Dynamics of the Determinants of Teleworking in Colombia, Brazil, and Argentina 2019-2021

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Abstract
This article analyzes the determinants of the use of teleworking and makes an empirical application in Colombia, Brazil, and Argentina from 2019 to 2021. This to answer: (i) What are the determinants of teleworking? (ii) How have they evolved recently? and (iii) what similarities and differences are found between the countries studied? Therefore, we proposed a theoretical perspective to choose to use teleworking based on the rationality of firms and workers. In addition, we estimate econometric models of binary choice. We found that the probability of using telework increases in the quaternary and tertiary sectors of the economy; in small and, recently, in large firms; in workers with experience and, especially, with high levels of education. Regarding the evolution of these determinants, the estimates indicate that the relevance of the level of education, work experience and sectors prone to teleworking have been increasing over time; while having children at home show an increasingly negative effect, albeit slight. When comparing countries, it is found that the determinants of teleworking and its main patterns are similar.

Keywords: telework, occupational choice, technological change
Dinámica de los Determinantes del Teletrabajo en Colombia, Brasil y Argentina 2019-2021

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Resumen
Este artículo analiza los determinantes del uso del teletrabajo y hace una aplicación empírica en Colombia, Brasil y Argentina de 2019 a 2021. Esto para responder: (i) ¿Cuáles son los determinantes del teletrabajo? (ii) ¿Cómo han evolucionado recientemente? y (iii) ¿qué similitudes y diferencias se encuentran entre los países estudiados? Para ello, se propone una perspectiva teórica para optar por utilizar el teletrabajo con base en la racionalidad de las empresas y los trabajadores. Además, se estimaron modelos econométricos de elección binaria. Se encuentra que la probabilidad de utilizar el teletrabajo aumenta en los sectores cuaternario y terciario de la economía; en pequeñas y, recientemente, en grandes empresas; en trabajadores con experiencia y, especialmente, con altos niveles de formación. En cuanto a la evolución de estos determinantes, las estimaciones indican que la relevancia del nivel de educación, la experiencia laboral y los sectores propensos al teletrabajo han ido aumentando con el tiempo; mientras que tener niños en casa muestra un efecto cada vez más negativo, aunque leve. Al comparar países, se encuentra que los determinantes del teletrabajo y sus principales patrones son similares.

Palabras clave: teletrabajo, elección ocupacional, cambio tecnológico
The way of working has changed throughout history, depending on the technology of production, and recently on the digitalization process. Furthermore, the world has experienced a profound shock due to Covid-19 isolation measures. In this context, teleworking has been shown as a new strategy to produce. Therefore, it has been the subject of recent studies.

Having a glance at history, it is found that initially the production was given on a small scale through hunting and gathering. Afterwards, some 500 years ago, the scientific revolution began and with it an acceleration of production. Three major industrial revolutions have been documented that wrought such an increase in production (Harari, 2014). These range from the creation of the factory and, the modernization, to the automation of processes and the introduction of Information and Communication Technologies (ICT) (Comín, 2011; Martínez et al., 2020).

Today humankind is immersed in an era of science and technology convergence, that is convergence of the fields of nanoscience and nanotechnology, biotechnology and biomedicine, cognitive science, and advanced ICT (Rocco et al., 2013). The confluence of these transdisciplinary fields generates a new perspective and broadens the range of production possibilities. In this context, there is talk of a fourth industrial revolution that promotes digitization in manufacturing with intelligent products that are created from cyber-physical systems, hyperconnectivity, the Internet of things and Big Data (Chung, 2021; Requeijo, 2021).

Therefore, digital technologies have been gaining importance in the modern world. A process of adopting these technologies has been presented. Initially there was a phase where people acquired digital skills, then their use became widespread and now there is a phase of digital transformation, where digital technologies penetrate more aspects of daily life, such as work (Laloux, 2014; Berger, 2016). Currently, it is possible to work outside the facilities of a company. New forms of work have appeared such as remote work, home-based work, teleworking, among others. This research focuses particularly on “teleworking” understood as “the use of ICT – such as smartphones, tablets, laptops and desktop computers – for the purposes of work outside the employer’s premises” (Eurofound & ILO, 2019, p. 5).

Several studies have predicted a massive adoption of teleworking, at least since the 50's (Baruch, 2001). Nevertheless, teleworking has only been widely
used since 2020 due to Covid-19 (ILO, 2020b). In any case, teleworking is not for every worker or firm. This has begun to be studied by the scientific community. Most of the literature on the subject has found that the presence of teleworking is related to variables such as the economic sector, educational level, work experience, soft job skills, occupation, number of children in the home, disability, among others (Baines, 1999; Lamond et al., 1998; Nilles, 1975; Maurizio, 2021; Raghuram et al., 2003; Las Heras & Barraza, 2019; Becerra-Astudillo et al., 2022; Acosta, 2018; Peiró & Soler, 2020; Oviedo-Gil & Cala, 2023). All of them could be potential determinants of teleworking, but it is required to test it in specific contexts. For this it is relevant to consider a possible rationality of the use of teleworking, but theoretical framework is limited about this specific issue.

This research considers three questions to solve, namely, (i) what are the determinants of telework? (ii) How have they evolved recently? and (iii) what similarities and differences are found among the countries studied? Therefore, the study takes the following steps. First, we review academic literature. Second, we propose a theoretical perspective for the decision to use or not telework based on the theory of rationality of firms and workers. Third, we present the data used, explaining that the databases were harmonized to allow comparability between countries with information provided by workers in official labor market surveys from 2019 to 2021. Fourth, we run binary choice econometric models in three large countries of Latin America, namely, Colombia, Brazil, and Argentina. In this way, we offer a more robust approach as it includes a bridge between the rationality behind teleworking and the data that captures reality.

Thus, this research contributes to the study of teleworking because it proposes some of its theoretical determinants, which are empirically contrasted. This, in turn, allows estimating the magnitude and dynamics of the determinants before, during and after the isolation measures by Covid-19 in the reference countries.

This study found that the probability of using telework increases in the quaternary and tertiary sector of the economy; in small firms and, recently, in large companies; in workers with experience and, especially, with high levels of education. Estimates also indicate that the contribution of level of education, experience, and sectors prone to teleworking have been increasing
over time, while children at home show an effect, albeit slightly. When comparing countries, it is found that the determinants of teleworking and their main patterns of evolution are similar.

**Literature Review**

In order to identify potential determinants of teleworking, it is necessary to review relevant literature that has detected strong relationships between teleworking and the characteristics of the workers and firms that use it. Among the findings of the scientific community, it has been pointed out that teleworking has shown a relationship with economic and context variables. The most outstanding variables mentioned in the literature are recounted in Table 1.

**Table 1**

*Potential determinants of the use of teleworking from the literature*

<table>
<thead>
<tr>
<th>Potential determinant of the use of telework</th>
<th>Stylized fact in literature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economic sector</strong></td>
<td>From the first mention of teleworking by Nilles in the seventies, this type of work was conceived as a potentially strategy for the information industry. Which, according to the same author, &quot;(...) encompasses many government organizations, much of the banking and financial industry, the administrative functions of most major companies, and the automated or semi-automated production of goods&quot; (Nilles, 1975, p. 1142). This fact has recently been reiterated in multidisciplinary studies (ILO, 2020a; Eurofound &amp; ILO, 2019; Tapasco, 2021).</td>
</tr>
<tr>
<td><strong>Management and organizational capacity of the firm</strong></td>
<td>The effective implementation of teleworking requires a decision by the employer (ILO, 2020b), which needs to be supported by decentralized business structures and relationships with high degrees of autonomy. So, firms must allow flexibility of the working day,</td>
</tr>
<tr>
<td>Potential determinant of the use of telework</td>
<td>Stylized fact in literature</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td><strong>Educational level and work experience.</strong></td>
<td>Lamond et al. (1998) encourage to understand teleworking as a process that involves several dimensions, including the extensive use of ICT and the intensity of knowledge required. Those conditions occur in individuals with significant levels of education and experience. In fact, in Europe it has been found that teleworking is more common among professionals and managers (Eurofound &amp; ILO, 2019). A similar situation occurred in Latin America, where telework jobs were maintained during the pandemic, mainly for the most qualified workers, wage earners aged 25-44 years-old with a university level (Maurizio, 2021).</td>
</tr>
<tr>
<td><strong>Soft skills.</strong></td>
<td>These correspond to the competencies that enable people to function in a given environment. For teleworking, the soft skills identified are ability to: (i) work autonomously and for results, (ii) require little supervision, (iii) have communication skills, (iv) be adaptable and organized, and (v) have a solid knowledge of their work (Amigoni &amp; Gurvis, 2009; Raghuram et al., 2003).</td>
</tr>
<tr>
<td><strong>Propitious occupation.</strong></td>
<td>In the same way as the economic sectors, the occupations may or not be conducive to telework. This is how the pioneering work of Nilles (1975) specifically mentions professional, technical, managers, officials, owners, administrative and sales workers.</td>
</tr>
<tr>
<td><strong>Relationship with the head of household.</strong></td>
<td>Flexible jobs that make it possible to attend to family and work responsibilities are more in demand by workers who are spouses rather than heads of</td>
</tr>
</tbody>
</table>
Recently, few studies that directly look at the determinants of telework have begun to appear. Ollo-López et al. (2020) examine the impact of individual, organizational and country level factors on telework using the European Working Conditions Survey and considering an extension of the technology acceptance model and the technology-organization-environment model. They find that high-skilled, family-responsible workers who live far from their jobs use teleworking more.

Similarly, Tokarchuk et al. (2021) built their conceptual framework on a resource-based view of the firm to investigate the determinants and the switch towards Italian high-tech firms’ teleworking due to the COVID-19 crisis. They find that the pandemic emergency served as a dramatic thrust for telework adoption, as the organizational readiness, previous telecommuting experience.

Finally, Georgescu et al (2021) use a survey conducted onto 377 persons living in Bucharest (Romania) to identify factors of the decision to continue with teleworking after the end of the pandemic. Their results show that the probability of continuing to telecommute increases if the field of activity is IT and also if people are younger, while it decreases if there was an unpleasant work experience at home.

<table>
<thead>
<tr>
<th>Potential determinant of the use of telework</th>
<th>Stylized fact in literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children in the home.</td>
<td>One of the greatest responsibilities at home is raising children, therefore, their presence pressures adults to spend more time on care tasks (ILO, 2021).</td>
</tr>
<tr>
<td>Disability.</td>
<td>Disabling conditions in individuals often limit their employment opportunities. The telework modality could expand these possibilities. This has been found in studies such as (Vélez, 2013; ILO, 2021).</td>
</tr>
</tbody>
</table>
Theoretical Perspective

As mentioned before, there is a limited theoretical framework about the rationality of choosing to telework. Previous studies have tried to adapt the technology acceptance model, the technology-organization-environment model, or the theory of the firm. In order to consider rationality of firms and worker about telework use, this research proposes a theoretical perspective based on the theory of the firm (Pindyck & Rubinfeld, 2009; Samuelson & Nordhaus, 2019) and the choice theory applied to the labor market, especially, to the job choice (Mortensen, 1987; Pissarides, 1984; McConell et al., 2007; Faggian, 2021). It is also considered the stylized facts identified by the literature as referenced in the previous section. In this way, the analysis is more complete.

The theory of the firm constitutes a microeconomic approximation of how companies make their production decisions. The heart of his reasoning is Milton Friedman's postulate of profit maximization (Friedman, 1953). This has been widely used to describe what happens in the real world with firms and makes trend generalizations (Pindyck & Rubinfeld, 2009). In this theory, a firm maximizes its profits by establishing the best combination of labor and capital inputs to produce at the lowest cost and sell its product at the highest possible price.

Let us assume that initially a firm that maximizes profits with a group of employees who work under the traditional mode, but could adopt teleworking, either because it is part of an economic sector that can operate in this way or because it has jobs suitable for teleworking. That would be the status quo.

Firm Analysis

The firm aims to maximize its profit, it already does it, and wants to continue doing it (Pindyck & Rubinfeld, 2009).

\[ \text{Max: } \text{Profit} = \text{Income} - \text{Costs} \] (1)
Income is the result of the price and quantity of the product that the firm generates and sells. That quantity of product depends, among other elements, on the work and its productivity. Of course, the modality of work used could generate differences. Then, the productivity of a traditional worker who becomes a teleworker ($P_T$) experiences a typical learning curve, where initially there will be a reduction in productivity due to the change in work modality and then it reaches a new stable level that may be lower, equal to or greater than the average productivity of an on-site worker ($P_O$). Since $P_T$ is initially unknown, the firm can estimate an expectation of it, assuming that there will be $M$ workers who turn out to be more productive in teleworking with productivity $\phi$, $I$ workers who maintain their productivity $\theta$ and $R$ workers who reduce their productivity to $\rho$:

$$E(P_T) = \phi M + \theta I + \rho R$$

(2)

This expectation is compared with the calculation of productivity in traditional mode:

$$P_O = \theta (M + I + R)$$

(3)

As a result, determining whether (2) is greater than, equal to, or less than (3) will depend on:

$$\frac{\phi - \theta}{\theta - \rho} \geq \frac{R}{M}$$

(4)

That is, of the expected productivity gains ($\phi - \theta$) due to workers who become more productive, in relation to the expected losses ($\theta - \rho$) associated with those who are less productive from their homes. This comparison will consider the soft skills of the group and type of workers that are part of the firm, and it is recognized that they can telecommute. Thus, the firm would evaluate aspects such as the degree of autonomy, experience, and knowledge of its workers, among others, in this comparison.

So far, it has been analyzed the incidence of teleworking on the firm's income, which could be due to production, but it could also be due to costs. The costs of a firm are due to a variety of items. When teleworking is examined, it would be reasonable to consider white-collar workers, that is, those who work in an office using ICT (Nilles, 1975). The input costs associated with office work for the firm ($C_O$) would be:
The Cost of the Facilities (CF): the use of the office and the furniture
The Cost of Equipment (CE): acquisition and maintenance of computer equipment, other ICT and similar
The Cost of Public Utilities (CPU): electricity, internet, water supply, sewage, etc.
The Cost of General Services (CGS): general maintenance, cleaning, cafeteria, etc.

\[ C_{0} = CF + CE + CPU + CGS \] (5)

Assuming the use of teleworking for all staff, CF and CGS would be a direct saving for the firm; while the CE and part of the CPU would have to be assumed eventually by the firm, at least partially, in an \( \alpha \) proportion. The firm would supply some of the equipment and grant some transfer to pay for public utilities, which would be less expensive in teleworking since their price for households is usually lower than for firms. However, the firm has an established administrative structure for supervision and control, as well as proven practices of collaborative work among its human resources in the traditional mode. For this reason, it would have to incur new sunk costs \( C_{S} \) to adjust that administrative structure to remote operation. Then, the cost of work using telework would be:

\[ C_{0}^{T} = CE + \alpha CPU + C_{S} \] (6)

Then, if

\[ C_{S} > CF + (1 - \alpha)CPU + CGS \] (7)

It would be an incentive to use teleworking.

Therefore, the firm, faced with the choice of using telework or not, keeping its profit constant, compares:

- An estimate of the labor productivity of its human resources on-site versus teleworking modality.
- A valuation of office cost savings versus the costs of adapting to remote management and collaboration.
Using Teleworking in a Part of the Staff

Nevertheless, the firm could be able to use teleworking in a part of its staff by offering telework only to those workers who increase or maintain their productivity under this modality. In this case, assuming the employer can clearly identify those workers, the productivity analysis is restricted to:

\[ E(P_T^P) = \emptyset M + \theta I \]  

(8)

Where “\( E(P_T^P) \)” is the productivity expectation of the staff that increase or maintain their productivity in telework. This has to be compared with the productivity of this worker in traditional condition, namely:

\[ P_O = \theta (M + I) \]  

(9)

Then, if there is any productivity gain, there will be an incentive to use telework. However, it is also necessary to analyze costs. By using teleworking and traditional work the cost would be a composition of previous equations. This in the fraction \( (R/L) \) for traditional workers and \( ((M + I)/L) \) for teleworkers:

\[ (CF + CPU + CGS) \left( \frac{R}{L} \right) + \alpha CPU \left( \frac{M+I}{L} \right) + C_s + CE \]  

(10)

When this is compared with (5), it is possible to notice that there will be benefit of using teleworking in a part of the staff if \( C_s \) is less than the productivity gain \( (\emptyset - \theta)M \).

Worker Analysis

In order to analyze the decision to use telework from the workers' point of view, we rely on the theory of choice. In this theory, individuals seek to maximize their utility, which is determined by their preferences for goods or services (McConell et al., 2007), in this case by conditions associated with their jobs. Likewise, we rely on the job search theory that suggests that a person establishes a reserve salary, that is the minimum remuneration that she/he is willing to accept to dedicate time to work instead of remaining idle. Then, each person checks if a job offer has a salary equal to or higher than the
reservation salary to accept a job or to continue looking (Mortensen, 1987; Pissarides, 1984).

So, continuing with our analysis, if the firm decides to offer the possibility of using telework in part or the whole staff, the employer will check that each worker completes the suitable profile to be a teleworker. In other words, it must be a worker who can fulfill his/her tasks outside the facilities of the employer or contracting party with the support of ICT. This is a white-collar worker who knows his/her job, can perform it without guidance or constant supervision, is proficient in ICTs and has communication skills to manage and provide collaboration to his/her co-workers, as referenced in the literature review (Lamond et al., 1998; Gentilin, 2021).

In the status quo for the worker, she or he receives a remuneration \( W_O \) than exceeds her/his reservation salary\(^2 \) \( W_R \).

\[
W_O \geq W_R \tag{11}
\]

Then, the worker would review if there were any modifications in its remuneration and reservation salary perceived on teleworking condition and compare them.

\[
W_O^T \geq< W_R^T \tag{12}
\]

Where:

\[
W_R(C_T, X_P, X_L) \tag{13}
\]

The decision about being a teleworker depends on labor conditions \( C_T \), the personal \( X_P \) and labor \( X_L \) characteristics that affect preferences. Within \( X_L \) could be the educational level and work experience, while within \( X_P \) there would be preferences towards this type of work due to conditions such as the need or desire to allocate as much time as possible to housework and care task.

**Considerations**

- In this reflection, hybrid schemes on the same worker are not considered. That is, telecommuting some days and conventional work other days of the week, although this is a possibility.
- In an exceptional context such as an interruption of the firm's operations, teleworking may be mandatory. In that situation, firms where:
\[
\frac{\phi - \theta}{\theta - \rho} \leq \frac{R}{M}
\] (14)

...would go out of the market unless they promote their productivity or seek more productive employees. In addition, workers whose reservation salary is higher than the one they receive in teleworking will start a new job search process.

- Considering a dynamic perspective, the sunk cost occurs in the initial period, but this is diluted considering a broad period. So, with a medium and long-term vision, teleworking could be perceived as a strategy to increase the benefits of the firm.

**Data and Methodology**

The theoretical reflection proposes that the use of telework depends on the rationality of firms and workers, being a sequential decision that requires the willingness of both parties. Ideally, an empirical measurement would have every element of the decision. However, databases with all those characteristics are not detected, as is usual in empirical analysis. The most robust and complete information on the labor market in Latin American countries corresponds to official labor surveys. These surveys report multiple variables about the workers and their jobs, including some characteristics of the firms that employ them. Each database is a picture that makes it possible to identify who does teleworking and who does not. Thus, they reflect the decision made together with a set of observable variables associated with that decision. In that sense, we estimate a reduced form of the theoretical reflections through an equation that would explain the use of teleworking in the following way:

\[
\text{use of teleworking} = f(\text{firm decision}, \text{worker decision})
\] (15)

We approach it as a choice model, which has been widely applied in the literature to study the determinants of agents' decisions. For example, the representative consumer model (Dixit & Stiglitz, 1977) and the bundle of characteristics model (Archibald et al., 1986). And, assuming that the observable characteristics of workers and firms explain the decision to telework, an estimate from labor surveys might be:
Being a teleworker = \( f(\text{firm characteristics}, \text{worker characteristics}) \) (16)

From one side, the characteristics of interest in the firms are associated with labor productivity and costs associated with white-collar activities, which are not directly available in the surveys but can be approximated through variables, such as the economic sector and firm size. On the other hand, relevant characteristics of the worker for the analysis are given by equation (13), namely, work, and personal profile of the employee.

Data

In order to analyze teleworking this study includes large countries in the Latin America region, heterogeneous among themselves, with the largest populations and robust household surveys quickly available to the public. This research includes information for Colombia, Argentina, and Brazil. Then, the selection criteria is due to the population size. Brazil is the largest country in the region, so its inclusion is desirable and necessary. Colombia and Argentina are the next largest countries in Latin America with recent microdata published at the time of conducting this research. Then, they complete the triad selected for this research. In any case, the approach is expected to be feasible for any country with standard representative household surveys in the region.

The databases used are official labor market surveys from the first quarter of 2019 to the fourth of 2021. In Colombia, the National Administrative Department of Statistics (DANE) produce the Great Integrated Household Survey (GEIH), which has national coverage and is collected continuously (DANE, 2021). For Argentina, the National Institute of Statistics and Censuses (INDEC) carries out the Permanent Household Survey (EPH), whose coverage is 31 urban agglomerations and an urban-rural area, then, it is an urban survey (INDEC, 2003). Finally, the Brazilian Institute of Geography and Statistics (IBGE) produces the National Household Sample Survey (PNAD) with national coverage3.

The databases created for this study are consolidated annually, contain customized harmonized variables, and are restricted to urban areas to ensure
comparability between countries (remember that the Argentine survey only has urban coverage).

Methodology

An econometric strategy to find the determinants of a choice with two alternatives is the binary choice model. Below is a brief description of the model following to (Cameron & Trivedi, 2005) and adapting to this research.

The dependent variable is expressed as follows:

$$ y_i = \begin{cases} 
1 & \text{if worker is a teleworker, with probability } p \\
0 & \text{if not with probability } p (1 - p) 
\end{cases} $$

Due to the nature of the dependent variable, it is appropriate to apply a logit or probit model. Then, the probability of occurrence of the event (or decision) represented in the dependent variable can be explained by a vector of independent variables $X$ that are related to the event to be explained through the vector of parameters or estimators $\beta$. Then, the conditional probability model is given by the expression:

$$ p_i = Pr[y_i = 1 | x] = F(x_i'\beta) $$

Where $F(.)$ is a cumulative distribution function that ensures that the probability is between 0 and 1. This is usually taken a logistics $\Lambda(.)$ or a normal distribution $\Phi(.)$, giving origin to the logit model, or the probit model, respectively (Cameron & Trivedi, 2005). The probit model has the form:

$$ p = Pr[y = 1 | x] = \Lambda(x'\beta) = \frac{e^{x'\beta}}{1+e^{x'\beta}} $$

Meanwhile the logit model:

$$ p = Pr[y = 1 | x] = \Phi(x'\beta) = \int_{-\infty}^{x'\beta} \phi(z)dz $$

Measurement

Considering the previous literature review, the theoretical perspective on the rationality of the decisions behind teleworking, and the binary choice model,
for this research the specification of the econometric model would be given by:

$$p_i = Pr[y_i = 1 | x] = F(x_i' \beta) = \beta_0 + \beta_P X_P + \beta_L X_L + \beta_F X_F + \epsilon$$  \( (21) \)

Where:

- \( y_i \): 1 if the worker is a teleworker, or 0 if not;
- \( X_P \): set of personal characteristics of the worker;
- \( X_L \): set of labor characteristics of the worker;
- \( X_F \): set of characteristics of the firm;
- \( \beta \) are the estimators; and
- \( \epsilon \) is the random error.

Using the databases described the variables included in the model are presented in Table 2. The variables used in this study were harmonized, that is, their ranges or response options were homologated or standardized to make them comparable between countries. This was done for the explanatory variables of the econometric model, so that, for each country, the variables are used as described in Table 2.

<table>
<thead>
<tr>
<th>Determinant</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spouse</td>
<td>Dummy variable that indicates whether the worker is the husband/wife or permanent partner of the head of household⁴.</td>
</tr>
<tr>
<td>Children in the home</td>
<td>Number of people under 14 years old in the household⁵.</td>
</tr>
<tr>
<td>Highest educational level</td>
<td>A dummy for secondary level, and another one for university level.</td>
</tr>
<tr>
<td>Work experience</td>
<td>Constructed as potential experience: age minus years of schooling, minus the first 6 years of life⁶,⁷.</td>
</tr>
<tr>
<td>Economic sector</td>
<td>A dummy variable was added for each major economic sector: Primary (agriculture and mining); secondary (manufacturing, electricity, gas, water, construction); tertiary (trade, transportation, financial services, and other services); quaternary (ICT); and quinary (arts and entertainment)</td>
</tr>
<tr>
<td>Management and organizational capacity of the firm</td>
<td>Firm size. Dummy variables for medium and small firms Small firm (up to 5 workers); medium firm (from 6 to 50 workers); large firm (more than 50 workers)</td>
</tr>
</tbody>
</table>

Note. Disabilities, capacity and use of technologies are not considered due to the unavailability of comparable information in the databases of the countries studied. Source: own elaboration
For the dependent variable we follow the construction proposed by (Oviedo-Gil & Cala, 2022). So, a teleworker is anyone who works from home or does not have to travel to work while performing an occupation that could be performed remotely through ICT. This definition is consistent with the concepts accepted in Colombia, Brazil, and Argentina, as can be seen in the Table Table.

<table>
<thead>
<tr>
<th>National definition of teleworking</th>
</tr>
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<tbody>
<tr>
<td>Colombia</td>
</tr>
<tr>
<td>(...) It is a form of labor organization, which consists of the performance of paid activities or provision of services using information and communication technologies - ICT - for contact between the worker and the company, without requiring the physical presence of the worker in a specific job site\textsuperscript{8} (Law 1221, 2008, article 2).</td>
</tr>
<tr>
<td>Brazil</td>
</tr>
<tr>
<td>(...) provision of services predominantly outside the employer's premises, with the use of information and communication technologies that, by their nature, do not constitute external work\textsuperscript{9} (Da Silva, 2020, p. 2).</td>
</tr>
<tr>
<td>Argentina</td>
</tr>
<tr>
<td>(...) a form of remote work, in which the worker carries out his activity without the need to physically present himself at the specific company or workplace. (...) [teleworking] It is carried out using information and communication technologies (ICT) and can be carried out at the worker's home or in other places or establishments outside the employer's home\textsuperscript{10}</td>
</tr>
</tbody>
</table>

Source: Own based on (Law 1221, 2008), (Da Silva, 2020), and (Oviedo-Gil & Cala, 2022)

Below it is presented the annualized results obtained because such sample aggregation makes the estimates more robust, allowing inferences with a higher degree of statistical confidence.
Results

A summary of the main estimates obtained on the marginal contributions of the potential determinants of telework use are in Table 4, as well as the pseudo R2, the percentage of predictions correctly classified, and chi2 tests probabilities for the likelihood ratio and the Wald test. These estimates come from probit models, which showed higher log likelihood than logit models, also estimated to contrast this.

Based on the estimates, it is inferred that this modeling contributes to explaining the choice to telework, since, in all cases, the parameters of the likelihood ratio and the Wald test are large enough to obtain associated chi2 probabilities of 0.000. It should also be noted that the proportion of correct predictions is greater than 90% and that, in general, the estimators of the explanatory variables are statistically significant.

Table 4
Estimates on the evolution of marginal contributions of the potential determinants of the use of telework in Colombia, Argentina, and Brazil 2019-I to 2021-IV (%)

<table>
<thead>
<tr>
<th></th>
<th>Colombia 2019</th>
<th>Colombia 2020</th>
<th>Colombia 2021</th>
<th>Argentina 2019</th>
<th>Argentina 2020</th>
<th>Argentina 2021</th>
<th>Brazil 2019</th>
<th>Brazil 2020</th>
<th>Brazil 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spouse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of children</td>
<td>0.36</td>
<td>0.41</td>
<td>0.32</td>
<td>0.01</td>
<td>1.01</td>
<td>0.10</td>
<td>0.14</td>
<td>0.45</td>
<td>0.79</td>
</tr>
<tr>
<td>Secondary</td>
<td></td>
<td>**</td>
<td>**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>education</td>
<td>0.20</td>
<td>0.35</td>
<td>0.72</td>
<td>0.07</td>
<td>0.61</td>
<td>0.51</td>
<td>0.10</td>
<td>0.01</td>
<td>0.10</td>
</tr>
<tr>
<td>University education</td>
<td>1.04</td>
<td>1.76</td>
<td>2.16</td>
<td>0.54</td>
<td>7.23</td>
<td>4.56</td>
<td>0.48</td>
<td>0.93</td>
<td>1.54</td>
</tr>
<tr>
<td>Experience</td>
<td>4.51</td>
<td>9.19</td>
<td>7.0</td>
<td>2.18</td>
<td>7</td>
<td>9</td>
<td>1.53</td>
<td>3.45</td>
<td>6.92</td>
</tr>
<tr>
<td>Small firm</td>
<td>8.17</td>
<td>7.50</td>
<td>7.18</td>
<td>3.44</td>
<td>0.33</td>
<td>1.62</td>
<td>5.69</td>
<td>5.52</td>
<td>5.47</td>
</tr>
<tr>
<td>Medium firm</td>
<td>3.35</td>
<td>0.64</td>
<td>1.26</td>
<td>0.19</td>
<td>0.93</td>
<td>0.86</td>
<td>0.47</td>
<td>0.91</td>
<td>2.12</td>
</tr>
<tr>
<td>Secondary sector</td>
<td>4.34</td>
<td>4.75</td>
<td>4.42</td>
<td>0.05</td>
<td>1.37</td>
<td>0.29</td>
<td>4.38</td>
<td>5.82</td>
<td>6.13</td>
</tr>
<tr>
<td>Tertiary sector</td>
<td>3.75</td>
<td>7.02</td>
<td>7.65</td>
<td>0.23</td>
<td>2.63</td>
<td>2.09</td>
<td>3.89</td>
<td>5.79</td>
<td>8.00</td>
</tr>
<tr>
<td>Quaternary sector</td>
<td>0.07</td>
<td>1</td>
<td>4</td>
<td>7.42</td>
<td>3</td>
<td>7</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Quinary sector</td>
<td>5.45</td>
<td>24.1</td>
<td>21.1</td>
<td>0.20</td>
<td>2.23</td>
<td>1.87</td>
<td>23.7</td>
<td>24.2</td>
<td>25.4</td>
</tr>
<tr>
<td>Pseudo R2</td>
<td>0.1512</td>
<td>0.1151</td>
<td>0.112</td>
<td>0.2262</td>
<td>0.1933</td>
<td>0.1390</td>
<td>0.1909</td>
<td>0.1718</td>
<td>0.1283</td>
</tr>
<tr>
<td>Likelihood ratio</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>LR chi2(11)</td>
<td>17958.39</td>
<td>12723.34</td>
<td>12166.28</td>
<td>3468.28</td>
<td>7249.36</td>
<td>4233.14</td>
<td>34240.47</td>
<td>24084.85</td>
<td>18465.02</td>
</tr>
</tbody>
</table>
The results of the model, presented in Table 3, correspond to the marginal contributions of each explanatory variable on the probability of being a teleworker. We estimate and analyze the marginal effects and not the odds ratios given their more direct and intuitive interpretation. Thus, for example, in Colombia in 2019, being a spouse increases the probability of being a teleworker by 0.36%, while working in the tertiary sector of the economy increases it by 3.75%. Next, the analysis by each potential determinant or explanatory variable.

### Results Analysis and Discussion

#### Spouse

The status of spouse turns out to be statistically significant in the probability of being a teleworker, except in 2019 and 2021 in Argentina. The magnitude of these estimators is small. In Colombia, being spouse increases the possibility of being a teleworker between 0.32% and 0.41%, in Argentina it does so by 1.01% in 2020, while in Brazil it reduces it between -0.79% and -0.14%.

The estimators are positive, but small, in Argentina and Colombia possibly because having more responsibilities at home makes workers more likely to use telework, which is consistent with what is mentioned in the literature (Hatayama et al., 2020). In Brazil, the estimators are negative and decreasing, which may be related to the weak isolation requirements that the country implemented, unlike the other countries in the region. Given the economic crisis associated with the pandemic, the spouses could have been pushed to seek alternative income.
Number of children

The estimators indicate that an additional child at home slightly reduces the probability of being a teleworker. This could be seen in Argentina and Colombia, countries that even show an increase in the magnitude of this negative contribution since isolation measures due to Covid-19. In Brazil, having an additional child had a small positive contribution in 2019, and a small negative and statistically significative contribution in 2021.

Most academic papers state that workers would prefer to stay at home to take care of their children. Nevertheless, children at home could represent difficulties to keep productivity levels and to handle boundaries between working time and personal obligations (ILO, 2020a; MinTIC, 2020). This seems to be the case in Colombia and Argentina.

Education

The model includes a dummy variable for workers with secondary education and another one for workers with university education. Primary education or no education is in the intercept to compare against it. In each year and country, it is found that having a secondary education increases the probability of being a teleworker and having a university education increases such probability even more. These results are statistically significant, as well as analytically significant, since their marginal contribution is large, especially in university education. It can also be seen that the estimators grew from 2019 to 2021, especially since the pandemic in 2020. In Colombia there was an increase from 4.51% in 2019 to 11.67% in 2021, meanwhile, in Brazil it went from 1.53% to 6.92%. Argentina started with 2.18% and showed a magnitude of 16.39% in 2021. Hence, there is solid evidence regarding the importance of higher education in being a teleworker, and this has grown stronger over time.

This is consistent with what is indicated by Eurofound & ILO (2019) and Maurizio (2021). In those studies, it was evident that the use of telework was strongly associated with higher levels of education in European and Latin American countries.
Work Experience

Each year of additional experience increases the probability of being a teleworker in all the countries analyzed, according to statistically significant estimators. In Colombia experience is becoming more and more important during the period, especially since the pandemic. In Argentina there is also an increase in the contribution of experience to the probability of being a teleworker in 2020, the peak year of the pandemic and isolation measures, but it is slightly reduced in 2021. As for Brazil, the experience estimator showed a stable and positive behavior. These results are in the same direction as those suggested by Lamond et al. (1998), who affirm that teleworking requires intensity of acquired knowledge, which occurs in individuals with significant levels of experience. Although it could be contrary to the finding of Georgescu et al. (2021) that teleworking is more likely if people are young. One possible reading of the results is that teleworking can be found more in young people, but with enough experience to work without constant guidance.

Firm Size

Firm size was included as a proxy for their capacity of administrative adjustment when moving from traditional work to telework. Evidence suggests that small firms are more likely to use telework than large firms. This is contrary to what is found in the European or American literature. A possible reading of these findings could be that, in studied countries, larger firms were less flexible in their management practices to quickly switch to teleworking because the context of the pandemic did not allow for careful planning, but rather a reaction to the emergency. Large firms require time for adaptation.

Considering the evolution of the estimators, for small firm they were stable in 2019-2021 in Colombia and Brazil. In Argentina there were decreasing. Contemplating medium-size firm estimators they were declining in every country. Then, in 2019 work for a medium-size firm increases the possibility of teleworking compared with a large firm, but, from 2020 work for a medium-size firm reduce that possibility. It seems that large firms are adapting to new contexts.
Economic Sector

Estimations showed that working in the secondary sector, compared to the primary sector, increases the probability of teleworking in Colombia and Brazil. In the first country, the magnitude of this estimator remains at around 4.50% from 2019 to 2021, while in the second one the magnitude is increasing, going from 4.38% to 6.13%. In the case of Argentina, the estimators are not statistically significant.

There are particularly interesting results in the other economic sectors. In order to visualize them better, the Graph 1 could be consulted. By reviewing the estimators associated with working in the tertiary sector of the economy, that is, in service activities such as trade, transport and communication facilities, they are statistically significant for all the years and countries considered. Furthermore, they presented an increase in their magnitude in 2021 compared to 2019, in every country, although higher in Colombia and Brazil. It also could be noticed that these estimators turn out to be higher than the values of the secondary sector at the end of 2021.

In this study the quaternary and quinary sectors were also considered separately. The quaternary sector includes specialized activities in the 'Knowledge Sector', which concentrates on information-based services. While the quinary sector includes services activities that focus on the creation, rearrangement, and interpretation of new and existing ideas (Andrews, 2020). The results show that working in the quaternary sector leads to high and growing contributions to the probability of being a teleworker in the period of time and countries studied. In fact, it is the determinant that contributes the most to the use of teleworking. In Colombia, it goes from not being important to contributing 39.94%. In Argentina, in 2019 there was a contribution of 7.42% and that increased to 21.37% in 2021. The greatest contribution occurs in Brazil, which since 2019 was very relevant with 45.24% and by 2021 it reached 54.42%. This is consistent with the findings in the literature.

Finally, the estimates on working in the quinary sector reveal that its importance has been growing in Colombia. This importance is higher than in the tertiary sector, but not of the quaternary sector. In Argentina, the evidence indicates that its contribution is small and not significant. While in Brazil, the
contribution is important and has been maintained over time, although it does not exceed the contribution of the quaternary sector.

**Graph 1**

*Estimates of marginal contributions of the economic sectors on the probability of teleworking in Colombia, Argentina, and Brazil 2019-2021(%)*
Conclusions

Until now, the few approaches to the determinants of teleworking have been mediated by a theoretical framework that adjusts technology adoption models and firms' rationality. Here, we offer a more robust approach as it includes a bridge between the teleworking rationality and the data that captures reality. This based on a novel theoretical perspective on the rationality of firms and workers specifically proposed to understand the decision to telework use, not only adapting a general theory.

From the theoretical approach, elements arise to be considered from the point of view of the agents. For firms it is a priority to maintain or increase their profits. Teleworking could then affect profits through changes in costs or the ability to produce, that is, productivity. Therefore, the characteristics of the staff, its composition, and the type of tasks it performs, as well as the ability to adjust the management strategy, are crucial. For the workers, the concern is about changes in their reservation salary and the salary received together with the new conditions of their job. They should consider their ability to telework given job knowledge and skills based on their education and experience. They should also consider their personal and home conditions.

In this framework, it is assumed that the proposed rationality operated in various contexts that that allow estimating the evolution of the determinants

Source. Own elaboration based on GEIH-DANE, EPH-INDEC and PNAD-IBGE
Note. The outer gray lines indicate the 95% statistical confidence interval.
of telework. The results obtained contribute to solve the research questions as follows:

**Determinants of Teleworking**

The findings of this research suggest that the probability of using telework increases in the quaternary and tertiary sector of the economy; in small firms and, recently, in large companies; in workers with good levels of experience and, especially, with high levels of education, favoring university education. As for the personal conditions associated with responsibilities at home, results reveal a small effect, however, there is a slight trend that indicates that children at home reduce the likelihood of teleworking.

**Recent Evolution of the Determinants of Teleworking**

The economic sectors most prone to teleworking were increasingly decisive in their choice, especially the quaternary and tertiary sectors, followed by the quinary sector. In addition, the evidence indicates that small firms are more likely to telecommute, but since the isolation of 2020, large firms have been adopting it more than medium-sized firms. It is also found that teleworking is increasingly determined by the level of experience and education of the workers, while children at home show an impact, albeit slightly, increasingly negatively on the probability of teleworking.

**Similarities and Differences in Countries Studied**

The determinants of telework and its main patterns of evolution are similar across countries. In any case it is relevant to note that, in Colombia, work experience and the status of a small firm are more important in teleworking than in the other countries; in Brazil, the greatest importance is given to work in the quaternary and tertiary sector, while in Argentina there is the greatest increase in the contribution of university education.
Limitations and Directions for Future Research

Given the limited theoretical developments on this matter, this research considers the situation of firms and workers in the status quo, which is compared to a situation where telework is used. This assumes that agents have the power to choose. However, in the event of the pandemic, the use of teleworking was forced. In this condition, it is theoretically considered that the firms and workers that did not do so had to stop their activities, causing job losses and company closures. They could also operate at a loss temporarily. This situation could be considered theoretically and empirically more in depth.

For the empirical measurement, it would be ideal to have detailed information about all the key elements identified in the theoretical reflection. The measurement would be more precise by having databases with more information on the firms, in particular, on productivity and costs.

Notes

1 They could also be self-employed workers who work essentially for the company.
2 The reservation salary compensates the sacrifice of leisure for working and, therefore, stopping or not starting a job search process, following the approaches of the job search theory (Mortensen, 1987; Faggian, 2021; Pissarides, 1984)
3 Although Brazil has already published the base for the fourth quarter of 2021, it presents errors in educational variables consolidated by IBGE. So, we omit the use of that quarter.
4 We tried to simultaneously include the variable "spouse" and the variable "sex", but these are so correlated that the model asks to include only one of the two. So, we decided to include only “spouse” since the rationale considered is that being in charge of housework and care could encourage a greater probability of being a teleworker.
5 In the model estimation we tested a specification that separated "children aged 0-5 " and "children aged 6-14". However, the size and direction of the estimators do not present major differences with respect to the variable "children from 0 to 14 years of age". We also tried including the variable "number of adults aged 65 or over"; their estimators turned out to be statistically significant but so small that they do not contribute analytically to the analysis.
6 Since the construction of the "experience" variable is based on a transformation of the "age" variable, they cannot be included simultaneously.
7 There is no direct information about soft skills, but they are usually related to educational level and work experience
8 Own translation.
9 Own translation. The regulation of teleworking in Brazil - Law 13.467 (2017)
https://www.argentina.gob.ar/trabajo/teletrabajo/que-es - Own translation. Teleworking in Argentina is regulated by Law 27.555 (2020) that stipulates the contractual conditions that must be met, working hours, rights and duties, training, benefits, among others.

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Oviedo & Cala – Dynamics of the Determinants of Teleworking

https://www.marcialpons.es/libros/economia-laboral/9788448156497/


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