.8</td>
<td>Less than high school</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Age 30 to 39</td>
<td>0.6</td>
<td>0.7</td>
<td>High school</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Age 40 to 49</td>
<td>0.7</td>
<td>0.7</td>
<td>1 to 3 years of college</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Age 50 to 64</td>
<td>0.7</td>
<td>0.8</td>
<td>4-year college degree</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Graduate degree</td>
<td>0.6</td>
<td>0.6</td>
</tr>
</tbody>
</table>
1. Posit aggregate production function with CRS and output elasticity with respect to labor services = 2/3.

2. For fixed non-labor inputs, 1.1% labor productivity gain implies output gain of 0.73% \( (= (1.011)^{2/3} - 1) \) per period in the post-pandemic economy.
   - Flow GDP gains of roughly $160 billion per year.
   - PV GDP gain of about $4 trillion when capitalizing flow gains at 4% annual discount rate.

3. Flow gains are nearly 3X as large in COVID-like disasters, underscoring the high economic resilience value of moving to universal access.
Economic Resilience

• U.S. real GDP per capita was about 11% below its pre-pandemic trend in the second quarter of 2020 and about 4.5% below trend in the third quarter (Davis, Liu, Sheng).
• Our 2% estimated output gain from universal access during the pandemic recession would have materially moderated the U.S. output shortfall.
• Similarly, flow payoffs to universal access are larger in other disaster scenarios (e.g., another pandemic) that inhibit travel and in-person interactions but do not cut off the internet itself.
Potential Sources of Bias in Our Projections

1. Post-pandemic WFH level could be more/less than we project.

2. Pandemic-related stress and presence of kids at home (due to school closures) may have pulled down the relative productivity of WFH during the pandemic, which would cause us to understate the productivity of WFH after the pandemic.

3. We lack data on WFH efficiency for respondents with no WFH experience during the pandemic (about 1/3 of earnings-weighted respondents). Implicitly, we treat them as having the same productivity response to universal access as average respondent with WFH experience. If excluded persons hold jobs that are ill suited for WFH, which seems likely, it will lead us to overstate productivity and output gains from universal access.

4. Advances in complementary technologies are likely to improve the extent and efficiency of remote work over time.
### Table 6: Efficiency gains from universal access to high-quality internet by group

<table>
<thead>
<tr>
<th>Efficiency gain from perfect high-speed internet post-COVID (adjusted for the amount of WFH post-COVID)</th>
<th>Self-assessed</th>
<th>Efficiency gain from perfect high-speed internet post-COVID (adjusted for the amount of WFH post-COVID)</th>
<th>Self-assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>1.1</td>
<td>Ann. Earnings of $20 to $50K</td>
<td>1.0</td>
</tr>
<tr>
<td>Women</td>
<td>1.1</td>
<td>Ann. Earnings of $50 to $100K</td>
<td>1.2</td>
</tr>
<tr>
<td>Men</td>
<td>1.0</td>
<td>Ann. Earnings of $100 to $150K</td>
<td>1.3</td>
</tr>
<tr>
<td>Age 20 to 29</td>
<td>1.2</td>
<td>Ann. Earnings over $150K</td>
<td>1.1</td>
</tr>
<tr>
<td>Age 30 to 39</td>
<td>1.3</td>
<td>Goods-producing sectors</td>
<td>0.8</td>
</tr>
<tr>
<td>Age 40 to 49</td>
<td>1.1</td>
<td>Service sectors</td>
<td>1.1</td>
</tr>
<tr>
<td>Age 50 to 64</td>
<td>0.7</td>
<td>No children</td>
<td>0.9</td>
</tr>
<tr>
<td>Less than high school</td>
<td>0.3</td>
<td>Living with children under 18</td>
<td>1.2</td>
</tr>
<tr>
<td>High school</td>
<td>0.7</td>
<td>Red (Republican-leaning) State</td>
<td>1.0</td>
</tr>
<tr>
<td>1 to 3 years of college</td>
<td>1.1</td>
<td>Blue (Democratic-leaning) State</td>
<td>1.1</td>
</tr>
<tr>
<td>4 year college degree</td>
<td>1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate degree</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Controls: sex, years of education, log(2019 earnings), age bins, whether living with other adults, whether living with children, and whether living with a partner.

Additional controls in right panel: Employment status, % of WFH days in current week.

Slope coefficient says a 10 ppt increase in internet availability corresponds to a 1.4 ppt increase in well-being. Standard deviation of well-being in cross section is about 22 ppts.

“Please imagine a ladder with steps numbered from zero at the bottom to ten at the top. The top of the ladder represents the best possible life for you and the bottom of the ladder represents the worst possible life for you. If the top step is 10 and the bottom step is 0, on which step of the ladder do you feel you personally stand at the present time?”
Universal Access as a Source of Economic and Social Resilience

1. By raising output in the face of pandemics, biological attacks, and other disasters that require distancing, universal access to high-quality home internet service would strengthen economic resilience.
   - The capacity to quickly switch between production modes of roughly equal productivity is a valuable option that pays off especially in bad states of the world.
   - Firm-level examples: contamination events, flood damage, explosions, and fires that sideline the business premises as a place of work.
   - At the macro level, our analysis says that the output payoff to universal access during pandemic-like disasters is 3X as large as during normal times.
Universal Access as a Source of Economic and Social Resilience

2. Universal access provides a ready means of engagement and socializing when circumstances compel physical distancing.

3. Better internet service improves household access to online shopping and home delivery services during pandemic-like disasters.

4. Compliance with stay-at-home orders during the COVID-19 pandemic rose with access to high-speed internet service, even after controlling for household income (Chiou and Tucker, 2020) → Universal access can help contain a pandemic.

5. Better internet access promotes student engagement in remote-learning settings, the value of which is greater when a pandemic or other disaster leads to school closures.

Internet access is not a general-purpose source of resilience in the face of all disasters.
SARS-CoV-2 Forever?
There are sound reasons to fear that the SARS-CoV-2 virus “will ping pong back and forth across the globe for years to come,” triggering recurrent outbreaks of COVID-19 (Brilliant et al. 2021).

More Pandemics to Come?
Jones et al. (2008) document the emergence of 335 new infectious diseases in human populations from 1940 to 2004, with a rising incidence over time even after efforts to control for reporting bias. Urbanization, long-distance travel, and cross-border commuting create the potential for new disease outbreaks to spread rapidly and become global pandemics.
Concluding Remarks

What We Showed: Broader access to reliable, high-speed home internet service would raise U.S. productivity and output, and it would promote greater economic and social resilience during future disasters that inhibit travel and in-person interactions.

What We Did Not Tackle: How costly is it to expand and improve home internet service? What combination of infrastructure investments, competition reforms, and (possibly) subsidies to low-income households would most efficiently deliver an optimal level of internet access?
Our data and more research are at www.wfhresearch.com

To sign up for monthly results updates please click here.
End of Prepared Remarks – Extra Slides Follow
Notes: Each figure shows the distribution of raw survey responses, survey responses reweighted to match the share of persons in a given (earnings \times industry \times state) cell in the 2010 – 2019 CPS, and the distribution among persons earning more than $20,000 per year in the 2010 – 2019 CPS. Data are from 22,500 survey responses collected in May, July, August, September, October, November, and December 2020 by Inc-Query and QuestionPro. Each wave collected 2,500 responses, except the August and December waves, which collected 5,000.
Working from Home Exceeded Expectations

Relative to expectations, how has WFH turned out?

Compared to your expectations **before COVID (in 2019)** how has working from home turned out for you?

- **Hugely better** -- I am 20%+ more productive than I expected
- **Substantially better** -- I am to 10% to 19% more productive than I expected
- **Better** -- I am 1% to 9% more productive than I expected
- **About the same**
- **Worse** -- I am 1% to 9% less productive than I expected
- **Substantially worse** -- I am to 10% to 19% less productive than I expected
- **Hugely worse** -- I am 20%+ less productive than I expected
Desired and Planned Levels of WFH after the Pandemic

Rise with WFH Productivity Surprises during the Pandemic
Investments at home to enable WFH = 0.7% of annual GDP

How many hours have you invested in learning how to work from home effectively (e.g., learning how to use video-conferencing software) and creating a suitable space to work?  
**Mean hours:** 14.2 (SE = 0.2)

How much money have you and your employer invested in equipment or infrastructure to help you work from home effectively -- computers, internet connection, furniture, etc.?  
**Mean:** $603 (SE = 12)

Valuing time at respondent’s wage, the mean dollar-equivalent investment is $1,499 (36) among those WFH in 2020.

→ 1.2% of annual labor income and 0.7% of GDP.

**NIPA Data: Investment in Info Processing**

Equipment & Software rose from 3.8% of GDP in 2019 to 4.2% in 2020Q2 and Q3, even as GDP share of other investment fell 16%.
Since the COVID pandemic began, how have perceptions about working from home (WFH) changed among people you know?

- Hugely improved -- the perception of WFH has improved among almost all (90-100%) the people I know
- Substantially improved -- the perception of WFH has improved among most but not all of the people I know
- Slightly improved -- the perception of WFH has improved among some people I know but not most
- No change
- Slightly worsened -- the perception of WFH has worsened among some, but not most, people I know
- Substantially worsened -- the perception of WFH has worsened among most, but not all, people I know
- Hugely worsened -- the perception of WFH has worsened among almost all (90-100%) the people I know
### Long-Lingering Fears of Proximity to Others

If a COVID vaccine is discovered and made widely available, which of the following would best fit your views on social distancing? (N=16,655)

<table>
<thead>
<tr>
<th>Option</th>
<th>Percent of respondents</th>
<th>(SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete return to pre-COVID activities</td>
<td>27.0</td>
<td>(0.3)</td>
</tr>
<tr>
<td>Substantial return to pre-COVID activities, but I would still be wary of things like riding the subway or getting into a crowded elevator</td>
<td>35.2</td>
<td>(0.4)</td>
</tr>
<tr>
<td>Partial return to pre-COVID activities, but I would be wary of many activities like eating out or using ride-share taxis</td>
<td>24.6</td>
<td>(0.3)</td>
</tr>
<tr>
<td>No return to pre-COVID activities, as I will continue to social distance</td>
<td>13.2</td>
<td>(0.3)</td>
</tr>
</tbody>
</table>
Residual fear of proximity to other people (reasons cited)

You have stated that you *would not return completely to pre-COVID activities*, if a COVID vaccine is discovered and made widely available. What *reasons* are behind your answer? Please check all that apply

<table>
<thead>
<tr>
<th>Reason</th>
<th>Percent of respondents</th>
<th>(SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am concerned about the effectiveness/safety/that not enough people will take the COVID vaccine</td>
<td>85.22</td>
<td>(0.546)</td>
</tr>
<tr>
<td>I am concerned about other potential diseases</td>
<td>23.24</td>
<td>(0.649)</td>
</tr>
<tr>
<td>I have gotten used to social distancing, using e-commerce, and avoiding in-person goods and services</td>
<td>19.18</td>
<td>(0.605)</td>
</tr>
</tbody>
</table>

Observations 4,233

**Notes:** Data are from 7,500 survey responses collected in September, October, and November 2020 by Inc-Query and QuestionPro. Each wave collected 2,500 responses, but we only asked this question if the respondent stated they would not return "completely" to pre-COVID activities in the event a vaccine was discovered and made widely available. We re-weight raw responses to match the share of working age respondents in the 2010-2019 CPS in each {industry x state x earnings} cell.

Share of new patent applications that advance WFH technologies doubled from January to September 2020.

Reproduced from Bloom, Davis and Zhestkova (2021).
Figure 4: Many Workers Highly Value the Option to Work from Home

Value of the option to WFH 2 - 3 days/wk, % of current pay?

<table>
<thead>
<tr>
<th>Percentage Range</th>
<th>Value of the option</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than 35% raise</td>
<td>4.3</td>
</tr>
<tr>
<td>25 to 35% raise</td>
<td>4.4</td>
</tr>
<tr>
<td>15 to 25% raise</td>
<td>10.0</td>
</tr>
<tr>
<td>10 to 15% raise</td>
<td>16.2</td>
</tr>
<tr>
<td>5 to 10% raise</td>
<td>20.9</td>
</tr>
<tr>
<td>Less than 5% raise</td>
<td>10.3</td>
</tr>
<tr>
<td>Neutral</td>
<td>26.9</td>
</tr>
<tr>
<td>Less than 5% pay cut</td>
<td>3.6</td>
</tr>
<tr>
<td>5 to 10% pay cut</td>
<td>1.1</td>
</tr>
<tr>
<td>15 to 25% pay cut</td>
<td>0.7</td>
</tr>
<tr>
<td>25 to 35% pay cut</td>
<td>0.6</td>
</tr>
<tr>
<td>More than 35% pay cut</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Source: Responses to a two-part question.

Part 1: *After COVID, in 2022 and later, how would you feel about working from home 2 or 3 days a week?*
- Positive: I would view it as a benefit or extra pay
- Neutral
- Negative: I would view it as a cost or a pay cut

Part 2: How much of a pay raise [cut] (as a percent of your current pay) would you value as much as the option to work from home 2 or 3 days a week?

Data are from 12,500 survey responses collected in September, October, November, and December 2020 by Inc-Query and QuestionPro. Each wave collected 2,500 responses, except the December waves which collected 5,000. We focus on the above survey waves where we kept the same question and response options. We re-weight raw responses to match the share of working age respondents in the 2010-2019 CPS in each {industry x state x earnings} cell.
References


