Who on Earth Can Work from Home?

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1   Introduction

Implementing policies to counter the negative labor market impacts inflicted by the COVID-19 pandemic requires knowing which jobs are most at risk. Whether a job can be performed from home is a key determinant of labor market vulnerability given the widespread shutdowns, mobility restrictions, and social distancing policies. The feasibility of home-based work for the vast majority of occupations, in turn, is likely to depend on internet access, which is much lower in developing countries (World Bank, 2016).

This paper presents new estimates of the share of jobs that can be done from home across the globe, assesses which workers are most at risk, and explores the impacts of COVID-19 on labor market inequality. Our starting point is an occupational measure of home-based-work amenability based on the type of tasks carried out by the worker, such as the job not being location-specific or requiring contact with others (Dingel and Neiman, 2020). This measure does not account for the role of internet access as an enabling factor for working from home. We implement two adjustments to account for the constraints imposed by internet availability. First, we estimate which jobs require an internet connection to be done at home. Second, we estimate what fraction of workers in those jobs that require an internet connection have internet access at home. Thus we can identify the shares of three groups of workers: (i) those who can work from home without internet connection, (ii) those who can work from home, need internet *and* have internet access and (iii) those who can work from home *but* are not able to because of internet access constraints. Our home-based-work indicator thus measures the sum of the first two groups as a share of the labor force.

The fraction of workers who have jobs that can be done from home is much smaller in developing countries for two mutually reinforcing reasons. First, the share of ICT (Information and Communication Technologies) intensive jobs that require internet access increases with the level of economic development, and such jobs are more amenable to being performed at home. Second, internet connectivity, and especially residential access, is poorer in developing countries, further hampering the ability of workers to work from home. Failing to account for internet access causes overestimation of the number of jobs that can be performed from home across the globe by around 27 percent on average. The magnitude of the bias is negatively correlated with income. In low income countries, measures that do not consider internet access overestimate the number of jobs

amenable to home-based-work by a factor of 2.9, compared to a factor of 1.1 in high income countries. Failing to correct for this bias would result in an overestimation of the resilience of developing countries, lagging regions, and poor people during the pandemic.

Jobs amenable to working from home are also less prevalent in lagging regions within countries. They are less likely to be held by young, poorly educated, and poorly paid workers as well as those with temporary contracts. Workers' skills, as proxied by their education levels, are the strongest predictor of their ability to work from home. The labor market burden of the COVID-19 pandemic is thus more likely to be shouldered by the poor, who are more vulnerable to start with. Absent remedial action, COVID-19 is likely to exacerbate income inequality and pre-existing socio-economic disparities, especially in high-income countries where more jobs amenable to telework are available but are disproportionately held by high-income workers. The overall labor market burden of COVID-19, by contrast, is likely to be larger in developing countries, where fewer workers will be able to continue their employment as usual, and where social protection systems are typically less generous, or lacking altogether.

This paper contributes to the rapidly growing body of literature on the amenability of jobs to working from home[1] by considering infrastructure constraints and by offering global estimates of the prevalence of jobs amenable to working from home. We conduct a cross-country comparative analysis using occupation-level data for 107 countries from the ILO and complement it with an in-depth analysis of a range of countries (EU countries, Brazil, India, Mexico and Turkey) using individual-level data from labor force surveys. This allows us to validate the use of occupation (as opposed to individual) level data.

The already influential work of Dingel and Neiman (2020)—DN2020 from now on—uses the Occupational Information Network (O*NET) surveys containing information about whether the occupation requires working outdoors, using specialized equipment, contact with the public and so forth, to assess if an occupation can be done at home. They assume that if the occupation requires at least one of such tasks, then it cannot be done at home.[2] These occupation-level

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[1] A related strand of literature examines labor market vulnerability to COVID-19 by examining which jobs are deemed essential across countries (see e.g. Tomer and Kane, 2020, del Rio-Chanona et al., 2020, Fassani and Massa, 2020), and which ones require extensive face-to-face interaction (Avdiu and Nayar, 2020). Kahn et al. (2020) use data from unemployment insurance claims and vacancies to assess the impacts of COVID-19 in the United States.

[2] There are other studies that also use O*NET to estimate the jobs that can be done from home. For example, Leibovici, Santacreu, and Famiglietti (2020) focus on whether the occupation requires physical proximity to other people and

measures are then applied to data from the U.S. Bureau of Labor Statistics (BLS), and to data from several countries from the International Labour Organization (ILO). They find that lower-income countries have a lower prevalence of jobs that can be done at home.

Several articles have implemented different adaptations of DN2020. For example, Gottlieb, Grobovsek, and Poschke (2020) use labor force surveys from 57 countries and point out that low-income countries have a high share of self-employed agricultural workers. Their ability to work from home impacts the overall labor market effect of COVID-19 in lower-income countries. The DN2020 measure is based on the data from the United States, where farms are typically large and more reliant on hired labor. As a result, DN2020 assumes that only 8.3% of all agricultural workers can work from home. In poor countries farms are much smaller and a large share of agricultural workers is self-employed, which could imply that farming may be possible from home if plots are located very close to home (or perhaps, more relevant, may be feasible while respecting social distancing guidelines). Assuming that all these self-employed agricultural workers can do their jobs from home leads to a negative association between home-based work and GDP per capita. However, suing PIAAC data, Hatayama, Viollaz and Winkler (2020) show that the positive correlation between home-based work and GDP per capita remains positive when using country-specific measures of tasks instead of O*NET. Their sample includes countries at different levels of development such as Ecuador and Peru (where agricultural employment represents almost a third of total employment) and the United States and Germany (where the corresponding figure is about 1 percent).[3] The Appendix to this paper provides extended arguments regarding these measures and shows that the ability of agricultural workers to work from home is limited and, moreover, tends to increase, rather than to fall, with income per capita.[4]

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construct an index with three intensity categories (low, medium and high). They apply the index to the American Community Survey. Mongey, Pilossoph, and Weinberg (2020) use the same O*NET questions as Dingel and Neiman (2020) but construct a continuous index of working from home using the intensity scores as Leibovici et al. (2020).

[3] Their sample also includes lower income economies covered by the STEP surveys, where the positive correlation between home-based work and GDP per capita also holds. However, these surveys exclude rural areas in most cases, thereby excluding most agricultural workers.

[4] Given that agriculture remains an important source of employment in low-income countries, the assumptions on the ability of self-employed agricultural workers to work from home is an important determinant of the relationship between labor market vulnerability to COVID-19 and development. This paper follows the DN2020 approach, but we recognize that the treatment of agricultural workers is very important. One of our main conclusions, that ICT constraints are more likely to bind in low income countries, does not depend on the assumptions about the ability of the self-employed agricultural workers to work from home.

Garrote Sanchez, Gomez Parra, Ozden, and Rijkers (2020) apply DN2020's occupational measures in combination with indicators of essential sectors in European regions as determined and mandated by governments. They find that the possibility to work from home is lower for poorer workers and in less developed regions, but both studies fail to consider practical constraints to working from home.

Several papers have followed an approach different from DN2020 to identify the jobs that can be done at home. For instance, Hensvik, Le Barbanchon, and Rathelot (2020) use data from the American Time Use Survey (ATUS) and estimate the prevalence of home-based-work between 2011 and 2018. Alipour, Falck, and Schüller (2020) use data from a 2018 employment survey for Germany that includes a question on whether the worker would accept an offer from his or her employer to work from home temporarily. Adams-Prassl, Boneva, Golin, and Rauh (2020) collected new data from late March to early April 2020 in the United States and the United Kingdom, including a question about the share of tasks that they could do at home in their current (or last) job. They demonstrate that workers who are least able to work from home are most likely to lose their jobs. Bonacini, Gallo, and Scicchitano (2020) use data from the Italian Survey of Professions (ICP), which is the Italian equivalent of the O*NET, to construct an indicator of attitudes toward working from home. In general, all these articles find that working from home amenability increases with workers' earnings and education. Their indices are positively correlated with those from DN2020, but since they are based on developed countries the extent to which their findings generalize to developing countries remains an open-ended question, given that the task content of jobs may vary with development (LoBello et al., 2019).

Two articles use skills surveys from different countries to test if US-based measures such as O*NET lead to biased results. Saltiel (2020) uses skills surveys from developing countries at varying levels of economic development to identify the share of jobs that can be done at home. He uses an approach similar to DN2020 by assuming that a job cannot be done from home if at least one of several conditions related to the job such as physical intensity, not using a computer, frequent contact with people, and so forth holds. Hatayama, Viollaz, and Winkler (2020) also use skills surveys for an expanded set of 53 countries at varying levels of development. In addition to the type of tasks considered by Saltiel (2020), they incorporate a measure of internet connectivity at home as a determinant of working from home amenability. Both papers find that more educated

and formal workers have jobs more amenable to working from home, and that home-based-work amenability is higher in richer countries. Their measures of working-from-home amenability are positively correlated with those of DN2020, but their geographic coverage is constrained by the availability of skills surveys.

The remainder of this paper is organized as follows. The next section briefly reviews existing measures of home-based-work, explains why they may not be appropriate for developing countries, and how we adjust them to appropriately reflect ICT constraints. Section 3 presents estimates of the prevalence of jobs amenable to working from home across countries and shows that poorer countries have more jobs at risk. Section 4 explores implications of COVID-19 for inequality, showing that the pandemic will likely exacerbate both spatial and income inequality since lagging regions have more jobs at risk, and because poorer workers are less likely to be able to work from home. Section 5 presents robustness tests. Section 6 examines which workers are most at risk and demonstrates that labor market risk is inversely correlated with education; skilled workers are more likely to have jobs amenable to home-based work. Workers on temporary contracts, who are more vulnerable to start with, are less likely to have jobs that can be performed from home. Section 7 concludes and points out that our analysis suggests that COVID-19 will likely exacerbate pre-existing socio-economic disparities, both within and across countries.

2   Data and methods

Labor market vulnerability depends on the nature of the jobs that workers have. The main criterion used in the literature is the feasibility of home-based work. Dingel and Neiman (2020) use information from characteristics of more than 900 occupations based on two surveys from the US Department of Labor/Employment and Training Administration's Occupational Information Network (O*NET). When answers reveal that an occupation requires daily activities such as "working outdoors" or "operating vehicles, mechanized devices," or "contact with the public," they determine that the occupation cannot be performed entirely from home. DN2020's measure, which is based on the Standard Occupational Classification (SOC) system used in the United States, needs to be concorded to the International Standard Classification of Occupations (ISCO-08) that is widely used globally at the 2- (or 3)-digit level of granularity (depending on the country). As DN2020 acknowledge, their Home-Based Work (HBW) index is likely to present an "upper

bound" on the number of jobs that could feasibly be performed entirely from home, as it "neglects many characteristics that would make working from home difficult."[5]

For many jobs, one of the principal constraints on performing them from home is internet access. Even when a job is in principle amenable to working from home (teleworking), that option may not be available in practice if the worker does not have internet access at home. To properly measure this constraint and account for the importance of ICT, we first need to split the telework jobs identified by the DN2020 index into two categories - jobs that require internet and those that do not require it. Then, for those telework jobs that require internet, we must identify which workers actually have access to internet and for which workers the lack of access to internet constitutes a constraint. Our final objective is to classify jobs as amenable to being performed from home only if they do not require internet or if they require internet and are held by workers who have internet access.

Our first step is identifying telecommutable jobs that require internet access using detailed information on occupation characteristics from the O*NET surveys. We use two specific questions on the importance and frequency of computer and email use in the performance of the tasks. The answers to these questions are scored on a 5-point scale with higher numbers indicating greater dependence on computers and email use. We consider an occupation as requiring internet access if the combined average score exceeds 8 (of a total of 10). This leads to 55% of all SOC 8-digit occupations in O*NET as being classified as requiring internet. By combining this measure with the DN2020 index, we can now distinguish four different types of occupations: (a) those that can be performed from home and require internet; (b) those that can be performed from home without the use of internet; (c) those that cannot be performed from home and do not require internet; and (d) those that cannot be performed from home but do require internet. In the United States, 33.3 percent of all jobs can be done from home and require internet -e.g. fall into group (a), while a further 3.3 percent can be performed from home without internet usage -e.g. fall into group (b).

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[5] In addition, it is not clear how the tasks required to perform an occupation are the same across economies at different levels of development. Using PIAAC (Programme for the International Assessment of Adult Competencies) data at the country level to assess the variations in the task content of occupations, Hatayama, Viollaz and Winkler (2020) observe changes in the ranking of countries in terms of their jobs' amenability to working from home. However, both measures are highly correlated and most of the lower income developing countries do not have data on the task content of their jobs (the PIAAC survey covers mostly OECD countries), we apply the DN2020 index to all countries. The results from PIAAC countries using the Hatayama, Viollaz and Winkler's (2020) methodology are very similar and available upon request.

To apply our occupation-level measures to other countries, we aggregate our SOC8-digit measures to the SOC2-digit level using U.S. employment weights from the Current Population Survey (CPS).

The second step is to assess the actual availability of internet services by occupation and country. For this step, we combine information on the share of internet users by country and income level from the Gallup World Poll 2019 with data on average wages by occupation (at the two-digit disaggregation) from ILOSTAT. Gallup survey data provide the share of internet access at home among the top 60 percent and the bottom 40 percent of the income distribution in each country. This distinction enables us to account for the fact that internet use is positively correlated with income levels. The ILOSTAT data allow us to rank occupations by their average wages and assign them to either the top 60 percent or the bottom 40 percent of the income distribution in their corresponding country, which in turn allows us to concord them with the Gallup data to construct country-specific measures of internet penetration by occupation.

Once we have both the share of DN2020 jobs that require internet and the internet penetration across occupations, we calculate the share of jobs that can be done from home by summing the share of jobs that can be done from home and do not require internet with the share of jobs that can be done at home and need internet multiplied by the relevant internet access rates at home from Gallup.

Most of our global analysis relies on the ILOSTAT database (See ILO 2020 for details) that provides information on wages and employment numbers per occupation for over 180 countries. We restrict the country coverage to 107 countries for which 2-digit occupations are available. We also use individual data from the most recent (2018) European Labor Force Survey (EU LFS) as well as the labor force surveys from several large countries – Brazil (2017), India (2012), Mexico (2018), and Turkey (2018). These data sets are the most recent surveys and include education level, formality status, age, wages, and occupational category of a large and representative sample of the working population and enable us to validate the conclusions derived from the analysis based on ILOSTAT data.

3   Home-based work across countries

Our first exercise is to calculate the share of jobs that can feasibly be performed at home for all the 107 countries for which data are available in the ILO database. On average, 23.9% of all jobs can be done from home based on the standard DN2020 measure. However, once we account for internet access, this share drops to 18.7%. Put differently, failing to account for internet access would cause us, on average, to overestimate the share of jobs that can be performed from home by almost 30 percent.

Measures of the feasibility of home-based work that do not consider internet access are thus upwards biased, and this bias is especially large in low income countries. Figure 1a plots both the DN2020 and our modified home-based work (HBW) measure against GDP per capita. The distance between the two fitted lines is a measure of the magnitude of the bias associated with ignoring ICT and internet access constraints. The bias is largest in the poorest countries. For example, 5.5% of all jobs in Ethiopia can be performed from home according to the DN2020 measure, while accounting for internet access reduces the prevalence to 2.1%. Even more strikingly, in Nepal the number of jobs that can be performed from home drops from 14.7% to 6.3% once internet constraints are accounted for. By contrast, in rich countries such as Switzerland, Sweden, the United Kingdom, the Netherlands, and Luxembourg—where the DN2020 measure would be between 40 and 55 percent—internet access constraints hardly matter.[6]

How large is this bias in different parts of the global income distribution? Figure 1a does not provide a direct answer since it does not consider country size. Figure 1b presents the share of telecommutable jobs by level of income of the countries, weighted by the size of their employed population and separating between types of home-based work. The portion of jobs requiring internet, but lacking access is the bias of the DN2020 measure. It shows that the share of telecommutable jobs that do *not* require internet access is consistently very low. The share is slightly over 3 percent on average and is no more than 5 percent in any country. In other words, few jobs can be effectively done from home without internet. Developing countries are doubly disadvantaged; not only they have fewer telecommutable jobs, but also internet access is far more

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[6] Recall from section 2 that the association between GDP per capita and the share of jobs amenable to working from home depends critically on what we assume about the ability of agricultural workers to do their jobs from home; assuming that the agricultural self-employed can work from home would result in a negative association between GDP and the prevalence of work amenable to working from home (Gottlieb, Grobovsek, and Poschke, 2020).

binding when compared to richer economies. In low income countries, 10.2% of all jobs are telecommutable. However, only 3.8% of those jobs can be effectively performed from home. The DN2020 measure thus overestimates the number of telecommutable jobs by a factor of almost 3. In contrast, internet access constraints in high income countries only prevent 1 of every 12 telecommutable jobs (3.3 percent of 38.8 percent) from being performed from home. Upper and lower-middle income countries are intermediate cases where internet access limitations reduce the number of telecommutable jobs by around 22 and 41 percent, respectively.

Accounting for residential internet access limitations thus leads to the largest reductions in the share of jobs that can feasibly be performed from home in countries where telecommutable jobs are relatively scarce to start with. As a result, the correlation between GDP per capita and the feasibility of home-based work strengthens when internet connectivity is taken into consideration. This in turn implies that conventional measures of labor market exposure to COVID-19 may underestimate its impact on inequalities in job vulnerability across countries, a theme we will return to below.

4   Robustness tests and extensions

The construction of the home-based work indices based on O*NET surveys and the use of the Gallup World Poll data to determine internet access requires certain assumptions which might bias our results. The goal of this section is to use alternative assumptions and assess the robustness of our main findings as represented in Figures 1a and 1b. Figure 2 displays the share of jobs amenable to telework using alternative assumptions. As was the case in Figure 1b, countries are grouped according to their average income levels.

The DN2020 index is, in essence, a weighted average of different types of tasks and embodies ICT requirement via inclusion of email dependence in the calculation. We first remove this condition to expand the set of jobs that can be feasibly performed from home without internet usage and recalculate the DN2020 index. This modification guarantees that our results are not an artifact of constraining the set of jobs that can theoretically be performed from home to be ICT dependent by assumption. As expected, removing the constraint that jobs must require frequent e-mail use to be performed from home indeed raises the share of jobs that can be done at home, but only marginally.

This increase is solely driven by jobs that can be done at home *and* do not require internet whose share increases from 3.1 to 3.6 percent in high-income countries, and from 1.7 to 2.0 percent in low-income ones (Figure 2a).

Next, we use PIAAC (Programme for the International Assessment of Adult Competencies) surveys rather than O*NET data to identify the types and extent of occupations requiring internet access. The main shortcoming of O*NET data is that they are based on the task content of occupations as performed in the United States. The PIAAC surveys, in contrast, include rich information on jobs' characteristics for 35 countries. We restrict the sample to 29 high-income countries where internet coverage is near universal to avoid our measures of ICT usage being downward biased by limited internet availability. Following Hatayama, Viollaz and Winkler (2020), we use several questions related to internet use at work such as frequency of computer and email use, frequency of ICT usage, programming, and participating in video calls. We construct a continuous index of ICT usage and we calculate the share of jobs within each ISCO 2-digit occupation that are above the 50th percentile of this index. Occupations above the median in ICT usage are determined to require internet access. We then combine this occupation-level measure of ICT requirements with the DN2020 index to identify the share of jobs that are telecommutable and do not require the internet versus the shares of jobs that are telecommutable conditional on internet access. We identify the share of jobs that are telecommutable and require the internet as the minimum of the share of jobs that can be performed from home according to Dingel and Neiman and the share of jobs requiring internet in each ISCO 2-digit occupation. Telecommutable jobs that do not require internet are obtained by subtracting telecommutable jobs that require internet from all telecommutable jobs. This alternative index does not change the total share of jobs that can be done from home with respect to our baseline results significantly. It increases, marginally, the share of jobs that can be done at home and require internet access but lack connectivity, particularly for lower income countries. The results of using PIAAC to identify internet dependence are presented in Figure 2b. In this case, the share of jobs that can be performed from home without internet declines, from 3.1 to 2.6 percent in high income countries and from 1.7 to 1.0 percent in low income countries.

Our next robustness check uses a different method to allocate internet connectivity along the income distribution. We should recall that the Gallup data contain the share of people with internet

access only among the richest 60 and poorest 40 percent households; we do not have internet access information for every income level. As a result, our measure could be under-estimating connectivity for the relatively richer, and over-estimating connectivity for the relatively poorer households. To address this concern, we linearly interpolate internet access by income level based on those two estimates for each country to allocate internet. As seen in Figure 2c, this assumption does not change the results significantly either. The share of jobs that can be done in high income countries is identical due to widespread internet access. Similarly, the change in low-income countries is also minimal, but due to overall lack of internet access. The biggest change occurs in middle-income countries. In both upper- and lower-middle income countries, the share of jobs that require but lack internet access declines by around 0.5 percent, increasing the share of teleworkable jobs by the same amount.

Our final exercise uses data from the World Development Indicators (WDI) to allocate internet access. Since the data are not disaggregated by income level, we match the share of internet users by country by allocating connectivity to the highest earners. As an example, if 37% of the population has internet access, we assume that everyone in the top 37% of the income distribution has access and nobody in the bottom 63% has access. This procedure tends to increase the share of occupations amenable to teleworking across all country groups (Figure 2d). Higher wage occupations are more likely to be amenable to teleworking, and this allocation rule gives them preferential access to internet. The increase is about 2.3 percentage points in low-income countries, 5 percentage points in middle-income ones, and 3.1 percentage points in high-income countries. We also recalculated figure 1a under each scenario to see how the results change for each country and the results are available upon request. We see that the different assumptions explored in each of the scenarios (as presented in Figures 2a-d) do not lead to dramatic changes in our estimates, increasing our confidence in our results and further analysis.

The appendix presents additional robustness tests in which we explore how our results change with alternative assumptions about the ability of the self-employed, especially agricultural workers, to work from home. If anything, data from PIAAC surveys suggest agricultural employment in lower income countries is less amenable to working from home than in high-income countries. Based on these patterns, the DN2020 index (and our adaptation of it) does not appear to dramatically underestimate the ability of agricultural workers to work from home in developing countries.

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## 5	Inequality within countries

The correlation between underdevelopment and labor market vulnerability to COVID-19 is not limited to cross-country analysis; a strong correlation also exists within countries. This is shown in Figure 3a, which plots the correlation between the share of jobs that can be performed from home in 280 NUTS2 subregions of Europe against local GDP per capita. Richer regions have higher endowments of jobs that can be performed from home. Figure 3b presents similar findings for Brazil, India, Mexico, and Turkey. The home-based work-income gradient is much steeper in Brazil, Mexico, and Turkey than in India, reflecting the fact that they are not only richer but also have higher levels of internet penetration. These graphs suggest that the labor market impacts of COVID-19 are not only likely to increase inequality across countries but will also exacerbate spatial inequalities within countries as the lagging and poorer regions tend to have the highest share of vulnerable jobs.

Figure 4 illustrates the spatial variation in the share of jobs that can be performed from home across Europe (panel a), Brazil (panel b), Mexico (panel c), and Turkey (panel d). Starting with Europe, the share of home-based jobs tends to be higher in more developed regions of Northern European countries, compared to relatively poorer Southern European countries and EU new member states in Eastern Europe. Yet, there is significant heterogeneity within countries. Systematically, jobs performed in metropolitan areas such as Madrid, Paris, Lisbon, or Warsaw are more likely to be amenable to home-based work relative to more rural areas in the respective countries. Similarly, the Mexico City metropolitan area—as well as the relatively richer northern parts of Mexico— have higher shares of jobs amenable to home-based work than more rural and poorer areas. In Brazil, jobs in the relatively richer regions closer to the coast and around the metropolitan areas of São Paolo and Rio de Janeiro are more amenable to home-based work, while those closer to the Amazon are not. In Turkey, the same contrast emerges between the more urbanized areas in Istanbul, Ankara, and Izmir, and the more rural and poorer regions in the south and the east.[7]

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[7] In contrast, there is less spatial variability in the share of jobs amenable to telework in India (not shown here but available from the authors upon request), reflecting the severely limited internet penetration in the country at the residential level for employment purposes.

The next step is to analyze inequality between individuals by assessing how the prevalence of jobs that can be performed from home varies with income. Figure 5 shows how the DN2020 and our internet-adjusted measure vary with income across different groups of countries, based on the ILO database of average wages across occupations. The home-based work-individual income gradient is steepest in high-income countries which have the highest prevalence of telecommutable jobs. At the top income decile in high-income countries, almost 80 percent of the jobs can be performed from home. Accounting for internet access hardly impacts the gradient in rich countries, where internet access is much less likely to be a binding constraint. By contrast, the gradient is the least steep in low income countries, which have few telecommutable jobs to start with. Accounting for internet access flattens the gradient the most in poor countries with limited internet access. The impact is strongest for the higher income people in the least developed countries since they are more likely to have jobs that can be done from home but face internet access constraints. Poorer households, in contrast, do not have jobs amenable to home-based work and are therefore not affected by internet restrictions. In short, COVID-19's impact is quite different in rich and poor countries. Absent interventions, inequality is likely to rise the most in rich countries, but poor countries have higher shares of jobs at risk.

Figure 6 illustrates these patterns using representative data at the individual level from India, Brazil, Mexico, and Turkey. The chance of having a job that can be performed from home increases with individual income in all countries but less so in India, where labor market vulnerability is most widespread and internet access most limited. A worker in the top earnings decile in India has a 19% chance of having a job that can be done from home, whereas a worker in the bottom percentile has less than 1% chance of having such a job. By contrast, a worker in the top earnings decile in Turkey (which has the highest PPP adjusted GDP per capita in this group) has a 55% probability of having a job that can be performed from home, whereas a worker in the bottom decile only has a 7% chance of having such a job. COVID-19 is thus likely to exacerbate inequality within almost every country, but more so in higher-income countries.

This conclusion is supported by Figure 7, which presents estimates of the impact of COVID-19 on earnings inequality —measured by the Gini coefficient— under alternative assumptions about its impact on incomes. We assume COVID-19 leaves the incomes of those working in jobs that can be performed from home unaffected while all other workers lose, respectively, 30% and 50% of

their incomes. The figure shows the *changes* in the Gini coefficient under these two scenarios. Since richer individuals tend to be insulated from such shocks because of their ability to work from home, inequality is exacerbated, especially in rich countries, where a larger share of the higher income workforce can work from home. The increase in inequality varies with the magnitude of the income shocks; larger losses incurred by those who cannot work from home are associated with sharper increases in inequality. In poorer countries, because of lack of telecommutable jobs as well as internet access constraints, there is very little change in the income distribution, hence smaller changes in the Gini coefficients.

6 Which workers are most at risk?

Our analysis until this point captured averages across countries by occupation groups, income deciles, or sub-national geographic areas. The data indicate that labor market shocks associated with the COVID-19 pandemic impact poor countries, poor regions, and poor people more negatively. This section assesses whether there are personal characteristics of workers that can explain these patterns. More specifically, we assess which workers are most at risk by running individual-level regressions in which the dependent variable is having a job that can be performed from home. We estimate separate regressions for Europe, Brazil, India, Mexico, and Turkey. We control for age, gender, and education, first separately and then jointly. We also control for sub-national factors by including regional fixed effects. Standard errors are clustered at the region-occupation level.

While coefficients vary across countries, several common patterns emerge as reported in Table 1. Young workers (i.e. those between 15 and 24 years of age), who comprise the omitted age category in our regressions, are significantly less likely to have a job amenable to home-based work than older ones across all countries. Unlike the health risks of COVID-19, which are disproportionately borne by the elderly, the economic risk is thus concentrated among the youth. However, age differences only explain a very small share of the differences in labor market vulnerability as is evidenced by the low R2s which are consistently lower than 0.022 when age is the explanatory factor.

Second, gender has limited explanatory power and gender differences in labor market vulnerability vary across countries. In Europe and Mexico, women are around 10 percentage points more likely than men to have a job amenable to home-based work, whereas in Brazil the gap widens to 19.4 percentage points. In India, by contrast, there are no gender differences, and in Turkey women are 12.7 percentage points *less* likely to be able to work from home. However, it is important to bear in mind that these estimates only reflect whether a job can be performed from home and do not consider other dimensions of gender differences in susceptibility to COVID-19 induced labor market stress. Women are disproportionately shouldering caregiving and childcare needs stemming from the shutdown of schools and childcare centers (Alon et al., 2020, Sevilla and Smith, 2020, Wenham, 2020) or the illness of their family members, which constrains their labor supply (Heath et al., forthcoming).

Third, and most important, labor market vulnerability is inversely correlated with educational attainment. Workers with tertiary education are much more likely to be able to work from home in all countries and regions. Education explains a large share of the variation in the ability to work from home as is evidenced by the R2s which consistently exceed 0.2; it is the strongest predictor of who has a relatively safe job among the set of explanatory variables we consider here. While education offers protection in all countries, the probability of having a job amenable to working from home increases least with additional education in India, which is not surprising given that India has fewer jobs that can be performed from home to start with. Interestingly, when using the DN2020 telework variable instead of our home-based work measure, the coefficient of education level in India becomes similar to the one in the other studied countries (see annex 1), which attests to a lack of internet access being the binding constraint on highly educated Indians' ability to work from home.

Fourth, workers in temporary jobs are less likely to have jobs that can be performed from home. This is worrisome, as they are more susceptible to losing their jobs, and reinforces the conclusion that COVID-19 is likely to exacerbate labor market inequality and will disproportionately impact those least protected. Including all the explanatory variables, together with the regional fixed effects, does not change the significance of specific variables. Education level, age, and job security are still highly important for the ability to perform a job from home even when regional variances are taken into account within each country.

7   Conclusion

The COVID-19 pandemic will continue to cause severe labor market pain across the globe in the foreseeable future. To assess which jobs are most at risk, we create a new measure of which jobs can be performed from home by combining information on the task content of jobs with information on internet access by country and income groupings. On average, one in five jobs across the globe can be performed from home, but this number masks enormous heterogeneity across countries because the ability to telework is correlated with income. In high income countries one of every three jobs is amenable to home-based work, while in low income countries only one of every 26 jobs can be done at home.

Failing to account for internet access would cause one to overestimate the prevalence of jobs amenable to home-based work in low income countries by a factor of 4, and hence cause one to underestimate the vulnerability of poor countries which suffer two disadvantages; they have fewer jobs that are theoretically telecommutable to start with, and limited internet access is a bigger bottleneck for them.

Telecommutable jobs are highly unequally distributed across space, not only across but also within countries. They are less prevalent in lagging regions. The COVID-19 is thus likely to exacerbate spatial inequality, especially when one considers that local governments in lagging regions may have less fiscal capacity to cushion the COVID-19 shock.

Across all countries, jobs that can be performed from home tend to be much better paid. Absent remedial action, the COVID-19 pandemic is thus likely to exacerbate inequality, and especially so in relatively richer countries given the higher prevalence of jobs amenable to home-based work. Yet, the bulk of the labor market pain will be shouldered by workers in developing countries given the very limited feasibility of working from home and their limited recourse to social safety nets. Across the globe, young, poorly educated workers and those with temporary contracts are especially exposed to COVID-19 induced labor market pain, which is worrying since they are more vulnerable to start with. The COVID-19 crisis is thus bound to exacerbate domestic as well as global labor market inequality.