



BRIEFING PAPER

THE CASE FOR REMOTE WORK

Executive Summary

The case for remote work goes well beyond its use during the Covid-19 global pandemic. Recent research from economics and other social sciences collectively makes a strong case for the viability of remote work for the long-run. This paper brings this research together to argue that remote work (also called telework) is likely to become far more common in the future. Employees that switch to remote work do not become less productive in general; in fact, they are frequently more productive after the switch. Businesses that make the switch to remote work can also hire from outside their local labour market, and this may also mean they can hire more productive workers. Technological and social changes have made it increasingly easy for businesses and applicants to find each other, even when they are not physically close. Moreover, because workers value the flexibility of remote work, businesses that are remote capable can attract more productive workers (or equally productive ones for less cost). Lastly, the supposed benefits of clustering together to help workers exchange ideas and enjoy “knowledge spillovers” have shrunk and may even be gone in many cases. While the prevalence of remote work (pre-Covid-19) was small, it was already rising rapidly with plenty of room for further growth. Remote work has positive externalities and should be promoted by policymakers.

Introduction

In the midst of the Covid-19 global pandemic, the case for short-term remote work is obvious. What other choices do organizations have to keep the lights on when their workers are isolating themselves? But the case for *long-term* remote work is also much stronger than is typically thought. Remote work does not have to be merely an emergency response, to be discarded when the pandemic subsides. For many industries, it can be the new normal. Moreover, this report argues that for many industries it *will* be the new normal, and that this should be encouraged.

The arguments in this report mostly rely on academic research published within the last ten years. Individually, any one of these articles is suggestive. But taken together, they make a strong case that remote work is going to become much more common in the years ahead. This work is split across multiple academic subdisciplines, and the goal of this report is to bring these strands together.

Before beginning, it's necessary to define some terms. In this report, remote work refers to individuals working physically distant from collaborating coworkers. Remote work can certainly mean working from home, but it can also mean working in a coffee shop, or a coworking space, or even in a satellite office. As long as the work is mostly done physically separated from collaborating coworkers, the work is remote for the purposes of this report. In this report, when collaborating coworkers are physically clustered together in the same physical workplace, they are colocated.

Moreover, it's worth stressing what this report is not claiming. It does not claim that all positions will go remote - only that more will be. It does not claim that everyone will work from home - only that this will become more common, alongside working from coworking spaces and satellite offices. It does not claim that big cities will disappear - only that the choice to live in them will not be driven as much by the need to colocate near firms.

To be clear, this report does not claim that remote collaboration is more productive than face-to-face communication. In many ways, collaborating face-to-face probably *is* better than collaborating remotely. But collaborating remotely offers some significant advantages of its own: businesses that use a remote workforce can hire from a larger pool of workers creating opportunities for cost-savings and productivity gains.

What this report argues, instead, is that technological and social changes have reached a tipping point and that remote work will become more and more common.

Why Hire Remotes?

Over the last several decades, there has been a trend towards increasing geographic concentration in some industries. Within the United States, the

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“Remote work does not have to be merely an emergency response, to be discarded when the pandemic subsides. For many industries, it can be the new normal.”

cities with the most employment in innovative sectors in 2005 also saw the fastest *growth* of employment in those sectors in the years to follow.¹ The share of US computer science patentees residing in the top 10 US cities rose from 55% in 1970 to nearly 70% in 2010.² This would seem to suggest businesses are finding it more important than ever to be physically together, rather than remote.

To understand why this is so, and yet why remote work is likely to become more common, we first need to understand why firms colocate. Among the most important advantages of colocation is that of local knowledge spillovers: people are exposed to new ideas and fresh perspectives from other geographically proximate workers (both in the firm and the city), as well as the increased ease of transferring this knowledge. They can have serendipitous meetings and more easily build and maintain a social network to tap for advice and insight. In addition to local knowledge spillovers, colocated workers may also have better access to physical machines, artifacts, and customers; stronger incentives to work hard when under the supervision of colocated managers and surrounded by colocated peers; easier maintenance of corporate culture; and greater trust amid coworkers.

Different types of jobs benefit differently from these effects. For example, a web developer may benefit strongly from local knowledge spillovers in terms of exposure to new ideas, but otherwise be able to do their job just as well halfway across the country. A waiter, on the other hand, may not benefit much from local knowledge spillovers, but must be physically present to do their job. A lab technician might benefit strongly from local knowledge spillovers, as they discuss experiments with colleagues and friends, and also needs to be physically present to work with physical specimens.

In this report, I argue these advantages are waning or smaller than believed, which would tend to make colocation less attractive relative to remote work.

And remote work offers significant advantages of its own. This report focuses on two:

- **Access to a larger labor market:** A remote workforce can be drawn from the national (or even global) labor market, rather than the local one. Thus, firms capable of supporting remote workers may be able to find better-suited employees.
- **Cost savings:** Remote workers may not require office space in expensive cities, may reside in regions with lower living costs, and may also value the freedom to live anywhere, which is itself an amenity. These cost savings, in turn, may benefit firms, workers, or both. Firms may be able to hire remote workers for less than equally talented colocated workers, or firms may pass the savings on to workers in the form of higher wages and thus attract more talented workers than they would be able to

1 Atkinson, Muro, Whiton (2019)

2 Moretti (2019)

afford if they were colocated.

This report will argue that these advantages to remote work are growing or larger than believed.

A firm that is deciding whether to make a position remote or colocated weighs the relative advantages of these factors. If the productivity advantages of colocation outweigh the advantages of access to a larger labor market and potential cost-savings of a remote worker, then the firm will choose to make the position colocated.

Note, however, that the trend towards geographic concentration of some industries is perfectly consistent with the claim that the advantages of colocation are falling and the advantages of remote work are rising. As long as the productivity advantages of colocation are high enough, employers will hire colocated workers, whether the tradeoff is marginally or heavily in favor of colocation. And once they have decided to use colocated workers, firms get more out of their workers if they locate in cities where spillovers are likely to be large, due to the presence of other innovative workers.

In fact, the clustering of knowledge workers into cities could tend to increase the value of these spillovers over time, since there will be more workers colocated in technology hubs to exchange ideas with. The result is increasing concentration, even as the technology for remote work steadily improves. This is consistent with what has happened over the last few decades.

But this is just one possible equilibrium. As technology improves, it gets easier to do more work tasks remotely. Technological progress can also reduce the advantage of local knowledge spillovers by enabling remote communication of ideas and knowledge. Meanwhile, congestion costs eventually constrain the expansion of a city's population and density, which caps the maximum benefits of spillovers.

At some point, the advantages of colocation erode enough that remote work becomes the better option. And at that point, firms will switch to hiring remote, rather than colocated workers. Once this dynamic begins to hold, it has the long-run effect of lowering the value of local knowledge spillovers, since workers no longer cluster together geographically. This further undermines the case for colocation, resulting in a new equilibrium where remote work becomes widespread.

This report argues this new equilibrium, where remote work is common, is viable for many jobs. Importantly, it is not necessary for a remote worker to be *as productive* as a colocated worker in order for the remote worker to be the better choice. The remote worker merely needs to be productive *enough*, such that the advantages of a larger labor market and cost savings offset any productivity losses. It may well be that remote work becomes common, even though each individual remote worker would be more productive if colocated.

The rest of this report will present evidence that the advantages of

colocation are not as large as commonly believed, and are even shrinking. Meanwhile, the advantages of remote work are large and growing. As technology and our relationship to it evolve, the tradeoffs in deciding if a firm should go remote or colocate are trending in favour of remote work.

This paper is structured as follows:

- Section 2 reviews evidence (not related to knowledge spillovers) on the productivity of remote versus colocated workers. It argues that in many cases the productivity of remote work is close to or higher than the productivity of colocated work.
- Section 3 describes three trends that are making it easier for remote workers to find positions that are geographically distant.
- Section 4 presents evidence that cost-of-living differences and a preference for remote work make the cost of remote positions lower than the cost of colocated ones.
- Section 5 argues that local knowledge spillovers are declining.
- Section 6 presents empirical evidence that even before the outbreak of Covid-19, the prevalence of remote work was rising and had substantial scope to continue rising.
- Section 7 argues the shift to remote work is desirable and suggests some policies to accelerate the transition.

“By reducing stress about coordinating work and family schedules, remote work can also allow greater focus while at work.”

Remote Work Works

We first turn to evidence on the relative productivity of remote and colocated work. Since this may change with the state of information technology, I emphasize more recent studies.

A good summary of the literature up through the mid-2000s is provided by Gajendran and Harrison.³ Their paper highlights some of the main theoretical factors that may affect the relative productivity of remote and colocated workers. While remote work is typically assumed to be inferior to colocation, there are a variety of reasons this may not be true. Most obviously, remote work policies grant workers more flexibility in their physical work environment, which can allow workers to better optimize for their idiosyncratic preferences. Some are more productive in a silent enclosed space, others in their home, and others in a noisy coffee shop or coworking space. Remote work is also frequently associated with greater flexibility in work schedule, which can be another dimension along which workers can optimize. Some workers may be more productive working early in the morning and others late at night. By reducing stress about coordinating work and family schedules, remote work can also allow greater focus while at work. Lastly, the reduction in travel time can extend the hours employees are able to work each day.

3 Gajendran and Harrison (2007)

To assess the efficacy of remote work, Gajendran and Harrison collected 46 studies of remote work, all of which involved actual remote work rather than lab-based simulations. They typically found remote workers perform their job as well or better than their colocated peers. However, all of these studies were observational, and so the results are likely biased by selection effects: in other words, if remote work is a privilege, not a right, then only the most productive employees may be earning the right to work remotely, rather than remote work causing higher productivity. Gajendran and Harrison also found remote work is associated with greater perceptions of worker autonomy and job satisfaction, as well as with lower perceptions of work-family conflict, stress, and intent to seek new employment.⁴ For a smaller set of studies they also note the difference between occasional (less than 2.5 days per week) and intensive (more than 2.5 days per week) remote work. In general, the differences are not substantive, though the evidence suggests that the quality of relationships with coworkers is worse for remote-workers working from home more often. Lastly, Gajendran and Harrison also found remote work has no statistically significant impact on work performance, as rated by the individual worker, and a positive effect when rated by the supervisor - in general, remote work seems to be associated with better relationships between workers and supervisors.

For this early era of remote work, another study by Bercovitz and Feldman looked at the effects on innovation and invention specifically. They investigated the specific context of research collaborators who disclose inventions to their university's technology transfer office.⁵ Over the period 1988-1999, they studied 1,425 cases of inventions with multiple inventors. They found that disclosures where some of the inventors are not local are no less likely to receive patents, and actually receive higher royalties for their inventions.

We can also look at how well the work of academics fares when they collaborate at a distance. A study by Freeman, Ganguli, and Murciano-Goroff studied the citations received by academic papers for a sample of 126,000 papers published between 1990 and 2010 in the fields of particle and field physics, nanoscience and nanotechnology, and biotechnology and applied microbiology.⁶ For each paper, they mapped the institution of each co-author to the associated city. The results are mixed. Teams of coauthors spread across different US cities produced papers that were cited just as well as colocated teams in the fields of physics and biology. But teams which included *international* collaborators were not cited as well, and neither were papers in nanotechnology where the coauthors were spread across different US cities. One interpretation of these results is that remote work functions better in some fields than others, and that international collaboration presents additional challenges.

Turning from academic collaboration to business, economists Monteiro,

4 That said, if intent to seek new employment is reduced because workers value the option to work remotely, then intent to seek new employment may no longer be lower for remote jobs if they become widespread.

5 Bercovitz and Feldman (2011)

6 Freeman, Ganguli, and Murciano-Goroff (2014)

Straume, and Velento used a 2011-2016 survey of a representative sample of 5,000-6,500 Portuguese firms to assess the impact of remote work on firm-level productivity.⁷ Lacking a precise measure of remote work, they used positive responses to the question “Did your enterprise provide ...remote access to the enterprise’s e-mail system, documents, and applications?”

Simply comparing the productivity of firms that enable remote access to those that do not (and controlling for some obvious factors), remote-accessible firms are 15% more productive. But this result appears to be driven by more productive firms offering remote work, rather than remote work making firms more productive. So although they have data on thousands of firms, the authors prefer to focus on a subset of the 394 firms whose remote work status changed during 2011-2016. This lets them compare the productivity of workers, in the same firm, before and after they introduced or removed remote work access. Using this approach, they find remote work has a small but statistically significant *negative* effect on firm-level productivity. Enabling remote capabilities decreases worker productivity by 2-5%, depending on how the sample is weighted.

However, these headline numbers conceal important variation among types of firms. It turns out the negative impact of remote work is concentrated in lower-performing firms: mid-size and large firms do not see a reduction in productivity when they switch to remote work; neither do exporters; nor do firms with high-skilled employees. In fact, firms that do R&D increase their productivity by 4% when they offer remote work.

Better evidence for the causal effect of remote work comes from various natural and field experiments. Sherman conducted a field experiment where 187 employees of a life-sciences company in Cambridge, UK worked from home on even or odd weeks of a four-week period (allowing each participant to serve as their own control).⁸ During remote work weeks, employees worked, on average, 2.14 days from home, compared to 0.49 during in-office weeks. Self-rated performance was higher during remote work weeks too.

Likewise, Bloom and co-authors performed a remote work experiment made possible by the remarkable fact that one of the co-authors was a co-founder, first CEO, and Chairman of a large Chinese travel-booking company, CTrip. This allowed the authors to run a real experiment on a real company at large scale on employees who operated out of a Chinese call centre.⁹

In the experiment, CTrip conducted a lottery to assign half of 249 interested and qualified employees to work in the office one day a week and from home four days per week (to qualify, they needed to have been in the job at least six months, have broadband internet, and a private room

7 Monteiro, Straume, and Velento (2019)

8 Sherman (2019)

9 Bloom et al. (2015)

to work in). Once chosen, workers were not allowed to switch back to a full time colocated office until the nine-month experiment concluded. The experiment found home worker performance increased 13% relative to the control, mostly due to an increase in time spent on calls during the workday, which workers attributed to quieter working conditions. Attrition also dropped 50% relative to the control. Based on the results of the experiment, CTrip estimated participation in the program saved \$2000 per worker per year, and expanded the remote work option to its entire company.

While this provides clean evidence that remote work resulted in higher productivity, it is not obvious how applicable the results are outside of their specific context: a call centre where workers were still geographically constrained by the need to appear in the office one day a week. Fortunately, Choudhury, Foroughi, and Larson (2019) provide complementary evidence that full-time remote work policies can increase productivity.¹⁰ They studied various remote work programs at the US patent and trademark office (USPTO). Like the other study, qualifying patent examiners had access to a program where they work from home four days a week and in the office once a week, and the remote workers were more productive than their colocated peers, though this finding was observational, not experimental.

The main focus of Choudhury, Foroughi, and Larson, however, was on a more generous program for which it is possible to identify the causal impact. In 2011, the USPTO began implementing a “work-from-anywhere” program that allowed qualifying examiners to work remote all the time, and to relocate to anywhere (though they could be required to return to headquarters for up to 12 days or 5 trips per year). This program was oversubscribed, resulting in quasi-random allocation of the program to interested workers. Choudhury, Foroughi, and Larson compared the performance of workers selected for the work-from-anywhere program to unsuccessful applicants in the standard work-from-home program.

They found that remote workers in the work-from-anywhere program were 4% more productive than those in the standard work-from-home program (who were already more productive than colocated workers). They also found that a requirement that workers use modern collaborative software raised productivity for less experienced examiners (but had no effect on experienced ones), suggesting the importance of modern technology for enabling more productive remote work.

Altogether, these studies provide strong evidence that remote workers can actually have higher productivity than colocated ones. But again, the applicability of these findings to other forms of work is open to question. Perhaps remote work is effective for jobs that are mostly autonomous and independent, which may well describe call centre operators and patent examiners, but not for jobs where teamwork and collaboration are essential, such as a team of software developers. One of the studies, by Sherman, did include measures of “task interdependence” and found that workers with

“ Based on the results of the experiment, CTrip estimated participation in the program saved \$2000 per worker per year, and expanded the remote work option to its entire company.

10 Choudhury, Foroughi, and Larson (2019)

above median task interdependence did experience *less* benefit from remote work, though he did not find a negative effect. It may well be that the comparatively isolated work of patent examiners and call centre operators is unusually suited to remote work.

For some suggestive evidence on the effects of remote work on an organization requiring extensive collaboration, Karis, Wildman, and Mane performed a deep dive into how remote collaboration works (or doesn't) at Google, based on surveys, observations of meetings, interviews, and data on equipment use.¹¹ They concluded that "technical tools make keeping in contact and sharing information much easier than in the past... Although there is no effective solution to the time differences involved in long distance East-West collaboration, the other challenges are slowly decreasing, and the advantages of having a distributed workforce can now be more fully realized."

Moreover, a 2019 internal study by Google suggests that the ongoing challenges alluded to by Karis, Wildman, and Mane continue to shrink.¹² The more recent study found no difference in the effectiveness, performance ratings, or promotions for teams and individuals whose work required remote collaboration. The internet payments company Stripe also recently made a large push into remote work, noting in its 2019 announcement that "the technological substrate of collaboration has gotten *shockingly* good over the last decade" (emphasis in original) and that "while we did not initially plan to make hiring remotes a huge part of our engineering efforts, our remote employees have outperformed all expectations."¹³ A year later, Stripe's experience was positive enough that they decided to broaden the number of positions they would hire remotely and stated "we expect the number of remote-eligible roles will continue to grow."¹⁴

Lastly, Covid-19 provides direct evidence that remote work is more productive than commonly believed in many sectors. In April and May 2020, two sets of economists conducted surveys of small business owners and hiring managers in the US.¹⁵ They found a huge number of workers had shifted to remote work (estimates ranging from 23% to 74% of workers, depending on who is surveyed), essentially forcing a large chunk of the economy to give remote work a try. For small business owners, 29% believed productivity had increased for their remote workers and more than 50% of hiring managers thought remote work was going better than expected. More than 60% of hiring managers planned to increase their use of remote work in the future. All this evidence together suggests the (non-spillover) productivity advantage of colocation is shrinking, small, and maybe even negative in many industries.

11 Karis, Wildman, and Mane (2016)

12 Gilrane (2019)

13 Singleton (2019)

14 Shirley (2020)

15 Bartik et al (2020), Ozimek (2020)

Three positive trends for remote hiring

Giving existing workers the option to work remotely does not significantly reduce their productivity; indeed, it may raise it. But firms that use remote workers also have access to different workers than colocated firms. Remote workers can be hired from the local market but also from outside it. Therefore, remote positions can, in principle, access higher quality workers anytime there are higher quality workers outside the local market.

The problem for a firm is to identify these workers (and attract them). The next section will argue workers find remote positions attractive. This section discusses the steady improvement in technology for matching remote workers to interested firms. In the absence of direct evidence about trends in the hiring of geographically dispersed remote workers, this report focuses on three other trends that support the ability of distant firms and workers to match. These are: (1) increased use of the internet by job-seekers and employers; (2) the development of effective algorithms and information on online job markets; and (3) greater potential to form and maintain distant relationships via social networks.

TREND 1: INCREASED USE OF THE INTERNET BY JOB-SEEKERS AND EMPLOYERS

The main technology enabling better matching is, of course, the internet. A large number of studies have documented how the internet improves matching of buyers and sellers across many markets, such as airlines, books, rental and home vacancies, and food trucks.¹⁶ Surprisingly, however, studies of the spread of the early internet found little evidence that it facilitated better matching in labor markets. Studying the use of internet job search in 2000, economists Kuhn and Skuterand found it was no better than traditional job search.¹⁷ Another study, by Kroft and Pope, looked at the city-by-city rollout of Craigslist over 2005-2007 and found no detectable impact on local labor market outcomes (though Craigslist did reduce apartment vacancy rates and the use of print-based classified ads).¹⁸

These results are a useful reminder that full utilization of new technologies is not instantaneous. Yet things have now changed. Faberman and Kudlyak updated Kuhn and Skuterand's job search data from 2000 with new data from 2011.¹⁹ In those 11 years, the share of the unemployed with home internet access rose from 40% to 74%, and the share of unemployed job seekers using the internet to find work tripled from 26% to 76%. Farberman and Kudlyak found that internet job searchers were significantly more likely to find work within one year. Indeed, as they point out, the use of internet job search and job postings had become so routine at the time of their writing that they were regularly used by economists when studying the overall labour market.

16 Goldfarb and Tucker (2019)

17 Kuhn and Skuterand (2004)

18 Kroft and Pope (2014)

19 Faberman and Kudlyak (2016)

Online social networks - especially professional networks like LinkedIn - have also emerged as a secondary channel through which recruiters can learn about and contact potential hires. As of 2019, 27% of US adults have LinkedIn profiles.²⁰ An emerging literature also documents how the use of online social networks by recruiters has become common across a variety of countries, though it remains unclear how effective these recruiting methods are relative to traditional ones.²¹

TREND 2: IMPROVEMENTS IN THE DESIGN OF ONLINE JOB MARKETS

A bigger pool of candidates and positions can potentially make sorting through job posts and applications more challenging, but a variety of tools and algorithms are being developed to facilitate online job matching. Early examples included referral links (which allowed users to send promising leads to other people) and online application portals that verify applicants meet minimum criteria. Brenčić and Norris studied the use of these kinds of early job search tools by employers posting jobs on Monster.com over 2004-2006, finding they were indeed used by firms with the most experience with online job sites.²²

A number of papers have specifically studied the design of *oDesk* (now *upWork*), an online labour market for short-term remote work contracts. A study by Horton, for example, examined the efficacy of algorithmic recommendation tools on match quality on *oDesk*.²³ Horton's experiment relied on the fact that employers may invite specific *oDesk* workers to apply for positions. In 2011, the company performed an experiment where it provided recommendations of workers to invite to a random set of new employers. These recommendations were based on the availability of the worker (as inferred by *oDesk*), prior satisfactory performance, and skill match with the posted contract. A control group of employers were not shown recommended workers. Horton found that the algorithmically generated recommendations increased the probability of finding a suitable worker by 20% for technical jobs (but had no effect on nontechnical jobs).

Online labour markets also face issues related to trust. Since *oDesk* focuses on short-term contracts, these issues are particularly salient and the company has a number of features designed to reassure employers that workers are not shirking. For example, employers can require jobs be completed while using a program that captures screenshots of the worker's computer. More importantly for the question of match quality, *oDesk* provides information about past performance and does not allow employees to delete all this information.²⁴

This kind of basic information on past performance appears to be quite important in these markets. For one experiment, Pallais randomly selected

“the share of unemployed job seekers using the internet to find work tripled from 26% [in 2000] to 76% [2011].”

20 Iqbal (2019)

21 Stopfer and Gosling 2013, Berkelaar 2017

22 Brenčić and Norris (2012)

23 Horton (2017)

24 Agrawal et al. (2013)

952 *oDesk* workers to be hired for a 10-hour data entry task and then be given short or detailed publicly viewable performance reviews.²⁵ Workers with these reviews were substantially more likely to be hired again on the market, compared to those not hired as part of the experiment. Another study by Agrawal, Lacetera, and Lyons also found that having information on prior experience led to more hiring for remote workers, especially for workers from less developed countries.²⁶

TREND 3: GREATER POTENTIAL TO FORM AND MAINTAIN DISTANT RELATIONSHIPS VIA SOCIAL NETWORKS

While the emergence and steady improvement of online labor markets facilitates matching, more than 50% of jobs have typically been found through social ties.²⁷ These matches also tend to be good ones, at least in terms of having lower turnover and higher productivity.²⁸ To the extent that social networks are built by physical proximity, this is a powerful force for agglomeration and colocation. Our neighbours become friends, and our friends help us find jobs, and the jobs they help us find tend to be local.

That said, the emergence of email, videochat, and online social networks like Facebook, Twitter, and LinkedIn have the potential to expand our networks of geographically distant “weak ties” (relationships that are more acquaintance than friend). These weak ties have long been thought to play an important role in job search, since their connections to different communities makes them more likely to transmit novel information.²⁹

Gee, Jones, and Burke test the weak ties hypothesis using data on 6 million Facebook users over 2007 to 2011.³⁰ They find weak ties (as measured by the extent of overlapping friends or the extent of interactions) collectively help users find more jobs than close friends, simply because people don’t have many close friends but have many weak ties. Meanwhile, Dunbar finds some evidence that social networks help (young) people acquire more weak ties.³¹ In two 2015 surveys of UK adults, Dunbar finds most users of social networks report 150-180 friends on social networks, which is not noticeably larger than the typical size of offline social networks of around 150 (the so-called “Dunbar number”). However, when Dunbar breaks his data down by age, it turns out 18-24 year-olds report many more friends - 282 on average. Most of the increased size of young people’s social networks appears to reflect an expansion of weak ties, not close ties.

There’s also some evidence social networks help users maintain geographically distant social ties. For example, Laniado and coauthors studied user interactions on a popular Spanish online social network in

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25 Pallais (2014)

26 Agrawal, Lacetera, and Lyons (2013)

27 Gee, Jones, and Burke (2017)

28 Burks et al. (2015)

29 Granovetter (1973)

30 Gee, Jones, and Burke (2017)

31 Dunbar (2017)

2010.³² While they found users were more likely to *be* friends on the network if they were geographically close, distance barely mattered once friendships had been formed. The extent of online interaction between geographically close friends and geographically distant friends was very similar.

Online social networks may support the maintenance of a larger network of dispersed friends, but they do not necessarily help users form new distant relationships. There is some evidence, however, that this does occur in some online environments that function as “third places,” places where people “hang out” online and potentially meet new geographically distant people. McCulloch (2019) cites Twitter as one example and it has also long been recognized that online multiplayer games can function as third places, since they are, essentially, a place for people to hang out and interact in.^{33,34} Molyneux, Vasudevan, and Zúñiga (2015) surveyed a large nationally representative group of US adults and found online players responded affirmatively to statements normally used to measure social capital among offline communities, such as “I feel close to the people I play games with” and “I feel like I am part of a community of gamers.”³⁵ Trepte, Reinecke, and Juechems (2012) survey 811 mostly European players of e-sports and find similar evidence that online gaming leads to the creation of social capital and offline social support.³⁶ Online gaming is a very new way to form friendships, but one that might become more prevalent in the future. Forty-one percent of American adults play video games with other people online, averaging nearly five hours per week.³⁷

Finally, the internet and online social networks can also help people maintain relationships that are formed offline. A small literature on academic conferences and collaboration suggests short in-person meetings at infrequent conferences can be sufficient to establish lasting relationships between geographically dispersed individuals.³⁸ Of particular relevance is Bakhshi, Davies, and Mateo-Garcia (2015), which explicitly measures the impact of attending the 2012 Le’Web tech conference on attendees’ Twitter social network.³⁹ Following the conference, attendees “followed” other conference participants at a much higher rate than they followed non-attendees in the six weeks after it’s conclusion.

To sum up, one major advantage of remote work over colocated work is that remote work enables firms to access a larger pool of potential hires, and job-seekers to access a larger pool of potential employers. This increases the relative quality of the best match for a remote worker, relative to a

32 Laniado et al. (2018)

33 McCulloch (2019)

34 Steinkuehler and Williams (2006)

35 Molyneux, Vasudevan, and Zúñiga (2015)

36 Trepte, Reinecke, and Juechems (2012)

37 Entertainment Software Association (2019)

38 Freeman, Ganguli, and Murciano-Goroff 2015, Chai and Freeman 2019, Campos, Leon, and McQuillen 2018, and Boudreau et al. 2017

39 Bakhshi, Davies, and Mateo-Garcia (2015)

colocated one. However, realizing this advantage requires employers and employees to find each other. Fortunately, we have a variety of reasons to believe the ability of firms to match with remote workers is steadily increasing. Using the internet to search for employees and employers has become common, with better algorithms helping both parties sort through the larger pool of potential matches for the best fit. Social networks are another important part of job matching, but online social networks and communication technology are likely to increase the number of weak ties we can form and maintain across geographic distance.

A potential bottleneck to remote work is the tendency of people to most easily form close relationships with people who are physically proximate. While the internet may make it easier to strengthen relationships formed online or via travel, physical proximity remains a major determinant in the formation of relationships.

But, as discussed in the next section, the challenge of building and maintaining close relationships at a distance can also be reframed as a strength of remote work.

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Remote Work Reduces Costs

Remote work capabilities allow a firm to access a larger labor market. This will lead to better matching of firms with higher quality workers if they can find each other, and if firms can entice distant workers to work for them remotely. The last section reviewed the evidence on matching. This section reviews the costs of attracting and retaining remote workers.

As discussed in the last section, one of the challenges with matching job-seekers to remote firms is that job-seekers may use social ties to find work, and it is easier to build and maintain close social ties with local people. But this is also part of the appeal of remote work. Remote work means no longer having to choose between pursuing a distant job opportunity and maintaining close social connections with friends and family. Remote work is often framed as socially isolating, since it reduces workplace interactions (though even this critique may not be true of remote workers in satellite offices and coworking spaces). But this perspective ignores the fact that the reduction in workplace interaction may be more than offset by an increase in out-of-workplace socializing with people many workers would rather be spending time with anyway: their closest friends and family. While the importance of geographic proximity is a problem for creating good matches, it is actually a potential strength for attracting geographically distant workers.

These relationships are highly valued. In 2020, economists Koşar, Ransom, and van der Klaauw asked a representative sample of US adults about their moving preferences.⁴⁰ Respondents were presented with different choices for hypothetical moves, that varied in terms of income and other attributes.

40 Koşar, Ransom, and van der Klaauw (2020)

By comparing responses to the income offered, the authors inferred the dollar value respondents place on attributes like living near family. They estimated respondents would need to be paid an additional \$24,000 to no longer be near family, or 43% of their income. Even workers who describe themselves as “mobile” (as opposed to “stuck” or “rooted”) were willing to give up \$20,000 to remain near family.

Two papers by Dahl and Sorenson perform a similar exercise on actual (not hypothetical) moving decisions using a 2003 and 2006 sample of Danish adults.⁴¹ For example, in one exercise, they look at where Danish blue collar workers move after the plant they work at closes. By correlating the typical salary of blue collar workers in the region where workers eventually choose to reside with the presence of friends, family, and other characteristics, they can estimate the dollar value of proximity to home. They find a doubling of the distance to the hometown is associated with a salary that is approximately \$10,000 higher (compared to an average salary of \$32,000). They find similar sized effects for movement away from friends. Effects are even larger in absolute and proportional terms for Danish scientists and engineers.

A more acute version of this is the so-called “two-body problem,” when dual career couples must choose between cohabiting or pursuing geographically distant (colocated) job opportunities. Murray-Close documents that 1.9% of college-educated US adults in 2000 did not cohabit with their partner.⁴² The probability of non-cohabitation is higher for workers with more geographic specific occupations, suggesting this is at least partially driven by job opportunities in different places. Being unable to live with your partner is not the only resolution to the two-body problem though. McFall and Murray-Close examine the first jobs received by economics PhD recipients in 2008-2010 who are in a committed relationship.⁴³ They show that many of the recipients either live apart from their partner (17%), reject their first choice job (9%), or break up (8%). To the extent workers prefer to cohabitate to breaking up, remote work can help resolve the two-body problem.

Taken together, not having to move for a job is worth a sizable chunk of salary for most workers. Furthermore, there is some evidence that the aversion to moving is getting worse. Between 1997 and 2018, the probability a young renter in the UK would move for a new job fell by two-thirds.⁴⁴ There are many possible reasons why the probability of moving has fallen so much, and most of them are favorable for remote work. It may be that proximity to friends and family is something society is more willing to “purchase” as it gets wealthier, in this case by forgoing higher salaries by not moving. But more prosaic concerns also play a role.

One of these is the cost of living. Historically, one reason people move

41 Dahl and Sorenson (2010a), Dahl and Sorenson (2010b)

42 Murray-Close (2013)

43 McFall and Murray-Close (2016)

44 Judge 2019

has been to access higher wages. But Judge (2019) shows there has been a widening divergence in rent and home prices in the highest and lowest paying regions of the UK, partially eroding the value of moving for a higher wage.⁴⁵ In the US, too, Moretti (2013) estimates that approximately a quarter of the wage premium for people who are college-educated is accounted for by the higher cost-of-living in the places where they live.⁴⁶ As such, the shift to remote working can benefit both firms and workers. The USPTO's work-from-anywhere program, for example, paid its workers the same salary, regardless of where they chose to reside. Participants in the program enjoyed substantial increases in their real wage by moving to places with a lower cost-of-living.⁴⁷

Variation in the cost of living is also correlated with the cost of commercial real estate, which can be another source of savings for businesses hiring remote workers. In 2017, the median rateable value of commercial real estate in London and Cambridge was £192 per square meter, and £424 per square meter in the city centre, compared to a median value of £81 per square meter over England and Wales.⁴⁸ In the study of remote work at the Chinese travel booking company CTrip (discussed in section 2), the company estimated it saved \$1,250 per worker per year on reduced office space costs.⁴⁹ And the US Patent and Trademark office estimated that its work-from-anywhere program saved the agency \$38.2m in office space costs in 2015 alone.⁵⁰

Colocation is also expensive if the prevailing local wage is high relative to the wage of remote workers. The median wage for a graduate just one year out of school is 9% higher in London, compared to the UK national average. And after 10 years on the job, the median wage for a worker in London is 24% higher.⁵¹ As will be discussed in section 6, college educated workers also tend to have the greatest scope for remote work. If the productivity of remote workers is sufficiently close to those for colocated workers, then this suggests significant savings are possible for companies that hire remotely.

Lastly, in many cases, workers seem to value the ability to work from home, even if they must remain close to the office and this can lead to additional savings. The study of the Chinese travel booking company CTrip only allowed workers to work from home four days per week. Nonetheless, it found remote work reduced turnover by 50%, which led to annual savings of \$400 per worker.⁵² The fact that turnover fell so dramatically suggests workers like remote jobs. Mas and Pallais attempt to directly estimate the value workers place on the option to work from home by performing an

“Moretti (2013) estimates that approximately a quarter of the wage premium for people who are college-educated is accounted for by the higher cost-of-living in the places where they live.”

45 Judge (2019)

46 Moretti (2013)

47 Choudhury, Foroughi, and Larson (2019)

48 McDonald 2018

49 Bloom et al. (2015)

50 Choudhury, Foroughi, and Larson (2019)

51 Department for Education 2019

52 Bloom et al. (2015)

experiment with job applicants for a position in a call center in 2016.⁵³ As part of the application process, applicants were shown two versions of the position they were applying for, with different (randomly selected) wage differentials, and asked to choose which one they would prefer, if both were available. On average, workers were willing to accept an 8% pay cut to enjoy the option of working from home. Notably, this is far more than they are willing to accept in exchange for other perks, such as the option to set their own schedule.

That said, the study of CTrip does find some evidence that work from home was not as valuable after workers tried it. After their nine-month experience with remote work, 50% of the remote workers opted to return to the colocation option.⁵⁴ Only 35% of those who originally wanted to work from home took up the option when it was extended to them after the experiment. Interviews suggested workers felt lonely and isolated at home.

On the other hand, in a supplemental experiment Mas and Pallais found employees already working from home were willing to take a 19% pay cut on a hypothetical job to keep the option to work from home (compared to a 9% pay cut for those without an existing work-from-home arrangement).⁵⁵ These results suggest the population that self-selects for remote work values it more than the general population. In general, there is no reason to believe the value of remote work will not vary across people, firms, industries, and countries.

Taken together, variation in the cost of living, potential savings on office space and turnover, and the amenity value of remote work itself are all reasons why the cost of remote workers is likely to be lower than the cost of colocated ones. Firms can pass this value onto workers, and attract and retain better remote workers than they would be able to do with colocated ones.

Local Knowledge Spillovers are Declining

We now turn to the strength of local knowledge spillovers. It has been amply documented that innovation and economic activity tends to cluster in cities. For example, patent production and economic activity cluster in cities at a faster than the proportional rate - if city *X* has twice the population of city *Y*, it will tend to have *more* than twice the number of patents and economic activity.⁵⁶ A variety of rationales for geographic clustering have been suggested, and these can be grouped under the broad headings of sharing, matching, and learning.⁵⁷ In brief, cities allow better access to shared assets (infrastructure, but also labor pools and risk), they

53 Mas and Pallais (2017)

54 Bloom et al. (2015)

55 Mas and Pallais (2017)

56 Bettencourt et al. (2007)

57 Duranton and Puga (2003)

facilitate matching of (colocated) workers to firms, and they allow for the easier exchange of information (learning). Because these traits make firms more productive, firms will tend to locate in cities, despite the higher costs of doing so.

This section focuses on the last of these reasons, the access to knowledge that supposedly requires physical proximity. To the extent that access to industry knowledge really does require being close to other workers in the industry, the potential advantages of remote work are weakened. Suppose a firm allows workers to work remotely, but requires them to reside in the same city in order to benefit from local knowledge spillovers. Such a firm is restricted to the same local labor market as a colocated firm (or has to induce workers to move), with wages that reflect cost-of-living in the region. Without access to some of the strongest advantages of remote work, the firms may as well just decide to ask workers to work in a colocated office anyway.

Yet, this section presents evidence that local knowledge spillovers are declining and may be absent for some types of economic activity. This doesn't mean knowledge spillovers and learning aren't important - only that geographically distant workers are now able to access these benefits at a rate closer to (or identical to) geographically close workers.

For example, Balland and co-authors looked at the extent to which patent activity clusters into more populous cities over 1850-2010.⁵⁸ They found that bigger populations tend to have higher rates of patenting per capita. But they also found that the scaling coefficient peaked in 1960. Since then, the extent to which patents cluster into cities has declined. In this section, I'll argue the decline in the clustering of innovative activity reflects the decline in the importance of local knowledge spillovers, and that this decline is driven by better information and transportation technology.

The Strength of Local Knowledge Spillovers is Falling

One of the main ways economists have attempted to measure the importance of local knowledge spillovers is by looking at when patents cite earlier patents. The canonical paper here is Jaffe, Trajtenberg, and Henderson (1993), which argues that patents are more likely to cite local patents.⁵⁹ The idea is that if patents are more likely to cite the patents of local firms and inventors, and if patent citations indicate knowledge transfers, then this is evidence that knowledge is transferred most readily when it is local. The paper showed that patents are more likely to cite local patents.

58 Balland et al (2019)

59 Jaffe, Trajtenberg, and Henderson (1993)

But since then, a variety of papers have pulled in different directions.⁶⁰ However, two other papers suggest the canonical evidence from patent citations has become increasingly unreliable in the 21st century. Kuhn, Younge, and Marco (2020) show that there has been a sharp increase since 2000 in the number of citations of dubious quality. When they implement Jaffe, Trajtenberg, and Henderson (1993)'s methodology with only "high-quality" citations, they find the probability that two connected patents belong to the same city has declined.⁶¹ Arora, Belenzon, and Lee (2018) also takes a second look at Jaffe, Trajtenberg, and Henderson (1993) and essentially show that a placebo analysis based on patent citations that probably do not reflect knowledge flows obtains the same result for the years 2001-2014. This suggests using patent citations to measure knowledge flows may not be a good methodology.⁶²

These two papers suggest citations are an increasingly poor measure of anything beginning after the year 2000, because of changes in citation practice. Accordingly, it's worth looking instead at papers that do not use patent citations, such as Fitjar and Rodriguez-Pose (2017).⁶³ To test whether cities facilitate chance and casual encounters that result in innovation, in 2013 they asked 542 Norwegian firms about the most important partner involved in the creation of a new product or process in the preceding three years, and then how this partnership was formed. They found that casual and chance encounters account for about a fifth of these partnerships (targeted searches accounted for the remaining four fifths). However, there was no statistically significant difference in the probability that such a by-chance partnership was formed in or outside cities. Indeed, if anything, such chance encounters were *more* likely to happen outside of cities.

Another paper suggests the power of cities to facilitate unexpected encounters was higher in the past than it is today.⁶⁴ Mewes approached this question with US patent data, though not patent citations. Instead, he used the technology classifications assigned to patents; when a patent is classified as belonging to technology classes *X* and *Y*, Mewes interpreted this as an indicator that the patent combined pre-existing technologies *X* and *Y*. He was particularly interested in novel and unusual combinations of technology; if these arise when experts in typically separated fields learn of each other's ideas, then we would expect cities to have disproportionate advantages for these novel combinations. Mewes looked at the extent to which the advantage from city size changed between 1850 and 2010 in

60 Kwon et al. [2019] is an update to their work, extending the data through to the year 2015. It finds that local knowledge spillovers have been strengthening over time. Griffith and Van Reenen (2011), taking a different approach and looking at the time until a citation is received, found evidence that local knowledge spillovers weakened over 1975-1999. Yet another study, by Singh and Marx (2013), found some evidence that distance matters more than ever, while also finding other evidence that its importance is weakening.

61 Kuhn, Younge, and Marco (2020)

62 Arora, Belenzon, and Lee (2018)

63 Fitjar and Rodriguez-Pose (2017)

64 Mewes (2019)

producing “atypical” combinations. He found this advantage peaked in the 1970s and has been on a steady decline ever since.

Furthermore, Packalen and Bhattacharya use patent data in yet another way to suggest the advantage of cities for disseminating new ideas has fallen.⁶⁵ They scanned the text of all patents and pulled out important one-, two-, and three-word sequences (e.g., “microprocessor” and “polymerase chain reaction”). They call these word(s) “concepts” and interpret them as technological ideas. Because they can observe the date each concept was first mentioned in a patent, they can measure the “age” of the idea. They then looked at whether patents in cities used newer ideas compared to patents from outside cities. They found that the patents of big cities used to have a much higher probability of mentioning a very young concept, but that this difference faded over time. By the 2000s, they could statistically no longer rule out that the difference between big cities and average cities was zero.

Besides patents, academic papers represent another avenue for studying the importance of local knowledge spillovers. Head, Li, and Minondo focused on the citations mathematicians make in their published work.⁶⁶ For the time period 1990-2019, mathematicians were less likely to cite the work of mathematicians who were further away. However, the strength of this effect steadily fell over the entire period. Indeed, once you also factor in social ties between mathematicians (for example, that the cited mathematician is an advisor or former colleague), after 2004 there was no longer any relationship between distance and the propensity to cite.

More broadly, Wuestman, Hoekman, and Frenken studied the importance of geographic proximity in academic research by estimating the probability that a cited paper’s authors worked within 20km of the citing paper’s authors.⁶⁷ They found citations to dissimilar work are locally biased, but citations to similar work are not. One interpretation of these results is that researchers are able to easily keep track of developments in their own field, no matter how far away in space, and they cite accordingly. However, researchers do not as easily learn about relevant work outside their usual field, unless that research happens locally. This suggests local knowledge spillovers may still matter in academia, for example, by enabling serendipitous encounters with unexpectedly relevant ideas. But the analysis does not let us ascertain whether this has fallen over time or not.

Lastly, Kim, Morse, and Zingales (2009) examined the research productivity of academics in economics and finance over 1970-2000. By keeping track of the moves of individual academics, they could see how the productivity of researchers changed when they moved to top universities (where research productivity is measured in terms of how many articles they write per year, adjusted for the quality of journal). In this way they inferred the impact of colocation with other academics based on the

“One interpretation of these results is that researchers are able to easily keep track of developments in their own field, no matter how far away in space, and they cite accordingly. However, researchers do not as easily learn about relevant work outside their usual field, unless that research happens locally. ”

65 Packalen and Bhattacharya (2015)

66 Head, Li, and Minondo (2019)

67 Wuestman, Hoekman, and Frenken (2019)

individual productivity of a researcher. They found that the positive impact of being in a top university declined in each decade, such that there was no positive impact of being in a top university by the 1990s. Neither did the productivity of department colleagues matter for an economist's individual productivity in the 1990s.

Taken together, a variety of evidence from patents, academic journal articles, citations, and meetings suggests it's less important than ever to work physically near other people to access their expertise and ideas.

Better Transport and Communication Technology Facilitates Access to Distant Knowledge

What is behind the decline in local knowledge spillovers? It appears to be driven by improvements in transportation and communication technology.

To begin, Catalini, Fons-Rosen, and Gaule looked at academic collaboration between chemists living in different cities after Southwest Airlines opened a new route connecting them.⁶⁸ They found that in the years after new (low-cost) airline routes connect them, chemists published 50% more articles co-authored with chemists on the other end of the route. The effect was stronger for collaborations across different fields and when both chemists were more productive than the average for their department - both cases when being able to reach outside your local contacts is important. They found similar effects for other disciplines.

It's not only planes. Dong, Zheng, and Kahn looked at collaboration between academics in China when cities were connected by high speed rail.⁶⁹ They found similar results (although their results were more fragile and could partially disappear depending on the statistical method used): after a high-speed rail line was built between two cities, there was an increase in the number of papers co-authored by academics based in the cities. This effect was strongest when a "secondary" city was connected to a "mega" city, and when the cities were close enough so that high-speed rail became faster than air travel.

The evidence from airplanes and high-speed trains is consistent with roads as well. Agrawal, Galasso, and Oettl looked at what happened to innovation when US regions built more motorways.⁷⁰ They looked at private sector innovation and focused on the local impact, rather than how motorways enabled collaboration across states. They found a 10% increase in regional motorways was associated with 1.7% more regional patents over 5 years. It seems this is because the roads enabled easier access to distant knowledge. The authors focus on citations that patents make to other patents from the same region: the more roads, the greater the distance between these

68 Catalini, Fons-Rosen, and Gaule (2018)

69 Dong, Zheng, and Kahn (2018)

70 Agrawal, Galasso, and Oettl (2017)

patents.⁷¹ They also show the impact of roads is strongest in low-density cities, where inventors are more geographically dispersed. Intuitively, after my city builds a new motorway I'm more likely to cite patents from across the city instead of across the street, especially if there aren't many inventors nearby. Roads enable more local-but-not-*that*-local knowledge flows.

In general, anything that increases access to distant knowledge can erode the importance of being physically proximate to people. Furman, Nagler, and Watzinger studied the impact of patent depository libraries on local innovation.⁷² Comparing recipients of these libraries to nearby eligible sites that did not receive libraries, they showed increased access to information (i.e., the text of patents) increased local patenting by 17%. Moreover, patents from inventors living near patent libraries were more likely to cite patents belonging to more distant inventors. The library apparently reduced the need to be near other inventors to make use of their ideas.

Of course, you still need to be near the library. Or at least, you did, until the internet. Furman, Nagler, and Watzinger also showed that the local impact of patent depository libraries evaporates once the first internet searchable patent databases become available in 1995.

Improvements in digital communication technology have the same effect of facilitating remote collaboration and reducing the need to be geographically proximate. Two papers by Forman and Zeebroeck both looked at how internet access changes the collaboration patterns of firms with geographically dispersed establishments.⁷³ To measure the impact of internet access, they reached back a long way, to the 1992-1998 era, when internet access was first beginning to roll across America. One paper showed that after two establishments are connected to the internet, inventors in the connected establishments are more likely to be jointly listed on patents.⁷⁴ In contrast, getting internet access didn't seem to have any impact on the number of patents for solo-inventors or teams of clustered inventors which suggests the internet's main advantage was in facilitating collaboration, not merely in increasing access to knowledge.

And it does increase access to knowledge too. Studying the same era, another paper by Forman and Zeebroeck showed that when two establishments are connected to the internet, patents by inventors from one establishment were more likely to cite patents by inventors from the other.⁷⁵ More recently, another paper demonstrated how knowledge can be disseminated online with an experiment wherein randomly selected articles were tweeted out via a semi-large twitter account (the Thoracic Surgery Social Media Network, about 3,000 followers).⁷⁶ One year later,

71 Note that the citations discussed here and in the next few paragraphs occurred mostly before the year 2000, which is when Kuhn, Young and Marco (2020) (discussed earlier) argue the quality of patents began to decline.

72 Furman, Nagler, and Watzinger (2018)

73 Forman and Zeebroeck (2012) and Forman and Zeebroeck (2019)

74 Forman and Zeebroeck (2012)

75 Forman and Zeebroeck (2019)

76 Luc et al. (2020)

the number of citations to the tweeted articles was 3.1, compared to 0.7 in the control.

The preceding papers show internet access facilitates access to distant knowledge, but do not directly address the issue of whether this leads to less geographic clustering of inventive activity. Forman, Goldfarb, and Greenstein (2014) does.⁷⁷ They compared the growth of regional patenting over 2000-5 to patent levels over 1990-95. Overall, they saw a significant increase in the concentration of inventive activity: the counties with the most patents over 1990-95 also had the fastest growth of patents over 2000-5. What is novel, however, is that they show this effect was reduced by greater internet access: counties without much patenting activity in 1990-5 were able “keep up” better if the county had better internet access. Moreover, the moderating effect of the internet on the clustering of inventive activity was largest when they restricted attention to patents with distant collaboration among inventors. One interpretation of these results therefore is that people living in innovative counties in the 1990s didn’t really need the internet to find potential collaborators, so its presence or absence didn’t matter that much. But people living in less innovative regions benefited a lot from internet access, because it allowed them to find good collaborators and participate in the innovation economy.

Overall then, geographic clustering of economic activity tends to be clustered in cities, but this clustering has actually fallen along some dimensions over the last few decades. Geographic clustering can be caused by a variety of factors, sometimes grouped under the headings of sharing, learning, and matching. But the learning advantage of geographic proximity has been falling for a long time, due to improvements in communication and transportation technology.

The Rise of Remote Work

The relative productivity advantage of colocation is dropping and the advantages of remote work are rising. The productivity of individual colocated workers relative to remote ones is quite close to or even less than their remote peers, at least in some industries. As technology continues to advance, this is likely to be true in more industries. The ability to find high quality remote workers from large national labor markets is rising as we move more and more of our social and professional lives online. It costs firms more to hire colocated workers rather than remote ones, and this disparity may be growing if home attachment continues to rise. And the knowledge spillovers that accrue to collections of colocated workers has been falling and may now even be gone.

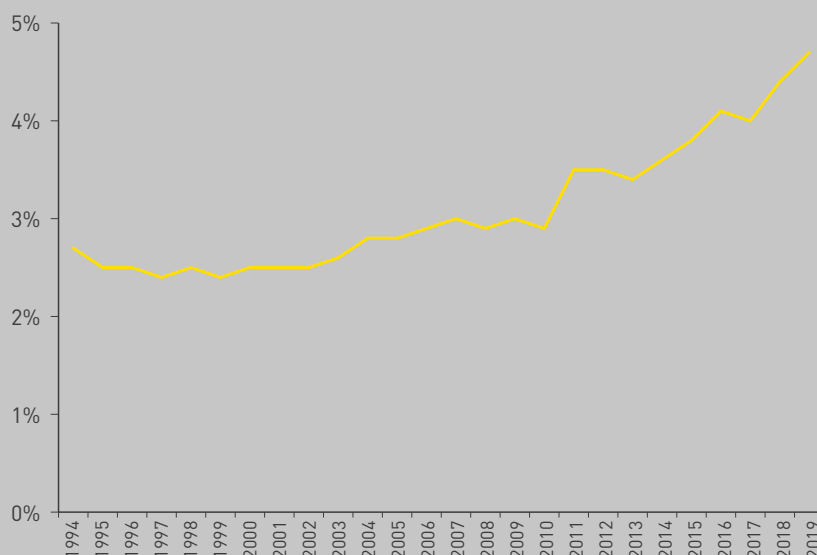
If these trends really are tilting the balance of tradeoffs in remote work’s favor, then it is possible that a tipping point has already been reached for some job roles. Since firms are also aware of these trends, we may begin to see an increasing share of jobs go remote. In this section, I review evidence that, even before Covid-19, we were already seeing the rise of remote work.

As indicated in figure 1, the prevalence of remote work in the UK was stuck just under 3.0% from 1994 to 2010, but has since begun to climb steadily to 4.7% in

77 Forman, Goldfarb, and Greenstein (2014)

2019.

Figure 1. Share of UK employed persons usually working from home, 1994-2019



Source: Eurostat

Since these numbers focus exclusively on those who work from their home, they omit those who work from satellite offices, co-working spaces, coffee shops, and other alternatives. Accordingly, they understate the true extent of remote work. In the USA, a 2019 survey commissioned by Upwork and the Freelancers Union finds a similar share of people who work from home as the US census (about 5%), but found that including alternative work sites raises the share of remote workers to 9.5%; including those who work remotely some of the time increases the percentage to about 36.1%.⁷⁸

The ability to work remotely varies significantly by industry. Prior to Covid-19, only 8.8% of leisure and hospitality workers had the option to sometimes work from home, but more than 50% of workers in the information, financial activities, and professional and business services industries did. Within a given industry, the option to work remotely is concentrated in management, business, and financial operations occupations (60.1%), and to a lesser extent in professional and related occupations (42.5%). Lastly, the option to work remotely is heavily concentrated in high-earning and high-education positions. Fully 51.9% of workers with a bachelor's degree or higher have the ability to work from home (at least for some of the time), as do 61.5% of those in the top earning quartile.⁷⁹

A variety of evidence suggests we are a long way from reaching the limits of remote work. Most obviously, under Covid-19, the share of work done remotely has jumped to unprecedented levels. A US survey found that 15% of respondents were working remotely before the pandemic and that just under 50% were working remotely during it.⁸⁰ Other surveys have found similar jumps. Bartik et al. (2020) find 45%

⁷⁸ Ozimek (2019)

⁷⁹ BLS (2019)

⁸⁰ Brynjolfsson et al. (2020)

of small business owners reported some of their workers switched to primarily remote work in response to the pandemic.⁸¹ Ozimek (2020) finds the share of hiring managers with no remote workers dropped from 46% to 6%.⁸² In the UK, of firms that responded to the Business Impact of Coronavirus Survey, the average proportion of the workforce working remotely rose to 48%.⁸³

Evidence from before the pandemic similarly indicates the non-emergency ceiling for remote work is much higher than 5-15%. To begin with, the 2016 Understanding America Survey simply asked a representative sample of US adults whether their job could feasibly be completed from home. Among college educated workers, 41% said yes. Among those with a high school degree or less, the number was 14%.⁸⁴ An alternative approach used data from two Occupational Information Network surveys on “work context” and “generalized work activities” to estimate the share of jobs that could plausibly be done remotely.⁸⁵ Their approach is to rule out occupations as a candidate for remote work if their survey responses indicate the job cannot be performed online (for example, if the average respondent says they have to wear protective or safety equipment). Using this approach, they estimate that 34% of jobs can be done remotely (though they interpret this number as an upper bound). Lastly, in 2017-2018, 28.8% of US workers aged 15 and over could work from home at least some of the time (and 24.8% did at some point).⁸⁶ Together, these studies suggest in the current job landscape that an upper bound of one fifth to one half of jobs can be done completely remotely, though this number will be skewed towards high education positions.

There is also demographic momentum for an increase in remote work. A pre-coronavirus survey by Ozimek finds 69% of Gen Z and millennial hiring managers allow team members to work remotely, compared to 58% of baby boomer hiring managers.⁸⁷ More than 40% of small business owners aged 18-34 planned to hire full-time remote workers, compared to just 10% of small business owners aged 50 and up. Although the differences are smaller, younger workers are typically more interested in working remotely or are already working remotely. All this suggests that demographic changes, on their own, could make remote work more prevalent, even without the changes documented in this paper.

An alternative measure of our ability to work remotely is to look at trends in the extent of knowledge work conducted by geographically dispersed collaborators: patents and academic papers. Figure 2 plots the share of US-coauthored scientific publications with (1) authors belonging to multiple

“More than 40% of small business owners aged 18-34 planned to hire full-time remote workers, compared to just 10% of small business owners aged 50 and up.”

81 Bartik et al. (2020)

82 Ozimek (2020)

83 Filipe Bell and Wilkinson (2020)

84 Mas and Pallais (2020)

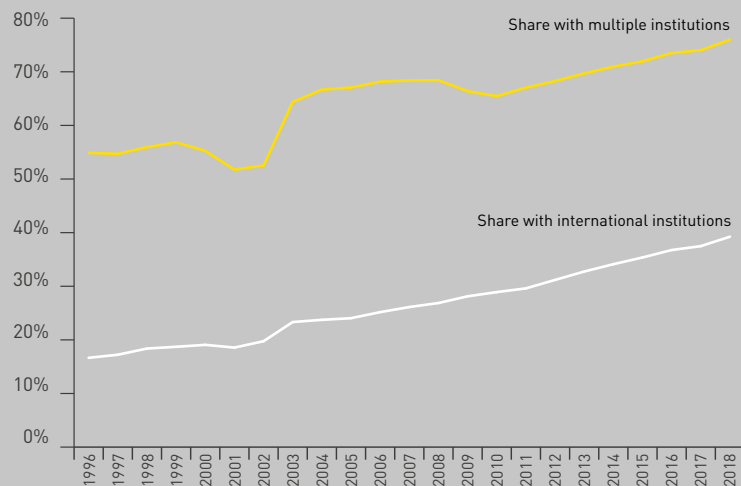
85 Dingel and Neiman (2020)

86 BLS, (2019)

87 Ozimek (2019)

institutions and (2) international collaborations.⁸⁸

Figure 2. Share of US Scientific Articles with Multiple Institutions and International Institutions, 1996–2018



The National Science Foundation data does not report the share of publications that are produced by colocated and remote collaborators, but two proxies are available. First, the share of papers with authors employed at multiple institutions provides a rough proxy for remote collaboration, since the majority of papers written by distant collaborators will belong to different institutions. This measure has increased from 55% in 1996 to 76% in 2018. This likely exaggerates the extent of remote collaboration though, since two co-authors may belong to different institutions that are geographically close. A second proxy that does not share this issue is the share of papers with a US institution and at least one institution belonging to another country. This has risen from 17% to 39% over 1996–2018. This measure likely understates the extent of remote collaboration, since it omits collaborations between geographically distant US institutions. Note that both measures may also be biased if coauthors belong to different institutions but temporarily reside in the same place while collaborating, or if they belong to the same institution but reside in different places while collaborating (i.e., because one of them is on sabbatical or holds a visiting position). So long as this bias did not systematically increase over 1996–2018, the trend is still towards more remote collaboration.

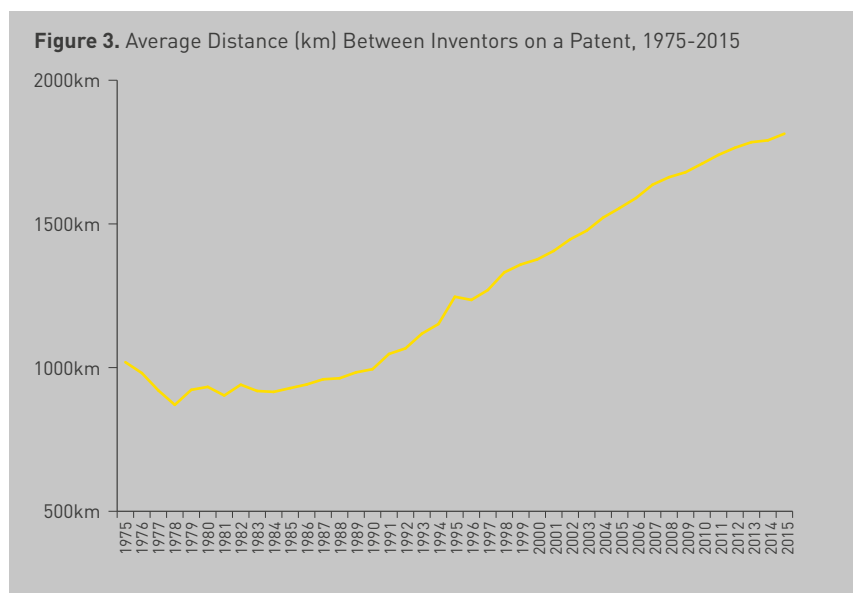
Some further evidence suggests that the above trends reflect a genuine increase in remote collaboration. Consider a survey of papers in the fields of particle and field physics, biotechnology, and nanoscience by Freeman, Ganguli, and Murciano-Goroff.⁸⁹ They map the institution of each paper's co-authors to an associated city. The share of papers with at least one

⁸⁸ Data from the National Science Foundation, Science and Engineering Indicators 2020. Articles are all journal articles listed in the Scopus database with at least one US-based coauthor.

⁸⁹ Freeman, Ganguli, and Murciano-Goroff (2014)

distant collaborator in their sample rises from 50% in 1990 to just over 60% in 2000, and then stays constant slightly above 60% through to 2010. Figure 2 shows a similar trend for the overlapping time period: the share of papers with co-authors from multiple institutions rose during the late 1990s before getting stuck around 67% between 2003 and 2011. From then on, however, the share of papers with multiple institutions steadily climbed to 76% in 2018.

As an alternative to academic collaboration, we can look at the location of inventors listed on US patents. The US Patent and Trademark Office's Patentview website lists the latitude and longitude of each inventor, which can be used to calculate the distance between inventors. Figure 3 displays the average distance between inventors listed on a patents with 2-5 inventors (which account for the vast majority of team patents).⁹⁰



The average distance between inventors stayed between 800 and 1,000 km between 1975 and 1990, and then began to steadily climb toward 1,800 km by 2015. When attention is restricted to patents with two inventors, we see nearly identical trends.

Alternatively, we can look at the extent of colocation by computing the share of patents with inventors who are unlikely to be collocated. Figure 4 reports the share of all patents with two inventors where the inventors are over 100 km apart and over 500 km apart.

⁹⁰ Distance is the average across all US patents applied for in a year of the average pairwise distance between all inventors listed on a patent, for patents with 2-5 inventors. Data comes from patentsview inventor location data.

Figure 4. Share of Two-Inventor Patents where Inventors are Greater than 100km and 500km apart, 1975-2015

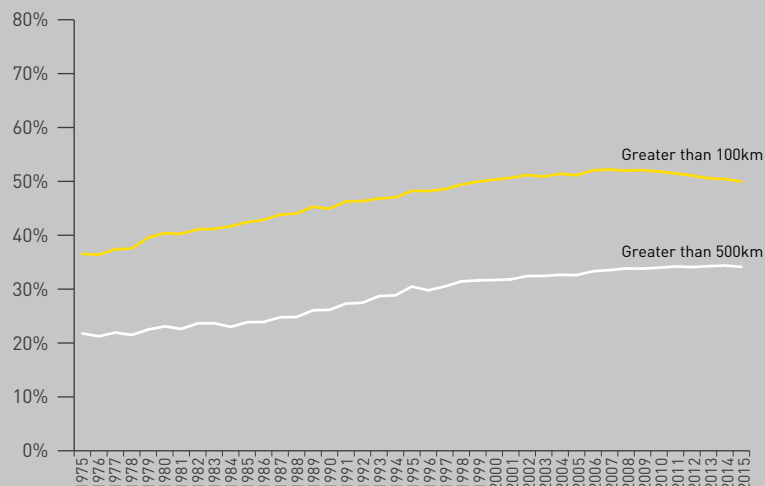


Figure 4 indicates it is indeed becoming more common for geographically distant inventors to collaborate on a patent. Inventors more than 100km apart accounted for 37% of two-inventor patents in 1975, and 50% of two-inventor patents in 2015.⁹¹ This is down slightly from a peak of 52% in 2007. However, the share of two-inventor patents with inventors more than 500 km apart rose from 22% to 34% over the same period.

Consistent with the evidence that remote work is becoming more attractive, remote work actually is becoming increasingly commonplace, as measured in a variety of ways. Remote collaboration on patents and academic research has grown to the point where it is no longer unusual. The share of positions that are performed from the home has begun to rapidly rise especially since 2010. Lastly, given estimates of the share of positions that could feasibly be performed remotely, there is a lot scope for further growth in remote working.

Policies to Promote Remote Work

For the most part, the arguments for remote work presented in this report are about the private costs and benefits - to firms and workers - of remote work. These private incentives are likely to push the economy towards a greater use of remote work, whether or not governments adopt policies to promote it. However, there are also positive externalities from remote work, such that active government policy to promote it may be desirable. These go beyond their utility in combating any future pandemics.

First, remote work may be able to raise aggregate productivity for the economy. In most models of agglomeration's effects on economies, there are benefits to greater agglomeration - such as better matching or learning

⁹¹ Data from patentview.org.

- but these are eventually offset by costs associated with congestion.⁹² These models pin down the predicted population of cities or regions by finding the population level for which the benefits of moving to the city for a potential new arrival (due to agglomeration effects) are exactly offset by the costs of moving (due to congestion costs). To the extent that there are positive externalities from agglomeration, in these models it can be optimal to adopt policies that encourage more people to move into cities, since that increases the size of the economy, which can be redistributed as desired.⁹³

However, these models assume the benefits of agglomeration are only obtainable through physical proximity. As discussed in sections 3 and 5, learning and matching may not much depend on physical proximity anymore if firms switch to a new equilibrium of remote work. If we can move into an equilibrium where we can obtain the benefits of agglomeration without congestion costs, then in principle we can benefit from the *digital* agglomeration of many more workers, without the attendant *physical* congestion costs. In practice, this means a remote equilibrium could potentially support the excellent matches and exchanges of knowledge across a population that is larger than could feasibly be packed into a physical city.

Second, remote work can reduce geographic inequality. The increased importance of agglomeration effects over the last several decades have led to economic prosperity for cities and economic decline in rural areas. This has had significant political and social cost.⁹⁴ While remote work is not a panacea, by decoupling where people live and work it spreads economic activity more equitably and may reverse the tendency for economic activity to cluster in a small number of superstar cities. In other words, remote work can help the government achieve its objective of levelling up the UK's regions.

Third, remote work may contribute to a reduction in carbon emissions by reducing commuting. This reduction will not be to zero, however, for a number of reasons: it may be partially offset by more frequent long-distance travel to meet colleagues face-to-face; workers may still commute to coworking space or satellite offices; and it may enable workers to live in smaller cities which are less energy efficient. Still, it is easy to imagine the net effect will be towards fewer emissions.

If there are indeed positive externalities associated with remote work, then government policy to promote remote work is appropriate. A detailed examination of potential policies is beyond the scope of this report, but I here suggest a few possibilities.

Policy 1: IT Infrastructure

Most obviously, remote work is only feasible when there is a robust underlying IT infrastructure, which implies continued support for

“While remote work is not a panacea, by decoupling where people live and work it spreads economic activity more equitably and may reverse the tendency for economic activity to cluster in a small number of superstar cities.”

92 Duranton and Puga (2003)

93 Hsieh and Moretti (2019), Rossi-Hansberg, Sarte, and Schwartzman (2019)

94 Wilkinson (2019), Case and Deaton (2020)

expanding broadband access to rural areas. An alternative approach would be to create community hubs for remote work, or to encourage coworking space companies to set up shop in small communities. Shared hubs could reduce the fixed cost of remote work by providing equipment for rent that may currently be too expensive for individual workers to own. They could also offer IT support and a more reliable internet connection.

At the same time, loans, grants, or tax relief for the purchase of equipment for a home office are also appropriate. Tax relief for some expenses are currently available in the UK for workers who have to work from home, but not for goods and services used for residential and business purposes (such as broadband internet), and not for workers who voluntarily choose to work from home. These criteria could be broadened.

Policy 2: Subsidies for Remote Work

It may be desirable for national and local governments to offer wage subsidies and other incentives for distant firms to hire local remote workers. This would be a micro version of the much larger tax breaks that are used today to try and lure businesses to invest locally. Essentially, the argument for subsidies is that there are positive externalities to remote work, so that it will be practiced at a lower than optimal rate without subsidies (at least initially). In the US, the Tulsa Remote program gives qualifying remote workers who move to the city of Tulsa a one-time \$10,000 grant.⁹⁵

Policy 3: Online Education and Training

Support for online degrees and worker training programs tailored to the needs of remote workers are also desirable. At present, those with the skills to work in the knowledge economy largely reside in cities, since that's where the jobs are. To skill up the kind of people who would most benefit from remote work, we need to offer online degree programs.

Online education has several virtues. First, it can serve as a screen on both employers and employees. The kinds of students who excel at online education are more likely to excel as remote workers too. Moreover, online education gives students an opportunity to try out the remote work lifestyle, while gaining a valuable skill. If it turns out they don't like it, they can transfer to a traditional university. To be effective screens, the courses should practice collaborative team-based pedagogy as much as possible. This would most develop the soft skills for working remotely, and would have the additional benefit of accelerating the development of norms for online collaboration and work.

Policy 4: Fostering Online Communal Spaces

We need to support the continued emergence of communal spaces for socializing and exchanging ideas online. This should occur across a diversity of spaces, to make remote work feasible for the broadest group of people possible. Supporting this work could take the form of grants for research, or experimentation with new forms of online community (analogous to

95 Tulsa Remote (2020)

grant support for the arts). At a minimum, the desirability of having places people want to hang out online should factor into the discussion around regulating big tech, which runs many of the platforms that make such spaces possible.

Policy 5: Promoting remote work

Lastly, promotion of remote work as viable for firms and workers may be a useful policy. The labour market may have more than one possible equilibrium - one where remote work is common, and another where remote work is rare. Moving from the equilibrium where remote work is rare to the one where it is common is challenging because it requires coordination among both employees and employers. If few firms are willing to hire remote workers, it does not make sense for workers to seek those jobs. Similarly, if there are few people with the skills needed to work remotely, then it does not make sense for firms to seek remote workers (and set up processes to make them effective). Neither do businesses invest as much in innovations that make remote work more effective, if they believe the market for such innovations will be small. A campaign to promote remote work can help employees and businesses coordinate and shift to the new equilibrium.

A campaign to promote remote work could highlight facts about the efficacy of remote work, as this report has done. It could also highlight the prevalence of remote work in key fields, as well as expected future trends. As suggested by Dias and co-authors it could also gather and disseminate best practices for remote work, so that firms that try it are most likely to learn about its potential.⁹⁶

Covid-19 and Remote Work

But in the short run, the most important push for remote work is the global Covid-19 pandemic. For the first time ever, nearly everyone capable of working remotely is doing so for an extended period of time. We are already learning from this that remote work is more productive than previously believed.⁹⁷

However, it is important to be aware of the ways in which the current shift to remote work diverges from the arguments made above. Firms switching to remote work may learn that the relative productivity of remote workers is higher than they believed. However, the current transition to remote work is far from ideal. It is rushed, often with minimal training, equipment, or coordination. Many remote workers are also taxed with caring for children who are home from school and daycare. Some are ill, or caring for the ill. All of these factors may pull down the productivity of remote workers.

⁹⁶ Dias et al. (2020)

⁹⁷ Bartik et al. (2020), Ozimek (2020)

It is also occurring in an environment of extreme economic uncertainty. It may be harder for firms to learn the productivity of workers, given huge shocks to demand for goods and services. At the same time, for workers the experience is likely to feel more socially isolating than it would typically be, since it is occurring simultaneously with generalized social distancing.

Moreover, many of the potential benefits of remote work do not apply in this environment. The current cohort of new remote workers is drawn from the local labor market, with all the attendant costs of office space and colocated wages. Firms are not benefitting from better matches or lower salaries. Neither are workers benefiting from better matches or higher real wages.

Nonetheless, despite all these caveats, it may still be that remote work becomes significantly more common after the emergency use of it subsides. Firms have learned that many positions can be done remotely, and plan to begin to hire remotely. Many firms and workers will also emerge from the pandemic with upgraded remote capabilities, ranging from digital infrastructure, to organizational strategies, to workplace norms. Perhaps most importantly, it may be that there are multiple equilibria in the type of work. Remote work faces a coordination problem: for firms, it's not worth investing in remote infrastructure if there are not many people looking for remote work, and for workers it's not worth looking for remote work if there are few firms offering it. Covid-19 might push us out of this old equilibrium, and into a new one.

“Covid-19 might push us out of this old equilibrium, and into a new one.”

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The Entrepreneurs Network

23 Great Smith Street
London
SW1P 3BL
United Kingdom