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Technology and the Future of Work: Why Do We Care?[1]

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Abstract

This article seeks to make a compendium of the research and empirical evidence available on the impact of technological change on labor aggregates. It has been documented that increases in labor productivity in the last decades did not have a negative net effect on employment levels. However, technological development and automation have been associated with changes in the composition of employment and polarization patterns that explain the significant fall in the share of middle-class occupations during recent decades in developed countries. In addition, specific characteristics of the digital economy have also been linked to trends in concentration and market power that could explain part of the decline in labor share over income in recent decades. Finally, the article discusses the economics discipline's efforts to anticipate these trends and forecast the future automation of jobs and public policy challenges for the labor markets of Latin America in the fourth Industrial Revolution.

Is the ongoing technological revolution the beginning of the end of the work society? Is automation, now that globalization is reverting, the fundamental reason behind the weakening of the middle class and the decline of labor shares in advanced economies? Can and should the public do something about it?

Interest in the impact of digital developments on both the labor markets and income distribution has increased dramatically in recent years, both in academic and policy circles. Initially, this concern focused on the possibility of a massive automation of employment and various dystopian narratives about the end of (salaried) human work. Through diverse methodologies, the economic literature has built a robust body of empirical evidence shedding light on regularities that dismissed some of the initial concerns while still highlighting major questions and challenges. Although these findings have been sourced almost exclusively from developed countries, they illuminate the fundamental patterns of the current changes in labor and income, and offer a good starting point to adapt the theoretical frameworks and the empirical methodologies to the idiosyncrasies of Latin American countries to think about the fourth industrial revolution from a developing perspective.

Why Are There Still So Many Jobs?

A classic argument to dismiss the scope of these changes is to highlight the relative stability in the aggregate levels of employment. Far from the dystopia of widespread unemployment and redundant human work, there are still no pronounced falls in employment levels or signs of an imminent human labor obsolescence. Indeed, a look at the US labor market from the mid-20th century to the present reveals even a slight increase in the employment-to-population ratio that, despite recent fluctuations around the 2008 global crisis, already

shows a recovery to levels similar to those of the 1980s (the same could be said of the Eurozone in the latest years).

However, if one thinks of automatic payment toll booths, the increasingly robotized industrial factory, or interactive automatic telephone customer service, one visualizes a landscape where technology gradually but effectively destroys jobs, reducing the available employment in the economy. A priori, it would seem difficult to reconcile these stable trends with the most basic intuition about the nature of technological change and the large amount of inherently human tasks that have been automated over time. How is this contradiction explained?

Autor and Salomons (2017) offer a preliminary answer to this paradox.[2] Based on their analysis of 19 developed economies during the last four decades, the authors document that increases in labor productivity in a particular industry have a two-fold effect on employment levels. First, a "direct" negative effect: a within-industry reduction in employment. Second, an "indirect" positive cross-industry effect, namely, an increase in employment in other industries. This external effect, in turn, can reflect a combination of multiple factors: "backward linkages" (higher productivity in an industry raises its production levels and thus its demand for inputs, stimulating production and employment in upstream industries), "forward linkages" (higher productivity reduces production price and lowers the costs of downstream productive sectors), and income effects (due to lower prices, consumers have more disposable income for consumption in other industries).

Although estimates of these direct and indirect effects vary significantly across industries, Autor and Salomons show that the latter tend to outweigh the former, resulting in a modestly positive net contribution of labor productivity to aggregate employment demand. While our perception often focuses only on direct substitution, which is less abstract and easily observable, a rigorous evaluation tends to offer a more complex and less linear panorama.

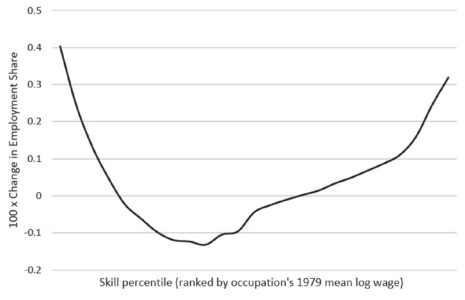
That said, this premise assumes that technology takes over gradually: what would happen when and if automation moves into all sectors at the same time? In other words, what would happen with this logic if there were no other sectors benefiting from the externalities of automation, and we only have the direct effects?

Polarization: Winners and Losers

Perhaps as important as the impact on the net labor demand, and definitely more urgent, there is the question of how technology alters the composition of labor across skill levels (as well as across labor commuting zones, age groups, and gender). On this front, the central concept has been the polarization (or the "hollowing-out") of the labor market: high- and low-skilled occupations (empirically associated with high and low wages some time ago) have gained participation in total employment at the expense of middle-skilled ones.

Many recent works have robustly documented this phenomenon in advanced economies, starting mainly from the beginning of the 1980s or 90s.[3] They generally proxy the skill content of occupations by their wages in an initial year, and calculate the variation of the share in total employment in the following decades, finding a polarization pattern in advanced economies that is graphically represented by a U-shaped curve, as can be seen in the following graph.[4]

Smoothed changes in employment by occupation ranked by wage percentile (United States, 1979–2012)



Source: Prepared by the authors on the basis of Autor (2015)

The link between automation and polarization can be explained by what the literature refers to as a "task approach" or, more generally, a "task-biased technical change."[5] What occupations are more likely to be replaced by innovation? According to this hypothesis, technological change tends to automate "routine tasks" that follow a set of easily definable procedures, which can be specified by means of a series of instructions that can be executed by computerized equipment. These tasks are usually characteristic of middle-skilled jobs, both "manual" blue-collar occupations like craft and manufacturing workers replaced by industrial equipment, and "cognitive" white-collar office and administrative occupations increasingly threatened by algorithms and data processing capacity.

On the contrary, technology finds it difficult to replace two types of non-routine tasks. On the one hand, there are abstract tasks, a set of activities that require skills such as persuasion, creativity, originality, or problem-solving, among others, typical of managerial, technical, and professional occupations, which are generally highly qualified. On the other hand, there are non-routine manual tasks, activities that require situational adaptability, visual and language recognition, and personal interaction, essential aspects fundamentally of low-skilled services such as cleaning, cooking, security, transportation, child and elderly care, among others. Many of them may seem like unsophisticated tasks, but they tend to appeal to intrinsically human virtues that do not follow explicit and easy-to-define rules, such as the empathy of a caregiver or the adaptability of a security guard to changing environments in unpredictable contexts. As expressed in Polanyi's paradox: "We can know more than we can tell." Our human capabilities are based on skills and rules that are often beneath our conscious appreciation, transmitted to us via culture, tradition, evolution. The difficulty of the recent technological advance to generate strong disruptions in both extremes of the occupational distribution would thus be explained by the inability to substitute either type of non-routine tasks.

Interestingly, this is not the only – nor even the most likely – explanation of the polarization pattern in developed economies. In fact, given that the data used in the polarization charts largely precedes the recent automation trends based on artificial intelligence, it is only natural that several alternative, unrelated hypotheses have been tried. Most notably, one that associates these trends with globalization: the offshoring of middle-skilled jobs, both manufacturing and administrative, to low-income developing countries. This explanation is also compatible with an increasing share of low-skilled services that cannot be offshored due to their "on-site" or "face-to-face" requirements, such as the case of gardeners, hairdressers, or cleaning staff.[6]

More recently, the literature has converged on Task-Biased Technical Change as its fundamental explanation of the ongoing trend, with a number of works robustly documenting the link.[7] Based on the O*NET database (and its DOT predecessor), which contains a detailed,

standardized, and weighted description, according to its relevance, of the relevance of multiple tasks within each occupation, these authors corroborate that middle-skilled occupations tend to be composed of a greater degree of tasks that can be defined as routine, and show how technology adoption correlates with the decline of occupations intensive in routine tasks, as opposed to high- and low-skilled positions. Conversely, the explanatory capacity of offshorability measures decreased sharply when the effect of technology is controlled for.

Another aspect highlighted by this literature is that the labor demand polarization does not translate into wage polarization. Indeed, the literature has had some difficulty explaining wage changes in response to task-biased technical change,[8] as recently in some countries wages grew monotonically regarding the degree of qualification of the occupation: the higher the occupation's qualification, the greater the wage growth.[9] In particular, occupations in low-skilled services that gained share in total employment did not experience a relative wage increase despite the increase in their relative demand.

We can think of at least two reasons for this to happen. First, the existence of complementarities with new technologies can increase the relative value generated by middle- and high-skilled occupations. For instance, the work of a software expert feeds into the provision of more valuable and sophisticated services, enhancing the productivity (and, as a result, the wages) in those sectors. In contrast, although safe from automation, the routine of a waiter has been virtually unchanged over time. Second, it is easier to move down than to move up the skill ladder. Even when the demand for skilled occupations increases, the qualification required limits the scope for a displaced middle-skilled worker to retrain into one of these jobs. Instead, they are more likely to compete for low-skilled occupations with fewer qualification requirements, driving down wages for low-skill jobs despite their sustained demand.[10]

Whatever the underlying reasons, the technologically-driven hollowing out of labor demand in advanced economies seems to translate into a wider wage premium that, in turn, feeds back in a more unequal income distribution.

The Rise of Superstars

Beyond its direct implications within the labor market, recent technological change has also had strong distributive impacts (with winners and losers) and impact on the distribution of total output between labor and capital.

Multiple works have documented the fall of the labor share since the 1980s and 90s in a very comprehensive set of countries.[11] Work for the United States shows that, starting in the 80s, this fall has been accompanied by a decline in the pure capital share over income, in favor of an increase in the share of profits, linked to the growing market power of firms.[12] Not without controversy, this phenomenon has begun to be linked to specific market characteristics of the digital economy that emerged during the last decades. In his work, Kurz documents that firms whose business models were transformed by the IT developments are particularly dominant in the growth of market concentration: 36 of the 50 firms with the largest surplus wealth in 2015 were key players in the digital revolution, and many did not even exist in the mid-1970s.

The more notorious companies of the digital economy, often referred to in

the literature as "superstar firms," typically operate under "winner-takes-all" (or "winner-takes-most") logic, whereby a dominant firm tends to capture the greater part of its market. Social networks provide the standard example: we all prefer to chat on the platform where we find the majority of our acquaintances, or to trade in purchase and sale websites in which there are more suppliers, more users reviewing products, and a strong base of potential customers for the seller (how many Facebooks or Amazons could realistically co-exist?).

Moreover, many digital giants have strong lock-in effects (incentives to block the migration of customers to other potential competitors). Think of a program or an operating system whose languages and customs are well known by clients and developers, or a social network that stores a lot of shared information of interest to the user. And there are also scale externalities (the number of customers improves the quality, quantity, and efficiency of the product) as in algorithmic search engines, which improve as the number of queries increases, making it possible to optimize recommendations, improve processes, and offer additional products.

For the United States and European OECD countries, labor shares decline the most in industries where superstars gained the most market share, which in turn tend to be those industries that experienced greater technological changes.[13] Moreover, for the United States, a positive link can be found between the share of IT workers of a firm and its corresponding market share, labor productivity, and operating margins.[14]

Finally, recent work has flagged the flipside problem of the digital concentration: its growing oligopsonistic power and the resulting depressing effect on wages, which may play a role in the declining labor shares looking forward.

At any rate, the concentration of these new markets, which is not necessarily associated with uncompetitive practices, presents challenges for competitive regulation, as they must prevent abuse while avoiding regulation that could penalize innovation.[15]

The Future of Work

Let's start with the obvious: we do not know what the jobs of the future will be. We only know that, although they may have the same names, they will be very different from current jobs. With this caveat in mind, the literature has tried to identify a number of occupations that are "vulnerable" to automation and, through workshops or surveys with labor market specialists, to forecast the hypothetical scope of employment automation in the coming decades.[16]

Predictably, the results from these speculative exercises vary widely, as a result of different approaches (in particular, whether the unit of analysis is the job or the task) and the technique used to scale up the results to the labor aggregates.[17]

Indeed, there are multiple factors that may bias the estimates and explain the variability across estimations. For starters, it is difficult to define precisely the degree of substitutability needed to completely eliminate a job, or force the reassignment of their tasks to other occupations. For instance, the domestic service did not disappear as an occupation with the appearance of the dishwasher and the washing machine. Defining that limit with precision can lead to very different conclusions: the McKinsey Global Institute estimates that less than 5 percent of occupations are entirely comprised of fully automatable activities, while 60 percent of occupations are composed of at least 30 percent of "vulnerable" activities.

Furthermore, these indexes depend fundamentally on the subjectivity and limited knowledge of both the experts consulted and the design of the research work and its weighting methodology, giving rise to multiple potential biases. In addition, the adoption of technologies may not be carried out in the short term even when there is technical capacity to develop them, either because of investment determinants and their cost effectiveness, or because of legal, ethical, or social issues, naturally difficult to predict and weight. Finally, it is difficult to consider if 47 percent of jobs in "high risk" indicate "a lot" (or 9 percent "a little"), since this ultimately depends on the future creation of jobs, which is even more difficult to forecast.[18]

For all these reasons, it is practically impossible to make statements of the type "an X amount of jobs in a Y occupation will be automated in the next Z years" with a satisfactory level of confidence. This does not necessarily mean that these works do not have any usefulness; we have a more or less clear idea of occupations that carry a lower automation risk: elderly care or primary education teaching appear less substitutable than warehouse storage jobs. And, even though the period and magnitude of automation cannot be accurately anticipated, these forecasts help illuminate trends, identify vulnerable activities, qualification levels, geographies, or age groups (and the corresponding people) to orient education and retraining, job placement, and income policies.

So, Why Do We Care in Latin America?

"Technological unemployment is a rich-country problem, light-years away from our more urgent problems." This is a typical response when one brings up the impact of technology on employment in a developing country. And, while it is true that workers in Latin America face more urgent problems, such as poor training, informality, and rationing, it is also true that, for many reasons, the threat of the technological revolution is even more pressing.

The core of the labor force is comprised of low- and medium-skilled routine workers (hence, the large "exposure to automation" ratios estimated by the World Bank). Indeed, using Autor's ranking of skill content in the "hollowing-out" chart as an absolute scale, we would probably place almost all of the region's labor in the most vulnerable two-thirds.[19]

The education menu is outdated and poorly matched with the present (let alone the future) demands of skills in the labor market (which suggests that the exposure ratio is likely to deteriorate). This, together with the difficulty in generating quality jobs, may explain the declining education premiums and the growing levels of over-education.[20]

In addition, the region is facing a demographic bonus (a temporary increase of the active-over-total population ratio), which is good news if the growing supply of labor finds its own demand, but could backfire if new entrants go into low-productivity occupations, or do not work at all.

And while in advanced economies the concern is a gradual replacement of full-time, full-benefit career employment by gig work or contingency contracts, and the challenge is to extend benefits to freelancers and zero-hour workers (by making benefits cumulative or portable, or by broadening unions), in Latin America, for the most part, independent work means something completely different: informal, below-minimum wage, precarious work for people with little or no skills that are rationed from regular labor markets. Technological unemployment may doubly affect this group, by eliminating many of the

low-skill routine task they currently perform, and by increasing competition from workers displaced from salaried jobs.[21] "Education + entrepreneurship," a recipe sometimes voiced in global panels on the future of work, would hardly apply in this case.

All of the above does not mean that technology is a threat and that Latin America is doomed to be a net loser as the new revolution deepens. On the contrary, technology means productivity and wealth, which governments should learn how to tax and distribute fairly. And, for the region, it also means that the development edge moves from cheap labor to know-how and knowledge, an area where we still have a chance to compete. More generally, what the evidence so far tells us is that, left to their own dynamic, the technological revolution represents a threat to equity, competition and, possibly, growth. It is the mission of public policy to turn this threat into an opportunity for shared prosperity.

NOTES

[1] This piece borrows from Eduardo Levy Yeyati, *Después del trabajo* (Editorial Sudamericana, forthcoming).

[2] David Autor and Anna Salomons, "Does Productivity Growth Threaten Employment?", *ECB Forum on Central Banking* (Sintra, Portugal: 2017).

[3] Maarten Goos and Alan Manning, "Lousy and Lovely Jobs: The Rising Polarization of Work in Britain," *The Review of Economics and Statistics* 89 no. 1 (2007): 118-133; Maarten Goos et al., "Job Polarization in Europe," *American Economic Review* 99 no. 2 (2009): 58-63; David Autor, "The Polarization of Job Opportunities in the U.S. Labor Market: Implications for Employment and Earnings," Center for American Progress and The Hamilton Project, 2010; David Autor, "Why Are There Still So Many Jobs? The History and Future of Workplace Automation," *Journal of Economic Perspectives* 29 no. 3 (2015): 3-30; David Autor and David Dorn, "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market," *American Economic Review* 103 no. 5 (2013): 1553-1597.

[4] The research documenting these patterns in developed countries is very extensive and other additional works can be mentioned: Alexandra Spitz-Oener, "Technical Change, Job Tasks, and Rising Educational Demands: Looking Outside the Wage Structure," *Journal of Labor Economics* 24 no. 2 (2006): 235-270; Kate Mieske, "Low Skill Service Jobs and Technical Change," unpublished MSc dissertation, University College London (2009); Daniel Oesch and Jorge Rodríguez Menés, "Upgrading or Polarization? Occupational Change in Britain, Germany, Spain and Switzerland, 1990-2008," *Socio-Economic Review* 9 no. 3 (2010): 503-531; Craig Holmes and Ken Mayhew, "The Changing Shape of the UK Job Market and Its Implications for the Bottom Half of Earners," Resolution Foundation, 2012; Adrian Adermon and Magnus Gustavsson, "Job Polarization and Task-Biased Technological Change: Evidence from Sweden, 1975-2005," The *Scandinavian Journal of Economics* 117 no. 3 (2015): 878-917. A recent IDB report sought to replicate these analyzes in four Latin American economies (Brazil, Chile, Mexico, and Peru), during the first decade of the 2000s. Only Chile and Mexico showed the classic polarization patterns of developed economies (IDB, 2017). However, the period evaluated is too short to evidence a structural change that began in the advanced economies around the 1980s and, therefore, more research is needed to know the depth of these patterns in Latin America.

[5] Daron Acemoglu and David Autor, "Skills, Tasks and Technologies: Implications for Employment and Earnings," *Handbook of Labor Economics* vol. 4 (2011): 1043-1171; David Autor et al., "The Skill Content of Recent Technological Change: An Empirical Exploration," *The Quarterly Journal of Economics* 118 no. 4 (2003): 1279-1333.

[6] Other alternative hypothesis can be mentioned. On the one hand, if preferences are non-homothetic, the increase in wealth of the high-wage segments could increase demand for low-skill services like childcare, cleaning, security, etc., placing a floor under their job losses (see Francesca Mazzolari and Giuseppe Ragusa, "Spillovers from High-Skill Consumption to Low-Skill Labor Markets," *Review of Economics and Statistics* 95 no. 1 (2013): 74-86). On the other hand, increased female labor participation could increase the demand of that low-wage occupations by an outsourcing of women's household production.

[7] Autor and Dorn, "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market"; Autor et al., "Untangling Trade and Technology: Evidence from Local Labour Markets," *The Economic Journal* 125.584 (2015): 621-646; Guy Michaels et al., "Has ICT Polarized Skill Demand? Evidence from Eleven Countries over Twenty-Five Years," *Review of Economics and Statistics 96* no. 1 (2014): 60-77; Maarten Goos et al., "Explaining Job Polarization: Routine-Biased Technological Change and Offshoring," *American Economic Review* 104 no. 8 (2014): 2509-26.

[8] Goos et al., "Explaining Job Polarization: Routine-Biased Technological Change and Offshoring."

[9] Mieske, "Low Skill Service Jobs and Technical Change"; Autor, "Why Are There Still So Many Jobs?"; Stephen Machin, "11 Changing Wage Structures: Trends and Explanations," in *Employment in the Lean Years: Policy and Prospects for the Next Decade*, ed. David Marsden (Oxford: Oxford University Press, 2011): 151.

[10] Autor, "Why Are There Still So Many Jobs?" Autor also emphasizes that differences in output elasticity of demand combined with income elasticity of demand

can influence the effects of automation on wages.

[11] Loukas Karabarbounis and Brent Neiman, "The Global Decline of the Labor Share," *The Quarterly Journal of Economics* 129 no. 1 (2013): 61-103; Thomas Piketty, *Capital in the 21st Century* (Cambridge, Massachusetts: The Belknap Press of Harvard University Press, 2014); Mai Chi Dao et al., "Why is Labor Receiving a Smaller Share of Global Income? Theory and Empirical Evidence," International Monetary Fund, 2017; David Autor et al., "The Fall of the Labor Share and the Rise of Superstar Firms," National Bureau of Economic Research, 2017.

[12] Simcha Barkai, "Declining Labor and Capital Shares," University of Chicago, 2016; Jan De Loecker and Jan Eeckhout, "The Rise of Market Power and the Macroeconomic Implications," National Bureau of Economic Research no. w23687, 2017; Mordecai Kurz, "On the Formation of Capital and Wealth," Stanford University Working Paper, 2017.

[13] Autor et al., "The Fall of the Labor Share and the Rise of Superstar Firms."

[14] James Bessen, "Information Technology and Industry Concentration," Boston University School of Law, Law and Economics Research Paper no. 17-41. According to Bessen, it is not the use and diffusion of the technology itself that stimulates concentration, but the development of markets in which these systems are owned by a single firm. Note that there is an important distinction between the digital economy and other markets where network effects are present. For example, the telephony or fax service also implies strong network effects, to the extent that the product only gains value as it is used by my users of interest (friends, family, colleagues). However, while the telephony network is not owned by a single firm and companies compete with each other to offer the best service within the same network, in the case of digital platforms or the operating systems, the network is owned by a single provider (or a few networks coexist, offering services with a certain degree of differentiation).

[15] This has been the criterion adopted by the European Commission in recent rulings against Google (a US $2.7 billion fine for several uncompetitive practices, including privileged placement of its own services), Amazon (forced to change the terms of agreement with e-book editors), and Facebook (a US $122 million fine for eluding its commitment not to combine datasets with WhatsApp, acquired in 2014).

[16] Carl Benedikt Frey and Michael Osborne, "The Future of Employment: How Susceptible are Jobs to Computerisation?", 2013, https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf; World Bank, "World Development Report 2016: Digital Dividends," 2016; Melanie Arntz et al., "The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis," OECD Social, Employment, and Migration Working Papers 189, 2016; McKinsey Global Institute, "A Future that Works: Automation, Employment and Productivity," January 2017.

[17] For example, Frey and Osborne estimated that 47 percent of US jobs were at "high risk of automation" (Frey and Osborne, "The Future of Employment.") Arntz et al. used the same task automation indexes developed by Frey and Osborne but, instead of collapsing them directly on the job descriptions of each occupation ("Occupation-based approach"), they matched them with data at the individual level in OECD countries that contained specific descriptions of the tasks performed by each individual worker ("Task-based approach"), reaching the conclusion that only 9 percent of employment in the US was at high risk of automation (Arntz et al., "The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis.")

[18] The McKinsey Global Institute tried to estimate the number and nature of jobs that could be created in multiple scenarios from 2017 to 2030 for 46 countries (McKinsey Global Institute, "Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation," December 2017.) This work can be considered an interesting first step, but more investigation is needed to accord and calibrate benchmark methodologies.

[19] Estimates that use the ranking as a relative scale, such as those estimated by the World Bank (World Bank, "Wage Inequality in Latin America: Trends and Puzzles") are not strictly comparable: for instance, jobs in the upper decile of the US skill-content ranking (proxied by wage levels) are rare in Latin America. Alternatively, we could proxy skill content by education levels, where the difference in the distribution in the US and the typical Latin American country are more visible.

[20] See World Bank, "Wage Inequality in Latin America: Trends and Puzzles"; and Martín González Rozada and Eduardo Levy Yeyati, "Does the Supply of Skills Create Its Demand?", Torcuato Di Tella University's School of Government, Working Paper, 2018.

[21] Not surprisingly, while only 44 percent of independent workers in advanced economies are full-time freelancers (McKinsey Global Institute, "A Future that Works: Automation, Employment and Productivity"), in Argentina this number is as high as 70 percent (Levy Yeyati, *Después del trabajo*).

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