

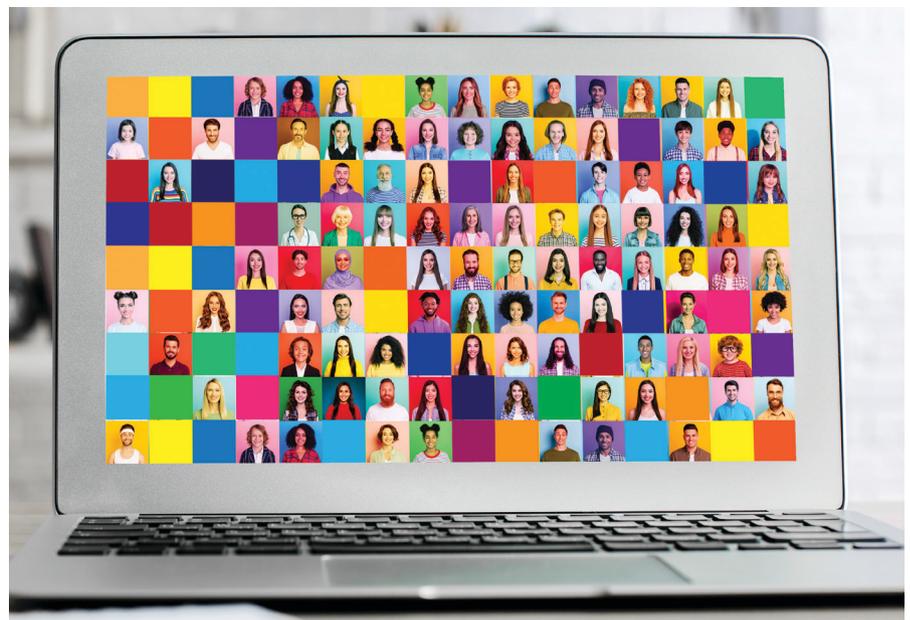
Economic and Business Dimensions

The Future of Information Work

Considering the recent effects of remote work on network structure.

COVID-19 CAUSED APPROXIMATELY one-third of U.S. workers to shift abruptly from working in offices to working from their residences.^{1,6,16} Early evidence suggested short-term output of knowledge workers did not drop and might have increased slightly.^{10,13} Furthermore, working from home has advantages such as time saved by not commuting and, for some, the flexibility and autonomy to set work schedules around home-life responsibilities such as childcare.⁹ As a result, many technology companies (for example, Twitter, Facebook, Square, Dropbox, Slack, and Zillow), announced remote-work policies to enable some or all employees to work remotely after the pandemic.⁴ Employees at other companies have threatened to quit if made to come back to full-time in-office work.¹¹ Few think work will go back to how it was pre-pandemic, but our and related research suggest remote work also presents challenges that should be addressed going forward,¹¹ both by improving remote workers' ability to connect with each other, and by effective use of hybrid workers' in-office time.

We analyzed data on the work patterns of Microsoft employees before and after Microsoft's firmwide work-from-home mandate in March 2020. For employees who worked from home prior to the pandemic, we assumed any observed change in behavior after the



work-from-home mandate was not due to working remotely, but to other factors, perhaps COVID-related. For the many Microsoft employees who worked in the office prior to the work-from-home mandate, we assumed changes in their behavior were due to a combination of working from home and the same outside factors that affected the employees who had worked from home to begin with. As illustrated in Figure 1, if work outcomes for these two groups moved in parallel prior to the pandemic, we could subtract out the differences in behavior changes between the two

groups to isolate the causal effects of working from home.¹⁶

Findings

Our research showed remote work caused the collaboration network in our dataset to become more siloed. For example, we found remote work caused a 7% decrease in the number of different business groups a person was connected to and a 26% decrease in the share of collaboration time people spent with those cross-group connections. Looking at the structure of the collaboration network itself (instead

of the business groups defined by the organization), remote work caused a 9% decrease in the number of bridging ties between working groups and a 41% drop in the share of collaboration time spent with bridging ties. This siloing effect (see Figure 2) could affect a team's ability to coordinate with other teams while executing toward a common goal. We also found remote work caused a 32% decrease in the share of time information workers spent with their weak ties. Past work shows weak ties are important sources of new information so being exposed to fewer of them could hinder information workers' ability to innovate.⁷

Corroborating evidence from surveys and diary studies also suggests the recent months have been difficult for people's collaboration networks and relationships,^{8,15} though these studies cannot isolate the causal effects of remote work specifically. People who report fewer or weaker workplace relationships also report lower productivity or fewer innovative ideas.³ Thus,

there is suggestive evidence the effects we found in telemetry data are affecting information workers' relationships and job performance.

Implications and Future Directions

Our work shows it can benefit companies and organizations to keep a close eye on their internal networks as work changes. This will allow them to intervene quickly when problems emerge, rather than years down the line when potential larger-scale effects become apparent. We are not aware of strong, causal studies on the effectiveness of interventions designed to bolster weak and cross-group network connections, which is an important area for future work. However, the available data suggests some potential strategies.

One approach teams can try is virtual "drop-in" spaces. Employees could enter this virtual space when they are working and are willing to engage with colleagues. Colleagues could then ask questions or initiate conversations with others in the virtual space via video or

chat. The shared virtual space gives colleagues a sense of togetherness even though they are working remotely from one another and lowers the overhead of starting a conversation with someone, analogous to being able to stop by someone's office to ask a quick question.² Since many impromptu office conversations happened in spaces outside meeting rooms, designing virtual environments for "small talk" before and after remote meetings could further facilitate spontaneous connections.¹⁴ These spontaneous connections could counteract the loss of novel information due to the atrophy of weak ties.¹²

Even with virtual spaces, employees will likely need to make an intentional choice to dedicate more time and energy to building and maintaining connections. Leaders and managers may want to make it clear that doing so is part of employees' job, not an additional task if they have extra time. This could mean asking employees about who else they have been talking to, connecting them to people in other parts of the company, or making sure that some of their time each week is set aside for relationship building.

More broadly, a key challenge for computer science, as a field, is to build technology to make it easier to form and maintain weak ties and foster serendipitous interaction within an organization while working remotely. For example, as people's interactions are increasingly mediated by workplace communication tools (such as Zoom, Microsoft Teams, Slack, or WhatsApp), what and when content gets surfaced or recommended to different people could play an important role in tie formation both at the individual and organization levels. Existing recommender systems were mostly optimized to maximize engagement, which may cause people to focus even more on strong ties if their content is more likely to be "engaging." Future work must explore ways to optimize recommenders for building and sustaining healthy and diverse connections.

Our research findings and these potential solutions raise many follow-up questions. How do the effects of remote work on collaboration networks affect longer-term outcomes, such as productivity and innovation? Our research suggests remote work causes

Figure 1. Schematic illustration of the difference-in-differences approach.

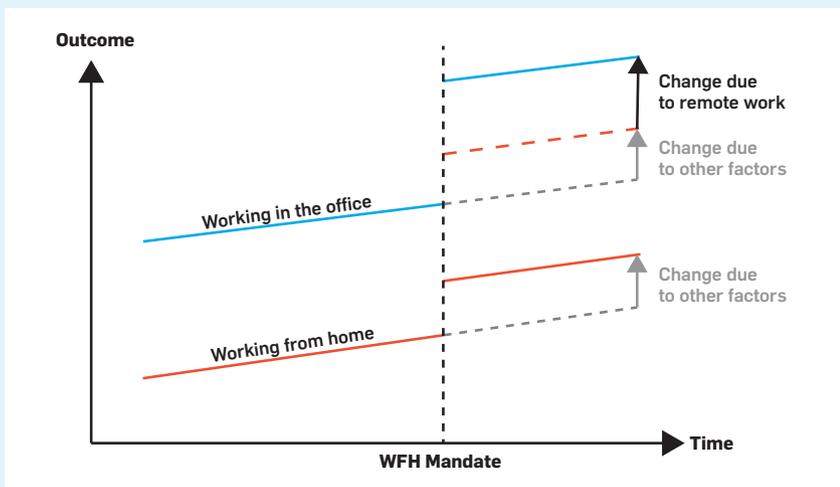
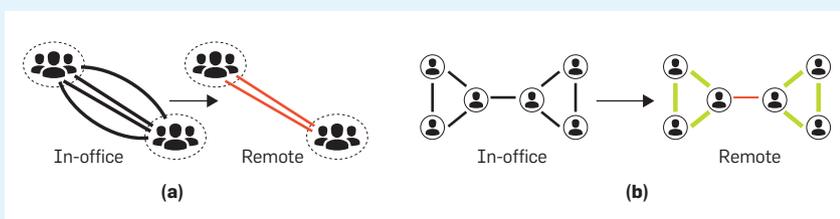


Figure 2. Schematic illustration of the effects of remote work. Remote work caused fewer ties and less time spent with ties across (a) business groups (defined by the organization) and (b) working groups (defined by the collaboration network itself).



the network to become more siloed, but longer-term studies are needed to understand the effects of those changes in network structure. We also find remote work decreased the extent to which people added new ties and dropped old ties, but what is the optimal level of network churn? Too little churn means networks are stagnant and people may not be making new connections they need; too much churn means networks are unstable and people are not building lasting connections. Similarly, what is the optimal share of weak-tie collaboration? If we know the optimal or desired configuration of a collaboration network, how can we nudge it in that direction?

Our paper studied the effects of full-time firmwide remote work, and these questions need to be extended to hybrid settings. Managers could prioritize in-office time for things research has shown are more difficult to do while remote, including brainstorming and relationship building,¹⁵ but how much in-office time is needed to maintain collaboration networks? Similarly, what is the best way to use limited in-office time to effectively support collaborative relationships, so people can leverage those connections via chats or video calls on days when they work remotely?

Hybrid work also presents additional challenges, particularly involving coordination. Flexibility is maximized if individuals choose which days to go into the office, but employees will miss many of the benefits of in-office time if they are not there on the same days as their colleagues. (This could also generate problems if those who have less in-person time with their manager get fewer promotions.⁵) If teams decide when they all come into the office this may solve the problem within teams, but it could still be difficult to coordinate and maintain relationships between teams. Finally, if in-office time is decided at the organization level then employees have less flexibility and office space will be less efficiently used—full some days and very low occupancy other days.

The state of information and knowledge work is evolving. Many U.S. companies implemented firmwide remote work for nearly two years and now a new transition—one to hybrid work—

has started. These transitions create opportunities to revisit existing norms, which are otherwise extremely difficult to break away from, and establish new norms that make the future of work better for everyone. They also create opportunities to revisit our tools and technologies to the benefit of work and workers alike. Researchers should try to shape this future to be one in which as many people as possible enjoy as many of the benefits of remote, hybrid, and in-office work, with as few of the drawbacks, as possible. **C**

References

1. Barrero, J.M. et al. 60 million fewer commuting hours per day: How Americans use time saved by working from home. *Econ Papers* (Sept. 2020); <https://bit.ly/39tRRKI>
2. Baym, N. et al. In *The New Future of Work: Research from Microsoft into the Pandemic's Impact on Work Practices*. 2021.
3. Baym, N. et al. What a year of WFH has done to our relationships at work. *Harvard Business Review* (2020).
4. Benveniste, A. These companies' workers may never go back to the office. Oct. 2020; <https://bit.ly/3wobaVW>
5. Bloom, N. et al. Does working from home work? Evidence from a Chinese experiment. *The Quarterly Journal of Economics* 130, 1 (2015), 165–218.
6. Brynjolfsson, E. et al. COVID-19 and remote work: An early look at U.S. data. Tech. rep., National Bureau of Economic Research, 2020.
7. Burt, R.S. *Structural Holes: The Social Structure of Competition*. Harvard University Press, 2009.
8. Butler, J. and Jaffe, S. Challenges and gratitude: A diary study of software engineers working from home during COVID-19 pandemic. In *Proceedings of the 2021 IEEE/ACM 43rd International Conference on Software Engineering: Software Engineering in Practice*, IEEE, (2021), 362–363.
9. Ford Robinson, D. et al. A tale of two cities: Software developers working from home during the COVID-19 pandemic. *Transactions on Software Engineering and Methodology* 31 (2022).
10. Forsgren, N. et al. State of the Octoverse: Finding balance between work and play. GitHub, 2020.
11. Mellor, S. Office workers to bosses: I'll quit if I have to go full-time back to the office. *Fortune* (July 26, 2021).
12. Olshannikova, E. et al. From chance to serendipity: Knowledge workers' experiences of serendipitous social encounters. *Advances in Human-Computer Interaction* 2020.
13. Spataro, J. Helping our developers stay productive while working remotely. Mar. 2020.
14. Tang, J.C. Approaching and leave-taking: Negotiating contact in computer-mediated communication. *ACM Transactions on Computer-Human Interaction* 14, 1 (2007).
15. Teevan, J. et al. The new future of work: Research from Microsoft into the pandemic's impact on work practices. Technical Report MSR-TR-2021-1. Microsoft, 2021.
16. Yang, L. et al. The effects of remote work on collaboration among information workers. *Nature Human Behavior* (2021), 1–12.

Longqi Yang (Longqi.Yang@microsoft.com) is a senior applied research scientist at Microsoft Corporation, Redmond, WA, USA.

David Holtz (dholtz@berkeley.edu) is an assistant professor of Management of Organizations and Entrepreneurship and Innovation at Haas School of Business, University of California, Berkeley, CA, and a research affiliate at the MIT Initiative on the Digital Economy, MIT, Cambridge, MA, USA.

Sonia Jaffe (sonia.jaffe@microsoft.com) is a senior principal economist in Microsoft's Office of the Chief Economist at Microsoft Corporation, Redmond, WA, USA.

Siddharth Suri (suri@microsoft.com) is a senior principal researcher at Microsoft Research, Redmond, WA, USA.

Copyright held by authors.

Coming Next Month in COMMUNICATIONS

Advances in the Quantum Internet

The Dawn of Crowdfarms

The Seattle Report on Database Research

Transforming Science Through Cyberinfrastructure

Computational Thinking in the Era of Data Science

FPGAs in Client Compute Hardware

Interpretable Machine Learning

hXDP: Efficient Software Packet Processing on FPGA NICs

Sampling Near Neighbors in Search for Fairness

Plus the latest news about the mathematical language of fairness, neurotechnology and the law, and crossing the uncanny valley.