DOES TELEWORKING AFFECT THE LABOR INCOME DISTRIBUTION? EMPIRICAL EVIDENCE FROM SOUTH AMERICAN COUNTRIES

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Abstract

This study aims to estimate the distributional impact of teleworking on the labor income in some South American countries, including Argentina, Brazil, Colombia, Ecuador, Perú and Uruguay. Using microdata from household surveys, our focus is on the period 2021 onwards to filter teleworking variables from temporary changes in the labor market caused by tighter restrictions on mobility during the pandemic. While in some countries we can measure effective telework, in others we approximate it based on a set of conditions that are required for teleworking. Then, we estimate how a marginal variation in the percentage of teleworkers affects not only the mean of labor income, but also other features of the unconditional distribution, such us the quantiles and some inequality indicators (Gini and Atkinson indexes). This analysis allows us to capture potential asymmetric effects of remote work across the entire unconditional income distribution. As empirical strategy, we employ a RIF (Recentered Influence Function) regression approach. The main results show that a marginal variation in the percentage of remote workers has a positive effect on the average labor income but with asymmetries across the income distribution that could led to an increase in inequality. Indeed, for most countries, high-income workers benefit the more from a deeper teleworking penetration. Furthermore, this result is also supported by our estimates of the effect of teleworking on Gini and Atkinson inequality indexes.

JEL classification: C13, J24, J30

Keywords: teleworking, inequality, income, RIF regressions, South America

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1. Introduction

The health crisis due to the coronavirus accelerated the introduction of changes in work modalities, among which the propagation of telework stands out. Beyond the behavior of the labor market during the stages of strict confinement, remote work became a work modality that coexists with face-to-face work. In the European Union, the average percentage of employed people who telework increased from 10% in 2019 to 24% in 2021[1].

Companies and workers who have implemented remote work have discovered its advantages, which generate the incentives to sustain it beyond the times when it was a resource to overcome the labor limitations of confinement. Telework presented workers with several benefits, such as reduced mobility, clothing, and time costs. According to Kahneman and Krueger (2006), going to work is one of the least pleasant daily activities, so, reducing or eliminating it can improve the happiness and well-being of workers and their productivity (Oswald et al., 2015). However, it must consider that the lack of virtual disconnection from the office sometimes led to longer working hours. For companies, remote work reduces costs associated with facility use, such as rent, utilities, energy, and cleaning expenses, although it requires some investments in computers and other equipment for teleworkers. Moreover, companies can benefit from the geographical flexibility of remote work, allowing them to efficiently fill positions and promoting their growth.

However, different economic activities and jobs have varying degrees of ability to adapt and capitalize on the potential benefits of telework. According to Dingel and Neiman's (2020) estimates, only 37% of employed people in the United States were able to work remotely, with significant differences between economic sectors and cities. For Argentina, Bonavida Foschiatti and Gasparini (2020) found that 26% of employed individuals could perform their work remotely. The literature generally highlights that several factors affect the feasibility of telework. These include the nature of tasks and activities associated with each occupation, which depends on the educational level and training of individuals and the work environment or context. The availability of Information and Communication Technologies (ICT) infrastructure, the proficiency of individuals in using these technologies, the level of autonomy in their occupations, the degree of digitalization of the company's processes, and the company's perspective on remote work, also matters.

Theoretically, teleworking could affect income through various channels, such as productivity or compensation schemes. This effect may differ among workers depending on the type of task, degree of autonomy of the job, worker's concentration, motivations, among other worker´s traits (Bloom et al., 2015). Thus, the impact of teleworking on wages is a question that can only be answered empirically. Previous research on the impact of teleworking on wages in the U.S. has yielded mixed results. The studies differ in their definition of teleworkers, with some including those who take some work to their home and others focusing solely on home-based teleworkers. Most of these studies are based on cross-sectional data and do not control for selection effects (Pabilonia & Vernon, 2022).

Hence, the incorporation of telework into conventional labor markets is likely to present social, productive, and distributive challenges, given its strong connection with knowledge-intensive tasks and particularly with ICT which enhance the productivity and wages of those who can benefit from its advantages, potentially enhancing income inequality. The latter has not been studied by the literature mentioned above. Given that, a question that naturally arises is how the expansion of remote work would affect labor income distribution. Therefore, this study aims to estimate the distributional effects of telework on the labor income of employed individuals in some South American countries.

For this purpose, we use microdata from household surveys on the period 2021 onwards, to filter teleworking variables from temporary changes in the labor market caused by tighter restrictions on mobility during the pandemic. While in some countries we can measure effective telework, in others we approximate it based on a set of conditions that are required for teleworking. Then, we estimate how a marginal variation in the percentage of teleworkers affects not only the mean of labor income, but also other features of the unconditional distribution, such us the quantiles and some inequality indicators (Gini and Atkinson indexes). This analysis allows us to capture potential asymmetric effects of remote work across the entire unconditional income distribution. As empirical strategy, we employ the Recentered Influence Function (RIF) regression approach of Firpo et al. (2009).

[1] Flash Datos de Teletrabajo 2022 | Ontsi - Red.es.

Our study contributes, on one hand, to the literature on telework measurement by proposing approximate measures for the different South American countries included in this work. Based on the telework definition provided by the ILO (2022), we identified and harmonized variables from household surveys to construct an almost telework variable in those countries where it is not directly measured. Furthermore, since these measures are based on data regularly collected by national statistical institutes, they will allow for tracking the evolution of this employment modality over time. On the other hand, our study contributes to the literature on the analysis and measurement of the distributive impact of remote work by estimating the effect of increased telework participation on the labor income distribution in a region historically characterized by high levels of inequality.

The main results show that a marginal variation in the percentage of remote workers has a positive effect on the average labor income but with asymmetries across the income distribution that could led to an increase in inequality. Indeed, for most countries, high-income workers benefit the more from a deeper teleworking penetration. Furthermore, this result is also supported by our estimates of the effect of teleworking on Gini and Atkinson inequality indexes.

The paper is structured as follows: Section 2 reviews the literature; Section 3 defines the measures of telework and the sources of information used; Section 4 explains the methodology adopted to quantify the distributional impact of telework on labor income; Section 5 presents the analysis of the main results; Section 6 presents the concluding remarks.

2. Literature review

2.1. Theoretical background

From a theoretical perspective, telework can influence the earnings of workers through various channels. Firstly, the effect on worker productivity stands out. When working from home, commutes to the office and other activities that employees find unpleasant are avoided (Kahneman et al., 2004; Kahneman & Krueger, 2006), allowing them to allocate their time to more enjoyable activities, like resting or spending more time with their family. A better balance between work and family positively impacts worker happiness and well-being, thereby increasing productivity (Clark et al., 2019; Oswald et al., 2015). Additionally, flexibility regarding the workplace could allow workers to find a better work environment, particularly for tasks requiring prolonged concentration, by reducing interruptions that occur in the office and unforeseen absences. Consequently, this could increase their network time and, consequently, their productivity (Bloom et al., 2015).

However, telecommuting could also have a negative impact on worker productivity. Depending on individuals' autonomy levels and motivations, the lack of direct supervision while implementing remote work could lead to neglect of tasks. Moreover, isolation resulting from the lack of personal contact with office colleagues and increased stress due to the inability to separate work and family responsibilities could worsen workers' mental health and hence their performance (Taskin & Bridou, 2010; Rockmann & Pratt, 2015).

An additional factor influencing the effects of telework on productivity, not considered in the previous analysis, is its intensity or frequency of implementation. For instance, a person engaging in full-time remote work might experience more isolation than someone who attends the office a few days a week. Thus, as telecommuting intensity increases, productivity losses might outweigh gains, ultimately reducing total productivity. This suggests a "U"-shaped relationship between productivity and telecommuting intensity (Criscuolo et al., 2023). Therefore, if telecommuting is voluntary and workers can decide its frequency, it's expected that they and companies will opt for an intensity where gains surpass costs, maximizing productivity. Behrens et al. (2021) use a general equilibrium model to analyze the relationship between telecommuting intensity and productivity, finding that, given current technology, productivity is maximized when working remotely one to two days a week.

Secondly, telecommuting could affect wage earners' incomes if companies, aiming to maximize profits, introduce compensation schemes that incentivize or penalize the adoption of remote work by their employees. Depending on supervision and coordination costs, companies' ability to measure employee work outcomes, and task autonomy levels, a higher telecommuting percentage could enable companies to reduce costs associated with facility use. Furthermore, if telecommuting leads to higher job satisfaction, employee turnover rates could decrease, resulting in savings in hiring and training costs for new personnel (Bloom et al., 2015; Criscuolo et al., 2023). Thus, companies would offer rewards to workers for adopting remote work, regardless of their productivity, as both parties would benefit.

However, companies could also penalize remote work. They might perceive an employee's adoption of telework as a sign of reduced commitment to the job (Bourdeau et al., 2019). This could affect their chances of promotion within the company and their income trajectory (Rhee, 2008; Bloom et al., 2015; Glass & Noonan, 2016; Emanuel & Harrington, 2021). On the other hand, companies could view telecommuting as reducing the flow of knowledge and information among employees, weakening the rate of human capital accumulation and the company's future growth, leading them to promote in-person work (Battiston et al., 2017; Behrens et al., 2021).

Thirdly, telecommuting could also affect employees' incomes in terms of their valuation of remote work due to the mentioned benefits (better work-life balance, reduced commuting costs, etc.), and their willingness to voluntarily give up a portion of their income to sustain it, even when the company doesn't provide any incentives/penalties related to telecommuting. By saving some costs associated with commuting (like travel and meal preparation costs, for example), the employee would offset a part of the lost monetary income while gaining non-monetary compensation due to the improved work-life balance.

Thus, the arguments for and against telework suggest that, theoretically, the effects are ambiguous, depending on additional factors such as the intensity of teleworking adopted, the type of industry and tasks that do workers, personal motivations, and available ICT infrastructure.

2.2. Empirical background

The literature on potential teleworks driven by the COVID-19 pandemic provides evidence on the difficulties of adapting to remote work. Dingel and Neiman's (2020) influential work defined potential telework as the percentage of employed individuals who could work remotely based on their occupation and work context. Using the O*NET survey, they found that 37% of employed individuals in the United States could adapt to remote work, with variations across industries and regions. Similarly, Bonavida Foschiatti and Gasparini (2020) estimated that 26% of employed individuals in urban agglomerates in Argentina could telework using a comparable methodology.

Besides the task characteristics and work context of each occupation, there are various other factors that impact the feasibility of telework, such as the quality and accessibility of ICT infrastructure, digital skills of workers, degree of occupational autonomy, size, and level of digitization of firms, and work organization (Milasi et al., 2020; Weller, 2020). As a result, studies that rely solely on task characteristics to define telework, which constitute the majority in the literature, may only represent an upper bound of potential telework.

Some authors, such as Garrote Sanchez et al. (2020), Albrieu (2020), and Schteingart et al. (2021), incorporate access to ICT and computer technology as additional factors that affect the feasibility of telework. Garrote Sánchez et al. (2020) find that estimates of potential telework based solely on task characteristics overestimate the capacity for remote work in low-income countries by 2.9 times on average when compared to estimates that incorporate ICT access. The overestimation factor is lower in high-income countries (1.1 times). Similarly, Albrieu (2020) finds that accounting for internet and computer access decreases potential telework from 27-29% to 25% and 18%, respectively, at the local level. In the United States, Chiou and Tucker (2020) show that high internet connection speeds correlate with better compliance with confinement measures and likely affect the ability to perform remote work and the complexity of tasks that can be performed remotely.

Aside from the factors that make remote work possible, estimating potential telework in developing countries using the task composition of high-income countries is also not free of bias, since the characterization of tasks in an occupation differs according to the country's level of development (Lewandosky, Park, Hardy, and Du, 2019). To remedy this bias, some papers (de la Vega, 2021; Gottlieb *et al.*, 2021) resort to surveys on the characteristics of tasks representative of a set of developing countries[2], finding that the ability to adapt to telework results lower than that estimated based on the composition of tasks in developed

[2] Among the main surveys used, the following can be mentioned: Living Standards Measurement Study (LMSM - World Bank); Skills Toward Employability and Productivity (STEP - World Bank); Labor Force Surveys (LFS - International Labour Organization); Program for the International Assessment of Adult Competencies (PIAAC - OECD).

countries. Saltiel *et al*. (2020), for example, uses the STEP survey and shows that potential telework is lower in 93% of occupations than estimated using O*NET over the United States. De la Vega (2021) shows that the estimates of potential telework for Argentina from O*NET are higher than those obtained with other surveys more in line with the level of development of the country in those occupations that exceed 20% of potential telework but are lower in those below that level.

This study is closely related to research on the economic and distributive consequences of telecommuting, which also gained significant momentum with the COVID-19 pandemic. Regardless of the approach taken, measuring the potential of teleworking was critical in the context of the pandemic, as it served as an essential first step in analyzing the economic and distributional impacts of lockdown measures. In this sense, several studies use measures of potential telework to examine the differences in the adaptability to remote work between occupations, economic activities, regions, and countries (Dingel & Neiman, 2020; Gottlieb et al., 2020; Garrote Sanchez et al., 2020; Adams-Prassl et al., 2020; de la Vega, 2021).

These qualitative studies find that potential telework varies significantly between economic activities and occupations, and within occupations, with higher income and education levels having greater feasibility for telework. Furthermore, potential telework is positively correlated with a country's per capita income, with developing countries having lower potential telework due to a higher rate of self-employment and less use of ICT-intensive tasks. Therefore, teleworking can help alleviate the effects of isolation in a pandemic context, but it can also generate unequal distributional effects within and between countries.

Despite the obvious interest in the distributional impact of isolation measures, few studies have analyzed the effects of quarantine on income inequality. In this line, we can mention the contributions of Palomino et al. (2020) and Bonavida Foschiatti and Gasparini (2020), which simulate different scenarios regarding the duration of isolation and measure the distributional effect on labor income inequality. Palomino *et al*. (2020) study the distributional effects in European Union member countries and find that the Gini Coefficient would increase between 0.7 and 4.2 points according to the extent and severity of the quarantine and the country analyzed. Bonavida Foschiatti and Gasparini (2020) estimate a similar relationship between isolation measures and the distribution of labor income in Argentina. For example, they estimate that the Gini Coefficient would increase from 4.0 to 10.0 points approximately depending on the duration of quarantine. It should be noted that these papers employ measures of potential telework based on the task approach, although they perform several robustness exercises considering the essential activities (not affected by the isolation measures) and the place where people work, which do not invalidate the main conclusions.

For their part, Irlacher and Koch (2020) perform a Mincer regression to assess income differences between teleworkers and face-to-face employees in Germany with potential telework data from surveys and find a premium for performing remote work of about 10%. In turn, using quantile regression they estimate that the return to telework increases as the conditional quantile of labor income increases. Varvello et al. (2022) employ household surveys to obtain various approximations of remote work in Argentina, and using two RIF regression approaches, they estimate the effects of remote work across the entire unconditional income distribution. They find that a marginal increase in the telecommuting rate raises the inequality of labor incomes as measured by different standard inequality indicators.

Our study contributes, on one hand, to the literature on telecommuting measurement by proposing approximate measures for some South American countries. Based on the telecommuting definition provided by the ILO (2021), we identified and harmonized variables from household surveys to construct an approximate telecommuting variable in those countries where it is not directly measured. Furthermore, since these measures are based on data regularly collected by national statistical institutes, they will allow for tracking the evolution of this employment modality over time. On the other hand, our study contributes to the literature on the analysis and measurement of the distributive impact of telecommuting by estimating the effect of increased telecommuting participation on the distribution of labor incomes in a region historically characterized by high levels of inequality.

3. Telework data and measurement

3.1. Difficulties in measuring telework through household surveys

According to the definition provided by the ILO (2022), telework refers to employees who, on a permanent basis, carry out their tasks in a location different from the employer's premises, and through the use of ICT. This definition excludes independent workers, those who sporadically work from home, and home-based workers who do not use ICT. Consequently, its accurate measurement is not straightforward as it requires the identification of various factors (Maurizio, 2021).

Firstly, it's necessary to determine whether the worker is a remote worker or a home-based worker, which requires distinguishing between the default place of work and the actual place where tasks are performed. This distinction seems relatively simpler for employees, as the employer's premises can be considered their default workplace. However, it's more complex for self-employed workers who lack this clear distinction. Hence, remote work and telework are typically defined for employees.

Secondly, it's essential to identify the worker's use of ICT and associate it with work related tasks. In other words, a remote worker who uses ICT for non-work purposes would not fall under the telecommuting category. Thirdly, an additional factor to consider relates to the frequency of telework, as it could be someone who engages in remote work only sporadically.

On the other hand, a subset of telework falls under another employment category known as home-based work. Household surveys typically conducted by national statistical institutes collect data for this category. Home-based work encompasses all workers (employees, self-employed, employers) who routinely carry out their tasks from their homes, irrespective of the default place of work.

3.2. Data used and criteria adopted

We use microdata from the latest available household surveys for the following countries: Argentina (*Encuesta Permanente de Hogares* and *Módulo de Acceso y Uso de Tecnologías de la Información y la Comunicación*, fourth quarter of 2022), Brazil (*Pesquisa Nacional por Amostra de Domicílios Contínua*, fourth quarter of 2021), Colombia (*Encuesta Nacional de Calidad de Vida*, 2021), Ecuador (*Encuesta Nacional de Empleo, Desempleo y Subempleo,* July 2022), Peru (*Encuesta Nacional de Hogares*, first semester of 2022), and Uruguay (*Encuesta Continua de Hogares*, 2022).[3] We focus on the period 2021 onwards to filter teleworking variables from temporary changes in the labor market caused by tighter restrictions on mobility during the pandemic. Considering country-specific data limitations, for each of them we use the time period that most closely resembles the annual period.

We consider teleworkers as those who are home-based workers and use ICT for their work tasks, including both employees and independent workers. While in some countries we can measure effective telework, in others we approximate it based on a set of conditions that are required for teleworking. In this sense, we distinguish between “real teleworkers”, defined as individuals who are explicitly asked if they currently or have previously engaged in telework, and “almost teleworkers”, that is, individuals who are not exactly identified as teleworkers, but who declare working from home and using ICT. Due to data limitations, in some countries the use of ICT is tied to work tasks, while in others it is not. Table A1 (Appendix) summarize how we constructed teleworking variable for each country.

To conclude this section, descriptive statistics are presented for workers in each country regarding their participation in telecommuting, socioeconomic variables used as controls in regressions, and labor income inequality.

As seen in Table 1, the percentage of workers engaged in telecommuting is similar across the studied countries, ranging from 3.1% in Brazil to 3.6% in Peru.

Regarding the socioeconomic variables used as controls, there is a substantial heterogeneity among the analyzed countries, reflecting the diverse productive and social structures of the region. For instance, Brazil and Uruguay exhibit a high percentage of workers who have not completed primary or secondary education, while in the other countries over 45% of workers have completed at least secondary education.

[3] In the case of Uruguay, we only use the implementation databases provided by the national statistics institute.

Furthermore, Argentina, Brazil, and Uruguay are characterized by wage employment, whereas Colombia, Ecuador, and Peru have a significant share of self-employment. The distribution by economic sectors also demonstrates variations between these groups of countries, with the former showing notable involvement in the service sector and the latter having a strong presence of primary activities. Lastly, the level of formality/informality among wage earners also differs among the analyzed countries. Colombia, Ecuador, and Peru display visibly higher levels of informality compared to Argentina, Brazil, and Uruguay.

Table 1 also shows indicators of household labor income inequality. Looking at the Gini coefficient, it's evident that the degree of inequality varies relatively little among the countries, ranging from 0.42 in Peru to 0.53 in Brazil. The Atkinson indicators present a similar picture, maintaining the country ranking, except for the Atkinson index with ε = 2, which, by using a more egalitarian welfare function, Peru is ranked as the country with the highest level of inequality.

Table 1

Descriptive statistics of the employed and indicators of inequality of labor income

	Argentina	Brazil	Colombia	Ecuador	Peru	Uruguay
Teleworking distribution (%)						
Face-to-face worker	96,7	96,9	96,8	96,8	96,4	96,7
Teleworker	3,3	3,1	3,2	3,2	3,6	3,3
Gender distribution (%)						
Female	52,5	51,5	35,0	44,7	52,1	53,5
Male	47,5	48,5	65,0	55,3	47,9	46,5
Educational level distribution (%)						
No education	3,6	9,7	6,2	1,9	5,7	6,8
Incomplete primary education	15,0	37,5	0,1	7,1	13,2	12,8
Complete primary education	12,1	7,8	17,7	20,4	11,5	15,2
Incomplete secondary education	21,6	7,0	19,1	12,9	17,4	37,3
Complete secondary education	21,5	23,0	31,5	29,7	25,8	8,3
Incomplete tertiary/university education	12,2	3,8	1,8	8,1	10,4	9,1
Complete tertiary/university education	14,1	11,2	23,5	19,8	16,2	10,5
Occupational category distribution (%)						
Employee	75,0	65,1	39,9	55,1	46,7	70,2
Self-employed	21,5	30,8	58,3	41,2	49,2	25,8
Employer	3,5	4,1	1,8	3,7	4,1	4,0
Economic sector distribution (%)						
Primary Activities	1,9	16,6	32,2	25,8	41,0	9,3
Trade	17,9	18,0	16,6	20,1	17,2	16,6
Construction	10,2	7,4	7,0	5,4	5,2	6,9
Manufacturing industry	10,3	11,2	6,4	10,4	6,5	9,6
Services	59,7	46,8	37,7	38,3	30,1	57,6
Type of company/institution distribution (%)						
Private	76,2	79,4	94,8	90,7	79,1	84,2
Public	23,8	20,6	5,2	9,3	20,9	15,8
Formality distribution (%)						
Formal worker	67,5	60,5	25,0	34,4	19,4	76,5
Informal worker	32,5	39,5	75,1	65,6	80,6	23,5
Average age (in years)	37,5	36,9	41,5	42,5	42,2	41,0
Number of observations	46.460	461.795	102.960	14.421	41.252	55.056
Income inequality indicators *						
Gini	0,45	0,53	0,50	0,47	0,42	0,46
A(.5)	0,17	0,24	0,21	0,18	0,15	0,17
A(1)	0,32	0,41	0,37	0,33	0,29	0,34
A(2)	0,63	0,66	0,63	0,59	0,67	0,72

Source: own elaboration based on data from household surveys.

Note: statistics marked with an (*) were obtained from the SEDLAC - CEDLAS database.

4. Methodology

Traditional linear models, estimated through Ordinary Least Squares (OLS), are useful for measuring the effect of a given regressor on the expected or mean value of a response variable Y, conditional on a vector of K explanatory variables $\mathbf{X}$. In a model without interactions, given that $\frac{\partial E[Y_i|\mathbf{X}_i]}{\partial X_{ki}} = \beta_k$, this coefficient measures the effect of a unit increase of the k-th regressor on the conditional expectation of Y_i.[4] However, this effect can also be extrapolated to the unconditional expectation of the dependent variable by applying the Law of Iterated Expectations (LIE), which allows us to express the unconditional expected value of Y_i as an average of the conditional expectations. Thus, it is obtained that $\frac{\partial E[Y_i]}{\partial E[X_{ki}]} = \beta_k$, which implies that this coefficient also measures the effect of a unit increase in the unconditional mean of X_{ki} on the unconditional expectation of Y_i.[5] In short, in a model with these characteristics estimated by OLS, the beta coefficients play a double role, since they measure the effects of the regressors on the conditional and unconditional expectation of the response variable. This interpretation is the same regardless of whether the regressor of interest is a continuous or discrete variable.

However, OLS estimates are not necessarily an adequate summary of the impact of a regressor on different distributional statistics of Y_i, such as quantiles or different inequality indicators. For this purpose, the use of other econometric techniques is required. Among them, RIF regressions (Firpo et al., 2009) allow us to quantify the effect of a marginal increase in telework on different distributional statistics. In a practical sense, a marginal increase in telework is a "small" increase in the percentage of teleworkers, for example, an increase of 1 percentage point (p.p.) or 10 p.p., which are small changes compared to the maximum possible variation of 100 p.p.

RIF regressions are based on the concept of "influence function" (IF) introduced by Hampel (1968, 1974). Following Rios-Avila and Maroto (2022), consider the cumulative distribution function (CDF) of the random variable Y, denoted F_Y. Any distributional statistic v (such as mean, variance, τ-quantile, Gini coefficient, etc.), mathematically is a functional that collapses the information of the CDF of Y into a single scalar that summarizes some distributional characteristic, i.e., $v_{F_Y} = v(F_Y)$. If a new observation with value y_i is added to the population, both F_Y as $v(F_Y)$ will be modified, with the IF being the function that measures the influence -as a rate of change- that this observation has on the distributional statistic of interest.

To see the above more clearly, let's assume that F_Y corresponds to a population of size N and that G_Y is the CDF that arises from incorporating a new observation, so that the population is now of size $N + 1$. This new distribution function can be written as a convex combination between F_Y and $I[y \geq y_i]$, the latter being an indicator function that assumes the value 1 if the expression in square brackets is true and 0 otherwise.[6] The weights are, respectively, $\frac{N}{N+1}$ and $\frac{1}{N+1}$, hence:

$$G_Y = \frac{N}{N+1} F_Y + \frac{1}{N+1} I[y \geq y_i]$$

Let v_{F_Y} and v_{G_Y} be distributional statistics corresponding to the distribution functions F_Y and G_Y, respectively, and let $\epsilon = \frac{1}{N+1}$ a measure of the relative change in population size.[7] Then, the change in v normalized by that relative change is $\frac{v_{G_Y} - v_{F_Y}}{\epsilon} = \frac{v((1-\epsilon)F_Y + \epsilon I[y \geq y_i]) - v(F_Y)}{\epsilon}$. Taking the limit of this ratio when $\epsilon \downarrow 0$, we obtain the influence function of the observation i on the statistic v as a directional derivative:

$$IF(y_i, v, F_Y) \equiv \lim_{\epsilon \downarrow 0} \frac{v((1-\epsilon)F_Y + \epsilon I[y \geq y_i]) - v(F_Y)}{\epsilon}$$

In this way, $IF(y_i, v, F_Y)$ is a first-order linear approximation of the relative influence of observation i on the statistic v. [8]

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[4] Under some additional assumptions about the error term, β_k measures the marginal effect of X_{ki} on Y_i. That is, the coefficient quantifies the impact at the individual level. See Rios-Avila and Maroto (2022).

[5] It is also possible to think of a β_k as the conditional and unconditional mean of the individual effects $\frac{\partial Y_i}{\partial X_{ki}}$ (Rios-Avila and Maroto, 2022).

[6] In other words, $I[y \geq y_i]$ it is a CDF with probability mass 1 in the value of y_i (Rios-Avila, 2020).

[7] Note that $\epsilon = \left|\frac{N-(N+1)}{N+1}\right|$.

[8] See Firpo *et al.* (2009), and Huber and Ronchetti (2009) for a formal discussion.

Firpo *et al.* (2009) propose using the "recentered influence function" (RIF) as a basis for estimating the effect of a marginal shift in the distribution of a regressor X_k on a statistic of interest v of the CDF of Y. The RIF is equivalent to the first two terms of von Mises (1947) linear approximation for the corresponding v:

$$RIF(y_i, v, F_Y) \equiv v(F_Y) + IF(y_i, v, F_Y)$$

This function can be obtained analytically for various distributional statistics, including quantiles, interquantile ratios, inequality indicators (such as the Gini and Atkinson indexes), among others.[9] An important property of the RIF is that its expected value is equal to the corresponding statistic of interest: $E[RIF(y_i, v, F_Y)] = v(F_Y)$. In turn, the LIE allows us to take into account the effect of a vector of regressors $\mathbf{X}$, because $v(F_Y)$ can be expressed in terms of the conditional expectation of the RIF: $v(F_Y) = E\big[E[RIF(y_i, v, F_Y)|\mathbf{X} = \mathbf{x}]\big]$.

Suppose that the vector $\mathbf{X}$ is composed of K continuous regressors and that the distribution of X_k undergoes a marginal shift of magnitude t, giving rise to the counterfactual distribution $F^*_{Y,t}$ for the variable Y. Firpo *et al.* (2009) define mathematically the "unconditional partial effect" (UPE) of the regressor X_k as $UPE_k \equiv \lim_{t \downarrow 0} \frac{v_{F^*_{Y,t}} - v_{F_Y}}{\epsilon}$, which measures the impact of a marginal shift of the distribution of X_k on the statistic v of the unconditional distribution of Y, *ceteris paribus*. The authors show that this effect can be calculated as an average derivative:

$$UPE_k = \int \frac{\partial E[RIF(y_i, v, F_Y)|\mathbf{X} = \mathbf{x}]}{\partial x_k} dF_{\mathbf{X}}$$

where $dF_{\mathbf{X}} = f_{\mathbf{X}}(\mathbf{x})d\mathbf{x}$. Note that the calculation of the UPE requires modeling $E[RIF(y_i, v, F_Y)|\mathbf{X} = \mathbf{x}]$. The proposal of Firpo *et al.* (2009) is to model this conditional expectation as a linear function of $\mathbf{X}$, which would allow it to be easily estimated by OLS.[10] If the model does not include interactions, it is clear that $UPE_k = \beta_k$, which shows that the UPE can be recovered from a regression model estimated by OLS, in which the RIF (corresponding to a certain distributional statistic of interest) is the dependent variable.

On the other hand, when X_k is binary and can only take values 0 or 1, the marginal shift that leads to the UPE_k should be considered as a small increase in the probability $P_{X_k} \equiv P[X_k = 1]$ (Firpo, Fortin and Lemieux, 2007). If we denote with T to this binary variable and with $\mathbf{Z}$ the rest of the regressors of the vector $\mathbf{X}$, the corresponding UPE is calculated as:

$$UPE_T = E[RIF(y_i, v, F_Y)|T = 1, \mathbf{Z} = \mathbf{z}] - E[RIF(y_i, v, F_Y)|T = 0, \mathbf{Z} = \mathbf{z}]$$

Again, if we assume that the conditional expectation of the RIF is linear in $\mathbf{X}$, we have that $UPE_T = \beta_T$. This coefficient measures the impact on v_{F_Y} due to a marginal increase in the proportion of observations with a value of 1 in T, *ceteris paribus*.

In this paper, the following family of RIF models for a set of statistics will be estimated by OLS:

$$RIF(y_i, v, F_Y) = \alpha + \mathbf{X}_i\boldsymbol{\beta} + u_i$$

The dependent variable is the RIF corresponding to the statistic v from the unconditional distribution of the hourly labor income (main occupation). The statistics of interest are the mean and 0.1, 0.15, ..., 0.9 quantiles, as well as Gini and Atkinson indexes (the latter with $\varepsilon = 0.5$, $\varepsilon = 1$ and $\varepsilon = 2$).[11] The natural logarithm of income is used for the RIF modeling of the mean and quantiles, while income without transformations is used for the inequality indicators.

The vector $\mathbf{X}_i$ includes the explanatory variable of interest (binary variable of telework) and a set of controls. These comprise the individual's age and age squared and a set of binary variables for: sex, aggregate sectors of activity (Primary Activities, Trade, Construction, Manufacturing Industry, Services)[12], geographical area, type of company/institution of the

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[9] See Firpo *et al.* (2009) and Rios-Avila (2020).

[10] However, modeling the conditional expectation of the RIF as a linear function of $\mathbf{X}$ should be considered as an approximation to a potentially nonlinear function, which may not be appropriate for describing the marginal effects of the regressors (Alejo, Favata, Montes-Rojas and Trombretta, 2021).

[11] The Atkinson index (A) is based on the theory of social welfare functions. It is an indicator that varies between 0 and 1 and is defined as follows $A = 1 - \frac{x^*}{\mu}$ where x^* is the "equally distributed income", defined as that which, allocated to all individuals, generates the same social welfare W as the observed distribution of income: $W(x_1, x_2, \dots, x_N) = W(x^*, x^*, \dots, x^*)$. Atkinson (1970) recommends using a function of type CES: $W = \frac{1}{N}\sum_{i=1}^{N} \frac{x_i^{1-\varepsilon}}{1-\varepsilon}$ in which the parameter ε allows to regulate the "inequality aversion": the higher its value, the more importance is given to transfers at the lower part of the distribution. In empirical applications ε it is usually chosen in the range (0,2] (Gasparini et al., 2012).

[12] The Primary Activities sector includes: Agriculture, livestock, hunting and forestry; Fishing and related services; Mining and quarrying. The Trade sector includes: Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods. The Services sector includes: Electricity, Gas, Steam and Air

main occupation (public, private), educational level (no education, and six levels corresponding to incomplete/completed primary, secondary and university education), occupational category (employee, self-employed, employer) and formality (formal, informal).[13]

The parameter of interest is the β_k corresponding to the binary telework variable, which measures the impact of a marginal increase in the percentage of teleworkers on the labor income distributional statistic v. On the other hand, α is the constant of the model. Robust standard errors are used.

5. Results

Figure 1 shows the effect of a marginal increase in the percentage of teleworkers on the mean and quantiles of the unconditional labor income distribution. For the mean, these effects are positive in all countries, which implies that a marginal increase in the rate of teleworkers raises the labor income (on average), although for some cases the results are not statistically significant at 95% confidence level. Also, the estimates are very heterogeneous between countries. For example, a 1 p.p. increase in the percentage of teleworkers raises mean income by 0.07% in Ecuador, but this effect is nearly five times higher in Peru (0.33%). Since these estimates are obtained from a RIF regression that simply models the mean of the dependent variable (i.e., a traditional OLS regression), if we multiply the values by 100, we approximate the average income gap between teleworkers and face-to-face workers. For instance, we can say that a teleworker has a labor income 7% higher, on average, compared to a face-to-face worker with the same observable characteristics.

Although these estimates could be an adequate summary of the average marginal effect of teleworking on labor income, they are not necessarily representative of what is happening at other points in the distribution. Indeed, Figure 1 suggests that there is an asymmetry in the impact of teleworking across quantiles, which is more noticeable in Brazil, Colombia, and Peru. Furthermore, for most countries the effect of teleworking tends to increase along the income distribution. For example, in Brazil, a 1 p.p. increase in the rate of teleworkers expands median income by about 0.12%, while the ninth decile grows 0.88%. As noted in the Section 4, these values are valid for small changes in the percentage of teleworkers; for example, we could say that a 10 p.p. increase in this rate expands Brazilian median income by 1.2%, but we cannot state that the "median income gap" between teleworkers and face-to-face workers is 12%, since the latter would imply a large change in the teleworking variable distribution.

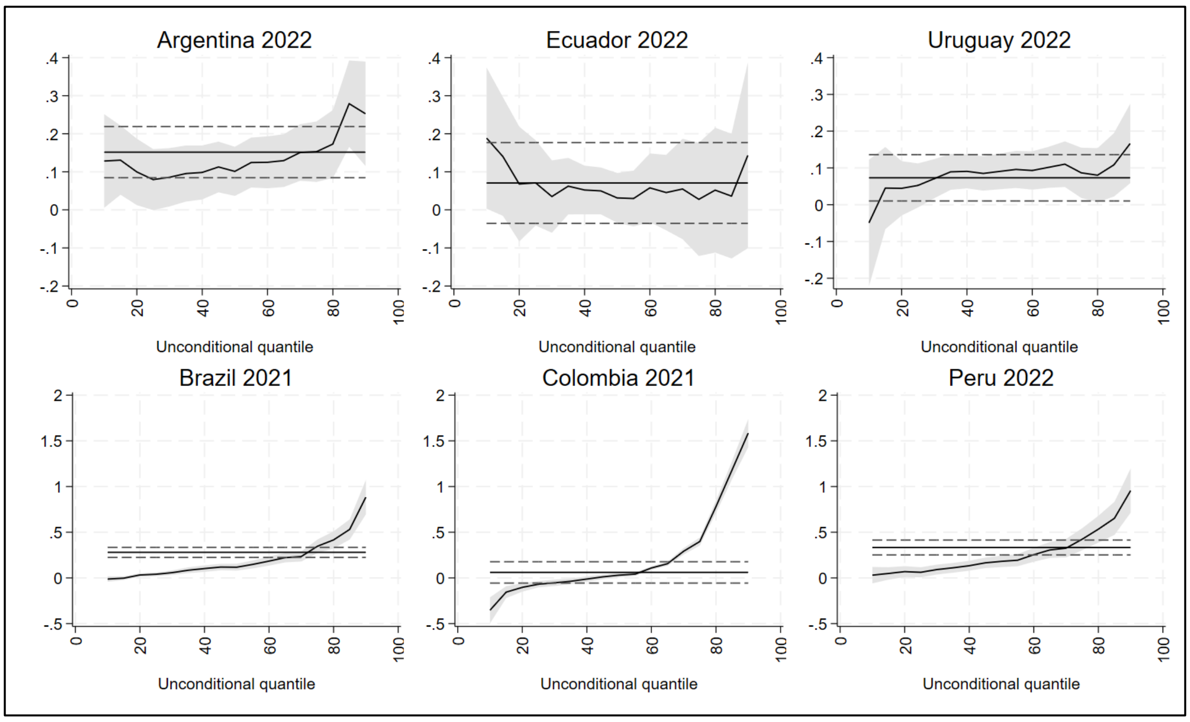
These patterns in the effect of teleworking have an important implication for the labor income distribution: since the higher deciles grow at a higher rate than the lower deciles, we can expect that a marginal increase in the percentage of teleworkers makes income distribution more unequal. In addition, it is interesting to note this increase in the marginal effect of teleworking across quantiles tends to be stronger in the upper part of the distribution. Beyond these general patterns, we detect some additional specificities in our results. On the one hand, Ecuador seems to be a particular case, since the effect of teleworking is similar for most quantiles, except at the lower part of the distribution, where the impact is above the average effect. Hence, in this country, teleworking seems to benefit low-income workers the most. On the other hand, in some specific countries, teleworking has a zero or even a negative effect on lower income quantiles. In these cases, we can expect a stronger unequalizing effect on labor income distribution, since low-income workers would not benefit or would even suffer a drop in income from an increase in the percentage of teleworkers.

Conditioning Supply; Water Supply, Sewerage, Waste Management and Sanitation Activities; Transportation and Warehousing; Accommodation and Food Services; Information and Communication; Financial and Insurance Activities; Real Estate Activities; Professional, Scientific and Technical Activities; Administrative and Support Service Activities; Public Administration and Defense; Compulsory Social Security Schemes; Education; Human Health and Social Services; Arts, Entertainment and Recreation; Other Service Activities.

[13] The following procedure was used to construct the formality variable. If there is a variable in the household survey that explicitly indicates whether an individual has a formal job, this variable is used, which is the case in Brazil and Peru. In the rest of the countries, formality is approximated by a variable indicating whether the individual contributes to any health or old age insurance. By applying these rules, the formality variable is defined for all occupational categories in all countries, with the exception of Brazil, for which formality is defined only for employees.

Figure 1

Effect of a marginal increase in the percentage of teleworkers across the income distribution.



Source: own elaboration based on data from household surveys.

Note: estimates show the percent change in hourly income labor due to an increase of 1 p.p. in the share of teleworkers. Solid horizontal line shows the effect of telework on the mean. Shaded areas and dotted lines show 95% confidence intervals with robust standard errors.

What unobservable factors could explain the heterogeneous effect of a marginal increase in telework on the distribution of labor income? First, we focus our attention on the middle and upper quantiles, where there are individuals with a higher probability of being teleworkers. As noted in the literature review, theoretically the effect of telework on labor income is ambiguous and even its magnitude may vary across individuals. One might think that workers located at the middle part of income distribution face greater difficulties in taking advantage of the economic benefits of teleworking compared with richer individuals, due to the type of task they perform or to their home's infrastructure in terms of ICT access and workspaces. This situation could occur if working from home increases the number of interruptions to the teleworker due to stress or difficulties in separating work from family responsibilities, or if not being monitored by a supervisor decreases the effort expended, affecting worker's total output. Telework may also increase the number of work hours required to achieve a certain output, affecting productivity. Hence, these individuals will probably not be able to capitalize on all the benefits of teleworking because their average product of labor (proxy measure of productivity) does not increase so much. On the contrary, high-income individuals could increase their productivity by teleworking, for not being affected by those constraints.

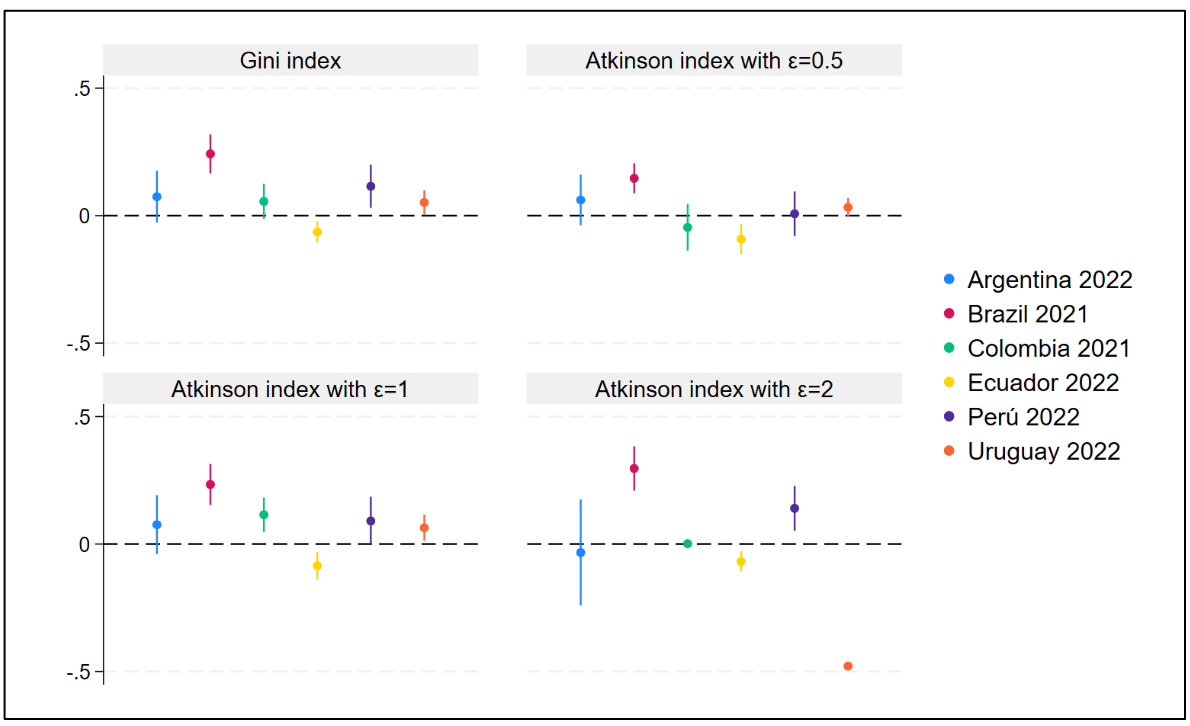
On the other hand, compensation schemes could also affect wages, for example, if companies penalize teleworking so that workers have physical contact that favors the exchange of knowledge and networking, or if workers voluntarily are willing to accept a lower income in order to continue teleworking. But, companies could also compensates teleworkers for their favorable impacts in reducing office costs. Indeed, it is likely that this channel reinforces the positive effects on productivity for high-income workers, which could explain why we found that the effect of teleworking increases rapidly in the upper part of the income distribution.

If we focus on low-income workers, for most countries it is hard to think that these individuals can effectively telework, due to the type of task they do. This restriction can explain why in some countries like Brazil and Peru the remunerations of low-income individuals are unchanged when the rate of teleworkers increases. But what explains the negative effects of teleworking found in the lower quantiles of Uruguay and Colombia? Our hypothesis is that a greater penetration of teleworking reduces some labor demands, like domestic service and in-office food service since these tasks could be performed by the teleworkers themselves in their homes. Given that workers that perform those activities usually locate at the lower part of income distribution, the fall in their remunerations could explain the negative effects found in the lower quantiles.

While the increasing trend of teleworking marginal effects across the income distribution provides a general idea of what is happening to labor income inequality, it is more precise to estimate these effects on some inequality indicators commonly used in the literature, such as the Gini coefficient and the Atkinson index (Figure 2). In doing that, we observe that teleworking is associated with an increase in most income inequality indicators, a result that is consistent with our previous findings shown in Figure 1. Again, the only exception is Ecuador, for which an increase in the percentage of teleworkers reduces all inequality indicators, since teleworking produces a stronger increase in the wage of low-income workers. However, we detect some differences in the marginal effect of teleworking across countries. For example, a 1 p.p. increase in the rate of teleworkers is associated with an increase of about 0.25 points in the Gini index of Brazil, measuring this index in a scale from 0 to 100, but this marginal effect is reduced to 0.05 points in Colombia and Uruguay. On the other hand, we also found mixed results when we adopt quasi-rawlsian preferences in the social welfare function (Atkinson index with $\varepsilon = 2$), since for some countries like Argentina and Colombia income inequality does not change, while for Uruguay it decreases. In the latter case, the Atkinson index falls since most quantiles grow at a higher rate than the mean, which reduces the index when $\varepsilon = 2$.

Figure 2

Effect of a marginal increase in the percentage of teleworkers on different measures of income inequality.



Source: own elaboration based on data from household surveys.

Note: estimates show the absolute change in inequality indicators due to an increase of 1 p.p. in the share of teleworkers, measuring those indicators in a scale from 0 to 100. Circles represent point estimates, while vertical lines show 95% confidence intervals with robust standard errors. In the case of Uruguay, confidence intervals for the marginal effect of teleworking on Atkinson index with ε = 2 are suppressed to facilitate visualization.

Although Figure 2 shows a picture of the impact of teleworking on inequality, strictly speaking these estimates are not directly comparable between countries, since they have different initial inequality levels, that is, before the hypothetical increase of 1 p.p. in the rate of teleworkers. Also, we cannot directly compare estimates across the different inequality indicators for the same country, since their absolute variations could have different meanings depending on the initial value of the inequality indicator. Hence, we compute the predicted relative change in inequality indexes, i.e., the ratio of the absolute change to the value of the inequality indicator in the respective regression sample (Table 2). For all indexes, it is clear that Brazil is the country in which teleworking produces the strongest increase in inequality in relative terms, with variations ranging from 0.6% to 1.1%, depending on the indicator used. However, the rest of the ranking does not have a unique order, but it varies depending on the inequality index used.

Table 2

Relative effect (%) of a marginal increase in the percentage of teleworkers on different measures of income inequality.

Country	Gini index	Atkinson index with ε = 0.5	Atkinson index with ε = 1	Atkinson index with ε = 2
Argentina	0.19%	0.50%	0.34%	-0.08%
Brazil	0.62%	1.11%	1.04%	0.83%
Colombia	0.10%	-0.14%	0.18%	0.00%
Ecuador	-0.07%	-0.11%	-0.10%	-0.07%
Peru	0.22%	0.02%	0.22%	0.25%
Uruguay	0.13%	0.23%	0.24%	-0.68%

Source: own elaboration based on data from household surveys.

Note: estimates show the percent change in inequality indicators due to an increase of 1 p.p. in the share of teleworkers.

6. Concluding remarks

The aim of this study was to measure the distributional impact of teleworking on the labor income in some South American countries. By using RIF regressions, we estimated the effect of a marginal increase in the proportion of teleworkers on selected features of the labor income distribution, including the mean, quantiles, and inequality indexes. To estimate this impact, a teleworking variable was constructed based on the definitions of the ILO but also considering the differences in data availability for each country.

Overall, the study found that a marginal variation in the percentage of remote workers had a positive effect on the average labor income but with asymmetries across the income distribution that could led to an increase in inequality. Indeed, for most countries, richer individuals (upper quantiles) benefit the more from a deeper teleworking penetration. Furthermore, this result is also supported by our estimates of the effect of teleworking on Gini and Atkinson inequality indexes, since we found that a marginal increase in teleworking rate increases these indicators. Thus, the spread of remote work may have unintended consequences in terms of income distribution.

Finally, it is worth noting that this study aimed to contribute empirical evidence to the literature that studies the effects of remote work on different dimensions of the labor market. Naturally, new questions arise that can be addressed in future research and extensions of the work, linked to the role played by different observable variables in the heterogeneity of the income gap between remote and face-to-face workers.

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Appendix

Table A1

Construction of teleworking variable for each country

Country	Household surveys questions		Logic conditions and type of teleworker	Universe of workers covered
	Question code	Verbatim question		
Argentina	pp04g	Where do you mainly perform your tasks?	The individual is considered as an **almost teleworker** if she/he declares that: (1) she/he works at home (no exclusive location), (2) his/her home has computer and internet access, and (3) he/she used ICT (computer, internet, and mobile phone) in the last months.	All workers
	ih_ii_01	In this household, do you have computer(s)?		
	ih_ii_02	In this household, do you have Internet access?		
	ip_iii_04	In the last few months, did you use the Internet?		
	ip_iii_05	In the last three months, excluding internet use, did you use a computer?		
	ip_iii_06	In the last three months, did you use a mobile (cell) phone?		
Brazil	S01028	Does this household have a microcomputer (including laptops, such as: laptop, notebook, ultra book, or netbook)?	The individual is considered as an **almost teleworker** if she/he declares that: (1) his/her home has a microcomputer or tablet and (2) internet access, (3) he/she used personal computer or tablet to access the internet in the last three months, and (4) normally worked at home (no exclusive location)	All workers
	S01028A	Does any resident of this household have a tablet?		
	S01029	Does any resident have access to the Internet at home using a microcomputer, tablet, cellphone, television, or other device?		
	S010301; S010302	To access the Internet in this household, does any resident use…		
	S070021	In the last three months, did you access the Internet from any location using a personal computer (desktop or laptop, such as a laptop, notebook, ultra book, or netbook)?		
	S070022	In the last three months, did you access the Internet from any location using a tablet?		
	V4021	Did you normally perform work at the establishment of that business/company?		
	V4022	So, where did you normally perform this work?		
Colombia	P3193	Have you worked under the telecommuting or work-from-home arrangement during the last 12 months?	The individual is considered as a **real telework** if she/he declares that: (1) she/he worked under telecommuting or work-from-home arrangement during the last 12 months, used the internet for work, and used a desktop, laptop, or laptop computer at least once a month.	All workers
	P1083	For which of the following services or activities do you use the internet:		
	P1910	How often do you use a desktop computer (anywhere)?		
	P1911	How often do you use a laptop computer (anywhere)?		
	P1912	How often do you use a tablet computer (anywhere)?		
Ecuador	P46	In which of the following places do you work?	The individual is considered as an **almost telework** if she/he declares that: (1) have an active cellphone, (2)	All workers
	pt01a	Do you have an activated cell phone?		

	pt1b01; pt1b02; pt1b03; pt1b04; pt1b05; pt1b06	Do you use on your cell phone…?	possess a desktop computer, laptop or tablet in their home, (3) have internet in the residence, (4) use the cellphone and computer, and (5) use the internet for work.	
	pt2c01	For what services/activities did you use the Internet in the last 12 months?		
	pt3c01; pt3c02; pt3c03	In the last 12 months, have you used the following devices from any location?		
	eqt19a011; eqt19a012; eqt19a013;	Does this household have...?		
	vi20	Does this household have internet?		
Peru	p522a	Last week, have you done your work? [...]	The individual is considered as a **real teleworker** if she/he declares that: (1) she/he works at home, doing remote work (using a computer, laptop, etc.), or (2) she/he does telework.	Employees
Uruguay	f78	Where do you usually work or carry out your activity?	The individual is considered as an **almost teleworker** if she/he declares that: (1) she/he works at home, (2) his/her home has computer and internet access, and (3) he/she used ICT (computer, smartphone, or tablet) to carry out her/his work.	All workers
	d21_15	Does this household have a microcomputer (including laptop, notebook, tablet, etc.)?		
	d21_16	Does this home have an internet connection?		
	f290	To carry out your work at home, did you use a computer, smartphone, or tablet?		

Source: own elaboration based on data from household surveys.