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Article

Potential and effective remote work in Brazil: Looking into the gap between metrics

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Potential and effective remote work in Brazil: Looking into the gap between metrics☆

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ABSTRACT

The main objective of this paper is to seek an explanation for the gap between the estimated remote work potential for Brazil and the remote work observed in the country. For this, at first, the teleworking potential is estimated based on the methodology of Dingel and Neiman (2020) applied to the Brazilian PNAD *Contínua* research based on the period prior to the beginning of the Covid-19 pandemic. In the research's second stage, this potential is compared with remote work measurement provided by the PNAD Covid-19 survey, which was carried out between May and November 2020. A potential and effective telework gap was found, and we sought to investigate its causes based on the first PNAD *Contínua* interviews conducted in 2019, which contains information on people's domicile. The results indicate that about a fifth of workers in occupations that can be performed remotely live in households without the necessary means to be in a home office, such as a computer with internet access or even continuous electricity. Thereby, the potential for remote work was refined considering the socioeconomic characteristics of the workers, via the characteristics of the households present in the PNAD *Contínua* survey, which resulted in a refinement in the initial estimate of the potential for remote work initially carried out here went from 22.7% to 16.7%, significantly closer to that observed in May 2020, whose percentage was 13.3%.
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1. Introduction

Due to the health crisis caused by Covid-19, social distancing measures were taken on a large scale in Brazil and in other countries. An immediate consequence of this was the decline in global economic activity. Invariably, the labor market began to suffer the effects of these decision-making. For a portion of the population, engaged in specific tasks, it was possible to continue

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exercising their work activities remotely, as Dingel and Neiman (2020) suggest, occupations that require majority of time walking or running, interaction with the public, or need a large equipment to be done, are not one of them.

ILO (2020a) show that countries with higher proportion of telework manage to minimize such losses inherent to social distancing. In addition, they manage to gradually reduce confinement, since home office workers can maintain their activities without adhering to the flexibility of distance at first.

Since the beginning of the Covid-19 pandemic, given the limitation imposed by the information available on the subject of home offices, methodologies were developed, based on the important work by Dingel and Neiman (2020), that focus on the assessment of the workforce potential to carry out their activities in a home office. Of these, we highlight scientific researchs by ILO (2020b), Albrieu (2020), Foschiatti and Gasparini (2020), Delaporte and Peña (2020), Saltiel (2020), Guntin (2020), Boeri et al. (2020) and Martins (2020).

The core work of Dingel and Neiman (2020) mapped the potential remote work in United States and 85 other countries. Based on the Occupational Information Network (O*NET) survey for the United States, the authors classified the occupations as likely or not to be performed through a home office. Then, they applied this classification to the International Labor Organization (ILO) database on employment by occupation for 85 countries to estimate the potential telework in these countries. Thus, Dingel and Neiman (2020) found a high correlation between per capita income and the potential to perform work activities from home. Brazil was the 45th country on the list, with a potential of 25.65% of employed people to carry out their work activities away from their workplace.

ILO (2020) also conducted an analysis about the potential remote work, that is, workers who are able to carry out their activities remotely. The research consists of classifying occupations into those likely to be performed at home using a Delphi methodology, which imply asking labor market specialists to estimates the probabilities by occupation category that can be done remotely. In the end, ILO (2020) received 23 usable estimates for 19 countries. To avoid use only one estimative to each country, the nations, and estimates, was pooled and so, reduced the idiosyncratic effect of each individual specialist. It is important to highlight that not all estimates were polled together, it was pooled by the similarities of the countries. So, the main difference between Dingel and Neiman (2020) and ILO (2020b) is that the ILO (2020b) estimation consider a proportion of workers in each occupation who are able to work from home, not the entire population of a specific occupation. Another advanced is, with the estimates vary from countries to countries, it reflects the changes in local infrastructure and labor conditions. However, the disadvantage is, as the estimates have been pooled, the result is presented for the region, not for each country. The result of this study indicates that the teleworking potential of Latin American countries is between 16% and 23%. The study also identified a high correlation between income and teleworking.

Furthermore, Albrieu (2020) and Foschiatti and Gasparini (2020) applied the methodology of the first study for Argentina and conclude that from 26% to 29% of occupations can be performed remotely. Guntin (2020) do the same for Uruguay, and estimate that between 20% and 34% of Uruguayan can do their jobs remotely. Boeri et al. (2020) used a similar methodology for countries in Europe and found out that the potential home-bases work in Europe is between 31% in Sweden or United Kingdom and 24% for Italy. Martins (2020), using a methodology similar to IOL (2020b) to Portugal estimates that 30% of the jobs can be done from home in Portugal. Delaporte and Penã (2020) adapted Dingel and Neiman (2020) and also Saltiel (2020) methodology for 23 countries in Latin America, in this study the potential remote work in Brazil was between 13% and 27% of employed workforce. It is noteworthy that Saltiel's (2020) work developed its own methodology based on data retrieved from 10 developing countries to identify the potential for teleworking in them, based on a flexible version of the methodology by Dingel and Neiman (2020). Due to the reason that it has been widely used as a reference in the international literature, the present work followed the methodology of these authors, at first, when estimating the potential remote work score.

In Brazil, during the Covid-19 pandemic, a survey was carried out to record the impacts of the health crisis on the health and work of the population. Brazil was one of the first countries to provide a nationwide survey following remote work, the PNAD Covid-19, which was prepared monthly by the IBGE, from May to November 2020. This survey was extremely important for understanding recent transformations that the Brazilian population has been forced to adopt due to the Covid-19 pandemic, although, due to its emergency nature, the survey has differences in the questionnaire in relation to the PNAD *Contínua*, which limits the possible comparisons. For example, the 434 occupational in PNAD *Contínua* occupational classification, as will be detailed in this paper, was summarize in 36 occupations.

Other locations that conducted a similar survey were Japan and the United Kingdom. As highlighted in Okubo (2020) for Japan, an increase in the percentage of people in remote work was identified during the first half of 2020, from 6% in January 2020–17% in June of the same year. For the United Kingdom, there has been a downward trajectory in remote work over the months of the pandemic, from 36% in April 2020–20% in August of the same year, as pointed out by Soares (2021). Out of curiosity, the potential remote work in the United Kingdom was 43,5%, as estimated by Dingel and Neiman (2020), however, it was not estimated for Japan.

After a systematic review of this theme, the state of their art verified in the national literature is: (i) the technical note of Góes et al. (2020) estimating the potential telework based on Pnad Contínua's microdate; and (ii) Góes et al. (2021) estimate the observed home-based work in Brazil with data from PNAD Covid-19. Thus, this paper extends this line of research by considering the individual characteristics as a limiter on potential telework.Therefore, this paper aims to contribute to the literature on the topic of remote work in the following lines: (i) application of the Dingel and Neiman (2020) methodology to obtain a first estimate of the potential remote work in Brazil, which will then be refined; (ii) comparison of potential with remote work effectively measured by the Brazilian PNAD Covid-19 data provided by IBGE, given the limitations imposed by the database; (iii) understanding of the overall picture, given the available data, the possible reasons for the occurrence of a gap between both

metrics (potential and effective); and (iv) carry out the refinement of potential telework in the country initially estimated, considering socioeconomic variables of the worker's households and not just the occupations of workers, thus advancing in the estimation of potential for remote work in the country, compared to that carried out by other authors for Brazil and the world. By considering the socioeconomic characteristic of the worker's households, hardly all people of a given occupation would be able to work remotely, as ILO (2020b).

For this purpose, the research has five sections in addition to this introduction. The second section presents the methodology and results for estimating the potential remote work in Brazil, the third section reports the results observed in PNAD Covid-19, providing a portrait of effective telework in the country. In turn, the fourth section discusses possible explanations about the difference between potential and effective remote work registered in Brazil and the refined estimation of remote work potential. Finally, the fifth section ends with brief comments by way of conclusion.

The results of this paper show that, Brazil's potential remote work was estimated at 22.7% of workers who were employed in the period prior to the Covid-19 pandemic, using the Dingel and Neiman (2020) methodology. It is worth mentioning that the same positive correlation between telework potential and GDP per capita highlighted in the international literature was observed in Brazilian states.

However, this potential was approximately 10 percentage points above the proportion of people in remote work effectively observed in May 2020, the month with the highest recorded value of teleworking by the PNAD Covid-19 survey. When investigating the possible reasons for this disparity between potential teleworking and the observed remote work, it was found that about a fifth of workers in occupations could be performed remotely, according to the classification of Dingel and Neiman (2020), did not have the means for telework. That is, they did not have a computer with internet access or even constant electricity in their homes. Finally, the potential remote work was revalued, considering socioeconomic factors of the workers' households, and it went to 16.7%, that is, 6 percentage points below the initial estimate and closest to what was observed in May by the PNAD Covid-19 survey (3.3 percentage points above).

2. Potential remote work in Brazil

For the initial estimation of potential remote work in Brazil, the National Household Sample Survey (PNAD *Contínua*) done by the IBGE was adopted as a basis, considering the period prior to the crisis aroused by Covid-19, that is, the first quarter of 2020. This monthly survey consolidated in quarterly mobile accounts, has about 200 thousand households interviewed with national and by state distribution.[1]

The PNAD *Contínua* survey is taken from the master sample of census sectors from the Brazilian Geography and Statistics Institute (IBGE). The sampling plan adopted is a conglomerate in two stages of selection, with stratification of the primary sampling units: (i) in the first stage, the primary sampling units are selected, with a probability proportional to the number of households in each stratum; (ii) in the second stage, 14 households are randomly selected within each primary sampling unit selected from the first stage.

We emphasize that throughout the research, each household is interviewed five times, during five consecutive quarters, with some variations of the questionnaire throughout.

2.1. Methodological aspects of potential remote work: adaptation of PNAD Contínua survey to Dingel and Neiman (2020) methodology

The main reason for working with the methodology of Dingel and Neiman (2020) for estimating the potential telework in the country is that it uses the Standard occupational classification (SOC), from the American survey O*NET, which is in accordance with the International Standard Classification of Occupations (ISCO-08). This structure of labor occupations is adopted on a large scale by several research institutes around the world, including Brazil, guiding the Classification of Household Occupation (COD) in the PNAD *Contínua*, and in other IBGE surveys. In this way, despite not having the same occupations, they have a similar structure, enabling their compatibility with the classification of occupations of the PNAD *Contínua*.

Our first estimation of potential teleworking in Brazil uses Dingel and Neiman (2020) method. By doing that, this estimate can be considered as upper limit for potential telework since it expected that the productive structure of an advanced country, such as the reference in the authors' work, may not be fully widespread in Brazil. However, it is understood that this is a not very relevant limitation, because, if desired, adaptations could be made to the productive structure of a given firm to enable remote work, in order to resemble more modern companies in Brazil or elsewhere. countries.

Furthermore, a second simplification of Dingel and Neiman's (2020) methodology is the hypothesis that the same occupation can be performed remotely regardless of the firm's activity, which may not be true. Furthermore, the remote work estimates do not address the potential effects of the social distancing policy implemented in each location, as well as the socioeconomic reality of each worker. However, to maintain the comparability of the results with other international studies, no adjustments are made in this regard in this first estimate. Therefore, this work used COD to define occupations whose tasks could be performed remotely.

[1] The appendix presents a panel (panel A.1) with the main variables used in the work

Table 1
Jobs likely to remote work (%).
Source: PNAD *Contínua*(IBGEk, 2020). Prepared by the authors.

Large Groups - COD		
Code	Description	Jobs likely to remote work (%)
1	Directors and Managers	61
2	Science professionals and intellectuals	65
3	Mid-level technicians and professionals	30
4	Administrative support workers	41
5	Service workers, sellers of businesses and markets	12
6	Agricultural, forestry, hunting and fishing workers	0
7	Construction workers, mechanical arts and craftsmen	8
8	Plant and machine operators and assemblers	0
9	Elementary occupations	0
0	Members of the Armed Forces, police and military firefighters	0

The COD describes and orders the occupations within a hierarchy that allows the aggregation of information regarding the workforce according to the characteristics that concern both the functions (tasks and obligations of the worker) and their content (knowledge, skills and other requirements for the occupation). This classification is divided into four hierarchical levels, the most aggregated being the Large Group (LG). Each one presents a set of occupational families aggregated by level of competence and similarity in the activities performed, bringing together broad areas of work. Each Large Group is identified by the first digit of the code. The Main Subgroup (MSG) is a more restricted grouping of information than the LG, with a total of 43 titles, bringing together similar occupations in terms of the work's nature or the level of qualification required. Each of the 127 subgroups (SGs) indicates the domain of professional fields of aggregated occupational families. The Base Group (BG) is the classification unit for practical purposes, bringing together a set of similar occupations, in a total of 434 base groups, these base groups were made compatible with the occupations presented in Dingel and Neiman (2020).[2]

Table 1 indicates the percentages of occupations subject to remote working by COD Large Group. Note that the LG group composed of "professionals of science and intellectuals" has the greatest potential for telework (65%), while for the LG group that includes "members of the Armed Forces, Police and Military Firefighters" it is not possible to carry out potential remote work. The appendix presents a panel A.1 with the main variables used in the work.

2.2. Results of potential remote work for Brazil based on the methodology of Dingel and Neiman (2020)

From the classification presented in the previous subsection resulting from the adaptation of Dingel and Neiman (2020) methodology by using data available for Brazil through the PNAD *Contínua* survey, the percentages of people likely to work remotely in each Federation Unit (UF) were calculated, based on the individual's occupation variable and the UF variable (state of origin). The results for Brazil, segmented by UF, are summarized in Table 2.

From Table 2, it's noticed that Brazil has a percentage of people with potential for teleworking of around 22.7%, which corresponds to 20.8 million people. We recall that Dingel and Neiman (2020) obtained, as a result for Brazil, a percentage of 25.6%.

Table 2 still registers the result by UF, where it is observed that the Federal District, has the highest percentage of potential to telework (31.6%) around 450 thousand people. On the other hand, the state of Piauí is the one with the lowest percentage of teleworking score (15.6%), that is, around 192 thousand people could potentially be teleworking.

From Table 2, when relating potential remote work to GDP per capita in Brazilian UFs, its positive correlation is evident, as illustrated in Graph 1, a result that corroborates what was observed in the international literature on the subject as well as in Dingel and Neiman (2020). In graph 2, we replicate the work of Dingel and Neiman (2020) highlighting the Brazilian position and also present the positive correlation between GDP per capita and potential remote work by countries. Graph 2.

The comparison between Graphs 1 and 2 shows the positive correlation between GDP per capita and potential remote work, which is verified both between countries and between Federative Units of the same country.

It is noteworthy that local distancing policies can influence the effectively observed result of remote work in each federative unit. We emphasize that a detailed follow-up of these distancing measures is carried out in Moraes (2020) and (Oliveira, 2020). In fact, other factors can influence the number of people working remotely because during the pandemic there was heterogeneity in the policies practiced by the federative units, the Union and between them, as shown by Góes and Borelli. However, this result is not captured in the present study.

[2] A list of COD codes that can be performed remotely is available at: < https://www.dropbox.com/sh/0b124tg4tgiba9e/AACNvTsYNmpGwSdftuhE2Vg8a?dl=0 >

Table 2
Ranking of states (UF) in proportion of potential telework.
Source: PNAD *Contínua* 1st quarter (2020) (IBGEk, 2020). Prepared by authors.

	Potential No. of people working remotely	Ranking of Potential remote work	*Ranking* – GDP per capita	Potential remote work (%)
Federal District	450,424	1	1	31.6
São Paulo	6,167,672	2	2	27.7
Rio de Janeiro	2,009,689	3	3	26.7
Santa Catarina	854,848	4	4	23.8
Paraná	1,286,367	5	7	23.3
Rio Grande do Sul	1,289,754	6	6	23.1
Brazil	20,889,687	–	–	22.7
Espírito Santo	412,936	7	10	21.8
Roraima	44,571	8	13	21.1
Tocantins	134,190	9	15	21.0
Rio Grande do Norte	272,011	10	19	20.9
Goiás	676,624	11	9	20.4
Minas Gerais	2,012,468	12	11	20.4
Mato Grosso do Sul	261,999	13	8	20.3
Paraíba	282,133	14	25	19.8
Sergipe	175,446	15	20	19.4
Amapá	61,524	16	16	19.1
Acre	55,686	17	22	19.0
Ceará	678,710	18	23	18.8
Pernambuco	654,613	19	17	18.8
Bahia	1,057,602	20	21	18.6
Mato Grosso	310,227	21	5	18.5
Alagoas	182,735	22	24	18.2
Amazonas	288,905	23	14	17.7
Maranhão	386,388	24	27	17.5
Rondônia	134,854	25	12	16.7
Pará	554,655	26	18	16.0
Piauí	192,657	27	26	15.6

3. Analysis of effective remote work in Brazil during the pandemic via PNAD Covid-19 survey

As mentioned, Brazil was one of the first countries to provide a national survey monitoring the effects of the pandemic on the work and health of its population, the PNAD Covid-19, that is prepared monthly by IBGE between May and November 2020. Such survey allowed the construction of remote work panorama in Brazil between May and November 2020 and was extremely important for a better understanding of the recent changes in labor market that the Brazilian population was forced to adapt due to the Covid-19 pandemic.

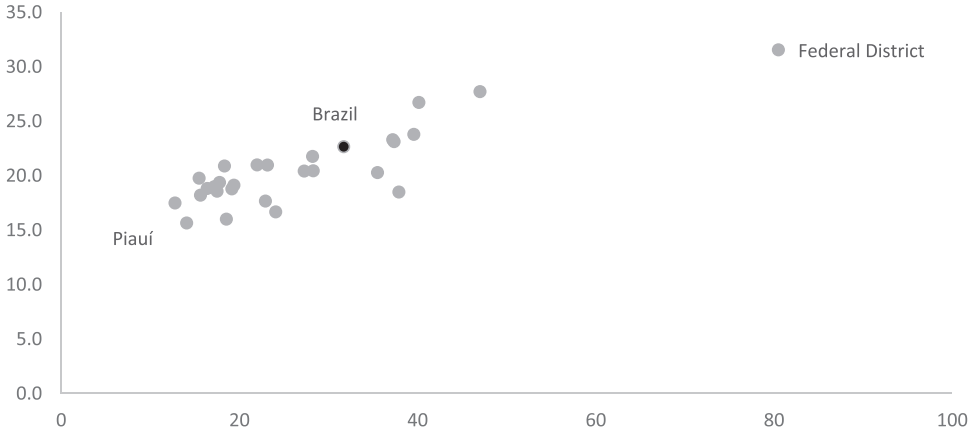
Based on this survey, it was possible to monitor the monthly evolution, the amount of employed people exercising their activities remotely, among other information. As its official title indicates, this is a survey composed of a sample of households and, like all surveys carried out by the IBGE during the pandemic period, it was carried out by telephone. It had 193,600 households distributed in 3364 municipalities. It was built based on a sample of the base of the 211,000 households that participated in the PNAD *Contínua* survey.

As mentioned earlier, the PNAD *Contínua* sample is taken from the IBGE's master sample of census sectors. The sampling plan adopted is a conglomerate in two stages of selection, with stratification of the primary sampling units. In the first stage, the primary sampling units are selected, with a probability proportional to the number of households in each stratum. In the second stage, 14 households within each primary sampling unit selected in the first stage are randomly selected. Thus, in a way, it can be said that the PNAD Covid-19 is a survey using a probabilistic sample of households built in two stages.

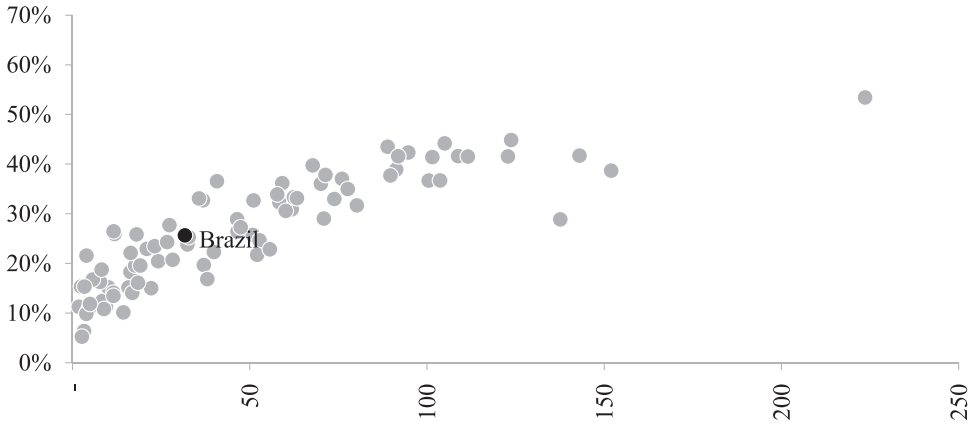
It should be noted that, as it was carried out on an emergency basis and by telephone, the PNAD Covid-19 did not adopt the same questionnaire and structure as the PNAD *Contínua*. In this way, the number of possible crossings is limited. For example, while the COD has 434 occupation classifications, the PNAD Covid-19 has only 36, with a large contingent of people in teleworking in broad classifications such as “34 – Another higher-level profession” or “36 – Others”, that is, without direct correlation with occupations in COD. Despite such difference between the surveys, it is still possible to compare the potential of teleworking with observed remote work. Panel A.1 in the appendix presents the main variables of the PNAD Covid-19 used in the study.

3.1. An overview of effective remote work in Brazil

It was found that during the months of the PNAD Covid-19 survey, there was a reduction in the number of people working remotely in Brazil, from 8.7 million in May to 7.3 million in November (see Table 3), which represents a reduction from 13.3% to 9.1% of the employed population and not on leave in the month. It is also worth mentioning the drastic reduction in the number of people employed and on leave due to social distance, which went from 15.7 million in May to 2.1 million people in November.



Graph 1. Proportion of potential remote work by GDP per capita. (% - $1000 BRL).
Source: PNAD *Contínua* 1st quarter (2020) (IBGEk, 2020). Prepared by the authors.



Graph 2. Relation of potential remote work and GDP per capita in the world. (% - $1000 USD).
Source: Dingel e Neiman (2020).

These results were possibly influenced by the social distancing policies practiced throughout the pandemic. Thus, it is expected that the month of May is the most likely to present a result closer to the potential for remote work in the country, given the levels of transmission and deaths observed. At the same time, the month of November, the period in which the lowest numbers of deaths were registered throughout 2020 (after the start of the pandemic), is the month with the most distant result from this potential.

Graph 3 shows the distribution of people working remotely according Brazilian State, based on data from November of 2020, the last month of PNAD Covid-19. It is observed that the Federal District, Brasília, had the highest percentage of employed people working in home office, with 20%, followed by Rio de Janeiro (15.6%) and São Paulo (13.1%). On the other hand, Pará accounted for 3.1%, Amazonas (3.5%) and Mato Grosso (3.8%) which had the lowest percentages of employed population working remotely.

Graph 4. shows the portion of people actually working remotely in relation to each Brazilian state GDP per capita. That is, it shows the correlation between income and telework, similar to the one highlighted earlier, however, now for effectively observed telework.

It was evident that not only in relation to potential remote work, but also in relation to effective remote work, the positive correlation shown in Graph 1 and in the work of Dingel and Neiman (2020) between GDP per capita and the proportion of people working remotely is maintained.

3.2. Comparison of effective remote work by PNAD Covid-19 with estimates of potential remote work in Brazil

We present in Table 4, a summary table, built from several methodologies available in the literature on the estimates of potential remote work. Comparing the results of potential remote work estimates from the mentioned research highlighted

Table 3
Distribution of employed people in Brazil. (Millions of people and %).
Source: PNAD Covid-19 (IBGEa, 2020). (Instituto Brasileiro de Geografia e Estatística - IBGEa, 2020; IBGEb, 2020a; IBGEc, 2020b; IBGEd, 2020c; IBGEe, 2020d; IBGEf, 2020e; IBGEg, 2020f; IBGEh, 2020g,IBGEi, 2020). Prepared by the authors.

Groups	No. of people in May	No. of people in June	No. of people in July	No. of people in Aug.	No. of people in Sep.	No. of people in Oct.	No. of people in Nov.	Nov. (%)
Employed	84.404	83.449	81.484	82.141	82.934	84.134	84.661	
Employed not temporarily away from work	65.441	68.693	71.746	75.454	77.564	79.447	80.229	94.8
Employees not temporarily away from work working remotely	8.709	8.694	8.403	8.376	8.073	7.596	7.330	9.1
Employed and temporarily away from work	18.964	14.756	9.737	6.687	5.370	4.687	4.432	5.2
Temporarily away from work due to social distance	15.725	11.814	6.784	4.145	3.003	2.341	2.087	47.1
Temporarily away from work for other reasons	3.238	2.942	2.953	2.542	2.368	2.346	2.345	52.9

with the result observed in the country through the PNAD Covid-19, it is noted that, in general, the remote work effectively counted was below the estimated potential.

Using the methodology adapted from Dingel and Neiman (2020) for the PNAD *Contínua*, this paper found a potential of 22.7% of national occupations to be carried out remotely, a difference of 9.4% points in relation to what was observed in May (maximum remote work point calculated via PNAD Covid-19) and a difference of 13.7% points in November (minimum point).

Table 4 shows a greater difference in the potential estimated by Dingel and Neiman (2020) compared to that observed in Brazil, and that this difference is even greater when Delaporte and Peña (2020) adapt Dingel and Neiman (2020) methodology. Possibly, the methodology of Dingel and Neiman (2020) is not the best one to the reality of remote work in Brazil, and it can be refined given the conditioning factors for carrying out the work remotely, as we will do in the next section. On the other hand, when Delaporte and Peña (2020) use Saltiel's (2020) methodology for Brazil, there is a potential remote work lower than that observed in May, which may mean that the methodology was too restrictive to estimate the potential remote work given the Brazilian productive structure.

It is noteworthy that the international literature also detects a difference between potential and effective. As highlighted in Dingel and Neiman (2020), the potential telework for the UK was 43.5%. Soares (2021) points out that, in a survey similar to PNAD Covid-19 carried out in the same location, effective remote work ranged between 38% and 20%, depending on the month of the survey, showing a discrepancy between what was observed and what was estimated potential.[3]

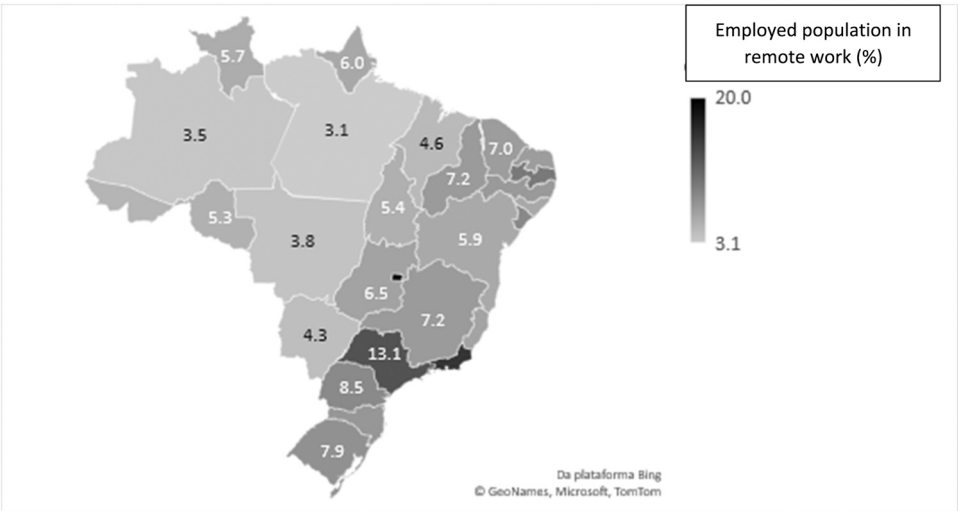
4. Discussion of factors that may justify the difference between potential and effective remote work in Brazil: a qualitative and quantitative analysis

In the first interview questionnaire of PNAD *Contínua* applied in Brazil, information about the interviewees' domicile of residence is asked. This survey assesses how many households have access to basic inputs for remote work, such as computers, internet access and electricity, among other socioeconomic variables. Panel A.1 in the appendix shows the main variables used in the PNAD *Contínua* first interview.

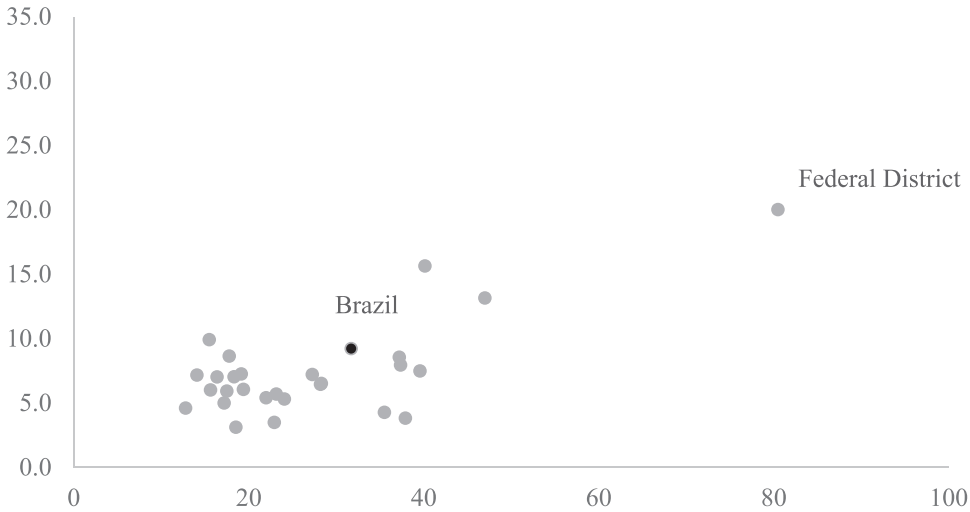
Therefore, it is possible to assess the share of households in which employees capable of performing their work remotely, in the period before the pandemic, had the means to effectively work in a home office. It is clear that, if the company had the motivation to put its employees in remote work, each firm could provide a computer for the employee, as well as replace the transport aid with an internet aid, but there is no data to assess such situations, although such measures may be the result of advances in labor legislation and motivate public policies in the future.

The first necessary condition for the worker to perform their work activity remotely is to have access to electricity. Considering only people in jobs that potentially can be performed remotely, it is found that 0.02% of these do not have electricity supply in their homes. However, 0.65% of them do not have electricity continuously, that is, these individuals would face difficulties while working from home, as shown graph 5.

[3] It is worth noting that Dingel and Neiman (2020) did not make an estimate for Japan, making the same comparison unfeasible.



Graph 3. Distribution of people working remotely in Brazil by state of residence. (%).
Source: PNAD Covid-19 (IBGEi, 2020). Prepared by the authors.



Graph 4. Proportion of people working remotely by GDP per capita, (% - $1000 BRL).
Source: PNAD Covid-19 (IBGEi, 2020). Prepared by the authors.

As important as electricity, it is the means of work, here understood as a computer with internet access. The collected data allow us to identify whether the household has a computer or not, which may be a limitation given the possibility of having more than one worker in the same household. In any case, data from the Brazilian PNAD *Contínua* survey indicate that 21.82% of people in occupations with the potential to be performed remotely do not have a computer at home (see graph 5).

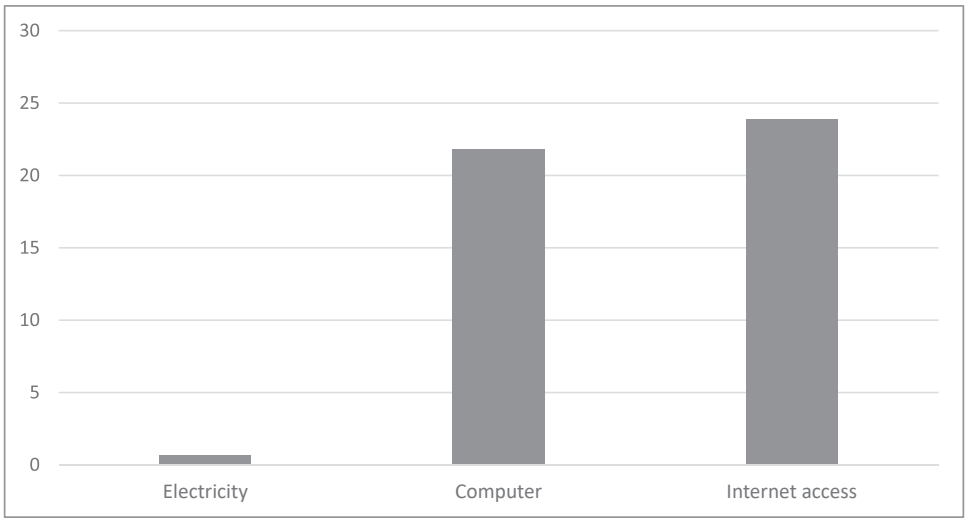
Assessing households that have a computer with internet access, data from the PNAD *Contínua* from 2019, first interview considered, showed that 23.88% of people in occupations that can be performed remotely do not have this means of work, highlights graph 5. That is, about 2% of people in occupations with the potential to carry out their work activities remotely have a computer, but do not have access to the internet.Graph 5.

With this, the potential remote work of people carrying out their activities remotely decreases to 15.78 million, a reduction of approximately 5 million people, which represents approximately a quarter. Therefore, the potential actually reduces to 16.7%, significantly closer to the 13.3% that was pointed out by PNAD Covid-19 of May 2020.

Again, another point that can help explain the difference between what is observed, and potential remote work is the difference in the productive structure between Brazil and the United States, which was the reference country in the study by Dingel and Neiman (2020). An intuitive way to carry out this assessment would be to compare the occupation in PNAD Covid-19 and those available in PNAD *Contínua*. However, as highlighted, as the first one was designed to be carried out by telephone,

Table 4
Comparison of potential remote work estimates with the remote work observed in Brazil.
Source: Dingel and Neiman (2020), Delaporte and Peña (2020). PNAD *Contínua* (Instituto Brasileiro de Geografia e Estatística - IBGEa, 2020), PNAD Covid-19 (IBGEi, 2020). Prepared by the authors.

Categories/months	Proportion of people employed in remote work	Deviation from PNAD data of May in Brazil (percentage points)	Deviation from PNAD data of Nov. in Brazil (percentage points)
Estimated potential for Brazil	22,7	9,4	13,7
Dingel e Neiman (2020)	25,0	11,7	15,8
Delaporte & Peña with Dingel e Neiman (2020) method	27%	13,7	16,8
Delaporte & Peña with Saltiel (2020) method	13%	-0,3	3,8
PNAD Covid-19 – (May)	13,3	0	4,1
PNAD Covid-19 – (November)	9,2	-4,1	0



Graph 5. Proportion of workers in occupations likely to be carried out remotely without the means to do so – by production factor.(%).
Source: PNAD first interview of 2019 (IBGEj 2020). Prepared by the authors.

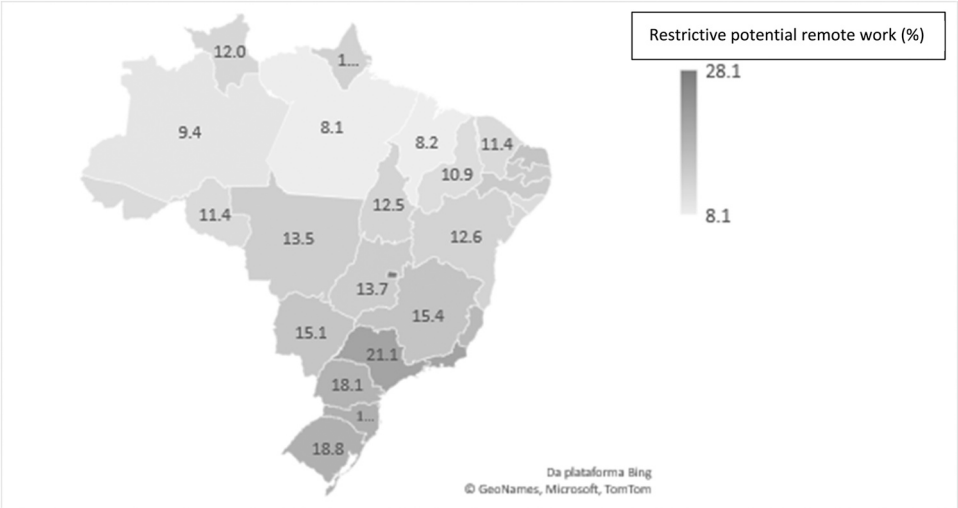
Covid-19′s survey had its questionnaire and the possibility of answers reduced. As an immediate consequence, the occupancy classification was reduced from 434 to 36, thus making it not possible to compare the data to perform this measurement.

4.1. Restrictive results in potential remote work per Federative Unit

As suggested, the proportions of people with potential to perform their activities remotely in the country segmented by Federative Unit were refined, considering the socioeconomic characteristics of the worker's domicile, as shown in Graph 6. With this, a general reduction in potential remote work was observed in each state, highlighting the scores for states of the North and Northeast region. The states of Pará and Maranhão presented, since then, the lowest percentages of potential remote work, with respectively 8.1% and 8.2%. On the other hand, Brasília, the Federal District (28.1%) and São Paulo (21.1%) kept the highest percentages.

Graph 7 highlights the variation between the first estimate based on Dingel and Neiman (2020) reported in Table 2, and the second estimate, calculated under the condition of feasibility of working remotely. The reduction, in percentage points, of each Brazilian state is evident, with emphasis on the states of the North and Northeast region, as it was the case of nine states that presented reductions. This result is expected, since these are the regions with the lowest score for development indicators in the country. The state of São Paulo stands out, with the eleventh sharpest drop. On the other hand, the Federal District, which previously had the greatest potential, was also the one with the smallest reduction, which is in line with the reality of being the richest Federative Unit in Brazil.

When comparing the potential remote work, after the feasibility assessment, with that observed in May, by federative unit, it is noted that after the feasibility analysis, some locations recorded a percentage of employees who were not on leave exercising their activities remotely superior to the potential remote work, of which the states of Ceará, Rio de Janeiro, Paraíba and Piauí stand out. For Brazil as a whole, the result shows that the potential remote work was 3.4% points above that observed in May.



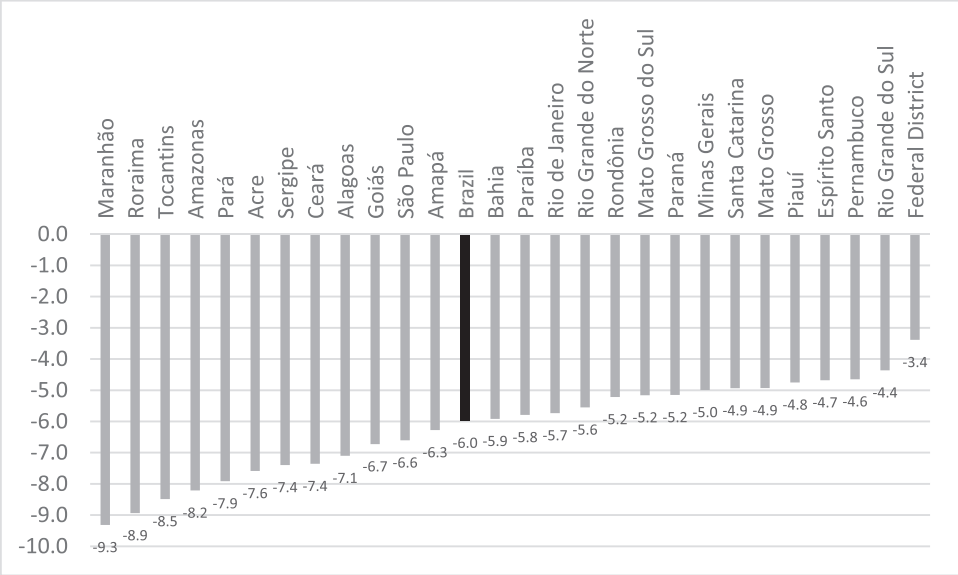
Graph 6. Distribution of the potential remote work of people employed after evaluating the feasibility of carrying out their work remotely in the country, according to the state of residence. (%).
Source: PNAD *Contínua* 1st interview (2019)(IBGEj 2020). Prepared by the authors.

Along the same lines, the states of Santa Catarina, Mato Grosso and Rio Grande do Sul were the ones that registered the greatest disparities between potential and effective remote work, as shown in Graph 8.

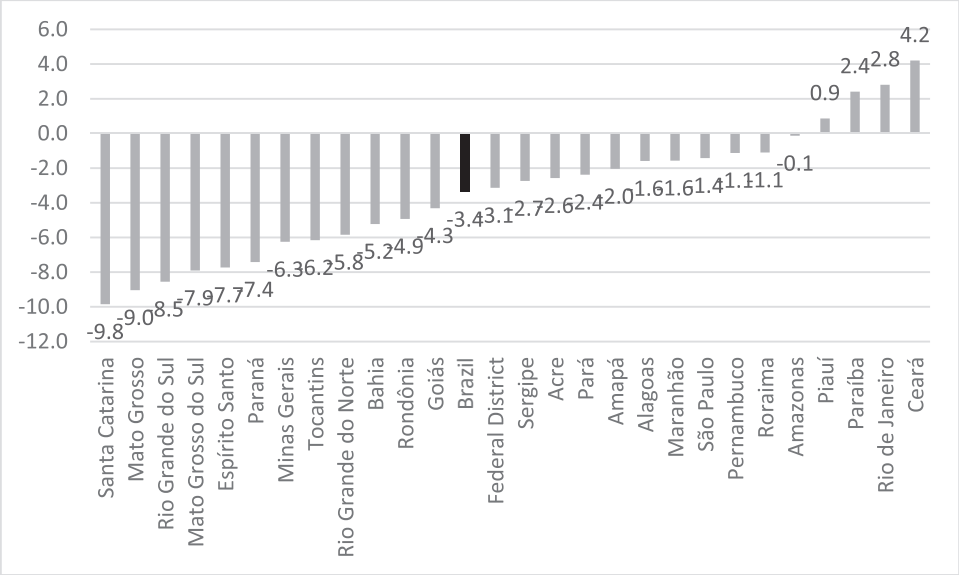
Lastly, Graph 9 relates potential remote work to GDP per capita, as shown in Graph 1. There is a positive correlation between both variables again, based on the diagnosis carried out by Dingel and Neiman (2020).

5. Final considerations

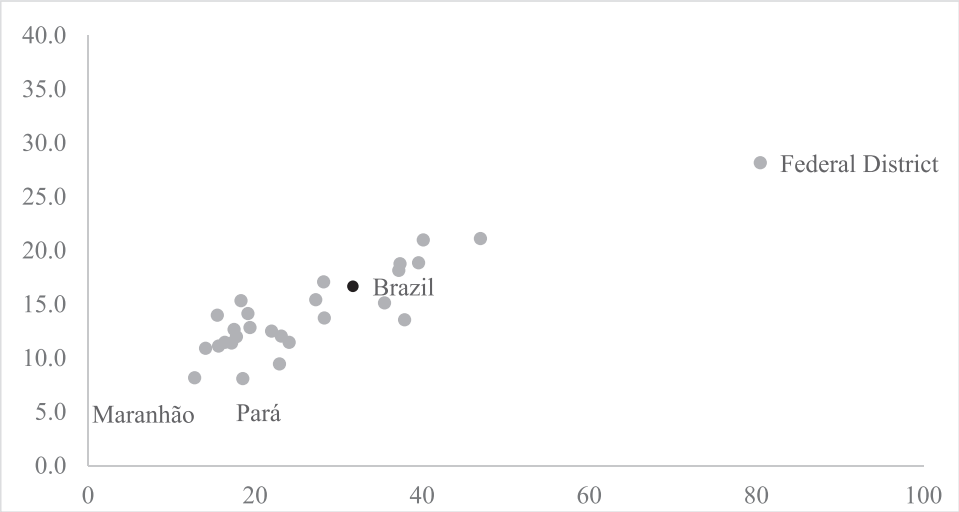
The objective of this research can be divided into four stages: (i) apply Dingel and Neiman (2020) methodology for an initial estimate of the potential remote work in Brazil; (ii) compare this potential with remote work effectively measured by the IBGE's PNAD Covid-19 Brazilian survey; (iii) seek to understand, given the data limitation, possible reasons for the gap between both metrics (potential and effective); and (iv) carry out the refinement of the potential telework in the country initially estimated, considering socioeconomic variables of the worker's households and not just the occupations of workers, thus advancing in the estimation of remote work potential in the country, compared to that carried out by other authors for Brazil and in the world.



Graph 7. Variation of potential remote work between the two situations (with and without restrictions on the means for remote work). (%).
Source: PNAD *Contínua* 1st interview (2019) and 4th quarter (2019)(IBGEj 2020) (IBGEk, 2020). Prepared by the authors.



Graph 8. Comparison between potential remote work after feasibility assessment and remote work observed in May 2020. (%).
Source: PNAD *Contínua* 1st interview (2019) e PNAD Covid-19 in May (2020) (Instituto Brasileiro de Geografia e Estatística - IBGEa, 2020; IBGEj 2020). Prepared by the authors.



Graph 9. Correlation between potential remote work analysis after feasibility assessment and GDP per capita.
Source: PNAD *Contínua* 1st interview (2019)(IBGEj 2020). Prepared by the authors.

By applying Dingel and Neiman (2020) methodology in Brazil, it was estimated a potential remote work in the country of 22.7% of workers employed in the period prior to the Covid-19 pandemic. By relating this potential, by Brazilian Federative Units, with the respective GDP per capita, the same positive correlation highlighted in the international literature was found.

However, observing the results recorded via PNAD *Contínua*, it was found that this potential was approximately 10% points above the proportion of people in remote work effectively observed in May 2020, the month with the highest score. It is noteworthy that during the months in 2020, the proportion of people not on leave carrying out their work activities remotely underwent a reduction, until reaching 9.1% in November 2020, that is, less than half of the potential estimated by Dingel and Neiman (2020) methodology adapted to Brazil.

Therefore, using the first PNAD *Contínua* interview for the year 2019, some possible reasons for the disparity between potential and effective remote work were investigated and advance in the assessment of the country's potential remote work, considering not only the occupations of workers, but the socioeconomic characteristics of the households where they reside. It was found that about a fifth

of workers in occupations that could be performed remotely, in the classification of Dingel and Neiman (2020), did not have the means to do so, that is, they did not have a computer with internet access or even constant electricity in their homes.

Next, the potential remote work was recalculated for the country (16.7%), which corresponds to 3.3% points above that observed in May by the PNAD Covid-19 survey and also 6% points below the first estimate based on the work by Dingel and Neiman (2020), which can be considered a refinement of this metric. Nevertheless, it was verified that the greatest variations in potential remote work occurred in Federative Units in the North and Northeast regions, which are the states with the lowest scores on development indicators.

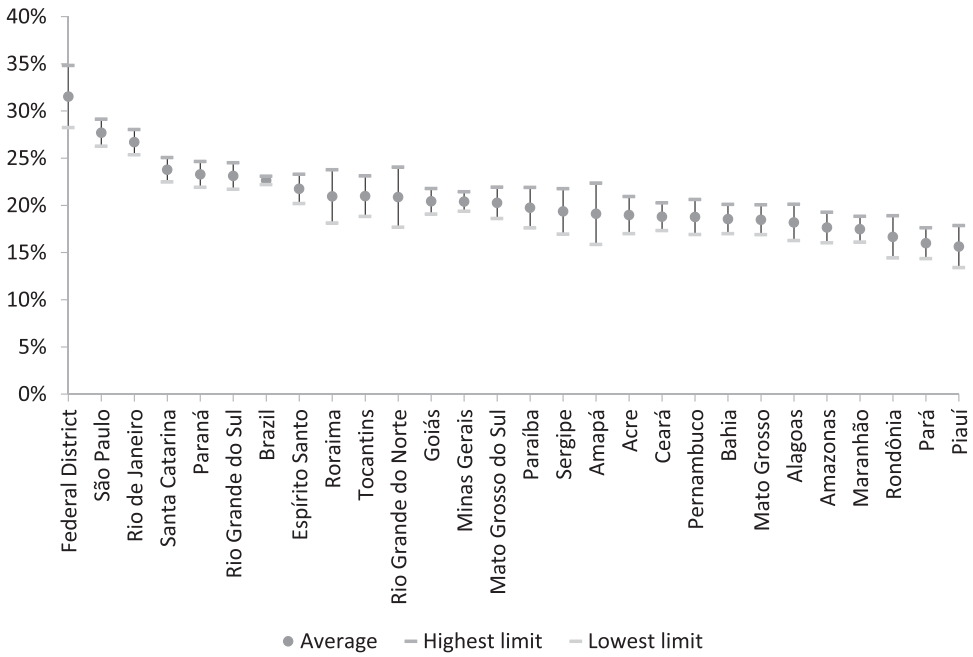
Conclusively, as evidenced by the work, the percentage of people exercising their activities remotely in Brazil is not negligible. Nor is it possible to ignore the contingent of workers with the potential to perform their activities remotely. Remote work represents not only a significant change in the labor market, but also highlights the need to change its normative regulation. That said, this article aims to provide support for this important discussion.

Appendix

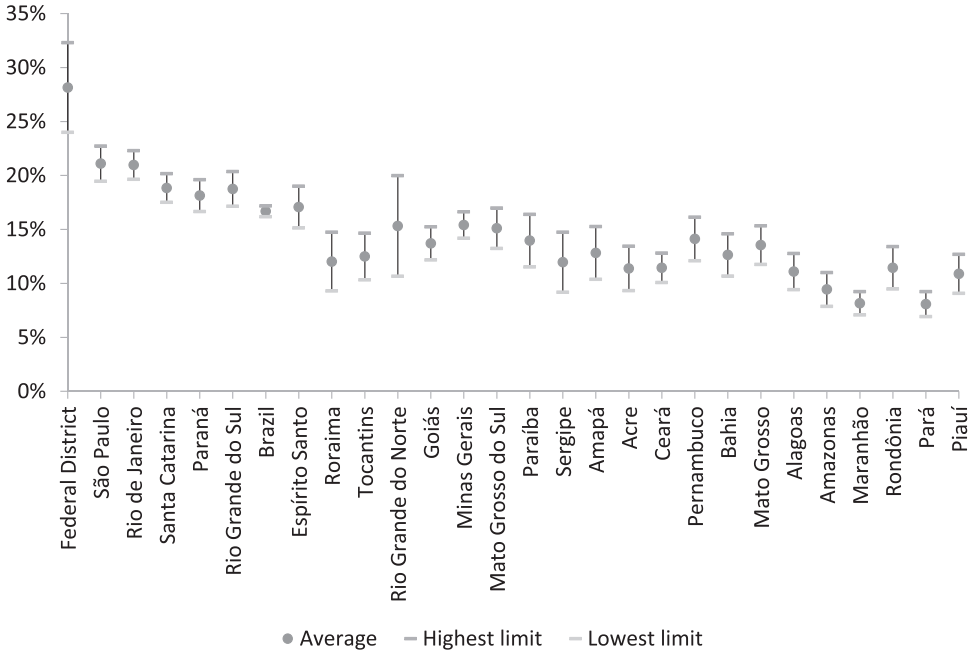
(See Panel A1, Graph A1, Graph A2).

PANEL A1
Main variables used from the surveys.(IBGEk, 2020; Instituto Brasileiro de Geografia e Estatística - IBGEa, 2020; IBGEj 2020)

Created variable	Variable id in the survey	Description
PNAD Covid-19		
Federative Unit	UF	Reports to the Federative Unit that the domicile is located
Worker situation	c001, c002, c003	People classified as workers, worker and absent due to social distance and worker and absent for other reasons
Remote work	c001 e c013	People classified as workers and performing their activities remotely due to social distance
PNAD Contínua trimestral		
Federative Unit	UF	Reports to the Federative Unit that the domicile is located
Occupation	V4010	COD - occupational classification
Works	V4009	Indicates the number of jobs the person has
PNAD Contínua primeira entrevista		
Federative Unit	UF	Reports to the Federative Unit that the domicile is located
Occupation	V4010	COD - occupational classification
Works	V4009	Indicates the number of jobs the person has
Electricity supply	S01014	Home with electricity supply
Constant electricity supply	S01015	Home with constant electricity supply
Computer	S01028	Home with, at least one computer
Internet	S01031	Home with internet access via computer



Graph A1. Proportion of people working from home and their respective confidence intervals. (%).
Source: PNAD Contínua(IBGEk, 2020).



Graph A2. Proportion of people working from home and their respective confidence intervals. (%).
Source: PNAD Contínua 1st interview (2019) (IBGEj 2020).Prepared by the authors.

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