Fear and Loathing of Technological Progress?

Leveraging Science and Innovation for the Implementation of the 2030 Agenda for Sustainable Development[1]

Draft for Discussion. Nor for Quotation/Not for Circulation

1- A Brave New World?

"The fear has even been expressed by some that technological change would in the near future not only cause increasing unemployment, but that eventually it would eliminate all but a few jobs, with the major portion of what we now call work being performed automatically by machines."[i]

It may come as a surprise that these words were written in 1966, in the report of the United States Presidential Commission on "Technology, Automation, and Economic Progress." Established in 1964, the Commission had the following as a key recommendations to deal with the uneven benefits of technological change and with the future impact of automation on jobs:

"Technological change and productivity are primary sources of our unprecedented wealth, but many persons have not shared in that abundance. We recommend that economic security be guaranteed by a floor under family income."[ii]

This recommendation is not that different, in either substance or motivation, from the current interest in establishing a universal basic income, which has been defended by some as a way of dealing with a future in which automation and artificial intelligence will render the need for labor redundant.[iii]

Of course, any discourse on technological change is always ambivalent. There is no questioning that scientific progress and technological innovation have been underlying drivers of the improvements in the standards of living throughout the history of humanity. And there is little doubt that more technological change will be needed to meet not only the challenge of continuing to increase productivity, but also to enable us to transition to more sustainable patterns of production and consumption, mitigate and adapt to climate change, meet sustainably our food needs, and continue to improve health and education.

This ambivalence, it is argued here, is driven by overly simplistic framings of the impact of technological change, which can be described as techno-determinism. The history and economics of science, technology, and innovation shows that technological change co-evolves with economic, social and political systems, and never determines outcomes on its own.

Still, evidence points to the breakdown of some key empirical regularities that do raise the question on whether, and how, technology can be harnessed to deliver the 2030 Agenda for Sustainable Development. The recent decrease across a wide number of countries of the labor share of income, and

[1] Based on the Keynote "Technological Innovation and the Sustainable Development Goals: Delivering the SDGs and Strengthening Citizens' Trust in Government." Delivered by Pedro Conceição to the International Conference on Disruptive Technologies and the Public Service. Singapore, 29 September 2017. The views are of the author and not of UNDP.

the breakdown of the synchronous growth in average family earnings and increases in labor productivity, coupled with rapid advances in automation and artificial intelligence, motivate this question.

The answer proposed here is that there are two ways in which technological change can be leveraged to support the implementation of the Sustainable Development Goals.

The first is in the way in which technology, along with finance, is already recognized as one of the two key “means of implementation” of the 2030 Agenda. This was perhaps the most significant innovation of the Addis Ababa Action Agenda, with its chapter on technology, and proposals to enhance international cooperation to deploy technological innovation in support of the SDGs, especially in developing countries.

The second corresponds to a deeper and more fundamental perspective, in that all countries in the world, including developing countries, can have a more active and deliberate engagement with science, technology and innovation. Technology, from this perspective, is more than just one “flow” to be transferred from where it was first discovered to where it needs to be deployed. This would correspond to a shift similar to the one that occurred at the first International Conference on Financing for Development, where the debated moved beyond “funding development” to the broader agenda of “financing development.”

Following this second contribution implies the recognition that technology does not determine our future, but it is in our hands to invest in science, technology and innovation, in all countries in the world, and shape the policies and institutions that can harness technology for development. This is an investment and engagement that cannot wait, it is not something that we can do in developing countries only after other, more urgent, priorities have been taken care off. This was the mistake that we committed for decades when it came to the environment, thinking that we could somehow wait to take care of it after industrializing. We now know that this was misguided.

Then, as now, once investment is made in the looming issue without delay, the parameters of the situation change.[iv] By placing environmental concerns at par with other concerns, relative prices and the relative promise of business areas shift and the private sector begins to invest in a future-conform pattern of industries. This in itself facilitates more rapid convergence toward a sustainable future. Similarly, shifting the public sector’s focus on embracing new technologies encourages rapid private sector investment in those. The resulting productivity gains can in part be channeled to reduce inequality, broaden the set and improve the quality of public goods provided, and to bolster moves toward a circular economy and toward mitigating climate change.[v] This kind of shift in mindset and engagement is needed to fully leverage technological innovation for the SDGs.

2- *Le Temps, ce grand sculpteur* (That Mighty Sculptor, Time)

Both the fear of, and the optimism over, the impact of technological change is underpinned by an assumption of techno-determinism. There is no question that major technological revolutions impact on economies and societies in ways that changes them fundamentally. From that perspective, four technological breakthroughs loom large, starting with the Neolithic (or agricultural) revolution, when we were first able to domesticate plants and animals. The other three correspond to a succession of industrial revolutions, the first centered on technologies and modes of production linked to the steam engine, the second characterized by the use of electricity, the internal combustion engine, and telecommunications, and, finally, the third linked to the digitalization of information and the use of computers and the Internet.

Yet, the history and economics of science, technology, and innovation paints a picture that could not be farther away from techno-determinism.

Let us take the agricultural revolution. The simplified and deterministic view is that the domestication of plants and animals led to the emergence of the institution of the state and of civilization as we conceive of it today, enabling the transition from people living as hunter-gatherers in small groups of mobile and dispersed groups, to sedentary and concentrated communities of people, living along cultivated plants and livestock, in ever larger agglomerations, under a ruler that held monopoly over taxation and the use of violence.

Recent thorough analysis of the historical and archeological record, rendered very compellingly by James C. Scott, paints a more complex narrative.[vi] The fact is that 4,000 years (!) passed between the widespread use of the technological breakthroughs of plant (initially mostly grains) and animal (initially mostly sheep and goats) domestication, and the consolidation of the agro-pastoral societies that we came to associate with states and with civilization. Despite our association of agriculture with a "superior" form of social, political, and economic organization, there was no immediate benefit, for thousands of years, from a direct and quick transition from hunting-gathering to agro-pastoralism. Even though the technology was widely known and used, the mere availability of technology did not lead to an exclusive reliance on cultivated plants (in part because agriculture was very labor intensive, requiring much more energy and effort that hunting and foraging).

What happened during those millennia was a long process over which our ancestors "experimented" over hundreds of years with multiple, hybrid, approaches to finding and producing food. In fact, the Mesopotamian alluvium – which at the time was not a desert between two rivers, like today, but characterized by vast wetlands and marshes – was the ideal setting for this kind of experimentation, given that it has larger variations in rainfall and vegetation over short distances than anywhere else in the world, along with very high seasonal variation in rainfall. And here, as in the upper Nile, it was possible to practice "recession farming" that was less taxing on the use of labor to prepare the land for cultivation, relying instead on the periodic river floods, which, after receding, left the land readily prepared for planting.

Over time, sedentarism, farms, irrigation, and small towns emerged, quite independently from having the formal structures of the state. The emergence of large settlements resembling what we conceive today as a civilized sate (one of the first of which was Uruk, in Southern Mesopotamia, the largest city in the world by 3,200 B.C., with between 25,000 and 50,000 inhabitants) was not a natural evolution from the technological revolutions in producing food, one that is purported to have led to the accumulation of surpluses that "freed" people from the subsistence economies of hunter-gatherers, but almost the other way around. It was the creation of the state as an institution (a ruler, having monopoly power over violence and taxation, walls delimiting territory, specialized functions to manage the administration of the state) that ultimately enabled the systematic mobilization of the labor required (most of which was forced, and used not only for agriculture, but to build city walls and monuments) to make the small and independent towns that existed scattered since 5,000 B.C. grow into larger cities and, ultimately, civilizations.

To give one more example, albeit at a smaller scale (in both impact and timespan), another narrative of direct technological determinism is how the use electricity during the second Industrial Revolution led to the Fordist/assembly line mode of industrial organization. Paul David carefully analyzed the transition from using steam power to electrical motors (dynamos) in the transition from the 19^{th} to the 20^{th} century in the United States.[vii] Factories that relied on steam power were dependent on a large, central engine that transmitted energy through a system of belts and shafts. To minimize power losses through transmission, the engine was at the bottom of a multi-story building (some of these buildings still stand, for instance, in the SoHo neighborhood of New York City), with narrow aisles and cramped spaces, an arrangement that was similar to those powered by waterwheels already in use in the early 19^{th} century (Figure 1).

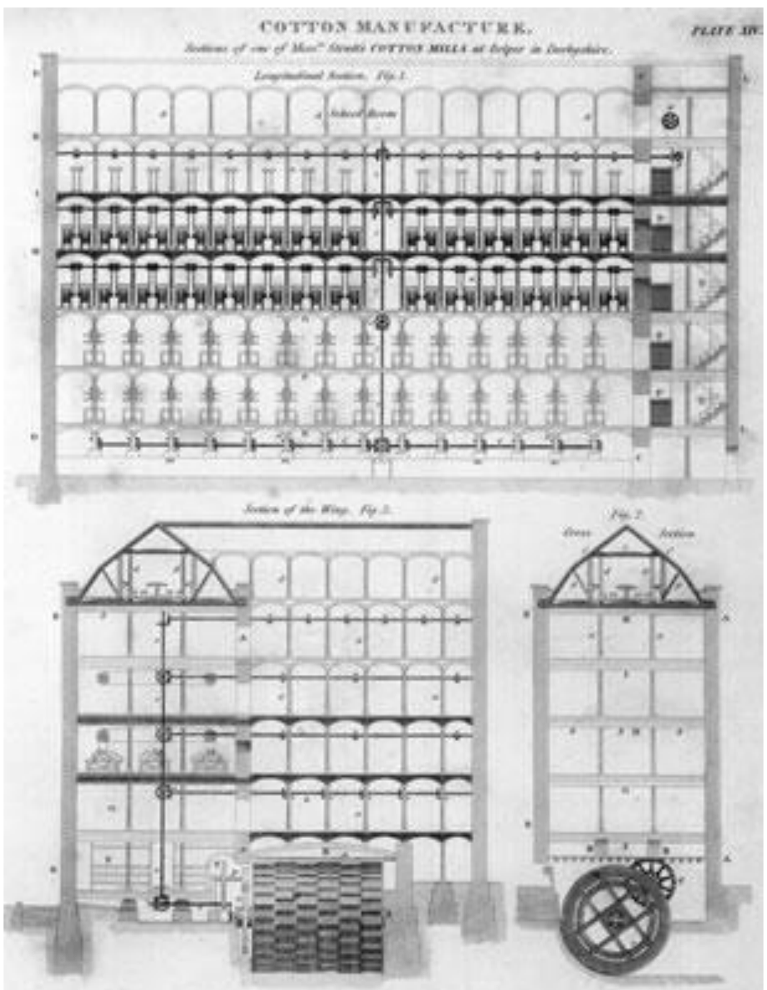

Figure 1- Jedediah Strutt, North Mill at Belper in 1819, showing vertical shaft leading from waterwheel to horizontal drive shafts running the length of each floor. [Rees's Cyclopædia, 1802-1819. Drawn by John Farey, and engraved by Wilson Lowry.]

Edison's breakthroughs with electricity happened in the early 1880s, but by 1899 only 8 percent of all urban dwellings in the US had electric lighting, and electric motors in manufacturing represented less than 5 percent of all available factory mechanical drive in the country. Even though the potential to shift from water or steam mechanical power to electricity was quite evident since the very onset of electricity, factory owners did not find it profitable to just replace steam engines with electrical ones. It took time and experimentation to finally realize that just replacing a steam engine with an electrical one, but maintaining the same organization of work, would not yield many benefits. It was not until the 1920s that a radical transformation of manufacturing started to take hold. Instead of relying on a single source of power, many electrical motors were attached to different pieces of equipment, enabling them to function independently, and to fix each separately in case of need, instead of shutting down the whole operation in case of any malfunction. Equipment could be placed on a single-story, with larger corridors that made the handling of materials easier, and also made for a safer working environment. It took, thus, more than four decades from the technological breakthrough of electricity to having the incremental improvements, technical but also organizational, that ultimately led to payoffs that we associate with the "Fordist" way of organizing work.

The point here is not to argue that technology does not influence in fundamental ways our economies and societies, quite the opposite. The point, rather, is that by retrospectively establishing linear and simplistic narratives linking technological change with social, economic and political outcomes, we fail to grasp the crucial point that this impact is co-determined with the evolution of institutions, public policies, and business decisions. And that failure leads us to project into the future either doom and gloom scenarios of a job-less world or of "Star Wars" worlds in which the whole experience of human existence is reimagined. We simply assume that the new technologies will directly substitute and replace the old ones – which, in the case of automation and artificial intelligence, means humans.

One implication of having this broader understanding of what Chris Freeman and Carlota Perez have described as "techno-economic paradigm" transitions[viii], is that given that these transitions take time and are historically contingent, the impact of technological revolutions can be quite different from what it was initially assumed. For instance, one of the most striking economic regularities over the course of most of the 20th century (at least until the 1990s – more on this later) has been that the labor share of income has remained stable in those market-based economies that have industrialized. That this could happen in capitalistic economies seemed all but impossible to Karl Marx and other observers of the transition to industrial societies in the 19th century, given that the returns were tilted so much to the owners of capital. As David Autor noted, by mid-20th century Keynes was referring to this regularity as "a bit of a miracle."[ix]

How was this possible? Dani Rodrik argued that it was due to the creation of new institutions (such as the labor movement and, later, trade unions) and political actors (political parties representing the interests of labor) that ultimately enabled a broad sharing (at least between capital and labor) of the benefits of the technologies of the industrial revolutions, and enabled market-based economies and democracy to prosper. Other institutional innovations (social insurance, transfers, regulatory and competition law) systematically harnessed the technologies of successive industrial revolutions towards a stable and balanced (compared to what was expected at the outset of the industrial revolution) allocation of income across labor and capital.[x]

This does not mean, however, that these transitions in techno-economic paradigm are not painful. In Karl Polanyi description of the transition towards the second industrial revolution, these processes are shown to be quite traumatic.[xi] Joseph Stiglitz argues that this is because economic and political structures are designed for stability, and thus effective in absorbing "small" shocks, but struggle – indeed, may need to change in fundamental ways – to manage structural changes, such as those associated with technological revolutions.[xii] Stiglitz, following on a similar point made earlier by Carlota Perez, sees "deep downturns" in economic activity, such as the Great Depression of the 1930s and the Global Financial and Economic Crisis that started in 2007 as reflecting economic and political systems struggling to adjust to structural transformations linked to technological revolutions.[xiii]

3- Is it the End of the World as we know it?

As we transitioned to the 21st century, some of the stable features that we have come to take for granted as signifiers of our ability to harness the technologies of (at least the first two) industrial revolutions for broadly shared economic growth have been shaken.

First, there has been a decrease, both in developed and developing countries, in the labor share of income – that all-important signifier of the painfully acquired achievements in managing the transition from agricultural to industrial societies. In developed economies, the downward trend started in the late 1980s, and reached its lowest level of the past half century just prior to the global financial and economic crisis of 2008. It has remained at those low levels ever since. In developing economies there is more heterogeneity, but an average downward trend is also noticeable.

A recent analysis by the IMF has thoroughly documented these trends.[xiv] It has established that, in advanced economies, the erosion of demand for routine-based occupations (linked to technological change) can account for more than half of the overall decline in the labor share of income. The decline in the relative price of investment goods (Figure 2), driven primarily by technological change, especially in information and communication technologies has incentivized the replacement of labor by capital. Middle-skilled workers – the mainstay of the middle-classes in developed countries – have suffered a particularly negative impact. Between 1995 and 2015, middle-skilled occupations dropped 10 percentage points in the labor share for OECD countries, with the majority of the gains accruing to high-skill occupations – but low skilled increased their share, as well (Figure 3).

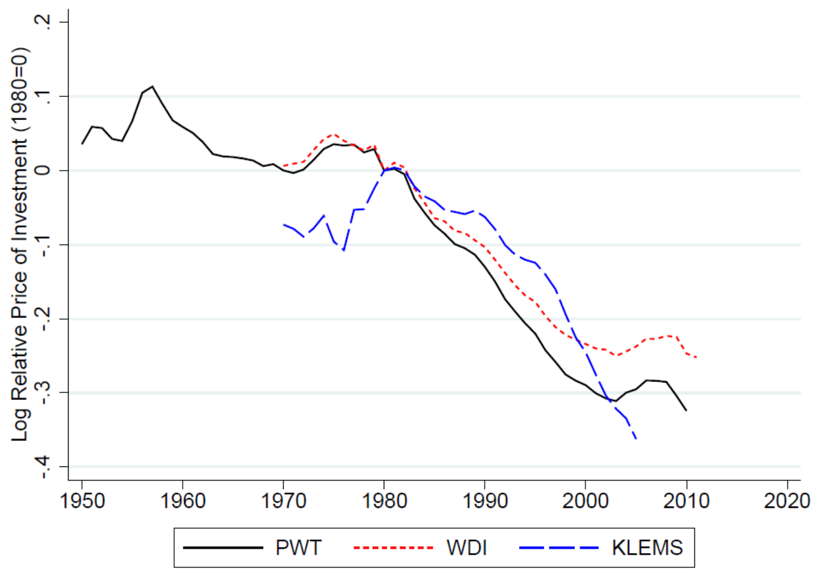

Figure 2- Decline in the Relative Price of Investment Goods. [Loukas Karabarbounis Brent Neiman. 2014. "The Global Decline in the Labor Share." NBER Working Paper No. 19136.]

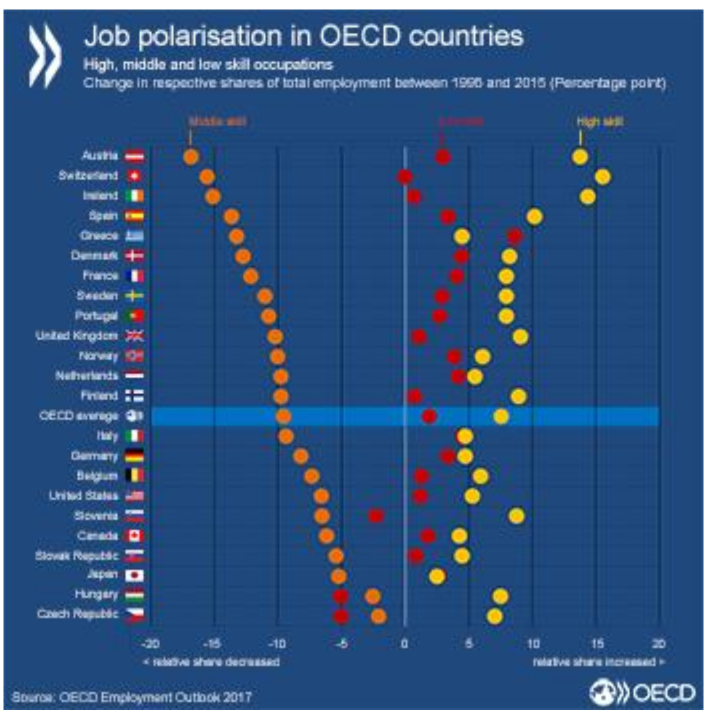

Figure 3- The Hollowing-out of the Labor Market in Developed Economics. [OECD. 2017. Employment Outlook. Paris: OECD.]

A second empirical regularity that has been broken – related to the first – is the relationship between increases in labor productivity and improvements in the earnings of a median household. Up to the 1980s, when the labor share of income started its downward trend, real average earnings for the bottom 90 percent of the population - an indicator that is a good proxy for the income of the typical family – increased in tandem with productivity growth (Figure 4). Since then, there has been a significant, and widening, decoupling between these two indicators, with earnings of a typical family remaining flat or increasing less that productivity growth. The historical experience prior to this more recent period was that when labor productivity goes up, earnings for the majority of the population also rise in tandem. The International Labor Organization has shown that while that labor productivity rose by 17 percent between 1999 and 2013 in 36 developed economies, real wages increased by only 6 percent over the same period in those countries.[xv]

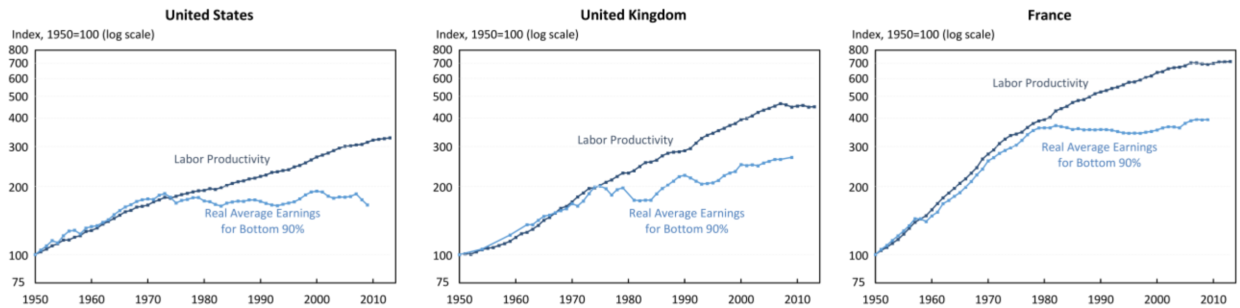

Figure 4- Breakdown in the Relationship between Labor Productivity and Average Earnings. [Jason Furman. 2014. Global Lessons for Inclusive Growth. Presentation to the Institute of International and European Affairs. Dublin, Ireland, May 7.]

A third development is the increase in corporate profits and market power of firms. While very difficult to measure, this is well documented for US firms. In perfectly competitive markets, the difference between the prices that firms command and the marginal cost of production should be very close to each other. If the price is higher than marginal cost, the size of this “mark-up” gives an indication of how much market power (ability to charge above cost without fear of competitive entry) a firm has. Mark-ups in the US stood at 18% in 1980 but have increased to 67% now (Figure 5). The economy-wide profit rate in the US relative to GDP, calculated from the national accounts, has increased fourfold between 1980 and 2014. While multiple factors may account for these developments (deregulation, aggressive private equity and merger and acquisitions, increased vertical and financial integration of competitors), the technologies of the third industrial revolution – which benefit from “network externalities,” meaning, that everyone wants to join or use the product that everyone else is using, leading to “winner-takes-all” or takes most outcomes – appear to be a key factor in creating and maintaining market power.[xvi]

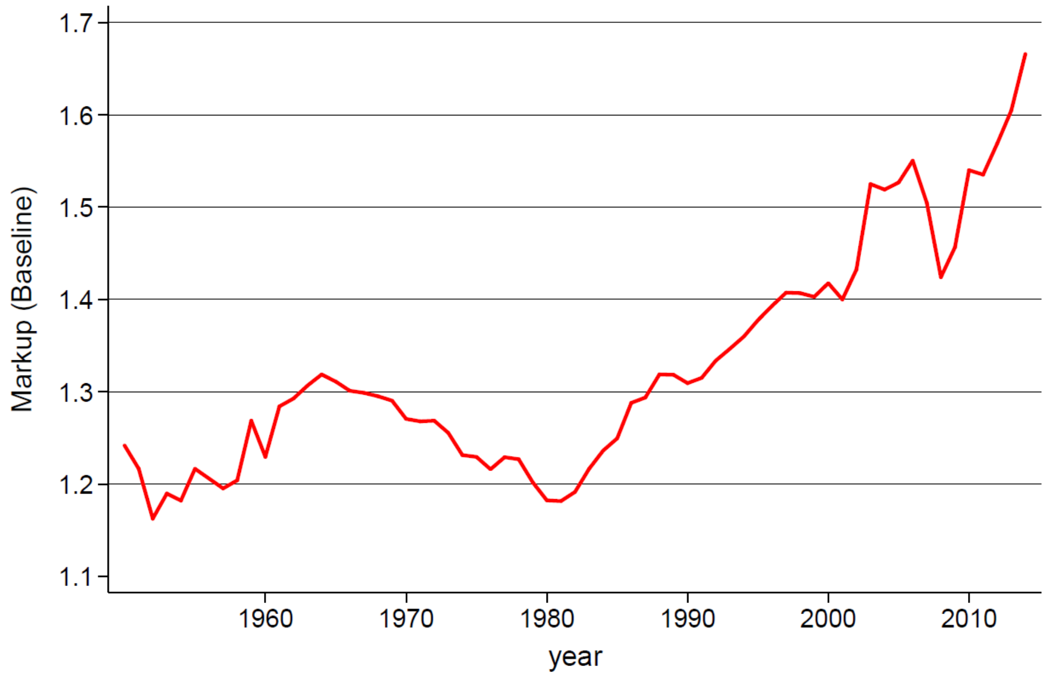

Figure 5- Average Markup for US Firms. [Jan de Loecker and Jan Eeckhout. 2017. "The Rise of Market Power and the Macroeconomic Implications. NBER Working Paper No. 23687.]

The decline in the labor share of income and the rise of corporate profits are the key proximate causes of a fourth major shift: the increase in corporate savings (profits that are not paid to taxes, labor, or debt or equity holders), which grew from below 10 percent of global GDP in early 1980s to close to 15 percent of GDP in the 2010s.[xvii] As a consequence, while in the 1980s most global investment was funded by savings held by households, today two-thirds of global investment is funded by corporate savings (which, together with household and government savings equal national savings). Still, the rise in the flow of corporate savings has been so massive that, even net of expenditures in physical investment (which have remained flat), the corporate sector has been accumulating cash, repurchasing its own stock, and accumulating other financial assets (across countries and sectors around the world).

Finally, income inequality has been going up in a large number of countries, both developed and developed (Figure 6). Even where inequality is coming down (as in Latin America and Sub-Saharan Africa), it is often doing so from very high levels, implying that around the world we have a situation in which income inequality is either high or increasing. There is no single explanation for this fact that is universally applicable to all countries,[xviii] but there is no question that, in most developed economies and several emerging ones, this is clearly related to the developments just noted, and in which technology plays a central role, in both increasing the allocation of income to the holders of capital, and the share of labor income that goes to the higher-skilled population at the top of the income distribution. While global integration of economic activity has also played a role (particularly for developing countries, in which the expansion of global value chains increased the capital intensity of production), technological change itself has enabled (along with policy decisions to decrease barrier to trade) much of that global integration.[xix]

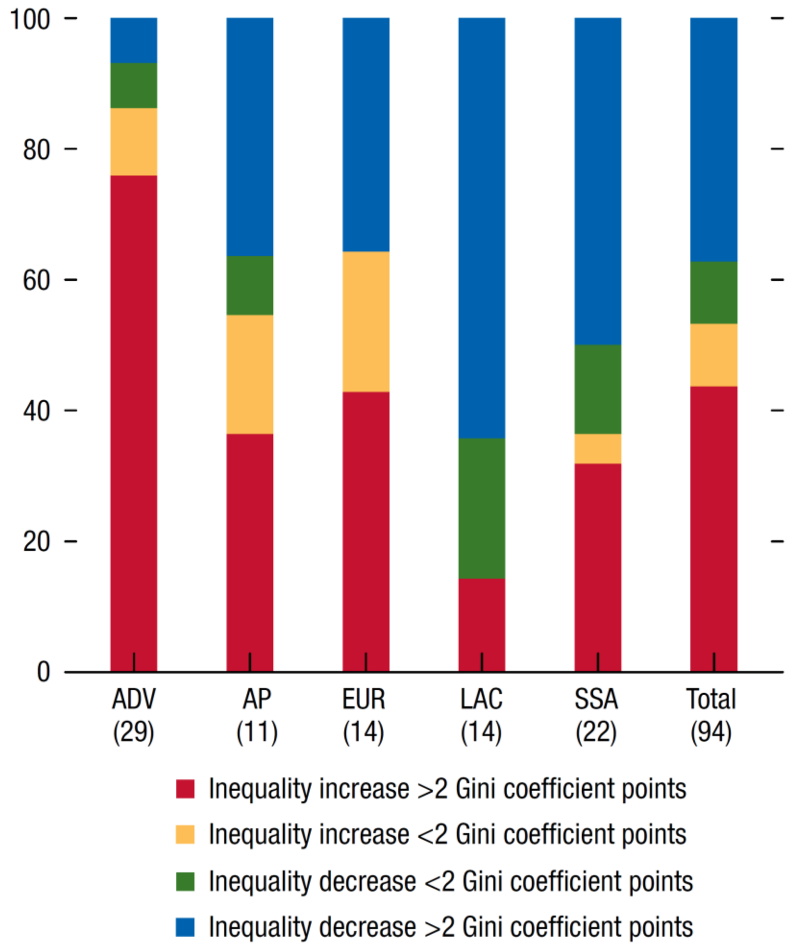

Figure 6- Change in Inequality by Region, 1985-2015 (Percent of total number of countries in region; ADV = advanced economies; AP = Asia and Pacific; EUR = Europe; LAC = Latin America and the Caribbean; SSA = sub-Saharan Africa). [IMF. 2017. Fiscal Monitor. Tackling Inequality. Washington, D.C.: IMF].

If the breakdown of these empirical regularities reflects already, to a large extent, the adjustment to the technologies of the third industrial revolution, there is concern that disruptions will only increase as the technologies of the "fourth industrial revolution" (automation and artificial intelligence) take hold. Especially given the apparently unstoppable improvement in computational power (Figure 7) and the progress on artificial intelligence, in particular "superintelligence," which has been so quick and staggering that is now approaching the replication of at least some (though far from all) cognitive abilities. This is leading to some bombastic projections of the job-destroying potential of these technologies. The World Bank has estimated that two-thirds of all jobs in developing countries are susceptible to automation, with numbers as high as 85 percent vulnerable in Ethiopia, even though some of these projections may be exaggerated, given that they rely on an extreme, or at least very direct, form of techno-determinism (see also the discussion in the next section).[xx] Serious economic analysis is being conducted on whether we will reach a "singularity point" that completely eliminates the need for labor as an input to economic activity, with virtually all income flowing to the holders of capital, and accelerating economic growth to levels of income that would be, essentially, unbounded.[xxi]

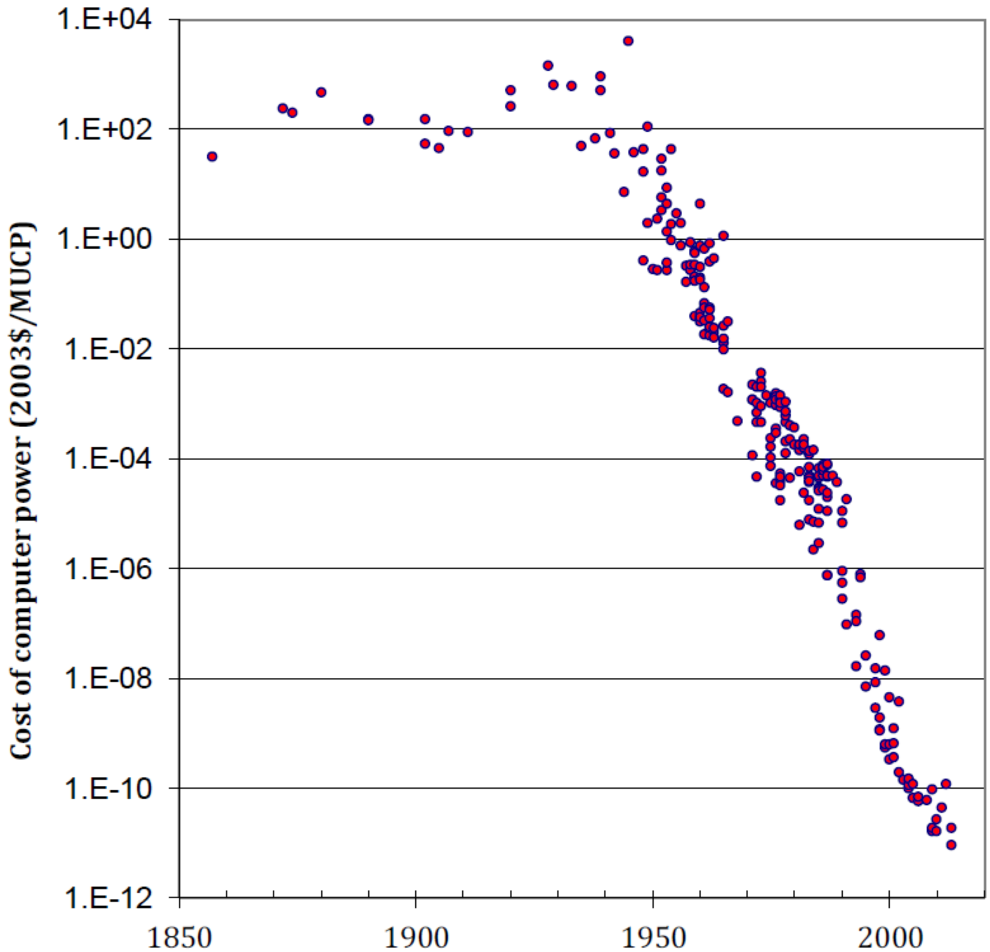

Figure 7- Progress of Computational Power, measured by the decrease in the real cost of a computation per second. [William D. Nordhaus. 2015. "Are we Approaching and Economic Singularity? Information Technology and the Future of Economic Growth." NBER Working Paper No. 21547.]

An objective reality is that many people are being left behind (especially those at the middle of the skill/income distribution), and that this is generating anger and sentiments of alienation. There is strong evidence of direct effects of job losses on reducing academic performance by adolescents and youth of affected families, exacerbating inequality.[xxii] And many of those that do have jobs fear for their future, or the future of their children. All of this builds into a sense of insecurity and of not being in control of one's own destiny. Political scientists working on the evolutionary theory of leadership emergence suggest that affinity/dominance and prestige/competence are dual pathways to political leadership.

There is strong evidence that when people feel under threat of economic uncertainty the support for leaders with whom there is a strong sense of affinity escalates.[xxiii] More fundamentally, there is a lack of trust in government and in institutions more broadly, especially for those at lower levels of income. A recent survey found that in 18 of 28 countries there is a double-digit gap in the trust in institutions between high-income and low income respondents.[xxiv] Along with economic insecurity, there is an erosion in the trust that governments and institutions are adequately managing the real and perceived challenges associated with technological change.

4- Where do we go from here?

While we do not know how the world will evolve, we at least have, in the 2030 Agenda for Sustainable Development, a shared agreed framework on where we want to go. The 2030 Agenda pledges to “leave no one behind,” and includes goals and targets to eliminate poverty and hunger, tackle inequality, respect planetary boundaries, address climate change, and ensure that we all leave in peaceful and inclusive societies. The Agenda is quite clear that meeting the Sustainable Development Goals (SDGs) call for nothing short than “transforming our world.”

This transformation will have to occur amidst a number of unfolding trends and compounding challenges, which range from our real last chance to take action to mitigate climate change, to managing massive demographic shifts (urbanization, ageing developed societies, and very young developing ones). We are confronting an upsurge in violent conflict, with the tripling of major conflicts since 2010: in 2016, more countries affected by conflict than at any time in last 30 years, and with more civilian casualties, which doubled between 2010 and 2016.[xxv] Threats to biodiversity are more severe than commonly understood, with recent evidence showing sharp reductions in population declines of vertebrates, even in species of low concern when it comes to the risk of extinction.[xxvi]

Science and technological innovation will be crucial to meet the challenges of implementing the SDGs from two perspectives.

First, new and improved technologies will be needed. This was clearly recognized explicitly in the 3rd International Conference on Financing for Development, held in 2015, and which resulted in the Addis Ababa Action Agenda (AAAA). Perhaps the most significant breakthrough in the AAAA is the explicit recognition that technology, as much as finance, is essential to meet the universal 2030 Agenda. Just to give an illustration, the transition towards renewable energy – crucial to meeting SDGs ranging from climate change, to electricity access, to improving food security, to move towards sustainable patterns of production and consumption – will depend on further advances in wind, solar, and battery technologies.

It should be noted that technology on renewable energy is improving very rapidly already. For example, in March of 2016, the price for unsubsidized solar energy hit a historical minimum of 3.6 cents per kilowatt-hour (kWh) – the average retail price for residential electricity in the US is 12 cents/kWh. In October 2017, a bid for a solar plant in Saudi Arabia hit 1.79 cents/kWh, which is “cheapest unsubsidized electricity ever, anywhere, by any technology.”[xxvii] Looking ahead, “renewable energies are expected to capture three-fourths of the $10 trillion the world will invest in new power generation through 2040.”[xxviii] Still, as with aggregated food being available to meet, in principle, the caloric needs of every single person in the world coexisting with hunger, just the fact that we will be able to produce more energy from renewables does not ensure access (even when renewables also offer options to enhance access through off-grid solutions, like decentralized solar panels).[xxix]

But the consideration of science, technology, and innovation will be needed from a second perspective as well. One that takes the premise that while future pathways are uncertain and unknown, nothing is pre-determined, and certainly not by technology alone. That institutions will adapt and evolve, and so must public policies, and that in managing those processes lies an important, if not crucial, contribution to restoring people's trust in governments and institutions.

Government stances, in this context, should not be to resist or reject technological, and not to be either too optimistic (things will sort themselves out) or too pessimistic (we are bound to a future with no jobs). The UN's Department of Economic and Social Affairs (DESA) has undertaken a balanced assessment of the future impact of technological change on labor markets, and has provided important concrete recommendations in this regard.[xxx] The analysis, for instance, shows that looking at the impact of technology on occupations, as opposed to specific tasks, may lead to over-estimating the number of jobs at risk. In fact, a study is cited in that report that finds that only one occupation has disappeared in the US since 1950: that of elevator operators. All others have changed, with the use of technology for different tasks, but have not led to the outright elimination of occupations. The DESA study also points to the importance of managing the fundamental dislocations and uncertainties associated with technological change, in ways that are inclusive and enables people to manage shocks, to ensure people feel safe and secure. This calls for a consideration of a wide range of sectors, from fiscal policy, to social protection, to education.

This is not to suggest that we can assume that future development pathways can just replicate those of the past, even with appropriate social protection and other policies in place. Dani Rodrik has shown that countries are "running out of industrialization opportunities sooner and at much lower levels of income compared to the experience of early industrializers," largely as a result of labor-saving technological change.[xxxi] But fully harnessing science, technology, and innovation for the SDGs implies that countries, at all levels of income, need to invest in developing *their own* innovation systems.[xxxii] Technological innovation is more than a flow to be transferred. Technological innovations take place everywhere, and respond to challenges and opportunities that are unique to each society. It is a misconception – and unacceptably dismissive – to conceive of developing countries as "recipients" of technology. Countries at all levels of income innovate and harness technologies in ways that surpasses – the expression "leapfrog" is sometimes used – what has been achieved in countries at higher levels of income. The way in which countries in East Africa, and especially Kenya, have harnessed mobile phone technology to advance financial inclusion is a widely known case in point.

Often ignored in the discussions and debates on technological change is the deep interdependence with science. It is almost as if technological innovation flows from the ether or from brilliant entrepreneurs in "innovation hubs." Mariana Mazzucato has popularized a vast scholarship tracing how investments in science, by private but crucially also by public actors, underpin technological innovations such as the smart cell phones, that are so familiar and ubiquitous as to have been disembodied of all the scientific effort that has gone into making them possible.[xxxiii] And, if anything, more and more research and development effort is needed to continue to push technological advances. To take the example of Moore's law, a recent study found that "the number of researchers required today to achieve the famous doubling every two years of the density of computer chips is more than 18 times larger than the number required in the early 1970s."[xxxiv]

Harnessing technology for the SDGs calls for all countries to be actively engaged in shaping the broader set of institutions and policies, global and national, that will determine the impact of technological change on sustainable development, in a way that is diversified and nationally relevant.[xxxv] Only in this way can we guarantee that technology does not determine our destiny, but, rather, that we shape technology to fulfill the aspirations of the 2030 Agenda.

Notes

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[i] United States. 1966. National Commission on Technology, Automation, and Economic Progress. Report. Washington: U.S. Government Printing Office: xii [https://babel.hathitrust.org/cgi/pt?id=coo.31924050772056;view=1up;seq=14]

[ii] United States. 1966. National Commission on Technology, Automation, and Economic Progress. Report. Washington: U.S. Government Printing Office:100 [https://babel.hathitrust.org/cgi/pt?id=coo.31924050772056;view=1up;seq=126]

[iii] See, for instance, this debate between two columnists in the *New York Times*. https://www.nytimes.com/2016/03/09/business/economy/a-future-without-jobs-two-views-of-the-changing-work-force.html

[iv] Balazs Horvath contributed to this paragraph.

[v] I am grateful to Balazs Horvath for this paragraph.

[vi] James C. Scott. 2017. *Against the Grain. A Deep History of the Earliest States*. New Haven: Yale University Press.

[vii] Paul David. 1990. "The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox." *American Economic Review*. 80(2): 255-361.

[viii] Christopher Freeman and Carlotta Perez. 1990. "The Diffusion of Technological Innovations and Changes of Techno-economic Paradigm." In F. Arcangeli and others (eds.). *The Diffusion of New Technologies*. New York: Oxford University Press.

[ix] David Autor and Anna Salomons. 2017. Does Productivity Growth Threaten Employment? [https://www.ecbforum.eu/uploads/originals/2017/speakers/papers/D_Autor_A_Salomons_Does_productivity_growth_threaten_employment_Final_Draft_20170619.pdf]

[x] This is an oversimplification of the process involved in determining the allocation of income between labor and capital, given that this allocation is determined by elasticity of substitution between the two, which, in turn, is influenced by technologies of production available.

[xi] Karl Polanyi. 1944. *The Great Transformation*. New York: Farrar&Rinehart.

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