Universidad Nacional Autónoma de México

Problemas del DESARROLLO | REVISTA LATINOAMERICANA DE ECONOMÍA

Volume 49, Number 195, October-December 2018

CONTENTS

NEW TECHNOLOGIES: THE BIPOLARIZATION OF EMPLOYMENT AND JOB INCOME?

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Date received: February 19, 2018. Date accepted: May 16, 2018.

Abstract

The digital revolution has disrupted how companies behave, their environment, and their consumption patterns, while changing the job and wage structure in the sectors in which they operate. On its own, this revolution has entailed a major upheaval with no end in sight, which is why it is better to learn to manage it than deny it or pump the brakes. Latin American countries use new technologies to different extents, but do not produce them. The result is negative fallout for jobs and employment, a burgeoning informal sector, and higher job income in advanced countries and in the emerging Asian economies that do make these technologies.

Keywords: Latin America; digital revolution; employment, job income; Asian countries; emerging economies.

1. INTRODUCTION[2]

From this moment forward, the digital revolution will disrupt how companies behave, their environments, modes of consumption, and the job and salary structure at the branches it impacts. Some believe it will liberate mankind from everything that is painful about work; to others, it would destroy jobs. What is worse, in many areas, robots, interconnected machines, machine learning, etc. could even replace humans.

Without being overly cataclysmic,[3] one might speculate that in the near future, technological change will occupy an increasing percentage of the nature of jobs. With automation, the risk that jobs become bipolarized (highly skilled vs. unskilled, to the detriment of the general medium-skilled jobs) is real. The magnitude of this shift depends and will depend on the speed at which the machines incorporating profoundly new technologies expand. Nevertheless, job bipolarization, which is already here to stay in some sectors, can be masked by job creation in other less digital industries, the dynamics of which rely on the growth in global demand and the advent of new necessities. Globally, it may be less obvious in certain fields, or even not appear at all. At present, greater use of new technologies is already an additional cause driving the widening inequalities in job income.

Latin American countries resort to new technologies in varying degrees, but do not produce them. The flipside is that several fields, especially financial services and "Uberized" transportation—like in Brazil and Chile—use them exhaustively, precisely because their research and investment are not up to the challenge of making these technologies themselves. The result is that the negative impact on job bipolarization, including unemployment, the rise in informal jobs, and eroded job income, is probably more severe than it is in advanced countries and in the emerging Asian economies that do indeed produce them.

In Latin America, the "truncated" digital revolution, due to the inability to produce new technologies, augments the risks mentioned above, as societies are very unequal, and at the same time, it further entrenches the technological dependence, to a greater extent than ever before.

This paper draws on a comparative approach. While true that "comparisons are not appropriate," as what happens in one country cannot be identically transposed to another, and the history, culture, and environments are different, comparisons still allow for the imagining and underscoring of differences; comparisons pave the way to the realm of possibilities and enable us to formulate "prohibited" questions, break with fatalism, and suggest ways to prevent people from becoming further marginalized.

The purpose of this paper is to advance on two core points: the effects of new technologies on employment and job income in advanced countries, in order to understand what might happen, in the worst-case scenario, in emerging countries in Latin America, if they fail to take measures to actively engage in this revolution (producing and using) and social shift (managing needed mobilities).

2. AN OVERARCHING VISION OF THE PLACES WHERE NEW TECHNOLOGIES ARE PRODUCED AND USED

The cloud has little to do with its humble beginnings, meant to create smart phone applications. One is an extremely involved enterprise, which requires a considerable financial dimension, and the other is not. Generally speaking, the digital revolution is diverse, as are the places where it is happening. Moreover, if we start to think about automation and the digital revolution, we have to specify the technologies, their uses, and the places where they are being implemented, because the fallout for employment and income will not be the same, and it is not possible to generalize about the effects of using a given technology in a given place across all sectors.

For that reason, Manyika *et al.* (2013) introduced 12 technology breakthroughs that will likely have an impact on jobs and growth by 2025 in four groups: the first is related to information technologies (IT) and their uses (mobile Internet, the cloud, Internet of Things, and automated knowledge exchanges); the second is tied to the new age of materials (latest-

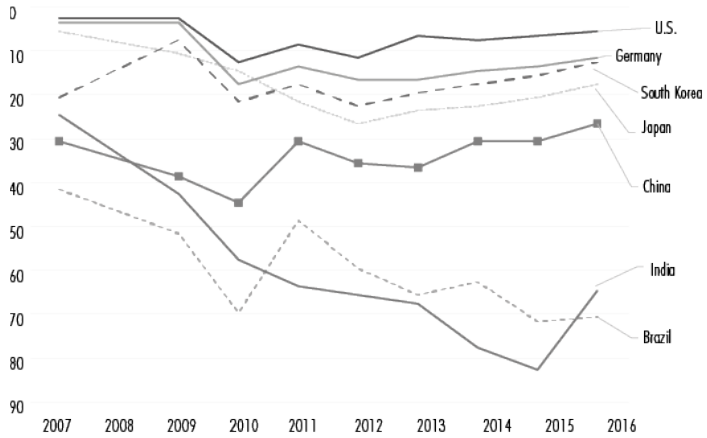
generation genetics, new materials); the third are so-called smart machines (advanced robotics, autonomous vehicles, 3D-printing); and the fourth, new approaches to energy (energy storage, renewable energy, and unconventional hydrocarbons). This is more less the same classification proposed by the Organization for Economic Cooperation and Development (OECD), and could be expanded further, as the Employment Policy Board highlighted in its 2017 report. This categorization will evolve depending on the problems and countries in question; for example, in China, Manyika *et al.* (2013) focus more on e-commerce and fintech.

Among Emerging Countries, the Weakness of Latin America

With the digital revolution, the unit price of computing power per second has fallen exponentially since 1950, and even more so since the aughts. Computer and digital technologies, integrated with other technologies, improve performance. In short, these technologies are paving the way to particularly powerful network effects that enable production to increase.[4] As the Conseil d'Orientation pour L'Emploi (COE) (2017, p. 15) pointed out: "By fostering the appearance of new models, digital technologies are no longer merely a new component to go further in terms of automating and optimizing production processes: they are radically disrupting the way in which certain sectors and fields operate and are organized, and lead to the rise of other new ones, which entails regulatory challenges." We are therefore witnessing a profound transformation.

To a great extent, innovation performance reflects the efforts invested in new technologies. In a recent study, Scott (2017) featured a series of compound indices built to measure innovation; they consider research and development as a percentage of gross domestic product (GDP), the number of students enrolled in the sciences, the number of scientific publications, high-tech product exports, number and even quality of patents, and institutions, etc. The chosen sub-indices, their numbers, and their weightings vary depending on the compound indices calculated. The National Innovation Index, designed by the Chinese Ministry of Science and Technology, looks at 40 countries; China is currently ranked 18th, a slight improvement over 2011. The Bloomberg index includes 69 countries; China has been climbing the ladder since 2014, reaching spot 21 by 2016. The World Economic Forum index gathers together 135 countries; China was ranked 29th in 2009 and 2016, with a bump between 2010 and 2015. The Cornell University index, called INSEAD, considers 128 countries, and is constructed around 103 indices; China was ranked 25th in 2016 with a particularly high score on the sub-indices of technology and knowledge production (ranked sixth), and particularly low on quality of institutions (ranked 79th). Finally, in 2016, the United States earned the highest score, followed by Germany and South Korea, Japan, China, and much further down the list, India and Brazil (see Figure 1).

Figure 1. Comparison and Evolution of Innovation Indices by Country



Source: Scott op. cit., p. 14.

When the comparison is limited to research and development, China went from a little over 1% of GDP in 2000, to a little over 2.1% in 2016, but remained far behind South Korea (4.3%), Japan (3.4%), and the developed countries (Germany and the United States: 2.9%), although it has advanced more than Brazil (1.2% in 2014) or Argentina (0.6%), according to the World Bank (2018) and Unesco (see Table 1). Measuring the same statistic in absolute terms, the gap between China and Brazil is even wider, at a ratio of 12 to 1, to the extent that when GDP (in PPP) per capita is equivalent, the population in China is seven times larger. The understanding is that "small" countries or countries that are less technologically advanced need to dedicate more resources to research and development as a percentage of GDP than big countries (and need more targeted policies). Otherwise, they will be losing out on the ongoing Industrial Revolution. Such is the case of South Korea and Israel, each of which allocate 4.3% of their GDPs.

Table 1. Latin America, Research and Development as a Percentage of GDP

Country	*2004*	*2008*
Paraguay	0.08	0.06
Colombia	0.16	0.15
Panama	0.24	0.21
Ecuador	0.07	0.25
Mexico	0.40	0.38
Costa Rica	0.37	0.40
Chile	0.40	0.40
Cuba	0.56	0.49
Argentina	0.44	0.52
Uruguay	0.26	0.64
Brazil	0.90	1.09
Latin America and the Caribbean	0.53	0.63
OECD	2.17	2.33

Source: OECD-ECLAC (2012).

The rise in digital technologies and their applications is, therefore, profoundly unequal across countries. Several advanced economies are on the cutting edge of producing new technologies, like Japan, Germany, the United States, and Switzerland, not to mention another country extremely specialized in producing a limited number of technologies: Israel. Other emerging countries are starting to catch up with the advanced nations: China and South Korea; yet others are being left out or threatened,[5] like Brazil, Argentina, Mexico, contrary to the optimistic forecasts from the CAF-Latin America Development Bank (2017).[6] In spite of that, several flagships in these latter countries use new imported technologies, like Embraer in Brazil or Softtek in Mexico. But, generally speaking, according to *The Future of Work, Regional Perspectives* (ADB, ERBD, IADB, 2018, p. 90):

> Information and communication technologies (ICT) development and penetration are lower in the region than in the developed world. Latin America and the Caribbean takes advantage of only about 6 percent of its digital potential, compared to an average of 12 percent in Europe and 18 percent in the United States...In terms of personal, business, and government adoption of ICTs, Latin America and the Caribbean scores considerably lower than the subgroup of advanced economies, and lags the emerging Asian, European, Middle Eastern, and North African countries, and Pakistan.

Two cases are worth highlighting here: the countries that produce new technologies spread them throughout their industrial fabric, services, and other consumers; and, the non-producers, which only manage to introduce them to their industrial sectors, services, and consumers. The former group produces these new technologies and therefore enters the international division of labor in a positive manner. Their exports acquire demand elasticity with respect to high incomes and competitiveness at no cost. Limiting our view to Latin American countries, it emerges that they are at a disadvantage, and it may get worse if they fail to capitalize on the spread of new technologies to upgrade their industrial sectors, not to mention engage in producing new technologies, because the region's role in the international division of labor becomes regressive, due to its relative inability to export complex products (Xiaodan and Metodij, 2017).[7]

Access to imported goods that include new technologies, like capital goods, is increasingly reliant on the price of the merchandise that each country sells abroad. This new risk of dependency can limit a country's investment capacity when it becomes more expensive to import capital goods. And that is by no means the only risk. It has frequently been said that industrial revolutions have not led to a rise in unemployment in the medium term precisely because so many jobs have been created to manufacture new machines. If these machines are not produced, however, then the risk of being unable to avoid rising unemployment becomes real.

The Mass Arrival of Several Asian Countries to the Ranks of the Emerging Economies

South Korea seems to have managed to come onto the scene in certain sectors, like robotics (widespread production and use in the automotive sector), chip production, and microprocessors. So, is that true of China, too? Responding to this question is no easy feat, because changes are happening rapidly in the country. The case of the integrated circuits can help elucidate it, though. In 2010, only several advanced countries and South Korea were able to produce digital circuits. Manufacturing them required tremendous amounts of investment with a very high research quotient. From 2011 to 2016, Chinese production of integrated circuits tripled. By 2017, its growth had far overcome the rates seen in advanced countries. Nevertheless, the processes and the memory are imported or made in China by non-Chinese players, like Samsung or Intel.

The example of the cloud is also interesting. China is making considerable efforts to develop the cloud and catch up with the top companies in the United States, like Amazon Web Service, Microsoft, etc., especially with Alibaba 'Cloud (Aliyun). The cloud is evolving thanks to lower production costs, the advent of artificial intelligence, and the introduction, in some countries, of policies to protect information in the cloud, as it is considered to be strategic.[8] The top American companies are losing out, in relative terms, on their ability to monopolize the cloud, and in response, they are now aiming to "colonize," which is to say, to control the borders beyond their control.

Therefore, it might be speculated that this would make a favorable climate for major Chinese companies. That is not necessarily the case. In fact, the history of the top companies mentioned above with respect to the cloud is quite different than it is for the case of the Chinese companies, as in the former, the cloud was planned for new clients and large

companies, while in the latter, cloud services are tied to consumption. Moreover, as *The Economist* (2017) pointed out, Chinese companies are struggling to design complex applications.[9]

However the case may be, China is becoming a major player in certain sectors, which is not the case of the emerging countries in Latin America, as has been seen. According to Woetzel *et al.* (2017 a and b), Chinese growth sometimes moves at "lightning speed," in certain sectors like e-commerce and other transaction-type services, like mobile phone payments.

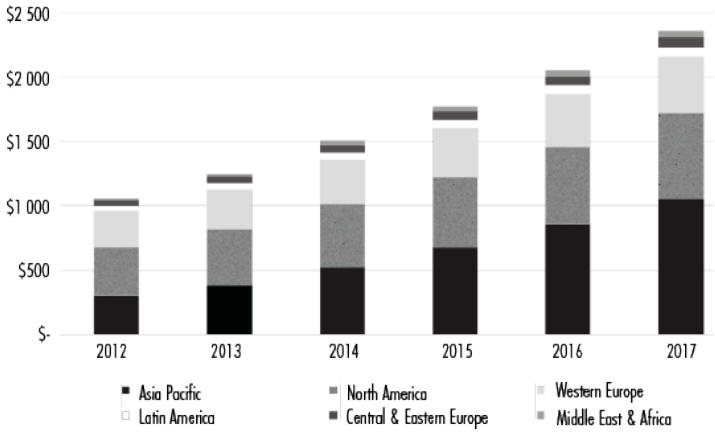
China was ranked first in 2016 in e-commerce, despite the sector barely existing at all back in 2005. Mobile phone payment volumes were 11 times higher in China than in the United States in 2016 (see Table 2). E-commerce continues to be marginal in Latin America, as shown in Figure 2.

Table 2. Retail E-Commerce as a Percentage of Global E-Commerce

Year	*United States of America*	*China*
2005	35%	Less than 1%
2016	24.1%	42.4

Source: Woetzel et al. (2017a, p. 18).

Figure 2. E-Commerce in Billions of Dollars by Principal Region, 2012-2017



Source: Suominen (2017, p. 21).

While China makes massive use of robots[10] in the automotive industry, up until now, it has produced relatively few so as to make the progression significant in any way. According to UNCTAD (2017, p. 46), China produced 5.3% of the world's robots in 2013, and 8% in 2015, the same as Germany (7.8%), but much less than Japan (54.4%) and South Korea (12.6%), with the rest produced principally by the United States and Switzerland. In 2013, robots accounted for one-fourth of the Chinese market, and by 2016, one third. Progress in using robots in the automotive industry has been tremendous since 2012. Among a group of six countries (China, United States, Germany, South Korea, Japan, and Mexico), China experienced the most growth since 2010 (between 20% and 25% a year), with half of the robots going to the automotive industry (UNCTAD, 2017, p. 48). Nevertheless, if we look at the number of robots for every 10,000 employees in 2014, China was still far off from South Korea (around 370 robots), Japan (320 robots), Germany and Sweden (180 robots, respectively), the United States (140 robots), Taiwan, France (100 robots), Mexico (20 robots), and Brazil (5 robots), pursuant to data compiled by UNCTAD (2017, p. 49).[11]

Progress in the realm of new technologies in China is uneven. Digitalization is shifting rapidly, but in an unbalanced fashion: venture capital investments in 2016 were concentrated in financial technology (7.158 billion dollars versus 5.437 billion in the United States and 1.793 in the United Kingdom; virtual reality (1.312 billion versus 1.437 billion in the United States and 166 million in Japan, 20 million in France); self-driving cars (357 versus 582 million in the United States); mobile (992 million dollars against 1.724 billion in the United States); technology education (681 million against 1.282 million in the United States); robots and drones (227 million against 728 million in the United States); 3D printers (221 million versus 602 million in the United States). In all of these sectors, China was ranked second, except in financial technology, and in others, it was ranked third or even fourth. Such is the case of big data, where the United States is far ahead (6.085 billion) and so is the United Kingdom (1.673 billion), as the venture capital investments amounted to 942 million in China. In artificial intelligence, China is investing four times less than the United States (Woetzel *et al.,* 2017a, p. 19).

3. TOWARD BIPOLARIZATION: THE FALLOUT FOR JOBS AND WAGES

New Employment Models

Benhamou (2017) outlined four types of employment models coexisting at companies with ten employees or more in advanced countries. These models are defined around 15 variables. The first two of these variables aim to measure job

autonomy. The next two, how the quality of the job is determined. Three variables evaluate the cognitive dimensions of the job, another four examine the limitations of the job, and, finally, the three speeds. These latter variables refer to the degree of novelty in the tasks to be carried out. Two employment models are considered to be the simple and classic Taylorist models (low autonomy, low self-control, repetitive work, etc.), and the other two are modern "learning" and "adjusted production" or "Toyotism." The so-called "learning" models are characterized by organizational participation practices (decentralization, autonomy, teamwork). They are different from the Toyota method, which is more oriented to market limitations (quality, just-on-time, etc.).

With the digital revolution, employment models are shifting. Work is becoming more flexible and precarious, and in the future, the so-called "apprentice" form of a job will develop more or less quickly depending on the sectors affected by the digital boom, in forms parallel to the so-called conventional model, principally where unskilled labor is concerned, as it is threatened by the robotics of the future. Nevertheless, robotics does not, and will not, have the same impact on every sector of employment. Some sectors will end up with the learning model of employment (for example, the automotive sector), and others much less so (for example, distribution, like Amazon).

These disruptions to the employment model do not and will not have consequences for jobs and wages. Nevertheless, the overall trend will be one that moves toward differentiated labor polarization, a trend accentuated by the fact that it will make jobs more or less precarious.[12]

In general, Berger *et al.* (2017) showed that the percentage of employees who have the opportunity to leave their jobs in old industries to find jobs in the new industries plummeted in the United States between the nineteen-nineties and the aughts, going from 4.4% to a little less than 0.5%. The opportunity for unskilled workers to find jobs in the new industries is, therefore, much lower, except where particularly active training policies are in place. Mobility does not necessarily mean firing, even when changes are more or less offset by the creation of new job positions.[13] This desired mobility can be managed via sustained training policies. It is known that job stability is frequently a precondition to achieving greater productivity. On the contrary, precarious conditions do not encourage employees to engage with the company employing them. If precarious conditions are destined to become structural, due to the burgeoning use of new technologies, then the perverse effects of it will become evident and the gap between the expected increase in productivity and the real productivity level attained will remain, or even widen.

With the use of new technologies, employment is becoming more fragmented. Jobs tend to become increasingly flexible, both in terms of remuneration (as is the case of competition from low-wage Asian workers, and the impact of insecurity on wages) and the versatility of tasks, with no possibility for social mobility to be sufficiently satisfied in case of a dismissal,[14] especially for employees at small- and medium-sized enterprises. In the extreme case, workers become their own employers, and not only lose their liberty, but also their sense of belonging to a group. Workers are facing the restrictions over which they do not have control: the cloud and big data. The worker is "Uber."

The Bipolarization of Jobs and a Potential Increase in Unemployment and/or Part-Time Work

Myriad studies have been conducted in various countries, primarily the advanced ones (Acemoglu and Restrepo, 2017; Autor, 2015; COE, 2017; Hualde, 2018). Some studies assert that the rise in automation ought to lead to a rise in the unemployment rate, while others show that this is not necessarily the case, as the lost jobs are replaced by other jobs created either directly or indirectly by automation. In certain sectors (like distribution, but also finance, medicine, and justice), the software using big data will likely do away with many jobs, including the experts managing inventory, making diagnoses for prescription medicine, or analyzing legal situations). However, these jobs destroyed by automation could be the source of other indirect jobs.

The job structure changes depending on the speed at which new digital technologies spread throughout different sectors. In industry, medium-skilled jobs will suffer from automation, because they are generally more routine and easier to replace by robots or articulated arms, unless the cost of the equipment is not a definite incentive.[15]

Automation in the industry and in several services, like distribution, ought to exacerbate job bipolarization: more low-qualified and highly-qualified jobs at the expense of unqualified jobs. What appears, more or less, is this trend in companies engaging in automation; worldwide, it is less evident (see Table 3). To be exact, the degree of bipolarization falls as digitization rises, which is a paradox, as demonstrated by Autor (2015), who compared the rise (fall) of salaried jobs and the degree of skill measured by wage level, and found that the more wage jobs go up, the more important qualification becomes to the global economy. In the time periods 1970-1989 and 1989-1999, which is to say, a bit before the digital revolution, 5% and 12% of lower-skilled jobs increased with respect to total employment and 52% and 47% of the more-skilled jobs increased strongly in relative terms, while the two extremes (unskilled and over-skilled) did the same, but to a lesser extent. With the digital revolution, the situation changed starting in the year 2000: the portion of low-skilled jobs rose considerably in relative terms, and the number of more-skilled jobs fell considerably, especially between 1999 and 2007. Paradoxically, bipolarization fell and disappeared in the latter period to give rise to just polarization. With the advent of the digital revolution, the only observation really necessary to make is that the number of skilled jobs fell with respect to earlier time periods. These shifts are summarized in Table 3.

Table 3. During the Digital Revolution, Less Bipolarization than Before

	Unskilled	Low-skilled	Skilled	Medium-skilled	High-skilled	Over-skilled
1979-1989	+	--	-	+	++	++
1989-1999	+	+-	-	-	+	++
1999-2007	++	+	-	-	=	=
2007-2012	++	+	-	-	-	+

Source: Created by the author based on Autor (2014).

Is the bipolarization of jobs visible at the global level?

Depending on how new technologies are used and where they are implemented, jobs get destroyed. They may be low- or medium-skilled routine jobs or even skilled positions, which varies by the case in question. Other direct jobs are created: moderately skilled for support jobs, highly skilled when it comes to designing new automatons (robots). Indirect jobs, the majority of which are unskilled, are also created.

The trend toward job bipolarization in the affected sectors seems to arise more or less strongly depending on the sector in question. Nevertheless, job bipolarization measured at the global level seems to have waned in the digital revolution with respect to the period prior. It is a paradox highlighted by Solow (1987). Labor productivity growth in the United States between 1995-2004 and 2005-2016 went from 2.8% annually to 1.3% annually as automation flourished.

Automation, particularly Robotization, does not develop at the same speed across all branches and all industries. The automotive and finance sectors are currently the top sectors involved, and it is necessary to take a macro view to check the hypothesis that bipolarization implies many prejudgments. It is there that the problem of not having a bridge resides. Polarization observed in the most automated sectors may not appear at the global level:

- Because, in general, other more or less skilled jobs emerge and because the supply and demand structures evolve;
- Because automation, in a broad sense, destroys jobs directly and creates others, more or less complementary to new machines, in lower numbers, where it takes places (unless demand increases faster than supply[16]) and indirectly creates new jobs, in other sectors,[17] including lower-skilled, precarious, or part-time jobs (underemployment). This is principally dependent on the elasticity of demand with respect to income in combination with the elasticity of supply.[18] The employment structure, its evolution, and that of unemployment depend on other variables;
- Because globalization is the root of deindustrialization. For example, competition between low-wage countries (especially China and now Bangladesh, Vietnam, and India), with dumping that is more or less social and environmental), is at the heart of the fact that more jobs have
- been destroyed than those created thanks to the rise in automation;
- Because financialization contributes to deindustrialization, and its effects on employment in the industry are negative.

Nor is an assessment of labor structures and unemployment, as can be seen in experimental economics to confirm or refute the bipolarization by comparing two areas with vastly different degrees of automation, as Acemoglu and Restrepo (2017) did, relevant. The areas in question do not consist of exactly the same fields and, therefore, do not constitute similar samples. It is enough that *1*) one has numerous automobile factories and the other does not for the results to lose their significance; *2*) the number of jobs created and the possible rise in demand—after automation and the drop in relative prices—can benefit the least-automated zone; *3*) the point is, the production of robots can also happen in other areas and not produce new jobs, for which reason the results obtained lose the significance they ought to have (Mishel and Bivens, 2017).

Are income inequalities the result of the technology revolution?

The possible bipolarization of job income

The history of technical progress runs on a partially parallel track to that of inequality. According to Deaton (2017, p. 12): "Progress generates inequalities, which can be useful, because they trace out new paths and produce incentives to take on debt, but they come at a cost...". Even so, in recent decades, financialization is primarily at the base of accentuated inequalities between capital gains (dividends, interests, transfer value) and labor income (excluding senior management's "wages," which have risen sharply). Now, once again, and likely in the future, too, the digital revolution will play an increasingly large role in widening the income inequality gap. Unlike an employee who can go on strike to get a wage hike, robots do not go on strike. The owner of the robot captures the productivity gains, even when partially redistributed to highly skilled employees. The trend toward job income bipolarization (unskilled-highly skilled labor) will tend to develop further with digitalization, but not with the same intensity or at the same speed at every company replacing routine jobs with robots.

Job productivity levels are all over the map, more than they have been in the past, even across branches of the same company or across companies, leading to, as a result, greater wage divergences. Rising job income inequality is therefore more a reflection of increasingly pronounced inequalities across enterprises (those using new technologies a lot and those not) than across the departments of companies themselves. This, at the very least, is become apparent in the member states belonging to the American Union (Barth *et al.,* 2016).

Looking at the emerging economies that do not produce new technologies (excluding China, South Korea, and Taiwan), divergent productivity levels, already more pronounced than in the advanced economies, have widened (Salama, 2012) even more rapidly due primarily to two reasons: *1*) globalization shortens timeframes. Advanced economies are turning to new technologies faster than emerging economies. And, *2*) the spread of new technologies within each country is more unequal than ever before (Comin and Marti, 2013).

When new technologies reach into every branch of industry and services (finance, distribution, health care, education), then it is likely that we will begin to witness the bipolarization of job income and wage growth: average productivity will be below the mean, or even fall in absolute terms, unless policy sets rules to oppose or slow this trend.

Does exacerbated income inequality favor growth?

Unlike what is generally presumed, sharper income inequalities are not necessarily a prerequisite for stronger growth. There are times at which growth leads to bigger inequalities or even makes it worse. Growth regimes are not very inclusive but they are efficient in terms of GDP growth. Such was the case of Brazil during the dictatorship from 1964 to

1980, and the case of China since 1979. This "virtuous" cycle is in part explained by the advent of a third demand, that of the middle classes, which, due to their size, contribute to the profitability of the durable consumer goods sector, like the motor vehicle sector, and, therefore, drive their growth. Moreover, rising income inequality does not necessarily lead to economic stagnation (Salama, 2005). However, two conditions are necessary: a large population, such that even a fraction of the population is big enough, and an economy relatively closed to international competition.

Such was the case of Brazil and is the case of China.[19] If a country is open and there is enough competitiveness, then strong growth is compatible with rising inequalities, because a relative drop in domestic demand for some products is more or less compensated for by an increase in external demand. Nevertheless, rising inequalities are also at the root of less inclusive societies, which are less stable over time and are more vulnerable, characterized by low intergenerational mobility. Accordingly, excessive inequalities can constitute a progressive barrier to growth. Exclusive societies generate barriers and social contradictions and, in the future, political ones, too.[20]

Deducing from these considerations that rising inequalities are a "necessary evil" that supports the advent of new technologies may be misguided. The relationship between technical progress and inequality is complex and contradictory. According to A. Deaton, it is an "eternal dance."

4. CONCLUSIONS

Heterogeneity in the world of work has taken off since the nineteen-sixties in advanced countries. The separation between those on the outside and those on the inside; those who are more and less protected; those who cannot negotiate this imposed flexibility and those who can; the marginalized who are increasingly vulnerable and those who are less so; those living in precarious conditions and those who "benefit" from stable jobs, even if they are under threat and subject to change. The digital revolution is shaping spheres into places that will likely have fewer stable jobs, in which fewer people native to a given country can access the jobs reserved for only the most skilled, and tertiary education booms alongside a rise in entrepreneurship. With these transformations, it is necessary to reflect once again on what is happening in the world of work.

The digital revolution is imposing greater mobility alongside the need for more training throughout the entire professional career. If it proves insufficient, lower mobility will give rise to a widening divide between the labor demand and supply and, therefore, a rise in structural unemployment. It is also imposing the need for additional investment in research and development, in an attempt to reduce the fallout of dependency, especially in emerging countries that do not produce new technologies.

New technologies are spreading throughout the world faster than ever before, but also more unequally, both within and between nations. The spread has been slower in Latin America, even in the most powerful countries in the region, like Brazil, Mexico, Argentina, Colombia, or Chile. From that standpoint, Latin America is playing catch-up to the Asian countries and advanced economies. But the spread is also unequal within national borders, across companies, particularly in Latin America. Some enterprises are rapidly adopting new technologies, others are blocking their adoption, and yet others are failing to adopt them fast enough. As the OECD (2017) noted, with the exception of institutional measures, like raising the minimum wage beyond productivity growth, there is a major risk that job income inequalities will rise across companies, with a divergence between those that are adopting new technologies and those that cannot meet the requirements to continue being competitive. To these burgeoning inequalities across companies are added the inequalities derived from the use of new technologies.

To the extent that Latin America has fallen behind, the effects have been slow to be felt; in some sectors, like in the motor vehicle or finance arenas, they have only recently become apparent. But even if this spread is slower than it has been in other places, it is now starting to accelerate and the effects are coming into focus. Unlike the advanced countries and some Asian nations, Latin America is a consumer of new technologies that it does not produce, not even a little, not even at all. The job opportunities created by producing new technologies are practically non-existent. The only new jobs are thanks to use of new technologies. It is therefore possible that so-called informal activities rise as a result of the relative inability to create enough new jobs in sectors where productivity is on the upswing.

Is such a shift unavoidable? The comparative analysis revealed that it is not. Small countries are on the cutting edge in producing some of these new technologies. There are indeed opportunities for Latin American countries to break the cycle of growing marginalization, as long as they undertake industrial and fiscal policies that encourage investment far more than they currently do and, above all, considerably boost efforts in research and development.

The digital revolution is under way, it cannot be stopped, and as was the case of the Luddite revolt or the British cannons of Lyon, it would be a mistake to see the technology revolution as the sole cause of job losses resulting from the march of technical progress and machinery. If that were the case, it would be enough to break the machines or impose robots. But that would be neither relevant nor sufficient.

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[2] Translation from French by Marcia Solorza, Professor at the UNAM Faculty of Economics.

[3] For an introduction to the various forecasts, the method used, and their reliability, see World Bank (2018).

[4] There is said to be a network effect for an activity when the use-value of the product or service rises with the number of users.

[5] Regarding the challenges facing Latin American countries so that they are not overwhelmed by the digital revolution, and the need for structural reform, see Valladao (2017).

[6] Based on a compound index on the development of the digital ecosystem, which covers eight indices: institutional and regulatory, competition, infrastructure, production factors, then household digitalization, connectivity, production digitalization, and digital industries (the first four weighted at 15% each and the latter four at 10% each), each of which is in turn composed of four sub-indices. The CAF held that Latin America would exceed, since 2014, Asia and the Pacific (including China and South Korea, Australia, etc., with the exception of Japan) for cumulative investment in telecommunications per capita in purchasing power parity (p. 88), and among the other eight indices comprising the compound index, only those pertaining to household digitalization and the regulatory and institutional framework would be stronger in Asia than in Latin America, with the others being weaker or the same (p. 81). Generally speaking, the value of the compound index would by 74.40 in North America, 37.11 in Asia and the Pacific, and 45.47 in Latin America in 2015 (p. 15). In Latin American countries, Chile would lead the pack, followed by Uruguay, Argentina, Brazil, and, lastly, Mexico (p. 18). This surprising optimism could be explained by the makeup of the compound index, and probably because several other factors, like robot manufacturing, are not considered or are underestimated.

[7] A country's export complexity depends on the amount of effort invested in research and development. The higher it is, the greater the likelihood that an economy will manufacture complex products. Exports have two traits: their ubiquity and their diversification. Ubiquity is reliant on scarcity, which is tied to the amount of natural resources a country has or not, or the ability to produce sophisticated goods, which only few countries can make. Only these latter are considered. To isolate them and build an indicator of complexity, an attempt was made to use export diversity to measure the degree of ubiquity and, therefore, complexity. For more on the complexity analysis, see Hausmann et al. (2014).

[8] It is interesting to note that autonomous car algorithms use the cloud to gather driving data, and then add them to their computer systems to make less use of the cloud. See The Economist (2017).

[9] "In the West, almost all firms have long had sophisticated inhouse information-technology systems, which many are hesitant to abandon. In contrast, the IT of most Chinese companies is underdeveloped. Chinese tech companies plan to steal American cloud firms' thunder," The Economist (2017).

[10] The International Robotics Federation defines a robot as an "automatically controlled, reprogrammable, and multi-purpose" machine. Robots are in reality much more complete than the jointed arms with which they are often confused.

[11] "Automation is evolving more slowly than in developed countries. The density of robots is lower in Latin America than in other regions. The highest density is found in Mexico, at 0.1, versus nearly 1 in the majority of developed countries in 2014," according to ADB et al. (2018, pp. 92-93).

[12] Several studies underscore the "scheduled" end of indefinite jobs in the wake of new technologies, which require constant training and greater mobility, which could lead to a boom in subcontracted jobs (freelance workers). See, for example, ILO (2016) and Salazar-Xirinachs (2017).

[13] There is hardly consensus about the link between the possibility to fire at a lower cost and reducing unemployment. The evolution of unemployment is underpinned by multiple causes. Moreover, the desire to establish a causal relationship between unemployment and rigidity, without mentioning other causes that could act in favor of or against rising unemployment, is generally irrelevant. For example, unemployment may drop because the participation rate falls when people looking for work get discouraged, and pull out of the labor market. In the United States, the low unemployment rate is associated with a very low activity rate. See Husson (2018).

[14] Economists frequently forget that mobility can be harmed if it does not go hand in hand with active training policies. In that case, people suffer something like an injustice, challenging themselves, and feeling misunderstood and anguished for their failure to find an equivalent job. Between the time an employee loses a job and the time that person does or does not find a new job, the worker undergoes an experience that is very difficult to live.

[15] Robotization at a declining cost and rising labor costs in some peripheral countries could lead to the reindustrialization of advanced countries to the detriment of a select few peripheral countries. See Benedikt and Osborne (2016). This is the reason why China, in response to spiraling workforce costs and with an eye to these future shifts that would put it at a disadvantage, is robotizing a portion of its production.

[16] Autor (2015, p. 6) gives the example of ATMs, which have replaced a number of human cashiers in every bank. Even so, with the proliferation of branches, the number of human cashiers has risen slightly in spite of the considerable increase in ATMs.

[17] Automation boosts labor productivity in the industries that use it. This can give rise to lower relative prices, freeing up purchasing power and, therefore, additional demand to buy other products. This demand will not necessarily be applied to the area in which the automation has been developed or the reference area where productivity has been low, but it could be beneficial as a way to kickstart the process.

[18] Autor (2015, p. 7) recalls that the mechanization of agriculture has led to a considerable decline in jobs in this field, because the elasticity of demand with respect to income is lower than one, while the flight of digitization in the healthcare sector has had the opposite effect.

[19] China is seemingly open to international competition, but in reality, this openness is strictly controlled by a series of administrative measures meant to develop "nascent industry" and the added value produced in the country. The relationship between economic openness and protectionism and growth is much more complex than what the neoliberal tendency affirms (see Salama, 2006, pp. 101-106).

[20] See Wilkinson and Pocket (2013) among other works.

Published in Mexico, 2012-2018 © D.R. Universidad Nacional Autónoma de México (UNAM).
PROBLEMAS DEL DESARROLLO. REVISTA LATINOAMERICANA DE ECONOMÍA, Volume 49, Number 195 October-December 2018 is a quarterly publication by the Universidad Nacional Autónoma de México, Ciudad Universitaria, Coyoacán, CP 04510, México, D.F. by Instituto de Investigaciones Económicas, Circuito Mario de la Cueva, Ciudad Universitaria, Coyoacán,
CP 04510, México, D.F. Tel (52 55) 56 23 01 05 and (52 55) 56 24 23 39, fax (52 55) 56 23 00 97, www.probdes.iiec.unam.mx, revprode@unam.mx. Journal Editor: Moritz Cruz.
Reservation of rights to exclusive use of the title: 04-2012-070613560300-203, ISSN: pending. Person responsible for the latest update of this issue: Minerva García, Circuito Maestro Mario de la Cueva s/n, Ciudad Universitaria, Coyoacán, CP 04510, México D.F., latest update: January 9th, 2019.
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The online journal *Problemas del Desarrollo. Revista Latinoamericana de Economía* corresponds to the printed edition of the same title with ISSN 0301-7036