Technological change and labour market trends in Latin America and the Caribbean: a task content approach

Ignacio Apella and Gonzalo Zunino

Abstract

The aim of this paper is to analyse employment profile trends in the Latin American and Caribbean countries according to the task content of workers' jobs. This analysis seeks to approximate the impact of technological change on the labour market. The paper uses the definitions of an indicator that captures the relative importance of four types of tasks, namely cognitive versus manual and routine versus non-routine tasks, based on information from the Occupational Information Network (O*NET) and household surveys. The analysis finds that there has been growing demand for workers over the last two decades in occupations which are intensive in cognitive abilities, with higher remuneration than for occupations which are intensive in manual tasks. Cognitive skills are therefore a key variable for improving participation in current and future labour markets.

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I.   Introduction[1]

Technological change, such as advances in digital technologies, communications and robotics, can lead to an improvement in the general well-being of the population and reduce poverty, thanks to increased overall productivity in the economy.

The potential benefits of technological progress are important for both firms and consumers. Digital technologies, for example, can create jobs and bring benefits to small and medium-sized producers through the expansion of access to information and communication mechanisms, especially in those sectors which could be, or already are, users of these technologies. An example of this might be the creation of trading platforms connected via the Internet through which buyers and sellers can be brought together with minimal transaction costs.

From the point of view of consumers, the benefits from technological change are associated with potential reductions in the downstream prices of products as a consequence of the profits yielded by greater efficiencies and the increased range of goods and services available, generating a positive change in the consumer surplus. The majority of these consumer gains come from reduced marginal costs of production and distribution when the productive sector incorporates technological innovation and automates production processes, taking advantage of the economies of scale which are generated.[2]

However, possible negative consequences of rapid technological change have been analysed with concern in the literature.

For one thing, technical progress, in particular the advance of robotics, means that certain activities run a high risk of becoming obsolete, since routine tasks, for example, or those which can be replaced by a code, can be easily automated, leading to what is commonly known as technological unemployment.

A number of studies have drawn attention latterly to the potential labour market impacts of the recent process of technological change (Brynjolfsson and McAfee, 2014; Autor, Levy and Murnane, 2003; Spitz-Oener, 2006; Acemoglu and Autor, 2011; Frey and Osborne, 2013; OECD, 2016; Arntz, Gregory and Zierahn, 2016; Nedelkoska and Quintini, 2018). In particular, this group of studies not only discuss the possibility that technological change could displace many current occupations (Frey and Osborne, 2013; Brynjolfsson and McAfee, 2014; OECD, 2016; Arntz, Gregory and Zierahn, 2016; Nedelkoska and Quintini, 2018), but look in detail at the type of tasks that are most likely to be affected by this displacement and, conversely, the type of tasks that could be increasingly in demand because of the new technologies (Autor, Levy and Murnane, 2003; Spitz-Oener, 2006; Acemoglu and Autor, 2011; Arntz and others, 2016; Nedelkoska and Quintini, 2018). This approach to the effect of technological change on labour markets is usually called the task content approach.

Previous literature based on the task content approach states that jobs which are intensive in cognitive tasks, particularly non-routine cognitive tasks, will not just suffer less from technological displacement but will actually be stimulated by it (Autor, Levy and Murnane, 2003; Spitz-Oener, 2006; Acemoglu and Autor, 2011; Keister and Lewandowski, 2016). Thus, the employment that people can access and the productivity of labour will increasingly depend on the ability of workers to perform cognitive tasks.

At the same time, and in connection with this approach, a number of previous studies have warned that the incorporation of automated production mechanisms and advances in digital communication pose a risk to the labour market, not so much in the form of technological unemployment as because of their distributive impact, which could worsen inequality.

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[1]   This article is an extension of an earlier paper, Apella, I. and G. Zunino, "Technological change and the labor market in Argentina and Uruguay: a task content analysis", *Policy Research Working Paper*, No. 8215, Washington, D.C., World Bank, 2017.

[2]   However, the transfer of a technological improvement to final prices assumes a certain grade of competition in each market. In a market with a high concentration, profits from efficiency will be transferred to the profit margins of the companies.

Indeed, the automation of certain tasks, especially routine tasks, could change the structure of employment, increasing the weight of two major groups of workers: a highly skilled and productive group, working in occupations that are intensive in non-routine cognitive tasks and earning high incomes, and the group of low-skilled workers, relegated to low-productivity occupations that are intensive in non-routine manual tasks and earning low incomes. The change seems to be taking the form of a decrease in demand for the labour of workers with average skill and income levels, who are usually employed on routine tasks, whether manual or cognitive. A number of studies describe this process of employment polarization in developed economies (Acemoglu and Autor, 2011; Autor and Dorn, 2013; Goos and Manning, 2007; Goos, Manning and Salomons, 2014; Bussolo, Torre and Winkler, 2018).

The consequences of this will be distributed differently depending on whether machines are capable of replacing only unskilled work, skilled work, or all work. In any event, the new situation is challenging and calls for additional investment in the labour force if the benefits offered by technological change are to be realized. In other words, the productivity of workers needs to be raised by increasing their human capital so that they can adapt to the new forms of production. The benefits from the use of new production technologies are not automatic. Not only does access to information services and digital communication need to be improved, but new basic skills need to be incorporated into the workforce through education system modernization and ongoing training.

A major limitation of the previous literature from the perspective of policymakers in emerging countries is that most studies of the potential impact of technological change on labour markets is based on developed countries, while evidence for emerging countries, and particularly for Latin America and the Caribbean, is much more limited.

Emerging countries' characteristics are distinct from those of developed countries, which could potentially lead to different trends in technological progress and the task profile of labour markets. Economic structures and specializations differ between the two groups of countries. Emerging countries are characterized by lower wages and thus fewer incentives for automation compared with developed countries. Then, emerging countries usually perform less well in comparative tests of cognitive skills, which could entail constraints in the effort to move the labour supply towards a task profile that is more intensive in cognitive tasks.[3]

Stylized facts obtained for developed countries do not necessarily hold good for emerging countries, then, and the following question arises: is technological change also resulting in a growing demand for workers with cognitive skills in emerging countries? This paper aims to provide some elements for an answer to this question based on the evidence for Latin America and the Caribbean in the last two decades.

To do this, the paper will examine past trends in employment levels according to the type of tasks that workers did in their jobs, with a view to reaching an approximate assessment of the possible impact of technological change on the demand for labour and initiating a discussion on the possible public policy responses to this challenge. For this purpose, it will apply the task content methodology proposed by Acemoglu and Autor (2011) to a set of nine Latin American and Caribbean countries (Argentina, Brazil, Chile, the Dominican Republic, El Salvador, Mexico, Peru, the Plurinational State of Bolivia and Uruguay), which we consider to represent quite well the different characteristics of the whole region.

This paper provides new evidence that labour markets in the Latin American and Caribbean countries are not exempt from the process described. During the last 20 years, the labour force in the region has moved from more manual occupations to occupations that are more intensive in cognitive tasks. This allows us to state that, on average across the whole market, jobs are changing and with them

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[3] See, for example, the gaps in cognitive skills between emerging and developing countries in the Programme for International Student Assessment (PISA) test (OECD, 2015) and the Programme for the International Assessment of Adult Competencies (PIAAC) survey (OECD, 2013).

the type of skills, and workers, required. This phenomenon is characteristic of processes of change in the production functions of economies, particularly the adoption of new technologies such as robotics, which allow manual labour to be replaced in certain tasks.

The paper proceeds as follows. The next section discusses the theoretical framework of analysis for the relationship between technological change and the rate of substitution of factors of production. Section III presents the methodology and information used. Section IV analyses the main results obtained for a set of nine Latin American and Caribbean countries. Section V discusses the challenges that these tendencies entail for public policies. Lastly, section VI contains some closing reflections.

II.   Theoretical framework

The impact of technological progress on the performance of labour markets is discussed extensively in the literature (Autor, Levy and Murnane, 2003 and 2013; Frey and Osborne, 2013; among others), where it is suggested that it leads to a reduction in the level of employment in occupations that are intensive in routine tasks, i.e. occupations consisting principally in tasks which follow well-defined procedures that can easily be performed by some sort of algorithm. Not only technological progress itself, but also any reduction in the cost of accessing new production technologies, results in a potential displacement of part of the labour force by machines administered by a computerized system. Thus, technological change, and in particular the advance of robotics, could give rise to an increase in technological unemployment.

Frey and Osborne (2013) distinguish between occupations at high, medium and low risk of automation and argue that close to 47% of all work in the United States can be placed in the high-risk category. For its part, the World Bank (2016) estimates that an average of 50% of the current work in Latin America might not continue to be performed by people in the future.

However, not all jobs are susceptible to automation. Analysis of this phenomenon requires jobs to be differentiated not by the level of qualifications or skills they call for, as might be thought, but by the combination of tasks they involve. This framework of analysis, known as "task content", is proposed by Autor, Levy and Murnane (2003) and Acemoglu and Autor (2011), among others. According to these authors, tasks are not the same as the skills with which a worker is endowed, although the two concepts are closely related. While skills are tied to workers, tasks are tied to occupations.

Specifically, a task is defined as an activity which enables a product to be created (Acemoglu and Autor, 2011). However, workers need a number of skills to be able to carry out tasks. As an example, an architect needs great numerical and mathematical skills to perform cognitive tasks which are generally non-routine, such as the design and development of plans. Skills may be understood as workers' ability to perform particular tasks.

Tasks can be classified into two broad categories: routine and non-routine. A task is routine if its performance involves a clear and repetitive set of invariable actions. Many tasks, such as temperature control on a steel production line or the transfer of a car part to its place on an assembly line, have this characteristic. Since these tasks require the methodical repetition of an unvarying procedure, they can be clearly specified in a computer program and performed by a machine.

A non-routine task, on the other hand, is one that requires a number of actions to vary in time and those performing these actions to have the ability to adapt to the context using language, visual recognition and social interaction, among other things. As Polanyi (1966) puts it, these are the skills that mean a driver cannot be completely replaced, while the knowledge that a person has about their own body differs completely from their knowledge of physiology, and the rules of rhyme and prose do not in themselves explain what a poem conveys. Accordingly, the movement of a car through the traffic of a city and the writing of a poem fall into the category of non-routine tasks, the reason being that these

tasks require visual, socioemotional and motor processing abilities that cannot be described in terms of a set of programmable rules.

At the same time, the tasks in each of these two categories may be of either a manual or a cognitive nature, i.e. relate to either physical work or to knowledge. It is thus possible to establish four main categories of tasks:

(i)   Routine manual tasks, normally performed by low- or medium-skilled workers. Such tasks are highly codifiable and replaceable by automation, and examples of those performing them include assembly line workers and manual factory workers.

(ii)   Non-routine manual tasks, commonly performed by low-skilled workers. The performance of these tasks requires the ability to adapt to situations and involves language, visual recognition or social interaction. Drivers and mining and construction personnel are examples of workers who perform these types of tasks intensively. These tasks have a low or zero probability of being computerized, although Frey and Osborne (2013) have suggested that some of them, such as transport and logistics and administrative support, are at risk of being automated.

(iii)   Routine cognitive tasks, carried out by medium-skilled workers. Computers may be a substitution factor in some occupations more than others, specifically those that involve explicit and repeated sets of activities which can be coded in a computer program. The tasks performed by secretaries, salespeople, administrative staff and bank cashiers, among others, fall within this group.

(iv)   Non-routine cognitive tasks, normally performed by highly skilled workers. These tasks, which are often divided into the two broad subcategories of analysis and personal relations, require abstract thought, creativity, the ability to solve problems and communication skills. Computers may complement the performance of these tasks, increasing the productivity of the skilled workers. These tasks are commonly performed by professionals such as managers, designers, engineers or information technology specialists, teachers, and researchers, among others.

All occupations, with differing levels of intensity, involve one or a combination of the tasks described. The intensity of tasks appears to vary greatly between occupations. As an example, car drivers perform non-routine manual tasks the majority of the time but also perform personal non-routine cognitive tasks and routine cognitive tasks. In contrast, scientists spend the majority of their time performing non-routine cognitive tasks, but also perform routine cognitive or manual tasks, or both, with a lower frequency.

As the cost of accessing new technologies declines, computer-controlled machinery could replace those workers who perform largely routine tasks, especially manual ones. The phenomenon is not new, as such substitution has been seen since the first industrial revolution, but the technological revolution has developed in such a way that machines can perform cognitive tasks which a few decades ago were only performed by people. As Bresnahan (1999) points out, during the last three decades computers have increasingly performed tasks involving calculation and the coordination of activities and communications and taken over the work of bank cashiers, telephone operators and other performers of repetitive information-processing tasks.

On the other hand, the ability of computers to replace workers employed in the performance of cognitive tasks is limited. Combinations of tasks which demand flexibility, creativity, problem-solving and communication skills (non-routine cognitive tasks) are less susceptible to automation, with the need to produce a series of explicitly programmed instructions constituting a restriction.

Computer technology is more adept at replacing workers who perform routine tasks than non-routine tasks, but it can be a complementary factor in the performance of non-routine tasks, and may increase marginal productivity. To give an example, the ability to use a bibliographic search program through a networked computer increases the efficiency of researchers using such references as inputs and enhances the quality of their output.

Not all tasks are susceptible to replacement by machines, and decisions in the production sector about optimum combinations of production factors are found to be driven not only by the flexibility with which substitution can be carried out between factors but also by their relative prices. The simple model proposed by Autor, Levy and Murnane (2003) and also by Frey and Osborne (2013) allows these decisions to be formalized.

Let us assume a Cobb-Douglas production function for work and capital as follows:

$$Q = \left(L_r + k \right)^{1-\beta} L_n^{\beta} \tag{1}$$

where L_r and k are the work to be performed in tasks susceptible to automation and the capital that these tasks can realize, respectively. The two factors are perfect substitutes. L_n represents the value of the work required so that the tasks are not susceptible to automation. Assuming that the product price is the numeraire, and taking w_r, ρ and w_n as the wage for the work that can be automated, the price of capital and the wage for the complementary work, respectively, of the first order conditions, we obtain the following expression:

$$PMg_{Lr} = PMg_k = \left(1 - \beta \right) \frac{\left(L_r + k \right)^{-\beta}}{L_n^{-\beta}} = w_r = \rho \tag{2}$$

where PMg_{Lr} is the marginal product of labour in routine tasks, PMg_k is the marginal product of capital and $\theta = \frac{(L_r + k)}{L_n}$ is the relationship between tasks susceptible and not susceptible to automation within the production function. The optimal condition requires equality between the marginal productivity ratios of factors and relative prices:

$$\frac{PMg_{Lr}}{PMg_k} = 1 = \frac{w_r}{\rho} \tag{3}$$

This assumes a reduction in the price of capital, ρ, that implies that the technical substitution ratio is less than the relative prices, encouraging the company to reallocate factors of production in pursuit of economic efficiency, replacing labour with capital.[4]

Following Goos and Manning (2007) for the case of Great Britain, it is possible to see a tendency towards polarization in the labour market, with growth in high-income cognitive work and low-income manual occupations accompanied by a reduction in medium-income routine tasks. Falling prices for computing equipment are increasing the relative productivity of problem-solving skills, which explains the growth in occupations requiring the performance of cognitive tasks by a qualified labour force (Katz and Murphy, 1992; Acemoglu, 2002).

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[4]   In the case of additive production functions, the only effect in the face of an exogenous price shock is the substitution effect.

III. Methodology and information sources

To carry out this analysis, the information available in the Occupational Information Network (O*NET) database was used in conjunction with household surveys. The database provides information on the task content of occupations. O*NET data have been collected in the United States using the Standard Occupational Classification (SOC) system for approximately a thousand occupations since 2003, with periodic updating.[5]

Following the work of Acemoglu and Autor (2011), two sets of O*NET data are used: work activities and work context. Each contains descriptors intended to measure the importance, level or scope of the activity on a scale. For this, data from O*NET 2003 and 2015 are used to capture changes in the content of the tasks within each occupation over time.

In order to estimate the content of the tasks in the different occupations, the task elements provided by O*NET are mapped on to the corresponding four-digit occupations in the International Standard Classification of Occupations (ISCO). The results are combined with individual labour force data from household surveys. In general, each country has a specific version of the ISCO; in cases where a national classification is used, ISCO equivalents are applied. O*NET, meanwhile, uses a modified version of the Standard Occupational Classification (O*NET-SOC). A table of equivalences between these two classifications is employed so that the appropriate occupational attributes can be matched to the household survey data.

In many cases, the correspondence tables do not provide a one-to-one match between the occupational categories of O*NET and the household surveys. In these cases, the strategy used by Hardy, Keister and Lewandowski (2015) was followed. Four situations can be identified.

The first situation is one where an occupational code belonging to the O*NET classification corresponds to just one occupational code in the classification to be mapped to. In this case, the characteristics of the O*NET code are attributed directly to the classification in the household survey.

In the second situation, a specific code in the O*NET classification corresponds to more than one code in the classification to be mapped to. In this case, the characteristics of that one code in the first classification are attributed to all the occupations of the second classification.

In the third situation, a number of codes in the original classification correspond to a single code in the classification mapped to. In this case, the average value of the characteristics associated with the codes of the original classification are attributed to this latter code.

The final situation is one where a number of codes in the original classification correspond to several codes in the classification being mapped to. In this case, again, an average value for the characteristics associated with the relevant codes in the original classification is attributed to each code in the classification being mapped to.

The mapping once complete, following Acemoglu and Autor (2011) and Hardy, Keister and Lewandowski (2015), five measures were constructed for the content or intensity of the main tasks involved in occupations: non-routine cognitive analytical, non-routine cognitive interpersonal, routine cognitive, routine manual and non-routine manual. These are based on the attributes of the activities that each occupation requires. Attributes (elements) representative of each task were selected and are presented in table 1.

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[5] O*NET is the successor of the Dictionary of Occupational Titles (DOT), which is no longer updated. O*NET was launched in 1998 on the basis of the Bureau of Labor Statistics (BLS) Occupational Employment and Wage Statistics codes. It was changed to SOC in 2003, which implies that consistent measures of task content have been calculated since that year.

Table 1
Construction of task content measurements

Task	Task elements *(t)*
Non-routine cognitive analytical	Information analysis Creative thinking Interpretation of information for others
Non-routine cognitive interpersonal	Establishment of personal relationships Leadership, management and motivation of staff Training and development of others
Routine cognitive	Repetition of the same tasks Accuracy or precision is important The work is highly structured
Non-routine manual	Operation of vehicles or machinery Use of hands to manipulate, control or feel objects Manual dexterity Spatial orientation
Routine manual	Speed determined by that of the equipment used Control of machinery or processes Repetitive movements

Source: D. Acemoglu and D. Autor, "Skills, tasks and technologies: implications for employment and earning", *Handbook of Labor Economics*, vol. 4, part B, D. Card and O. Ashenfelter (eds.), Amsterdam, Elsevier, 2011.

The first step in building the five task intensity indices is to standardize each of the 16 indicators *(t)* taken from O*NET and attached to the occupations reported by individuals in the household surveys so that each of these indicators takes a value of zero for the average worker of the period in each country. Specifically, the values of each element *t* are normalized to make information comparable across time, using the following formula:

$$\forall j \in J t_{i,j}^{std} = \frac{t_i - \mu_j}{\delta_i} \tag{6}$$

where *J* is the combination of the 16 tasks listed in table 1 for occupation *i*, and μ_j and δ_j represent, respectively, the weighted average and the standard deviation of task *j* in the whole of the period from around 1995 to around 2015[6], computed as follows:

$$\forall j \in J \mu_j = \frac{\sum_i^N t_{i,j} w_i}{\sum_i^N w_i} \tag{7}$$

$$\forall j \in J \delta_j = \left(\frac{\sum_i^N w_i (t_{i,j} - \mu_j)}{\sum_i^N w_i} \right)^{1/2} \tag{8}$$

where w_i is the relative weighting attributed to occupation *i*.

After that, to construct the five measures of intensity for each task, all the elements of each group of tasks are added up and each of the five measures of intensity is again standardized. In this way, each of these five measures of task intensity takes a value of zero for the average worker of the period in each country. Normalization is carried out within countries. Thus, the concrete value of each task intensity index in a given country and period shows how it has evolved for the average worker over the entire period within the country concerned. It should be noted that these measures do not allow task intensity to be compared between countries, because each country has a specific index based on its own average worker in the period analysed.

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[6]   The specific period of analysis was subject to the availability of data in each country covered by the study.

An important limitation of the methodology applied arises as a consequence of the fact that the O*NET information used to identify the task profile of each occupation is based on surveys carried out in the United States, and the task profile of an occupation in an emerging country, with different levels of capital per worker, could be different from the profile observed in the United States.

IV. Empirical results

1. The relative importance of tasks

This section presents the empirical results relating to changes in the tasks performed in the course of the average job in the selected countries between the mid-1990s and the mid-2010s. The aim is to identify not only the changes but also the factors that prompted these changes and the effects on the wage distribution.

Figure 1 shows changes in the content of each type of task in the average job in each country between the mid-1990s and the mid-2010s.

Figure 1
Changes in the task content of employment by country, mid-1990s to around 2015
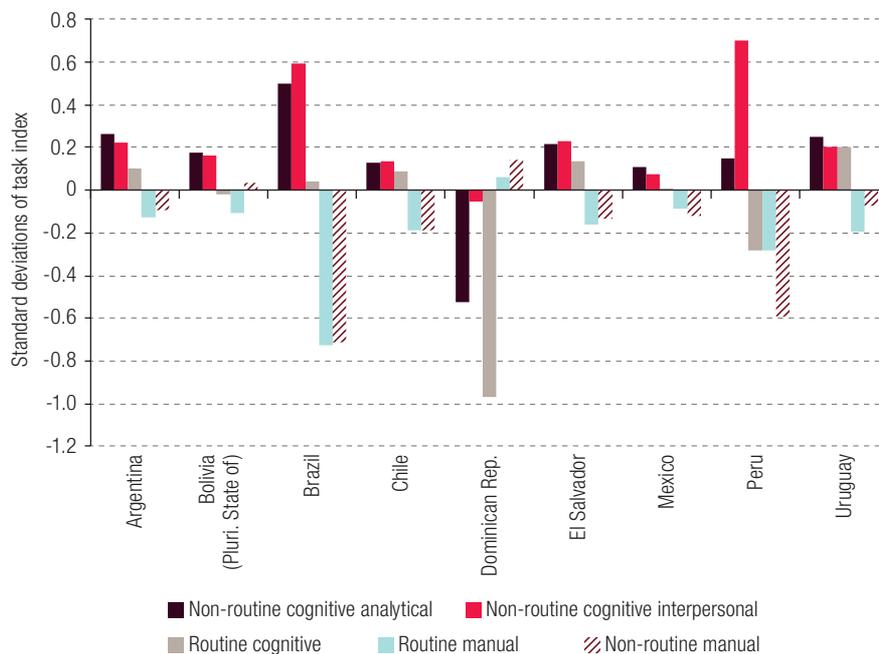
Source: Prepared by the authors, on the basis of O*NET [online] https://www.onetonline.org and household surveys conducted in the respective countries.
Note: Owing to the availability of information, a different period is covered for each country: Argentina 1998–2015; Brazil 1996–2013; Chile 1996–2015; Dominican Republic 1996–2014; El Salvador 1998–2014; Mexico 1996–2014; Peru 1997–2013; Plurinational State of Bolivia 1995–2015; and Uruguay 1995–2015.

When the start and end years in each country are observed, a clear common trend of change in the profile of the average employment in the region is appreciated, although with some differences that need to be highlighted.

As regards the content of non-routine cognitive tasks, whether analytical or involving interpersonal relations, all the countries analysed, with the sole exception of the Dominican Republic, show an

increase in the content of these tasks in the average job. This finding is consistent with a process of change in the tasks performed by workers in a context where many of them are at risk of automation. As mentioned above, non-routine cognitive tasks are not susceptible to automation, and it is therefore in this group of activities that space is opening up for the workforce.

In the case of manual tasks, both routine and non-routine, their relative importance within the average job decreased during the period of study in all the countries except, again, the Dominican Republic. The Plurinational State of Bolivia is a particular case, because although there was a drop in non-routine manual tasks, there was a small increase in routine manual tasks.

On the other hand, the importance of routine cognitive tasks in the average job rose in five of the nine selected countries: Argentina, Brazil, Chile, El Salvador and Uruguay. In the cases of the Dominican Republic, Mexico, Peru and the Plurinational State of Bolivia, conversely, the content of routine cognitive tasks in the average job has decreased during the last 20 years.

The findings suggest that there has been a change in the profile of employment in Latin America and the Caribbean in terms of the intensity with which the different types of tasks are carried out by employees in their occupations, with a shift from jobs intensive in manual tasks to a greater intensity or content of cognitive tasks. The only exceptions to this common trend in our set of countries are the Dominican Republic, where the profile of employment changed in the opposite direction, and the Plurinational State of Bolivia, where the content of routine manual tasks increased during the period under study.

In general, the relative importance of non-routine cognitive tasks, both analytical and interpersonal, has grown in the region during the last 20 years. At the same time, the average intensity of manual tasks, both routine and non-routine, has decreased. All these changes are in line with findings in the most developed countries (Autor, Levy and Murnane, 2003; Spitz-Oener, 2006) and with the results of Keister and Lewandowski (2016) for countries in Central Europe.

However, there is room for doubt about the evolution of the relative importance of routine cognitive tasks in some countries of the region. Autor, Levy and Murnane (2003) found that tasks of this type lost ground in United States employment, and Spitz-Oener (2006) obtained similar results for Germany. However, a review and update by Acemoglu and Autor (2011) for the United States found different trends during specific periods. In the same way, Keister and Lewandowski (2016) identified an increase in the intensity of routine cognitive tasks for several countries of Central and Eastern Europe.

The importance of the increased content of routine cognitive tasks in the average job in the countries of the region lies in the risk of automation that these types of task present. The fact that jobs are now more intensive in them poses a medium-term risk of displacement for some workers due to automation. As mentioned previously, tasks of this type are carried out by workers with an intermediate level of education and average labour incomes, which implies that a process of automation and displacement could lead to a worsening situation of distributive inequality.

2.   Factorial decomposition of the changes in task content

The changes in the content of the tasks observed raise some concerns about the mechanisms that are operating to alter the average employment profile in each of the countries analysed. It is possible to identify three major channels through which these changes in the importance of each task in the average job are being generated.

The first is associated with the movement of workers between economic sectors, commonly called the between-sector effect. As an example, migration of workers away from an economic sector such as agriculture, which is traditionally intensive in manual tasks, to the service sector, which is more

intensive in cognitive tasks, leads to a change in the profile of the tasks performed in the average employment in the country concerned.

As pointed out by Apella and Zunino (2017), this movement of workers between economic sectors can be prompted by different causes, such as changes in the terms of trade that affect a whole sector and put it at a disadvantage to international competitors, changes in global trade centres and the emergence of other countries with greater comparative advantages in the sector, the urbanization processes that take place as people leave jobs in rural areas and migrate to large cities to join the industrial, service or retail sector, etc. However, the role of technological change in this process is not minor. The incorporation of new production technology in sectors traditionally associated with manual tasks forces workers to seek employment opportunities in other branches of activity.

The second factor is the movement of workers between occupations within the same branch of activity, called the between-occupation effect. An example might be someone who ceases to work as a bank teller, an occupation that is intensive in routine cognitive tasks, and begins to work as a taxi driver, which is a non-routine manual occupation. This example indicates the importance that technological change can have for the average employment profile, encouraging movements of workers between occupations.

The third channel through which changes occur in the average content of the tasks performed by workers are specific modifications within each occupation over time, usually called the within-occupation effect. In other words, the incorporation of new production technology in each occupation forces workers to alter their roles within the workplace. The adoption of automated assembly machinery managed by a computer program requires workers to be reassigned from the tasks they previously performed, so that they may come to spend the majority of their time on tasks relating to sales and merchandising, for example. We approximate this change in the task profile of occupations over time by constructing the five intensity indicators based on the O*NET information from different years.[7]

In order to examine in detail the importance these transmission channels have had for the changes observed in the content of the different types of tasks performed in the average workplace in our set of countries, we now present a factorial decomposition exercise, which references the total changes in task intensity between the start point of the analysis (the mid-1990s) and the end point (the mid-2010s) for our set of countries, identifying the three possible separate effects mentioned above and the interactions between them:

(i)   Structural change or between-sector effect. The hypothesis for this effect is that part of the change in the relative intensity of the tasks the labour force performs is associated with a movement of the labour force between sectors or branches of activity, prompted partly by technological change but also, as mentioned, by other exogenous factors.

(ii)   Change between occupations or between-occupation effect. This effect derives from movements of workers between distinct occupations with different combinations of tasks.

(iii)   Changes within each occupation or within-occupation effect. In this case, we try to capture the contribution of changes which arise within each occupation, in terms of the combination of tasks required for its performance.

(iv)   The interaction of all the above.

The decomposition exercise methodology is described in detail in annex I, while the results are presented in figure 2.

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[7] Since O*NET is periodically updated, we can study changes in the task profile of occupations over time.

Figure 2
Factor decomposition of changes in the content of tasks performed
in the average job, mid-1990s to around 2015
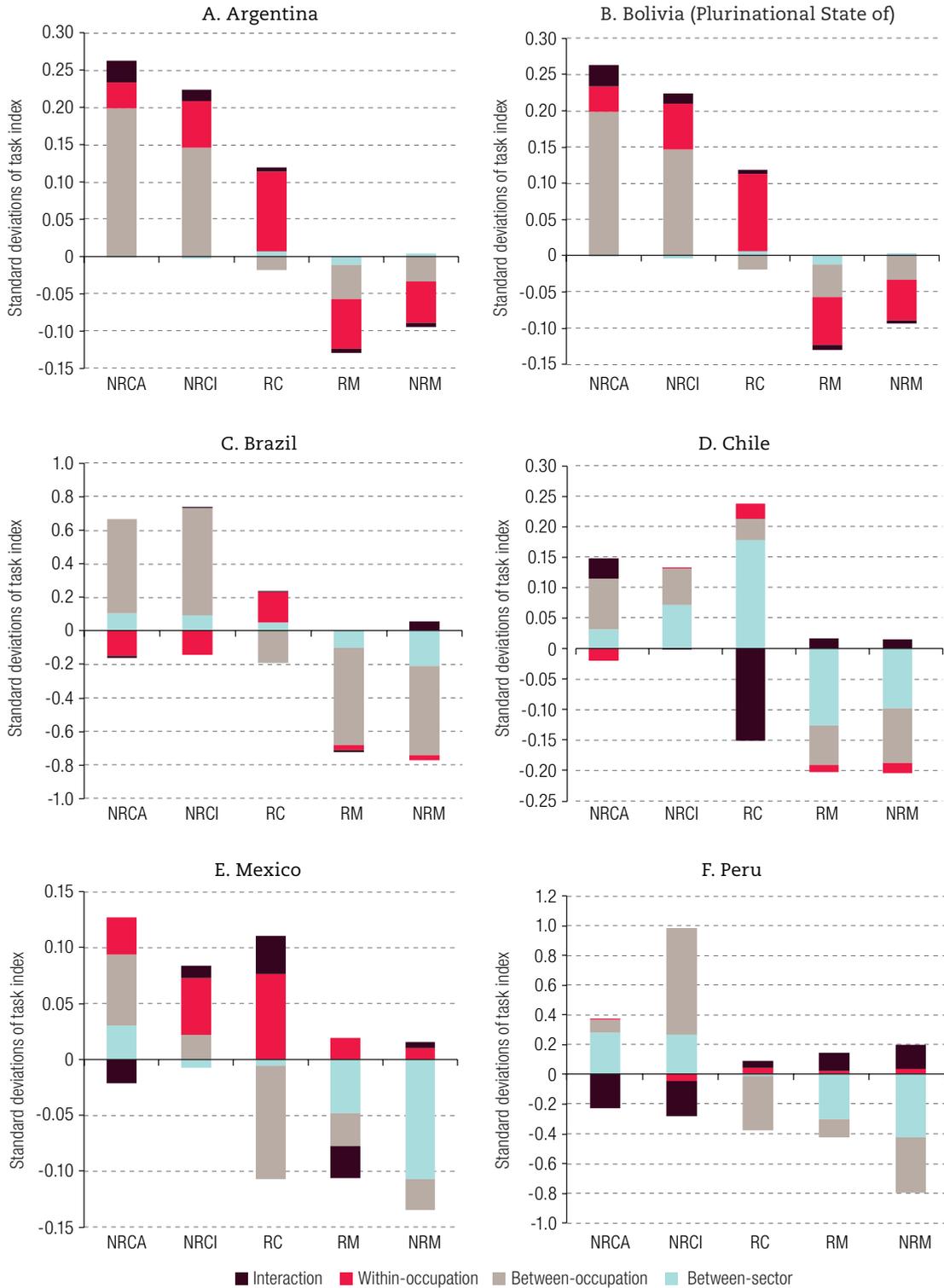
Figure 2 (concluded)
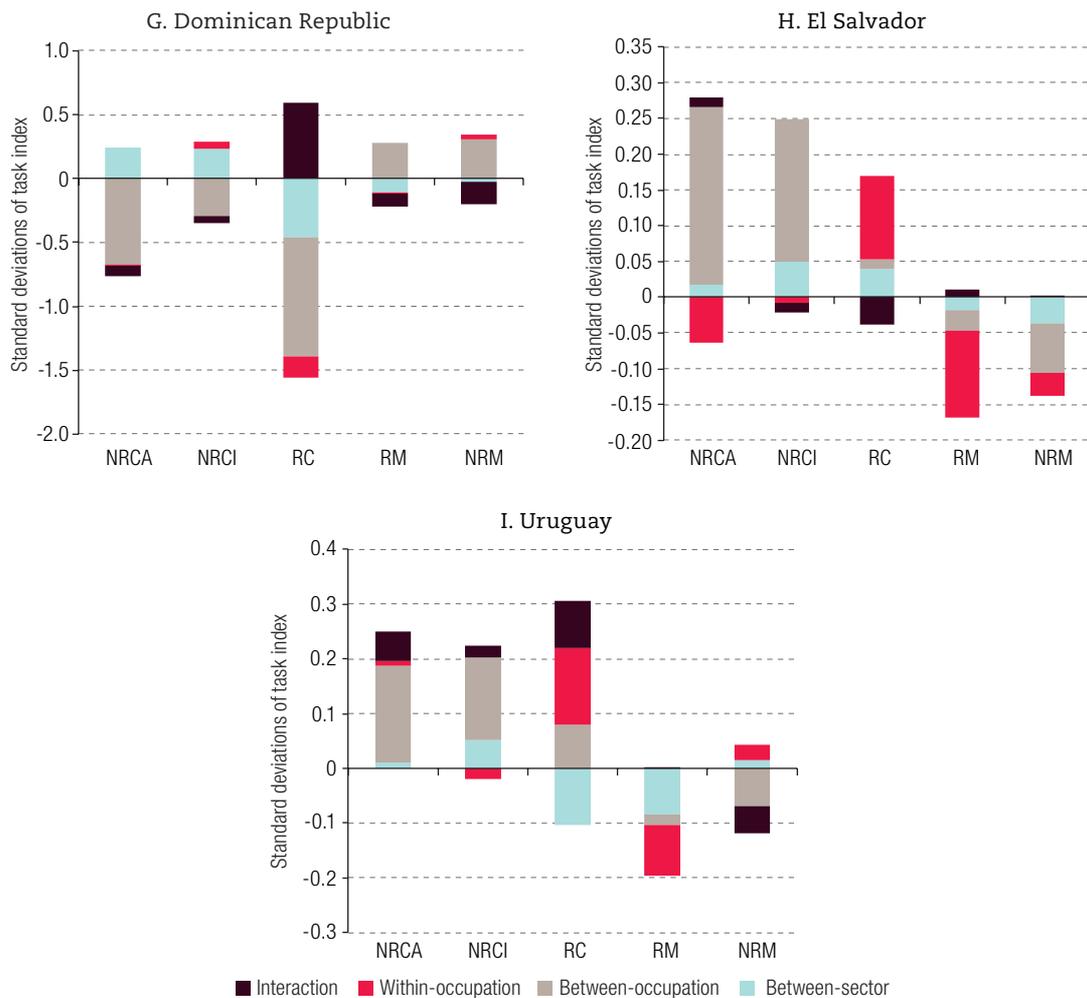
G. Dominican Republic

H. El Salvador

I. Uruguay

■ Interaction   ■ Within-occupation   ■ Between-occupation   ■ Between-sector

Source: Prepared by the authors, on the basis of O*NET [online] https://www.onetonline.org and household surveys conducted in the respective countries.

Note: NRCA stands for non-routine cognitive analytical, NRCI for non-routine cognitive interpersonal, RC for routine cognitive, RM for routine manual, NRM for non-routine manual, Int for interaction, WO for within-occupation, BO for between-occupation and BS for between-sector. Owing to the availability of information, a different period is covered for each country: Argentina 1998–2015; Brazil 1996–2013; Chile 1996–2015; Dominican Republic 1996–2014; El Salvador 1998–2014; Mexico 1996–2014; Peru 1997–2013; Plurinational State of Bolivia 1995–2015; and Uruguay 1995–2015.

To begin with the between-sector effect, it is observed that movements between branches of activity are an important factor behind the increase in the content of routine cognitive tasks in Chile and the decrease in the relative importance of routine manual tasks in Uruguay and Mexico. Likewise, the same effect explains a significant share of the increase in the content of routine manual tasks in the Plurinational State of Bolivia.

Observing changes in the employment shares of the different branches of activity over the last 20 years (see annex II for details), it can be seen that, both in Chile and in Mexico, there has been a significant fall in employment in industry and in primary activities (sectors that are intensive in manual tasks) and an increase in the real estate sector and services (sectors that are intensive in routine cognitive tasks). Similarly, in Uruguay there has been a significant shift of employment from the industrial sector to the service sector.

Contrary to the trend observed in the rest of the region, the share of routine manual tasks in the average job has increased in the Plurinational State of Bolivia in connection with a significant rise in employment in the primary sector, which showed an increase of 30% between 1995 and 2015.

This is an example of the between-occupation effect, which turns out to have been one of the main channels through which the profile of employment has changed in the region. Indeed, it is extremely important in explaining the increase in the content of non-routine cognitive tasks and the drop in the content of manual tasks in Argentina, Brazil, El Salvador, Mexico, Peru, the Plurinational State of Bolivia and Uruguay.

Lastly, changes in the relative intensity of tasks resulting from specific changes to each occupation, i.e. the intra-occupation effect, have played an important role in five countries: Argentina, El Salvador, Mexico, the Plurinational State of Bolivia and Uruguay. However, the tasks for which this effect is important varies substantially by country. In Argentina, changes in the combination of tasks within particular occupations explain the increase in the content of cognitive tasks, both routine and non-routine, and the drop in the importance of manual tasks. A similar picture, but less marked, is seen in El Salvador and Uruguay, where this effect explains the increase in the content of routine cognitive tasks in the average job and the reduction in routine manual tasks. In Mexico, the effect explains the increases in the relative importance of non-routine cognitive tasks, particularly those related to interpersonal relationships, and routine cognitive tasks. In the Plurinational State of Bolivia, lastly, the intra-occupation effect is important in explaining the increase in the content of routine cognitive tasks.

In a context of changes in the importance that some types of tasks have in the average job, requiring adaptation by the labour force, there is a risk of polarization in the labour market. The automation of certain tasks, especially routine ones, could cause its structure to become dominated at the top and bottom by two large groups of workers: on the one hand, highly qualified, highly productive individuals with high incomes working in occupations that are intensive in non-routine cognitive tasks, and on the other, a group of low-skilled workers relegated to occupations that are intensive in non-routine manual tasks and therefore have low productivity and provide low incomes. Meanwhile, workers with average qualifications and incomes, who generally perform routine tasks, whether manual or cognitive, face the risk of a decline in demand for their labour or in their incomes.

Figure 3 presents average task content per working hour, broken down into the four major task groups defined above, for each labour income decile in Latin America and the Caribbean at two different points in time: the mid-1990s and around 2015.

Consistently with the patterns observed in other countries, it can be appreciated that in those of the region most workers in the upper deciles perform non-routine cognitive tasks, while workers in the lower part of the distribution carry out manual tasks. As can be seen from the chart, however, the routine manual task content of occupations has decreased for workers in all labour income deciles. This result is in line with what has been previously discussed and with the replacement of these tasks by automatic production mechanisms.

Conversely, the importance of non-routine cognitive tasks has grown in all income deciles. In this process, two important facts can be observed. First, whereas in the mid-1990s only the occupations of workers in the top two deciles were intensive in this type of task, by the mid-2010s those of workers in deciles 7 and 8 were as well. Second, the gap between non-routine cognitive tasks and manual ones widened, suggesting that in the higher-income deciles the transition from manual to cognitive tasks, especially non-routine ones, was particularly intensive.

Figure 3
Latin America and the Caribbean: task content by labour income decile
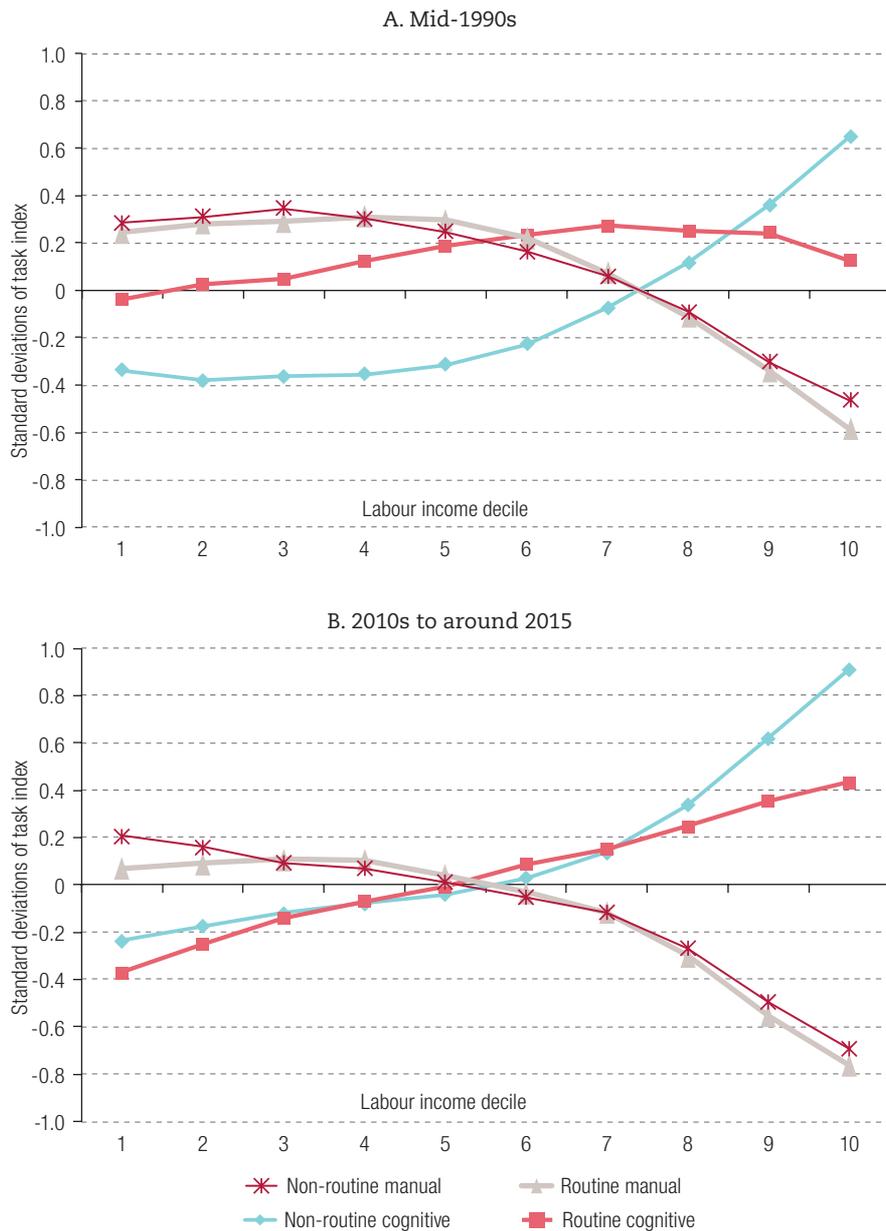
A. Mid-1990s

B. 2010s to around 2015

Legend: Non-routine manual, Routine manual, Non-routine cognitive, Routine cognitive

Observing the left tail of the distribution, it can be appreciated that although the gap between the content of non-routine cognitive tasks and the rest narrowed, these tasks remained the least prevalent among workers in the lowest income deciles. This suggests that workers with lower labour incomes are engaged in occupations which are intensive in manual tasks. Indeed, non-routine manual tasks are the most prevalent among workers in the lowest income deciles. While the content of this type of tasks

has declined almost throughout the distribution, it has remained practically unchanged among workers belonging to the first two deciles, which is an indication of how tasks of this type are concentrated in the lowest deciles.

If the last 20 years are considered, it is possible to observe a transition towards a content structure of tasks in which non-routine cognitive tasks are carried out mainly in the four highest income deciles (which are increasingly detached from the average) and non-routine manual tasks are concentrated in the lowest income deciles.

Although labour markets are not yet polarized, what happens in the future will clearly depend on the progress made with the automation of routine cognitive tasks. It is in occupations which are intensive in tasks of this type that workers with average qualification levels and incomes are employed, examples being credit analysts, office assistants, cashiers, sales personnel and editors, including translators. In most of the developed economies, occupations that are intensive in routine cognitive tasks tend to have remunerations situated around the mean of the distribution (Acemoglu and Autor, 2011, Goos, Manning and Salomons, 2014).

Our findings for the region are different from what has been described for developed countries. Both in the 1990s and in the mid-2010s, the share of routine cognitive tasks was substantial in the labour income deciles from the middle (the fifth decile) upward. In the mid-1990s, indeed, this type of task content was important in all the deciles from the fourth upward, but after 20 years it had lost ground in the occupations performed by workers in all but the highest deciles.

For this reason, given the increase in the content of routine cognitive tasks in the average job in the region, the risk of future polarization in the labour market will depend on the degree to which these are automated.

V.   Public policy implications

The process of technological change now going on not only in the region but worldwide is a potential source of productivity increases. However, some challenges arise from the point of view of the labour market, determining the conditions under which new technologies are used. Technological change could lead to a reduction in the demand for the labour of those on medium incomes (usually associated with routine manual tasks), polarizing the labour market between two broad classes of employment: one of poorly-paid activities involving the performance of non-routine manual tasks, and the other of better-paid activities involving non-routine cognitive tasks.

In this technological race, there is a clear public policy challenge associated with the need for low-skilled workers to switch to other types of tasks that are not susceptible to automation, i.e. tasks requiring intensive use of creative or social intelligence.

In the last 20 years, the labour markets of the Latin America and Caribbean region have experienced a substantial shift from manual work to cognitive work, which can largely be attributed to changes in the different occupations' share of total employment, modernization within occupations themselves and, in some cases, movements of workers between sectors. As in the United States, Germany and the countries of Central and Eastern Europe, the importance of non-routine cognitive tasks in the average workplace has shown signs of increasing considerably in the Latin American countries. Two effects of technological change and the reduced cost of accessing technology can be seen, one that is more short-term and one that concerns the medium or long term but requires immediate action.

The first is a reduced need for routine manual tasks and therefore an increase in technological unemployment in some segments of the labour force. The second is the challenge of preparing the

younger generations, as they acquire human capital, to perform occupations which do not exist yet but will certainly incorporate a major component of non-routine cognitive tasks.

With regard to technological unemployment, policies aimed at confronting the negative effects of the shift in employment from production that is intensive in routine manual work towards production that is intensive in technological capital and cognitive work are of crucial importance. The transition may be approached from two different perspectives, that of the demand for labour and that of its supply.

From the perspective of the demand for labour, i.e. of individual production sectors as they seek a profit-maximizing combination of factors, the transition could be attenuated by regulations limiting the substitution of labour by capital. These types of regulations, although often used, are probably an inefficient solution. Any initiative of this kind must take account of the economic and social costs entailed (e.g. increased production costs and reduced well-being for consumers who pay higher prices in the market) as well as the benefits (maintaining employment levels in certain occupations).

In the same way, it is important to stress that technological change is ongoing and therefore that access costs will continue to decrease. This implies that the trend towards automation will grow over time, and accordingly that the costs of deterring it will too. In other words, to maintain their effect, interventions of this type will need to be strengthened over time as technological change advances, requiring the acceptance of ever greater intervention costs.

Alternatively, public policy could focus on the labour supply. The consistent challenge here is to strengthen the spaces and instruments used to adapt the labour supply, i.e. to redesign ongoing training systems in a way that takes account of changes in the demand for labour. This should include the pursuit of public-private cooperation, not only in the area of financing, but also through the design of a training strategy and exploitation of economies of scale in training work. This means clearly identifying the factors which can jeopardize the success of this type of initiative, especially where older workers are concerned.

The medium-term challenge, although it actually needs to be addressed immediately, is to prepare the younger generations during their human capital accumulation process to perform roles which do not yet exist. Looking beyond the potential creative destruction of employment and the consequent technological unemployment, this could be a step towards higher overall productivity in the economy and the creation of occupations which are currently unknown.

Economic growth takes place as jobs become more productive, but also as more productive jobs are created and less productive ones disappear. The benefits may take the form of new products, new methods of production and transportation or new markets, but they appear through a constant process of restructuring and redistribution of resources, including the labour force. Since economies grow as high-productivity jobs are created and low-productivity jobs disappear, the relationship between higher productivity and job creation is not mechanical. Innovations may entail increases or reductions in employment levels in the short term, but in the medium term the tendency will be towards a close alignment between higher employment and economic growth.

In a context where many of the jobs that will be done by today's children do not yet exist, it is not possible to plan a specific course of training for such occupations. The challenge, rather, consists in developing children's cognitive skills so that they have the ability to think creatively and adapt to whatever situation presents itself.

To achieve this, it is essential to rethink the educational system at all levels, so that subjects can be rapidly adapted to the demands of employment as they arise. Accordingly, we suggest that there is a need to switch from an approach in which educational systems are based on the knowledge acquisition paradigm (memorization) to one which prioritizes the development of cognitive and socioemotional skills through problem-solving, as a foundation for the ongoing acquisition of technical skills.

The challenge is to recognize the importance and generate pathways for the development of a study mechanism associated with the development of critical thought, argument and analysis, i.e. the generation of transferable and rapidly adaptable skills which are useful in different activities.

It is crucial for all students in the education system to develop and learn basic cognitive skills, above all numerical and problem-solving skills, since cognitive deficiencies at an early age are extremely difficult to overcome later in life. This must be complemented by constant updating not only of tools but of vocabulary itself. As an example, a new kind of literacy (cognitive and digital) is a minimum requirement for Internet use.

VI. Conclusions

Technological innovation, such as the advance of digital technologies, communications and robotics, may entail an improvement in the general well-being of the population and reduce poverty by increasing the overall productivity of the economy. However, some possible consequences of rapid technological change have been analysed with concern in the literature.

For one thing, technical progress, and particularly the advance of robotics, means that certain activities are at high risk of becoming obsolete, since a number of them, such as routine tasks and those replaceable by a code, can be easily automated, leading to what is commonly known as technological unemployment. For another, a number of previous studies have warned that the incorporation of automated production mechanisms and the progress of digital communication pose a risk to the labour market, not so much because of technological unemployment as because of their distributive impact, which could worsen inequality.

The objective of this paper is to study past trends in employment levels according to the type of tasks done by workers in their jobs and thereby reach an approximate assessment of the possible impact of technological change on the demand for labour. A review of the trend in employment profiles in the Latin American and Caribbean countries over the last 20 years reveals a significant increase in the relative importance of cognitive tasks in the workplace to the detriment of manual tasks. These changes have been generated by within-occupation shifts in the combinations of task types performed to produce a good or service; the movement of workers between occupations within the same branch of activity; and structural changes, i.e. movements of workers between branches of activity. We find that the movement of workers between occupations within the same branch of activity is extremely important in explaining the increase in the content of non-routine cognitive tasks and the drop in the content of manual tasks in most of the countries analysed.

Moreover, consistently with the patterns observed in other countries, we found that most workers in the upper deciles performed non-routine cognitive tasks in the countries of the region, while workers in the lower part of the distribution carried out manual tasks. Taking the last 20 years, the gap between non-routine cognitive tasks and manual ones was found to have widened, suggesting that the transition from manual tasks to cognitive tasks, especially non-routine ones, was particularly intensive in the higher income deciles.

This trend towards an increasing prevalence of non-routine cognitive tasks to the detriment of routine manual tasks can be expected to intensify as technological change advances and can be appropriated and adapted by the production sectors of developing countries. Clearly this will entail a reduction in the demand for labour specializing in routine manual tasks, generating technological unemployment in the short term. However, any technological change which replaces workers with machines will have effects on all product and factor markets. An increase in production efficiency which brings down the costs of production methods could generate increased demand for other goods and services.

Thus, technological progress has two effects on the level of employment. First, there is a destructive effect as technological change leads to labour force replacement; second, there is an effect of new job creation as the number of production units that internalize new technologies increases and productivity rises, complementary employment in these sectors expands and other occupations are generated to meet new demand for goods and services. In this context, it is vital to design two different strategies, one relating to the short term and the other relating to the long term but requiring immediate action.

With regard to the potential for technological unemployment, it is important to implement mechanisms that strengthen the provision of ongoing training in a way that aids the adaptation of the labour supply. In other words, it is important to redesign systems of ongoing training in consideration of the new skills required in the market.

The medium-term challenge, although it actually needs to be addressed immediately, is to prepare the younger generations in their human capital accumulation process to perform roles which do not yet exist. Looking beyond the potential creative destruction of employment and the consequent technological unemployment, this could be a step towards higher global productivity in the economy and the creation of occupations which are currently unknown. Growing cognitive skills are required to meet rising demand for the performance of non-routine cognitive tasks. This being so, the Latin American and Caribbean countries need to improve the quality of their education systems and reduce the educational gap between different sectors of the population, because increasingly a person's level of education will be a key variable in their prospects of finding a good job.

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Annex A1

Task decomposition exercise

The decomposition is computed for each country according to the formula:

$$IT_{i \in T}\left(IT_i^{2015} - IT_i^{1995}\right) = \sum_{j \in S} t_{i,j,2015}^{2015} h_j^{2015} - \sum_{j \in S} t_{i,j,2015}^{1995} h_j^{1995}$$

$$IT_{i \in T}\left(IT_i^{2015} - IT_i^{1995}\right) = BS_i + BO_i + WO_i + INT_i$$

where:

$$\forall_{i \in T} BS_i = \sum_{j \in S}\left[t_{i,j,1995}^{1995}\left(h_j^{2015} - h_j^{1995}\right)\right]$$

$$\forall_{i \in T} BO_i = \sum_{j \in S}\left(t_{i,j,1995}^{2015} - t_{i,j,1995}^{1995}\right)h_j^{1995}$$

$$\forall_{i \in T} WO_i = \sum_{j \in S}\left(t_{i,j,2015}^{2015} - t_{i,j,1995}^{2015}\right)h_j^{1995}$$

$$\forall_{i \in T} INT_i = \sum_{j \in S}\left(t_{i,j,2015}^{2015} - t_{i,j,1995}^{1995}\right)\left(h_j^{2015} - h_j^{1995}\right)$$

where:

$t_{i,j,2015}^{2015}$ and $t_{i,j,1995}^{1995}$ = average intensity of task i for workers in sector j in year y (around 1995 and around 2015), calculated using O*NET 2015 and 1998, respectively

h_j^{15} = workers in sector j as a share of total employment in year y

T = the set of five tasks defined above

S = the set of 13 sectors identified using the one-digit Standard Industrial Classification (SIC)

Annex A2

Employment by economic sector

Table A2.1
Changes in employment by sector, mid-1990s to the mid-2010s
(Percentages)

Argentina		Bolivia (Plurinational State of)	
Description	Change between 1998 and 2015	Description	Change between 1995 and 2015
Agriculture, forestry and fishing	-0.2	Agriculture, forestry and fishing	29.9
Mining and quarrying	0.1	Mining and quarrying	-1.0
Manufacturing	-2.5	Manufacturing	-8.3
Electricity, gas and water	0.4	Electricity, gas and water	0.0
Construction	1.2	Construction	0.7
Wholesale, retail trade and repair activities	-2.9	Wholesale, retail trade and repair activities	-12.2
Transportation, storage and communication	0.6	Transportation, storage and communication	-0.4
Accommodation and food service activities	0.6	Accommodation and food service activities	0.3
Financial and insurance activities	-0.4	Financial and insurance activities	-0.1
Real estate activities	-0.3	Real estate activities	-0.1
Other services activities	2.9	Other services activities	-8.5
Activities of extraterritorial organizations and bodies	0.5	Activities of extraterritorial organizations and bodies	-0.2
Brazil		Chile	
Description	Change between 1996 and 2013	Description	Change between 1996 and 2015
Agriculture, forestry and fishing	-10.3	Agriculture, forestry and fishing	-5.5
Mining and quarrying	0.0	Mining and quarrying	0.6
Manufacturing	-4.4	Manufacturing	-5.3
Electricity, gas and water	-0.5	Electricity, gas and water	0.0
Construction	3.6	Construction	0.5
Wholesale, retail trade and repair activities	2.7	Wholesale, retail trade and repair activities	2.9
Transportation, storage and communication	-2.1	Transportation, storage and communication	0.4
Accommodation and food service activities	1.7	Accommodation and food service activities	2.2
Financial and insurance activities	0.4	Financial and insurance activities	-4.3
Real estate activities	5.8	Real estate activities	6.8
Other services activities	3.1	Other services activities	1.7
Activities of extraterritorial organizations and bodies	0.0	Activities of extraterritorial organizations and bodies	0.0
Dominican Republic		El Salvador	
Description	Change between 1996 and 2014	Description	Change between 1998 and 2014
Agriculture, forestry and fishing	-2.4	Agriculture, forestry and fishing	-2.7
Mining and quarrying	0.2	Mining and quarrying	0.0
Manufacturing	-7.9	Manufacturing	-3.8
Electricity, gas and water	0.2	Electricity, gas and water	0.2
Construction	1.2	Construction	-0.5
Wholesale, retail trade and repair activities	2.3	Wholesale, retail trade and repair activities	0.9
Transportation, storage and communication	0.1	Transportation, storage and communication	-0.2
Accommodation and food service activities	2.3	Accommodation and food service activities	3.8
Financial and insurance activities	0.7	Financial and insurance activities	-0.3
Real estate activities	1.6	Real estate activities	1.5
Other services activities	1.8	Other services activities	1.0
Activities of extraterritorial organizations and bodies	0.0	Activities of extraterritorial organizations and bodies	0.0

Table A2.1 (concluded)

Mexico		Peru	
Description	Change between 1996 and 2014	Description	Change between 1997 and 2013
Agriculture, forestry and fishing	-6.8	Agriculture, forestry and fishing	-3.8
Mining and quarrying	-0.1	Mining and quarrying	0.5
Manufacturing	-2.2	Manufacturing	-0.2
Electricity, gas and water	-0.1	Electricity, gas and water	-0.2
Construction	0.7	Construction	1.1
Wholesale, retail trade and repair activities	1.9	Wholesale, retail trade and repair activities	-1.5
Transportation, storage and communication	-0.5	Transportation, storage and communication	1.3
Accommodation and food service activities	2.6	Accommodation and food service activities	2.3
Financial and insurance activities	0.3	Financial and insurance activities	0.0
Real estate activities	2.1	Real estate activities	0.6
Other services activities	2.1	Other services activities	0.0
Activities of extraterritorial organizations and bodies	0.0	Activities of extraterritorial organizations and bodies	0.0

Uruguay	
Description	Change between 1995 and 2015
Agriculture, forestry and fishing	2.1
Mining and quarrying	0.0
Manufacturing	-11.1
Electricity, gas and water	-0.2
Construction	1.6
Wholesale, retail trade and repair activities	1.3
Transportation, storage and communication	1.9
Accommodation and food service activities	0.8
Financial and insurance activities	-0.5
Real estate activities	-2.9
Other services activities	7.0
Activities of extraterritorial organizations and bodies	0.0

Source: Prepared by the authors, on the basis of O*NET [online] https://www.onetonline.org and household surveys conducted in the respective countries.