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WEIZENBAUM SERIES\15

POSITION PAPER \

MAY 2021 \

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The Internet has coped well with Covid-19, but problems remain

Evidence to House of Lords Committee exploring the impact of Covid-19

The Internet has coped well with Covid-19, but problems remain

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DOI 10.34669/WI.WS/15

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WEIZENBAUM INSTITUTE: The Weizenbaum Institute for the Networked Society – The German Internet Institute is a joint project funded by the Federal Ministry of Education and Research (BMBF). It conducts interdisciplinary and basic research on the changes in society caused by digitalisation and develops options for shaping politics, business and civil society.

This work has been funded by the Federal Ministry of Education and Research of Germany (BMBF) (grant no.: 16DII121, 16DII122, 16DII123, 16DII124, 16DII125, 16DII126, 16DII127, 16DII128 – "Deutsches Internet-Institut").

Abstract

In this contribution to a 'call for evidence' by the House of Lords (UK), we investigate the pivotal role of the Internet during the Covid-19 pandemic. The Internet has enabled many to work from home, to shop and be educated online, and keep in touch with colleagues and friends. The swift move online of many activities raised concerns about the robustness and resilience of the Internet. Contrary to some concerns, expressed when national lockdowns were being imposed, the Internet did not collapse. However, while the Internet allowed many to work from home etc., not everyone has access to the Internet. Furthermore, there are many differences between those who do have access to the Internet – quite simply, some are able to access the Internet using connections that are a lot faster than others. This shapes what businesses and individuals can do online, with those with slower connections or connections shared between many users being disadvantaged compared to those whose connectivity is better. Finally, it is necessary to remember that not everything can move online. Some occupations, such as those with a greater knowledge content, are more amenable to the move online than those with a larger labour (physical) component.

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1 Introduction

We welcome the opportunity to contribute to this inquiry. The 'call for evidence' rightly draws attention to the far-ranging and multi-faceted nature of the impact of Covid-19 and outlines a number of questions in five specific areas: physical health, mental health, social interaction, work, and the ownership of digital technology.

In our evidence (below) we focus on the Internet. The importance of the Internet has been reinforced by Covid-19. Throughout the pandemic, the Internet has played a pivotal role – the Internet has enabled many to work from home, to shop and be educated online, and keep in touch with colleagues and friends. The swift move online of many activities raised concerns about the robustness and resilience of the Internet. Contrary to some concerns, expressed when national lockdowns were being imposed, the Internet did not collapse. Instead, the Internet adjusted to the increased and changing patterns of demand that resulted from the move online.

While the Internet allowed many to work from home etc., not everyone has access to the Internet. Furthermore, there are many differences between those who do have access to the Internet – quite simply, some are able to access the Internet using connections that are a lot faster than others. This shapes what businesses and individuals can do online, with those with slower connections or connections shared between many users being disadvantaged compared to those whose connectivity is better. Finally, it is necessary to remember that not everything can move online. Some occupations, such as those with a greater knowledge content, are more amenable to the move online than those with a larger labour (physical) component.

2 The Internet has coped well with Covid-19

Contrary to some early concerns, fuelled by problems with applications such as Netflix and some broadband outages, the Internet did not collapse under the weight of the increased demands placed on it.[1] The Internet has actually coped well with the sudden increases and shifts in traffic resulting from the global pandemic. To date, those reports that have emerged point towards a resilient Internet, which has certainly been placed under strain while demonstrating at the same time its robustness.[2]

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1 See, for example, Fleming, S. (2020) Will the coronavirus break the internet?, *World Economic Forum*, 23 March, available at www.weforum.org; Griffin, A. (2020) Netflix down: Streaming site and app not working as users unable to watch TV shows or films during coronavirus lockdown, *The Independent*, 25 March, available at www.independent.co.uk; Speare-Cole, R. (2020) Virgin Media down: Customers across the UK complain about broadband outage despite issue being 'fixed', *Evening Standard*, 28 April, available at www.standard.co.uk; Valenzuela-Gómez, M. (2020) Can't Connect? The Most Significant Online Service Outages in Q1 2020, *Speedtest.net*, 14 April, available at www.speedtest.net.

2 See, for example, BBC News (2020) Coronavirus: Broadband firms say no issue with extra demand, 16 March, available at news.bbc.co.uk; Burgess, M. (2020) No, coronavirus isn't going to break the Internet, *Wired*, 21 March, available at www.wired.com; Campling, A. (2020) Community content: Is the Internet about to collapse because of Covid-19? *IOD*, 30 March, available at www.iod.com; BEREC (2020) *Reports on the status of internet capacity during coronavirus confinement measures*, available at ec.europa.eu; Labovitz, C. (2020) Effects of COVID-19 lockdowns on service provider networks, NANOG79, 1 – 3 June, available at storage.googleapis.com; Thousand Eyes (2020) *Internet performance report – Covod-19 impact edition,* available at www.thousandeyes.com.

Although the volume of Internet traffic has increased, with growth that normally occurs over the course of a year occurring in just a matter of weeks, this has not resulted in persistent over-usage or congestion. The move online of many activities has changed where businesses and individuals use the Internet, with individuals work from home resulting in new demands being placed on residential broadband networks and the Internet. Pre-Covid Internet traffic patterns were characterised by peaks and troughs, but with lockdown these have changed. Peaks have increased, albeit sometimes not by much, but troughs have been 'filled in' as Internet usage occurs more consistently over a wider proportion of the day. Thus, traffic is spread out over more of the day. Furthermore, the analysis of an education network shows that the pre-Covid distinction between weekdays and weekends have been eroded, with a similarity in traffic volumes emerging.[3] It is suggested that this reflects changes in working habits among those using the network.

In an interesting analysis of Internet traffic, Feldmann et al. (2020) draw on data detailing Internet traffic in Europe. They illustrate and analyse the changing traffic volumes and patterns due to the pandemic.[4] In short, their analysis found that the traffic peaks have only slightly increased, but perhaps more significantly the pre-Covid troughs have been filled in. What this means in practice is that traffic growth does not (necessarily) result in congestion. As lockdowns were imposed in response to the pandemic, there was an (initial) sharp increase in traffic volumes - traffic increased 40% on 'hypergiant' networks and by more than 60% on other leading networks.[5] ISP and cloud providers dealt with this increase by scaling (expanding) their existing activities. These providers focus their investment on addressing traffic peaks and expected volume growths, which for ISP are typically around 30% per year. This provides many ISP with a 'buffer' that enables them to cope with unexpected growth in Internet traffic. Similarly, content and cloud providers have also scaled (expanded) their operations to cope with increases in demand. This contributed to the resilience of the Internet.[6]

Content and cloud providers can also reduce congestion by moving, for instance, updates to periods of low demand or amending the quality of the services that they provide.[7] The providers of streaming content typically use adaptive technology – video resolutions are amended to reflect the state of the network. If the network is congested, quality is reduced and vice versa.[8] In this context, Thierry Breton, a European Commissioner, approached Netflix

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3 Feldmann, A., Gasser, O., Lichtblau, F., Pujol, E., Poese, E., Dietzel, C., Wagner, D., Wichtlhuber, M., Tapiador, J., Vallina-Rodriguez, N., Hohlfeld, O. and G. Smaragdakis (2020) The Lockdown Effect: Implications of the COVID-19 Pandemic on Internet Traffic, *ACM Internet Measurement Conference* (IMC'20), 27-29 October, Virtual Event, ACM, New York, NY, USA.

4 For more details, see, Feldmann et al. (2020) The Lockdown Effect: Implications of the COVID-19 Pandemic on Internet Traffic, *ACM Internet Measurement Conference* (IMC'20), 27-29 October, Virtual Event, ACM, New York, NY, USA.

5 Broadly speaking, 'hypergiants' are firms that operate very large networks or clouds, often with a high level of outbound traffic, for example, Amazon, Apple and Facebook (Feldman et al., 2020, The Lockdown Effect: Implications of the COVID-19 Pandemic on Internet Traffic, *ACM Internet Measurement Conference* (IMC'20), 27-29 October, Virtual Event, ACM, New York, NY, USA).

6 Bednarz, A. (2020), Providers address capacity, supply-chain challenges brought on by COVID-19, *Network World,* 30 March, available at www.networkworld.com; Heaven, W.D. (2020) Why the coronavirus lockdown is making the internet stronger than ever, *MIT Technology Review*, 7 April, available at www.technologyreview.com; Humphries, M. (2020) Sony slows down PlayStation game downloads across Europe, *PCMag.com*, 24 March, available at uk.pcmag.com; Leighton, T. (2020) Working together to manage global Internet traffic increases, *The Akamai Blog*, 24 March, available at https://blogs.akamai.com.

7 Leighton, T. (2020) Working together to manage global internet traffic increases, *The Akamai Blog*, 24 March, available at blogs.akamai.com; Leighton, T. (2020) Can the Internet keep up with the surge in Demand? *The Akamai Blog*, 6 April, available at blogs.akamai.com.

8 Begen, A.C. and C. Timmerer (2017) Adaptive Streaming of Traditional and Omnidirectional Media, *ACM SIGCOMM Tutorial*, 21 - 25 August, Los Angeles, CA.

to ask them to reduce the quality of their services. Netflix was asked not to provide their highest video resolution in order to reduce the strain on networks by around a quarter.[9] Some felt such an approach was not necessary. When Netflix and others agreed to the changes, David Clark, one of the key figures in the development of the Internet, has been reported to have stated, in the context of the Commission's initiative: *"That just tells me they don't understand how the Internet works"*.[10]

What has happened within the UK? Internet traffic has increased. Openreach has released traffic data comparing two weeks, one before the national lockdown was imposed on the 23 March 2020 and one after. Aggregate traffic volumes increased from 641.3 petabytes[11] in the week commencing 24 February 2020 to 797.91 petabytes in week commencing 20 April 2020.[12] This is an increase of 24.4% nationally, though variations exist across the regions of the UK. The smallest increase was observed in Wales (19.95%), with the increase in Scotland (21.61%) only marginally larger. In contrast, the largest increase was observed in London (28.58%).

Regional variations can be observed with respect to Virgin Media's network. While, on average, each Virgin Media subscriber has downloaded an extra 3.4GB of data per day compared to February since the start of lockdown,[13] larger growths in data volumes are found in London than Wales.[14]

An analysis of traffic on an anonymous mobile operator in the UK,[15] clearly demonstrates the changes that have occurred as a consequence of the pandemic.[16] Drawing on data covering a 10-week period from late February to early May, Lutu et al. (2020) observe that after an initial increase in the volume of traffic compared to the start of the period, volumes subsequently declined. At one point, volumes nationally were effectively a quarter lower than at the start.[17] It is suggested that these declines reflect the impact of restricted mobility and the use of WiFi rather than cellular connections for data. Similar to Openreach and Virgin Media, regional variations are observable. While traffic volumes fluctuate over the period of the analysis, at the end volumes in the West Midlands and Inner London have fallen by more than the UK as a whole. In contrast, traffic volumes have fallen by less than the UK in Greater Manchester, Outer London, and West Yorkshire.

The imposition of the national lockdown in March 2020 has impacted on the performance of broadband networks. According to Ofcom, broadband speeds, both download and upload, marginally declined when periods just before and after the lockdown are compared – download speeds fell by 2%

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9 Archer, J. (2020) Netflix starts to lift its Coronavirus streaming restrictions, *Forbes,* 12 May, available at www.forbes.com.

10 Castor, A. (2020) A Netflix-induced Internet 'strain' in Europe? Nonsense, says MIT expert, Decrypt.co, 20. März, available at https://decrypt.co/22966/a-netflix-induced-internet-strain-in-europe-nonsense-says-mit-expert.

11 1 Petabyte is 1,000 terabytes, and 1 terabyte is 1,000 gigabytes

12 Jackson, M. (2020) Covid-19 impact – Openreach's network traffic by UK region update, *ISP Review*, 30 April, available at www.ispreview.co.uk.

13 Virgin Media (2020) *Virgin Media reveals extent of lockdown leap in broadband traffic growth*, 17 June, available at www.virginmedia.com.

14 Virgin Media's subscribers in London downloaded 20% more, compared to half of this in Wales (Virgin Media, 2020, *Virgin Media reveals extent of lockdown leap in broadband traffic growth*, 17 June, available at www.virginmedia.com).

15 As four out of the five authors of this study are affiliated with Telefónica, this operator may be O_2.

16 Lutu, A., Perino, D., Bagnulo, M., Frias-Martinez, E. and J. Khangosstar (2020) A Characterization of the COVID-19 Pandemic Impact on a Mobile Network Operator Traffic, *ACM Internet Measurement Conference* (IMC'20), 27-29 October, Virtual Event, ACM, New York, NY, USA.

17 Volumes in week 17 (19 to 25 April 2020) were 24% lower than in week 9 (23 February to 1 March 2020).

and upload speeds by 1%.[18] These declines are similar to that identified by cable.co.uk, who found that broadband speeds fell by 1.7% over the course of the UK's lockdown.[19] These declines are 'better', that is, lower, than those which occurred in many other European countries: speeds fell by 2.23% during Ireland's lockdown, which is a lot less than in the case of Italy (10.44%), Netherlands (13.01%) or Finland (24.81%) during their respective lockdowns.[20]

The relatively small declines within the UK may not be noticeable to many, especially when increases in broadband speeds in 2019 are taken into account: average residential broadband speeds increased in 2019 to 64.0 Mbit/s.[21] Having said this, UK broadband speeds arguably compare poorly internationally. In one recent ranking of countries by broadband speeds, the UK is placed 47 out of the 221 countries included in the analysis.[22] Furthermore, this does not take into account how many devices use the connection. One device using the connection will result in a different user experience compared to, for instance, a dozen or more devices sharing the connection.[23] And, of course, while the number of people living alone has grown in recent years, most households contain two or more people,[24] whose online activities may combine to worsen their broadband experiences. In other words, the frustrations felt when declines in broadband performance occur will be exacerbated when the connection is shared among several competing demands, especially if demanding applications like video conferencing are used.

3 Differences exist when accessing the Internet

Due to its development over the past decade or so, broadband is now more essential than ever.[25] But differences exist across the UK when it comes to access to broadband. At its most extreme, some do not have access to broadband, and for those that do it can vary significantly across the country when it comes to its speed.

With regards to those who have access to broadband, Ofcom differentiates between 'decent' (10 Mbit/s and above), 'superfast' (30 Mbit/s and

18 Ofcom (2020) *UK Home Broadband Performance – The performance of fixed-line broadband delivered to UK residential customers*, Technical report, 13 May, Ofcom: London, UK.

19 Cable.co.uk (2020) *How global broadband speeds changed during lockdown periods*, available at www.cable.co.uk.

20 Cable.co.uk (2020) *How global broadband speeds changed during lockdown periods*, available at www.cable.co.uk.

21 Ofcom (2020) *UK Home Broadband Performance – The performance of fixed-line broadband delivered to UK residential customers*, Technical report, 13 May, Ofcom: London, UK.

22 Cable.co.uk (2020) *Worldwide broadband speed league 2020*, available at www.cable.co.uk. In comparison, speeds in Germany (42.33 Mbit/s), France (51.33 Mbit/s) and Spain (55.84 Mbit/s) are faster than the UK, while Italy is slower (23.18 Mbit/s).

23 Over the years, various figures have been published. In 2015 it was estimated that there were 18 smart devices per household (Staples, 2015, Britain has 18 smart devices per household, *Broadbandchoices*, 3 July, available at www.broadbandchoices.co.uk), while two estimates in 2017 – 3.5 and 8.2 – were considerably lower than this (Aviva, 2020, *Technation: number of Internet-connected devices grows to 10 per home*, 15 January, available at www.aviva.com; Verdict, 2017, *Our average number of connected devices is at an all-time high*, 10 October, available at www.verdict.co.uk). In January 2020 it was reported that the average UK household had 10.3 device (Aviva, 2020, *Technation: number of Internet-connected devices grows to 10 per home*, 15 January, available at www.aviva.com).

24 Office of National Statistics (2019) *Families and households in the UK: 2018,* 7 August, available at www.ons.gov.uk.

25 Briglauer, W. and V. Stocker (2020) *Bedeutung digitaler Infrastrukturen und Dienste und Maßnahmen zur Förderung der Resilienz in Krisenzeiten*, EcoAustria Policy Note, Number 42, available at ecoaustria.ac.at.

above), 'ultrafast' (300 Mbit/s and above) and 'full fibre'.[26] Some premises are unable to receive 'decent' broadband: at the end of 2019, Ofcom reported that 610,000 premises fall into this category, with 449,000 of them being in rural areas.[27] This equates to 10% of all rural premises. While the number of premises unable to receive 'decent' broadband has fallen, to 590,000 in May 2020,[28] it remains stubbornly high and thus disadvantages a large number of individuals and businesses. Having said this, it is reasonable to expect the fall in the number of eligible USO premises will accelerate as the impact of the universal service obligation (USO) scheme is felt.[29]

The proportion of premises receiving 'superfast' broadband services did not change between September 2019 and May 2020.[30] In contrast, the number of premises receiving both 'ultrafast' and 'full fibre' broadband did increase. By May 2020, 57% of premises received 'ultrafast' broadband and 14% 'full fibre.'[31] In other words, 4.2 million homes were able to access full fibre based broadband services. A rapid increase in full fibre availability is forecast,[32] providing an increasing number of households and businesses with the opportunity of accessing the Internet via a technology that is considered to be considerably better than the alternatives.[33]

In April 2020, almost a month after the first national lockdown was imposed, an estate agent published a report identifying the best and worst places to work from home.[34] Although the underlying data is from the last three months of 2019, the analysis does illustrate the differences that exist across the UK. Average download speeds vary across the four nations of the UK, with only England displaying faster average speeds than that for the UK.[35] Average download speeds in Westminster (72.5 Mbit/s) and Tower Hamlets (61.3 Mbit/s) were considerably better than those in North Devon (24.3 Mbit/s), Dumfries and Galloway (23.6 Mbit/s) and the Shetland Islands (21.0 Mbit/s).

A more granular analysis of broadband speeds, which confirms the disparities noted above, was published in December 2020. The analysis, which uses data from the speed test made available via

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26 Ofcom (2019) *Connected Nations 2019 – UK report*, 20 December, Ofcom: London, UK.

27 Ofcom (2019) *Connected Nations 2019 – UK report*, 20 December, Ofcom: London, UK.

28 Ofcom (2020) *Connected Nations Update – Summer 2020*, 10 September, Ofcom: London, UK.

29 For an overview of broadband universal service see, for example, Hutton, G. (2020) *The universal service obligation (USO) for broadband*, Briefing paper Number CBP 8146, 2 October, House of Commons Library, available at www.parliament.uk/commons-library. BT, in their first progress report on the USO scheme (BT, 2020, *BT report on progress against the broadband USO*, 30 October, BT: London, UK), notes that the current availability of 4G can provide USO level services to around two-thirds of the 610,000 premises. Furthermore, BT also expect the number of premises connected to increase as network construction efforts start to come to fruition.

30 Ofcom (2020) *Connected Nations Update – Summer 2020*, 10 September, Ofcom: London, UK.

31 Ofcom (2020) *Connected Nations Update – Summer 2020*, 10 September, Ofcom: London, UK.

32 See, for example, FTT Council Europe (2020) *Covid19: FTTH Forecast for Europe*, 3 December, FTT Council Europe, available at www.ftthcouncil.eu.

33 Full fibre is often described as being 'future proof', providing faster speeds and improved reliability compared to other technologies. Briglauer, W., Stocker, V. and J. Whalley (2020) Public policy targets in EU broadband markets: The role of technological neutrality, *Telecommunications Policy*, Vol.44, article 101908; Stocker, V. and J. Whalley (2019) Who replies to consultations and what do they say? The case of broadband universal service in the UK, *Telecommunications Policy,* Vol.43, article 101823.

34 Jackson, M. (2020) Top UK areas for remote working by broadband speed and cost, *ISP Review*, 18 April, available at www.ispreview.co.uk.

35 Average download broadband speeds for the UK were 35.3 Mbit/s, compared to 40.1 Mbit/s in England, 34.8 Mbit/s in Scotland, 33.8 Mbit/s in Northern Ireland and 32.6 Mbit/s in Wales (Jackson, M., 2020, Top UK areas for remote working by broadband speed and cost, *ISP Review*, 18 April, available at www.ispreview.co.uk).

uSwitch, identifies streets across the UK with the fastest and slowest average download broadband speeds.[36] The street with the slowest speed can be found in Weybridge, Surrey (0.12 Mbit/s), while the fastest is in Warrington (636 Mbit/s).[37]

Some individuals and businesses will rely, extensively and sometimes exclusively, on mobile broadband. Notwithstanding the promise of 5G, mobile speeds are relatively modest and also vary geographically. A recent study identified mobile broadband speeds in the UK's 16 most populous cities.[38] The fastest speeds were found in Birmingham with an average download speed of 28.9 Mbit/s, followed closely by Liverpool (28.8 Mbit/s), Manchester (26.7 Mbit/s), Glasgow (26.7 Mbit/s) and Coventry (25.3 Mbit/s). The slowest average download speeds were found in Newcastle (20.1 Mbit/s).

The differences that these insights into broadband speeds highlight should come as no surprise. Speeds differ across the UK, reflecting the technological and socio-economic characteristics that shape the development of broadband infrastructure. These differences, quite simply, influence the extent to which individuals can work from home, businesses shift their activities online, students be educated remotely etc.

4 Not everyone can be online

Throughout the pandemic, we have regularly been encouraged to 'work from home'. Many have done so. A report by the Office of National Statistics,[39] covering April 2020, found that almost half of those employed were working from home, with the overwhelming majority of these prompted to do so by Covid-19.[40] There were regional variations in the extent to which people were working at home, with more people in the north-east of England and London doing so compared to the national average. Conversely, fewer people in Yorkshire and The Humber and the West Midlands were working at home compared to the UK.

That more people were not working from home in the UK is because not all occupations can be undertaken from home. One study in the United States found that just over a third of American jobs could be done from home.[41] Not only were these jobs better paid than those which could not be done at home, but they were unevenly distributed across the economy. As noted by the authors: *"[m]anagers, educators, and those working in computers, finance, and the law are largely able to work from home. Farm, construction, and production workers cannot".*[42] Similarly, a greater proportion of jobs in Durham-Chapel Hill (North Carolina) can be done from home than, say, in

36 Baker, N. (2020) The UK streets with the slowest broadband speed, *uSwitch,* 3 December, available at www.uswitch.com.

37 Baker, N. (2020) The UK streets with the slowest broadband speed, *uSwitch,* 3 December, available at www.uswitch.com.

38 Selecta (2020) *What city has the fastest broadband?,* 27 October, available at https://selecta.co.uk.

39 ONS (2020) *Coronavirus and homeworking in the UK: April 2020,* 8 July, available at www.ons.gov.uk.

40 Interesting the 46.6% of employees identified by the Office of National Statistics who worked from home in April 2020 is higher than another UK-wide survey. This survey, cited by Dingel and Neiman (2020, *How many jobs can be done at home*? NBER, 19 June, available at www.nber.org), found that 37% of employees were working at home in April and May 2020.

41 Dingel, J. and B. Neiman (2020) *How many jobs can be done at home?* NBER, 19 June, available at ww.nber.org.

42 Dingel, J. and B. Neiman (2020: 4) *How many jobs can be done at home?* NBER, 19 June, available at ww.nber.org.

Lancaster (Pennsylvania).[43] Several commentators have noted the relatively small proportion of jobs that can be done from home in emerging markets,[44] which reflects, among other things, the less knowledge intensive nature of their economies.

Assuming that your job can be done from home and that adequate broadband is available for this to happen, there are challenges associated with working from home. Clarke (2020) draws attention to how, when several people are working from home, perhaps in close proximity to one another, confidential discussions can be overheard.[45] Furthermore, participating in a video conference call with colleagues may reveal insights into the personal lives of participants that they would prefer not to share. And, of course, the distinction between office and home is blurred as personal devices are used for work purposes (or vice versa) and kitchens or spare bedrooms become home offices.

The impact of Covid is wider than these aforementioned (technology-based) challenges of working from home. There is the very practical issue of juggling childcare, work and housework. One early assessment suggested that Covid may change gender roles over the longer term, with husbands working at home taking more responsibility for childcare and housekeeping.[46] Another study, of Lithuanians working from home, found that while women welcomed the opportunity to work from home to achieve a "healthier lifestyle",[47] men were more likely than women to view working from home negatively.

There is also a concern that working from home may reinforce existing inequalities in the labour market. Research examining the labour market in Italy concluded that while there are benefits associated with working from home, not everyone can enjoy them to the same degree.[48] If working from home were to become more commonplace in Italy, those who are male, older, better educated and paid more would benefit the most. It is, however, worth remembering that while the relationship between Covid and inequality reflects the ability of work to be done from home, it is sadly wider than this issue alone, being multi-faceted in character.[49] This is clearly evident from a comparative study of the impact of Covid in Germany, the United States and UK.[50] Those in the UK, for example, who are employed on a permanent contract are less likely to have been made unemployed, and those who can work wholly from home are less likely to have seen their income decline compared to those who cannot do so (such as workers in the so-called 'gig economy'). While our understanding of the impact of Covid, on both our private and professional lives, is evolving, it is reasonable to conclude that the impact will be felt a lot more by some than others.

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43 46% of jobs in Durham-Chapel Hill could be undertaken from home compared to 29% in Lancaster (Dingel, J. and B. Neiman, 2020, *How many jobs can be done at home?* NBER, 19 June, available at ww.nber.org, page 7).

44 See, for example, Delaporte, I. and W. Pena (2020) *Working from home under Covid-19: Who is affected? Evidence from Latin American and Caribbean countries*, CEPR Covid Economics 14, 26 May, available at papers.ssrn.com; Dingel and Neiman (2020), *How many jobs can be done at home?* NBER, 19 June, available at ww.nber.org.

45 Clarke, D. (2020) The unexpected challenges of remote working, *Techradar*, 9 December, available at www.techradar.com.

46 Hupkau, C. and B. Petrongolo (2020) *Work, care and gender during the Covid-19 crisis,* A CEP Covid-19 analysis, Paper number 2, available at www.lse.ac.uk.

47 Raisiene, A.G., Rapuano, V., Varkuleviciute, K. and K. Stachova (2020) Working from home – who is happy? A survey of Lithuania's employees during the Covid-19 quarantine period, *Sustainability,* Vol.12, article 5332.

48 Bonacini, L., Gallo, G. and S. Scicchitano (2021) Working from home and income inequality: risks of a 'new normal' with Covid-19, *Journal of Population Economics,* Vol.34, pages 303-360.

49 See, for example, Blundell, R., Dias, M.C., Joyce, R. and X. Xu (2020) Covid-19 and inequalities, *Fiscal Studies*, Vol. 41 (2), pages 291-319; Patel, J.A., Neilsen, F.B.H., Badini, A.A., Assi, S., Unadkat, V.A., Patel, B., Ravindrane, R. and H. Wardle (2020) Poverty, inequality and Covid-19: the forgotten vulnerable, *Public Health*, Vol.183, pages 110-111.

50 Adams-Prassl, A., Boneva, T., Golin, M. and C. Rauh (2020) *Inequality in the impact of the coronavirus shock: evidence from real time surveys*, April, IZA Institute of Labour Economics, Discussion paper series, Number 13183, available at www.iza.org.