Marxism in the Digital Era

Impacts of Electronic-Digital Technology on Early-21st-Century Economies

Pio Verzola Jr.
Institute of Political Economy and PRISM

The world is now well inside the digital era, where so-called information/communication technologies (ICT, or more properly, electronic-digital technologies or EDT) are used in our daily lives.[1] Bourgeois theorists now talk routinely about the Third Industrial Revolution, with EDT as its cutting edge. Some even claim that we are entering a Fourth Industrial Revolution. The implication is that the world is fast evolving, or has already evolved, into a "new" and "digital" or "information-based" (even "post-industrial") economy together with new economic values, new social relations, even new worldviews.

Most Marxists also see the reality of this new technical revolution. Nevertheless, taking the standpoint of the working class as Marx did, we need to ask further: What exactly is the character and socio-historic significance of this revolution? How much of the "new digital economy" is really "new"? Or is it just the same old and ailing capitalist society still getting older despite high-tech prosthetics? Are the technological and social changes we see unfolding before us for the benefit of the toiling masses of the world, or only for the few monopoly capitalist exploiters and oppressors?

1. The reason I add "so-called" to the term "information/communication technologies" is that the preferred term is not ICT but "electronic-digital technologies" (EDT), which is technically more accurate. Strictly speaking, ICT include millennia-old implements such as pen and paper. I give credit to Tony Tujan for this conceptually important semantic correction. He promptly pointed out the difference between ICT and EDT, and suggested the change of term to avoid confusion. Hence in this paper EDT is used consistently. A more technical description of EDT is provided in the section on the Third Industrial Revolution (Electronic-Digital Era).

Many related questions need to be asked and answered, to help orient the working-class and people's movements in their tasks and directions as the 21st century unfolds. In this paper we hope to at least pose the questions more rigorously as continuing research topics using the framework of Marxist theory, and to offer some provisional answers.

1. Marxism on Technology and Production

Our first task is to locate the concept of "technology" within the Marxist theoretical framework.

Marx and Engels defined a society's forces of production (F/P) as: (a) people who exert work to produce goods; (b) the raw materials they work on; and (c) the instruments that they work with. The last two are also called the means of production (M/P).[2] Relations of production (R/P), on the other hand, are how people relate to each other in the course of production, in terms of (a) ownership of the M/P, (b) the various roles in the production process, and (c) how the resulting products are appropriated and distributed.

Marxist theory asserts that a society's level of F/P determines its R/P, as a whole, but the R/P also impart feedback that can hasten or dampen the further development of the F/P. In any specific society, F/P and R/P are tightly and dialectically intertwined — driving an inherent contradiction that defines the material base of that society. This material base, in turn, is dialectically intertwined with the socio-political, cultural-ideological superstructure of that society. These two dynamics are at the core of how Marxists analyze the workings of various societies as history unfolds.[3]

The term "technology" thus approximates the Marxist "means of production" (M/P), although we must remind ourselves that technology encompasses the folk and scientific know-how and skills that peo-

2. In a larger sense, the people engaged in production include their families and communities, because production always has a social character. In addition, the means of production ultimately involve nature's original raw materials and nature's forces that could be harnessed in production.

3. The famous quote from Marx is included as Appendix 1 of this paper.

ple wield in the production process.[4] In this broader but still Marxist sense, we should view technology as also encompassing the whole range of facilities, tools and other devices that society utilizes to interact with itself and the world at large, in most other realms of their social practice — and not just those used for production proper. Cell phones, microwave ovens, cars, or the entire US ballistic missile defense system — all these represent technologies. We emphasize this point because electronic-digital technologies in the past 50-plus years have impacted not just production but nearly all realms of social life.

We likewise take this occasion to recall that the Marxist usage of "production" is always in the context of a much broader view of how society reproduces itself. Production is always tightly interconnected with consumption and labor, including reproduction of labor power. In that interconnection, distribution and exchange play important roles. While Marx did focus on production as the starting point of his investigations into political economy (cf. Capital vol. 1), he also explored its live connections with the rest of daily social life under capitalism.[5] These questions of Marxist political economy are gaining importance today, because the scope of capitalist production has tremendously expanded in the past century. Thus our critique of the capitalist system as it now exists must also expand accordingly.

2. Review of the 1st Industrial Revolution

Marx and Engels grew up at the height of the original Industrial Revolution (1750s-1860s), and worked out their principal theories during the long 50-year cusp that linked the First and Second Industrial Revolutions. In our effort to understand the patterns of technological and social changes in today's electronic-digital era, it is instructive to see

4. As Marx remarked in *Grundrisse*, Ch.1: "... no production is possible without an instrument of production, even if this instrument is simply the hand. It is not possible without past, accumulated labour, even if this labour is only the skill acquired by repeated practice and concentrated in the hand of a savage."

5. For recent studies that reviewed Marx's writings on what are now called the "service sector" and "social reproduction" (aka domestic work), see for example Fiona Tregenna's *"Services" in Marxian Economic Thought* (2009), Ricardo Antunes' "The New Service Proletariat" in *Monthly Review* (April 2018 issue), and Ian Gough's "Marx's theory of productive and unproductive labour" in *New Left Review* (1972). Other sources are also listed at the end of this paper.

how Marx and Engels analyzed similar patterns in their own historical period. The transition from feudalism to capitalism, and capitalism itself, are very long periods divided into stages; each stage carries its own associated changes in productive forces and relations.

For example, we find incipient capitalism growing in the womb of feudalism, first in the form of the "putting-out" system or "domestic industry". This mode of production became prevalent in England in the 15th century. "The merchant-employer (almost a capitalist) bought raw material … and 'put it out' to the smaller craftsmen..." who typically worked at home with their own hand implements, say, a spinning wheel or weaving loom. The "capitalist" paid each worker for her labor and became the owner of the finished cloth, which he sold at a profit. (Eaton 1963, 54)

The crucial next step occurred when a successful master craftsman or merchant brought the artisans under one roof and made them work together in close cooperation, in exchange for wages. These became the first fully capitalist workshops. "Cooperation brings with it a great increase of productive power, overhead costs (per unit of output) are reduced, efficiency is stimulated by the contact of workers with one another in production, joint efforts make possible achievements of an altogether different kind from those within the power of individual workers. x x x This new productive power... is the fruit of the new technical developments and consequently new social conditions... " (Eaton 1963, 55)

This revolutionary step led straight to fully capitalist "manufacturing," which became dominant from the mid-16th to the end-18th century. In each "manufactory," a big number of workers still used hand implements; but these were now adapted to highly specialized functions according to the complex division of labor under one roof. As Marx said, "The collective laborer, formed by the combination of a number of detail laborers, is the machinery [mechanism] specially characteristic of the manufacturing period." During this same period, in general, machines played only a secondary part. (Capital, Vol. 1, Ch. 14)

Marx then analyzed the first Industrial Revolution, describing its capitalist essence as large-scale mechanized production, which used powered machinery operated by wage workers to mass-produce commodities. He explained: "In manufacture, the revolution in the mode of production begins with the labour-power; in modern industry it begins with the instruments of labour." He devoted an entire chapter of Capital on machinery and modern industry (Vol. 1, Ch. 15), with in-depth analysis into specific technological innovations and their impact on specific industries.

Dissecting the soul of industrial machinery as thoroughly as that of the commodity at the very beginning of Capital, Marx further said: "All fully developed machinery consists of three essentially different parts, the motor mechanism, the transmitting mechanism, and finally the tool or working machine." He then proceeded to trace how great strides and synergies were achieved in all three mechanisms throughout the Industrial Revolution. For example, Marx described in minute detail how steam engines came to run "an organized system of machines, … a mechanical monster whose body fills whole factories" employing more and more cheap labor.

He and Engels lived long enough to assess the impact of other technical innovations in the later phase of the Industrial Revolution, when heavy industry grew particularly in iron and steel (e.g., mass production of cheap steel through the Bessemer process and Siemens furnace) and capital-goods industries (e.g., more powerful and precise machine tools).[6] These, combined with the rapid expansion of railways and steamship transport, resulted in the overall maturation of free-competition capitalism and the intensification of its fundamental contradictions.

We take particular note of railways, which served as a strategic engine of growth in the 19th century because they evened up the level of industrial development across vast territories of Europe and North America. They sped up the pace of production everywhere, enhanced

6. In fact, as Regina Roth says in her paper "Marx on technical change in the critical edition", which analysed thousands of unpublished pages in the *Marx-Engels Gesamtaushgabe* (MEGA) and *Marx-Engels Collected Works* (MECW) collections, Marx had a sustained interest in the history of mechanical invention and the role that machines play in the economic system of capitalism.

labor force mobility, and spurred commerce and consumerism. This strategic role of railways multiplied further when combined with telegraph lines. The railway-telegraph network did much to consolidate the capitalist home market and the capitalist state.

The railway-telegraph combination is perfectly illustrative of a technology cluster which, in a conventional sense, "does not produce" anything but serves entire economies as an ubiquitous nationwide infrastructure. This would be repeated twice more in the history of capitalism: the road systems and radio/telephone networks in the 2nd Industrial Revolution, and the Internet and other computer networks at the core of an increasingly integrated telecommunications and automated transport system in the 3rd Industrial Revolution.

The first Industrial Revolution (1st IR) did not of course do away with agriculture, which provided food for the fast growing urban worker population. The change was that capitalist farms became more commercialized, consolidated and concentrated, and consequently grew bigger. The ability to mobilize bigger capital led to mechanization, fertilizer inputs, and infrastructure improvements on the land. In a manner of saying, agriculture was transformed into "just another industry." This example, of one type of production transforming another, would be seen again in the current digital era.

The introduction of more efficient machines and processes in the workplace increased the "organic composition of capital," as Marxists call the proportion of the value of the means of production ("constant capital") over the sum total of wages ("variable capital"). Increasing composition of capital drove down costs per unit of output and drove up rates of exploitation for the capitalist, even as it also tended to drive down rates of profit.

Meanwhile, workers turned into the machine's appendages. Superficially or hypothetically, mechanization could lighten the workers' physical burden for a while. But the bigger and longer-term impact was that more workers were thrown out of jobs. Also, speed-ups and work intensification became easier to implement. The same would be true for the next waves of industrial mechanization and automation.

The 1st IR fueled boom-and-bust cycles, intense competition and much restructuring among capitalists: some enterprises grew bigger, many others went bankrupt. Thus also grew a "reserve army of labor" — the often unemployed — which further pushed down wages. Increasingly, the big machines required more unskilled labor (including more women and children) and fewer skilled ones. These further pushed up rates of capitalist exploitation and economic inequalities.

The modern corporation emerged as the collective capitalist, through which industrial capital was able to dominate over commerce and banking, and further hasten capital accumulation. The business corporation (with monopoly characteristics emerging later) would serve as the basic economic unit of the capitalist system in the next 150 years. Corporations supported science and technological innovations, and expanded their foreign markets. These technical and market measures appeared to solve the periodic crises, but in fact only provided temporary relief while gathering fuel for more crises in the long term.

3. On the 2nd Industrial Revolution

The Second Industrial Revolution[7] (1880s-1920s) proceeded alongside the rise of modern imperialism or monopoly capitalism most clearly seen in Western Europe, US-Canada, Russia, and Japan. In this period, Marx's and Engels' fundamental critique of capitalism were even more clearly validated. But it was Lenin who synthesized all the new developments into his theory of imperialism.

Starting in the 1890s and advancing further from the steam engine, industry gradually developed two sources of power that were more efficient and more scalable: the internal-combustion engine (which ran on petro-fuels) and electric power (which could be generated by steam, flowing water, or internal-combustion engines). In close com-

7. The author is aware that, given the many essential continuities between the 1st and 2nd Industrial Revolutions, we could view the latter as basically just a continuation or just one distinct phase of the former. Admittedly, this point needs further study. However, the term "Second Industrial Revolution" has already gained some traction in social science and popular literature. Also, great advances in productive forces during the 1880-1930 period did help catalyze and shape monopoly capitalism. Thus I adopt the term in this paper for lack of a more convenient one.

bination, electrification and automotive power produced more industrial cities and industrial belts. They also provided factories a better capacity to drive conveyor belts, lifts, and other materials-handling facilities. Together with Taylor's time-and-motion studies, these innovations enabled capitalist firms to widely adopt the moving assembly line as the dominant form of mass production and factory organization.[8]

The earlier technologies of the 1st IR expanded into more industries. The synergies among iron-steel and coal industries, railways and telegraph networks continued. The machine tools industry greatly expanded due to easier access to electric power combined with the mass production of interchangeable (standardized and precisely crafted) parts. Meanwhile, 2nd IR technologies (internal-combustion engine, electric devices and machinery) and new processes developed by science labs created totally new industries for civilian and military use. They churned out new producer and consumer goods and services, such as cars, planes and fast ships, new alloys and synthetics, and electrical appliances for home and business use.

Fueled by imperialist greed and ambition, war and militarism became powerful drivers for scientific breakthroughs and technological innovation during the 2nd IR, especially in engineering, pharmaceuticals and petrochemicals, electronics, and nuclear physics. These would find expanded industrial, agricultural, service-based and consumer applications in the 1930s, during World War II, and in the early Cold War period, on top of their original military application which of course led to bloated war industries.

In *Monopoly Capital* (1966, 217-219) Baran and Sweezy focused particularly on three "epoch-making" innovations: steam engines of the 1st IR, railways that spanned both 1st and 2nd IR's, and automobiles that dominated the 2nd IR. "The automobile industry," the authors said, "has had a much greater indirect than direct effect on

8. In the moving assembly line system, complex processes were divided into discrete and simple steps laid out in sequence along a line under one roof. Workers operating tools in stationary work stations would install components step by step down the line, keeping pace with the mechanized conveyor belt. This system was iconized by Ford's assembly line of its famous Model-T cars. Thus Taylorism is often equated with Fordism.

the demand for capital. The process of suburbanization, with all its attendant residential, commercial, and highway construction, has all along been propelled by the automobile." They also argued that the petroleum industry "is in large part a creation of the automobile", in addition to some upstream industries (e.g., rubber and glass) and downstream service industries.

The 1st IR had revolutionized mass communications through the railway-telegraph system, the steam-powered rotary printing press, mass marketing, lithography, and photography. The 2nd IR, in turn, greatly expanded the public demand for mass communications through such media as radio, films, telephone and high-speed teleprinter systems, and cheaply printed books and periodicals. We shall see this trend grow further and turn qualitatively into an all-encompassing and irresistible tide in the current digital era.

Related to these is the rise and astronomical growth of the advertising industry. As statistics cited by Baran and Sweezy (1966, 122) show, US ad expenditures in 1890 amounted to $360 million, or seven times more than in 1867. By 1929, the figure had multiplied nearly 10 times to $3.426 billion. This trend would further intensify in the 3rd Industrial Revolution. (Further down we will return to this trend, in the context of interpenetration of production and the sales effort under mature monopoly capitalism.)

Corporations grew rapidly in size and concentration as the natural result of boom-and-bust cycles and competition, vertical and horizontal mergers and acquisitions. Their rapid growth was also spurred by new laws granting separate legal personality and more incentives to corporate business entities. Capitalist monopolies and cartels began to dominate entire industries, while huge finance capital accumulated in the hands of powerful finance oligarchies. Monopoly capitalism tended to become state monopoly capitalism. The biggest monopolies, spreading their tentacles to other parts of the world, turned into transnational corporations (TNC).

These new modes of capitalist ownership intensified the extraction of surplus, and worsened the exploitation and oppression of workers

as well as entire peoples of colonies and semi-colonies. The social character of production became even more marked. Marxism became dominant among working-class parties, and great class struggles and anti-imperialist struggles broke out — as represented by the Great October Socialist Revolution and militant workers' movements worldwide. All these sharply pointed to the socialist revolution and its alternative strategies for achieving industrialization and social equality under proletarian rule.

4. The Third Industrial Revolution (Electronic-Digital Era)

Conditions and factors

The Third Industrial Revolution (1950s to the present) was ushered in by a complex combination of factors and conditions after World War II. While we need more in-depth studies on this, several factors and conditions clearly favored a big push towards a new industrial revolution:

- First, the post-war US financial-economic-military superiority and the long period of business boom in 1950-1973.

- Second, the military-industrial complex in imperialist countries, the Cold War, and costly military interventions as imperialist responses to national liberation struggles in the neocolonies.

- And third, the worsening cycles of global crises after 1975, and new imperialist offensives under the flags of neoliberal globalization and neoconservative militarism.

All three conditions created a multiplicity of other factors, simultaneously and successively. These factors impelled the strongest imperialist states and TNCs to invest tremendous capital, human and natural resources in strategic research and development (R&D) programs and facilities. On such basis, they fed a continuous stream of technological innovations to expand old industries and create new ones — in the

hope of dampening the boom-and-bust business cycles and relieving the general crisis of imperialism.

To some degree, these factors likewise impelled socialist states (or former socialist states) to also engage in strategic R&D and compete with the major capitalist powers in high-tech fields, if only to fend off the relentless US-led imperialist military, economic, and other offensives, and to scale up their own capacity.

Basic character of the Third IR

The basic character of the 3rd IR — thus far — is the rise to dominance of high-tech industries and types of services powered by ICT, or more accurately, electronic-digital technologies. EDT enables increasingly higher degrees of automation and precision, tighter integration of operations from design to sales, greater diversity in product types, and other advantages. These ensure super-low costs and super-high profits for the monopoly capitalist groups that control the said technologies and the production chains dependent on these.

The core technology of the 3rd IR is the electronic-digital computer, or more accurately, the microprocessor ("computer chip" in street parlance) that is at the heart of computers, computer-driven systems, and other high-tech machinery. The microprocessor's power is multiplied by closely related hardware: memory devices, storage media and input/output devices for handling massive amounts of data, and communication systems for sharing such data across networks.

We consider computer languages, microprocessor instruction sets, and communication protocols, together with the resulting firmware and software, as a crucial part of EDT. Without these logic-and math-based tools for data processing, it would be impossible for computers to do any work or to work together, and for humans to operate them.[9]

9. It is important to consider both computer hardware and software (including the in-between hybrids called firmware) as interdependent tools. The strongest reason is that firmware and software are mental tools that have become "objectified", and such can already function outside the mind of individuals, be embedded in hardware, and be replicated and modified.

What makes the computer chip truly revolutionary is its capacity to mimic mental functions of the human mind, in programmable ways and at incredible speeds, and thus be able to run myriad other devices — from coffee pots and calculators to "lights-out" factories and spacecraft. It is as if bits of congealed human intelligence or tiny "brains", representing high concentrates of mental labor, could be pieced together into complex, versatile, tireless, and teachable tools, which in turn could be embedded into most kinds of machines.

The computer represents an intelligent multipurpose machinery. It is an enormously productive tool because, through a wide selection of software programs and options, it can be quickly reconfigured to do many things much more automatically, rapidly, continuously, and accurately compared to human faculties. It can thus do away with tedious manual operation or constant human attention. It can run as a stand-alone device, or drive other machines where it is embedded (industrial and construction machinery, transport vehicles, scientific instruments, office and home appliances, POS and ATM machines, etc.), and also function cooperatively with other computers through digital networks.

The 1st IR had mostly replaced the manufacturing worker's manual skills and physical strength with the tireless energy and the mechanical virtuosity of power-driven machinery. The 2nd IR expanded the power sources and functional roles of these machinery in more fields of production within and outside industry (including construction, transport, agriculture, etc.), thus further turning more types of manual labor into mere appendages of machines.

In the current case, the 3rd IR is turning more and more types of industrial, agricultural, transport, service, military, scientific, office, and home machinery into intelligent and interconnected machines. These machines require much less direct human intervention, and are replacing more and more kinds of labor (both mental and manual) that are slow, tedious, inefficient, uneven, error-prone, or hazard-prone.

This development has tremendous impacts on the organic composition of capital, on rates of exploitation, on the very structure of pro-

duction and work force, and on the resultant situation of the working class in terms of employment, wage arrangements, and workplace conditions.

Digital technologies further enhance monopoly capitalism's capacity to speed up, expand and globalize the great economic cycle of production-distribution-exchange-consumption. Computerization and the Internet are pumping up all aspects of this cycle, from research and development, to finance and trade (including the bloated sales effort and advertising industry), all the way to super-consumerism and super-waste.

Because of computers and the Internet, it is now possible for big capitalists to carve out new spheres of production, and to privatize, commodify, and mass-reproduce ever-wider types of social resources. Information-rich (cultural, educational, media, scientific) goods and services are now mass-produced in customized ways, precision target-marketed, and delivered in volume as profitable commodities. The same is true for previously marginal but now lucrative aspects of natural and human resources, such as pharming and other biotech processes, and tourism-oriented goods and services.

Foundation and phases of the Third IR

Information and communications have always been part of our social evolution as Homo sapiens. ICTs have existed for at least a million years, since primitive hominin bands learned to enhance human memory and extend human speech through symbols on media — even if these media are just hollow logs used as drums, cave paintings, notches on ivory tusks, or decorated pottery.

ICT has come a long way from Sumerian cuneiform tablets ca. 3500 BCE to modern civilization's printed books, telegraphy, telephones, and audio-visual media of the pre-digital era. In the mid-20th century, electronic-digital technologies began to take shape, subsume and reconfigure earlier ICTs, many other production technologies in fact, and thus usher in the Third Industrial Revolution.

Practical electronics for communications and instrumentation started in the 1920s (e.g., radio) and greatly diversified in the 1930s (e.g., television, radar, scientific instruments, xerography). Likewise in the first half of the 20th century, analog (i.e., non-digital) computers based on electro-mechanical devices began to be used for scientific computing. Right before and during World War II, information scientists and military intelligence started employing fully electronic, digital and programmable computers.

The crucial turning point in EDT was the invention in 1947 of the transistor as the first practical semiconductor device. From 1955 onward, transistors rapidly replaced the much bulkier and power-consuming vacuum tubes in radio and other electronic devices. Next, the invention of the semiconductor-based integrated circuit (IC) in 1958-59 and the microprocessor-type IC a few years later provided computers and electronic systems with tremendous computing power and storage capacity in increasingly mini-sized architectures.

Succeeding generations of EDT further advanced along the IC/microprocessor's many inherent advantages, e.g., smaller size, lighter weight, less power consumption, less failures, and of course the ability to execute vastly complex programs and to process immense volumes of data at lightning speeds.

Thence, EDT systems steadily replaced electro-mechanical and electronic-analog systems — at first in scientific, military and administrative fields, then in industries and services, including education and media, and eventually in households and personal devices. Thus we say that the 3rd IR began in the 1950s with EDT at the forefront.

The 3rd IR underwent three phases of EDT innovation.[10] In the first phase (1950s-60s), transistors and later ICs were used in telephone networks, radio communications, and military and civilian computers mostly for research, including defense and aerospace programs. EDT was barely used in industrial production, and digital consumer goods were almost unknown.

10. See Josef Taalbi, *Origins and Pathways of Innovation in the Third Industrial Revolution*, 2017.

In the second phase (1970s-80s), cheap miniaturized IC's with microprocessors at the core (by now popularly known as "chips") began to be mass-produced and sold commercially. These led to their wide use in computer numeric control (CNC) systems, which automated industrial machinery and telecommunications. IC chips also powered the rapid diversification of consumer electronics, from personal computers and peripherals, to game consoles and digital watches, to microwave ovens and vehicle dashboards.

In the third and current wave (1990s-2010s), computerization continued to permeate the majority of capitalist economies and a growing number of households. Alongside this is the rapid expansion and convergence of telecommunications, the Internet, and digital media. Telephone networks and consumer electronics are fast converting to digital, alongside the rapid spread of cell phones. These, in turn, reinforce the expanding mass production and distribution of information-based or information-rich commodities by online, software, and multimedia giants.

5. The Current Extent of EDT Use in Society

Semiconductor production and sales

The tremendous impact of EDT in today's world can be seen in the statistics of semiconductor chip production, sales, and usage. In terms of markets and usage, global IC-chip sales have steadily risen (in both volume and value) from 1987 to the present, despite three marked dips in 1996-98, 2001-02, and 2008-09.[11]

As of 2017, the biggest shares of the microprocessor market were for data processing needs (mostly computers) and communications needs (including mobile phones), with USD140 billion and USD115 billion in global revenue, respectively. The next largest markets were

11. Most of the statistics mentioned in this and the next paragraph are from Statista, the US Congressional Research Service, and US Dept. of Commerce, as cited by Brandon Gaille in https://brandongaille.com/25-microprocessor-industry-statistics-and-trends/ (posted June 18, 2018).

for industrial needs at USD45 billion, consumer electronics at USD43 billion, and automotive needs at USD 37 billion.

IC-chip production (which covers microprocessors, memory devices, logic devices, and analog devices) is spread around the world. A handful of firms, because of their high sales volume, operate their own fabrication facilities ("fabs"). Other chip firms are "fabless": they design and market chips, but contract out the actual chip production to "foundries" around the world, much of it in Asia.[12]

The semiconductor industry as a whole is tightly controlled by a small number of monopoly-capitalist firms based only in a few countries. Of the top 20 IC-chip firms, some 50% are located in the US. These include such powerhouses as Intel, Qualcomm, AMD, Texas Instruments, NVIDIA, Apple, and Sandisk. Other top firms are based in South Korea, Japan, Taiwan, and EU. (CRS 2016) The US remains the global leader in design work — the most critical first stage of IC production.[13] It also produces almost half of the world's semiconductor fabricating equipment, followed by Japan and the Netherlands.[14] While China does not yet have a global-top-20 semiconductor firm, it is fast catching up on other metrics.[15]

Industrial automation; robot production and deployment

Yet another measure of EDT's long-term impact on the economy is the dramatic growth of EDT-based automation in various production and service industries.[16] The capacity for advanced levels of automation, which combine various levels of mechanization and artificial

12. Although about 90% of fabrication work needed by the global semiconductor industry is based outside the US, in terms of control the US can still claim a 50% global market share in semiconductor production as of 2015. Korea is in 2nd place at 17%, Japan next at 11%, then EU at 9% and Taiwan at 6%.

13. http://www.semiconductors.org/clientuploads/Industry%20Statistics/White%20Pape%20Profile%20on%20the%20U.S.%20Semiconductor%20Design%20Industry%20-%20061016%20-%20Final.pdf

14. https://www.trade.gov/topmarkets/pdf/Semiconductors_Top_Markets_Report.pdf

15. https://qz.com/72542/china-just-surpassed-the-us-in-semiconductor-manufacturing-and-the-trend-is-likely-to-accelerate/; https://www.eetasia.com/news/article/8_on_Chinas_Semiconductor_Industry

16. Some authors differentiate between mechanization-type automation of physical tasks, such as materials-handling, and computerization-type automation of mental tasks, such as control of production procedures. For a finer distinction of the different levels and types of computer-based automation as applied to manufacturing, see Jörgen Frohm et al. 2008.

intelligence, is dramatically seen in the growing deployment of industrial robots.

The number of robots used in industrial production (both in factories and in warehouses) is rising. In the 2005-2008 period, the average number of robots sold was about 115,000 units per year. In the 2011-2016 period, the average annual figure rose to about 212,000 units, or 12% growth per year. In terms of industrial line, the main buyers and users of robots are the automotive, electrical and electronics, metal and machinery, rubber and plastics, and food and beverage industries. (IFR World Report 2017)

The world's total stock of operational industrial robots rose from 1.2 million in 2013 to 1.8 million in 2016. This represents an average increase of 10% per year since 2010; this is 10 times faster than the annual increase in the global human population. In terms of absolute number, as of 2014, Japan led the world with over 306,000 robots in use, compared to 237,000 in North America, 182,000 in China, and 175,000 in South Korea and Germany each.[17]

In terms of industrial robot density, Japan also led the world up to 2009. Up to now, Japan is the world's leader in robot development and production. As of 2016, however, the countries with the highest industrial robot density were South Korea (631 robots per 10,000 employees), Singapore (488 per 10,000), and Germany (309 per 10,000) — all three thus outranking Japan's 303 per 10,000. As global regions, however, Europe still has the highest industrial robot density (99 units per 10,000), followed by the Americas (84 units per) and Asia (63 units per).

In service industries, robot use for materials-handling is also increasing, on top of the already high levels of computerization of data processing and customer services in recent decades. The IFR notes that the sales of service robots, which reached a total of USD5.2 billion in 2017, are highest for medical, logistics, and field use, while sales of robots for personal and domestic tasks (e.g., house-keeping and

17. https://www.brookings.edu/blog/techtank/2016/06/02/how-technology-is-changing-manufacturing/

care-giver robots) are also fast rising.[18] Food businesses now increasingly use robots to deliver food. Wendy's (the US-based restaurant chain) has deployed self-service kiosks for customer ordering in its 6,000 restaurants. Amazon has around 15,000 robots working with its 50,000 human labor force. The number of driverless cars on the road are increasing.[19]

In recent years, robot production has increased while costs have gone down. Over the past 30 years, the average robot price has fallen by half in real terms. Cheaper robots are the result of faster and less costly methods of assembling, installing, and maintaining them. Robot assembly and maintenance are now easier with plug-and-play and self-diagnostic technologies.

Rapid advances in automation across many economic sectors are affecting, to a greater or lesser degree, the basic parameters of capitalist exploitation of labor through extraction of surplus value. These are posing new questions of political economy of capitalism and on the character and direction of the workers' movement. Economic, political and other social struggles will continue to intensify around such issues as wage scales, hours of work, occupational health and safety, employment and unemployment rights, migrant labor, social services, environment, and new forms of workers' organizations and collective bargaining. Marx's analyses of the inherent contradictions of capitalism within the whole economy and right inside the workplace remain valid in general, even as their application on the concrete situation of various economic sectors and different aspects of the toiling masses' daily lives will certainly require more extensive ground-level investigation.

The global reach of the Internet

By 1994, the Internet became truly global, producing new EDT-based corporate giants, fueling the dot-com bubble that burst in 2001, and giving rise to new conflicts. Young and old giants in media, telecom-

18. https://ifr.org/ifr-press-releases/news/why-service-robots-are-booming-worldwide
19. https://www.brookings.edu/blog/techtank/2016/06/02/how-technology-is-changing-manufacturing/

ms, and software continue to rule the field. They monopolize and maximize online opportunities for profit, for example, through social media, mobile platforms and apps, cloud computing, and e-commerce. At the same time, they are threatened by (or have to cope with) popular and free/cheap online services and small aggressive startups. The Internet has thus become a mirror and leveraging tool of social relations, competition and conflicts, in the real world.

As a third metric of EDT's social impacts, the increasingly global reach of the Internet is crucial in measuring how much of the globalized digital economy is directly affecting the world's population and reshaping (if at all) non-computerized economies and social relations. We especially focus on its effect among the workers, peasants, and other impoverished masses in the developing and least-developed countries that are most affected by the so-called digital divide.[20]

Of the world's total population of 7.6 billion (as of end-2017), nearly 4.2 billion are considered to have Internet access in at least one of various ways. This means a global 54.4% Internet penetration rate, with slightly higher rates for men compared to women. Of the youth population (15-24 years old) in 104 countries, some 830 million (around 80%) are online. Based on another dataset as of April 2018, globally there are nearly 4.1 billion active Internet users; 3.8 billion of these use mobile Internet access. Of all active Internet users worldwide, almost 3.3 billion are active social media users.[21]

The highest penetration rates are in North America (95.0%) and Europe (85.2%), representing 25.3% of all Internet users. Above-halfway rates are seen in Oceania/Australia (68.9%), Latin America/Caribbean (67.0%), and Middle East (64.5%). The penetration rate in Asia is nearly half (48.1%); at the same time, this represents nearly half (48.7%) of all Internet users worldwide. The Internet's penetration rate is lowest in Africa at 35.2 percent.[22]

20. The various statistics on Internet access in this section are from the ITU 2017 Measuring the Internet Society Report, as well as from the Internet World Stats 2018 updates (https://www.internetworldstats.com/stats.htm)

21. https://www.statista.com/statistics/617136/digital-population-worldwide/

22. https://www.internetworldstats.com/stats.htm

The key factor in expanding Internet access among the masses is the rapid expansion of mobile broadband (MBB) subscriptions, which have grown more than 20% annually in 2012-2017. This presumes rapid expansion of the market for affordable smartphones. The figure is expected to reach 4.3 billion globally by end-2017. In comparison, fixed broadband (FBB) subscription grew by 9% annually in the same period. MBB access is more affordable than FBB especially in developing countries, with steep price drops between 2013 and 2016. Even though least developed countries (LDCs) showed only a 23% of the population enjoying online access, they also registered the highest MBB subscription increases in the 2012-2017 period.

Despite great advances in basic Internet access for the masses, the more fundamental digital divide (not just online access, but effective control of access and content) remains a big issue between the advanced capitalist countries (especially the imperialist countries) and the rest of the world. This reflects monopoly capitalist control over what is emerging as a strategic global infrastructure for commodity distribution and exchange, as well as for free information and cultural exchange. Economic, political and other social struggles will continue to intensify around the key issue of privatized, commercialized, stratified, and unequal control over Internet access and content.

The so-called "Fourth Industrial Revolution"

The World Economic Forum and other capitalist think-tanks have recently announced the arrival of a "fourth industrial revolution" a.k.a. "Industry 4.0". As described thus far, the so-called "4th IR" is still part of the 3rd IR. It merely serves to complete the gaps and maximize capitalist gains in the still-evolving digital era.

The newest focus appears to be in the following technologies and their possible applications: Internet of Things (IoT); big-data analytics; artificial intelligence (AI); blockchain and crypto-currency; cloud computing; robotics; and virtual and augmented realities. The actual and imaginable applications of these new technologies are not just in the online world, but also in the real world, such as the growing use of drones and self-driving cars, ultra-realistic games and training en-

vironments, digital cash, and still cheaper and smarter phones in the hands of billions.

Whatever actual and potential advances might be achieved in these cutting-edge technologies should be monitored and estimated. Marxists can hone and use their tools of analysis to carefully project (or even guardedly speculate on) the interconnected social impacts of such new technologies. But those are no longer within this paper's scope.

6. Emerging Issues in the Digital-era Economy

In *Grundrisse* (1857-58) and *Capital* Vol. 1 (1867), Marx had already anticipated the fundamental impacts that increasingly automated machinery would create for labor in general. But neither he, Engels nor even Lenin could anticipate the magnitude and complexity of the technological advances and their social impacts that would occur a century later in the digital era.

Recent 20th-century and early 21st-century scholars and authors, both non-Marxist and Marxist, have offered their own analysis and synthesis of such advances and impacts. Many bourgeois and non-Marxist futurists, while critical of certain aspects of capitalism, generally welcome the 3rd Industrial Revolution as the starting point for a reformed capitalism — a post-industrial, gentler, greener, and thus more palatable version.[23] We will not critique these in this paper. There are, however, at least equally significant, theoretically more rigorous, and fast-growing Marxist or Marxian literature on this subject. These need to be critically studied and more widely discussed.

As early as the mid-1950s, Marxians such as Paul Sweezy and Harry Braverman were already noting the "scientific-industrial revolution" that was sweeping the US economy, with the computer and telecommunications at its very center. Sweezy predicted that these dramatic

23. These non-Marxist authors famously include E.F. Schumacher (*Small is Beautiful*), Alvin Toffler (*Future Shock*, *Third Wave*, *Powershift*); Jeremy Rifkin (works on the Third Industrial Revolution), and Daniel Bell and Alain Touraine. (works on so-called "post-industrial society").

advances would be as profound as the original Industrial Revolution, while Braverman prefigured some of its deeper impacts on the US labor force.[24]

The current generation of Marxists, though, still face great challenges in studying and synthesizing these trends more comprehensively and conclusively. The world is still probably in the early phases of the current Industrial Revolution. As Marxists ought to be most rigorous in seeking truth from facts and in combining theory and practice, we can only train our searchlights on the road and terrain up ahead, and only try to discern glimpses of future scenarios.

Overall social impacts of the Third Industrial Revolution

EDT has generated powerful factors for reshaping and advancing the forces of production under capitalism. Some impacts, especially in the advanced capitalist countries, are changing social relations and attitudes in obvious and not-so-obvious ways. As a whole, however, these changes merely represent new forms that prettify, new areas that replicate, and new methods that try to reinvigorate, the same old and exploitative capitalist ways of doing business. While this paper's limitations prevent a comprehensive and well-balanced listing and analysis of these impacts, we will at least highlight the main trends and share tentative Marxist views on the most important points.

At the basic enterprise level, EDT is speeding up, linking up, and finely coordinating so many types and stages of mass production through management software, computerized design tools, and still higher levels of mechanization through expanded deployment of intelligent machinery and industrial robots. At the industry level, EDT is enabling transnational corporate (TNC) giants to adopt just-in-time strategies, modularize their production, automate their cargo-handling facilities,

24. *Monopoly Capital* (Baran and Sweezy 1966) only marginally touched on the 3rd IR, but the authors had a draft chapter that discussed "the political economy of communication." Its finalization was overtaken by Baran's death in 1964. (Foster and Chesney 2015, 67-69) In the case of Braverman, his insightful 1955 article "Automation: Promise and Menace" foresaw important issues that Marxist political economy would grapple with in the next decades. His *Labor and Monopoly Capital* (1974) would explore these issues, especially the rise of the service sector and proletarianization of non-productive workers, more extensively.

maximize subcontractors, and manage their complex global value chains (GVCs) also known as global production networks (GPNs).

Beyond the mainline industries, EDT has also applied automation in capitalist agriculture, extractive industries, and construction. These are enabling TNC giants to further expand and intensify their global raw-materials extraction and mega-structure facilities on land, underground, and under the seas.

EDT is reshaping the whole services sector (apart from banking and finance — which were the first to go digital). These include transport and trade, as well as social services (e.g., education and health) and public works, which were supposed to be state responsibility but now increasingly privatized. Personal and domestic services, which in the time of Marx did not create surplus value ,[25] are now being incorporated piece by piece into very profitable capitalist operations with the aid of computerization and smart mechanization. The political economy behind e-commerce, online media, and other network-based services, with business models represented by the likes of Facebook and Google (in online media-ad platforms), Amazon and eBay (in retail buying and selling), Airbnb (in transient housing) and Uber (in taxi-like car transport), also deserve study.

EDT is speeding up great advances in science and technology — if not across-the-board, then at least in those areas with huge potentials for super-profit and other monopoly-capitalist advantages. Under capitalism, only the TNCs and imperialist states can harness enough funds to build and operate high-tech facilities for scientific research on anything beyond normal human-scale, i.e., from quantum-scale to cosmic-scale. Their advanced research programs always prioritize strategic industrial/financial and military/security applications. Thus, in monopoly-capitalist countries, the 3nd IR also enhances the military-industrial complex, the state's military, police, intelligence and

25. The reason for excluding personal and domestic services in the surplus-value creation chain during the time of Marx was because most servants back then were employed by rich families outside capitalist production. Nowadays, however, personal and domestic services are delivered more and more through capitalist businesses that provide temp labor and special facilities and equipment.

security capacities, and tighter economic control by the financial oligarchy.

We must continue to investigate and analyze the 3rd IR's tremendous impact on specific relations of production under capitalism. These include new forms of monopoly control beyond conventional ownership and control of TNCs, such as via GVCs, financial control, and intellectual property rights. We can also discern new forms of capitalist competition and new forms of profits and rents. A deeper understanding of GVC operations, and how they use EDT to leverage areas of cost reduction and profit maximization across the world, are particularly valuable for analyzing the political economy of neocolonial countries in their relation to imperialism.

The 3rd IR's impact on the globalized economy also includes new categories and new segments of the working class, even as Marx's fundamental characterization of the proletariat and its historic mission as the "gravedigger of capitalism" remains eminently valid. The relentless redivision of labor in the workplace beyond the blue-collar-white-collar dichotomy raises interesting issues about the changing structure and composition of the proletariat.[26]

We need to better understand the impact of the digital era on the changing conditions of social reproduction (reproduction of labor power) through households, domestic labor (or women's "unpaid labor"), and state/privatized social services. We need a deeper understanding of how service-type work is blending into all kinds of industries, generating factors for the expansion of the so-called "precariat" and "cybertariat" (including the phenomena of business-process outsourcing and independent online worker-contractors), increased global labor migration, women's roles in the labor force, and the implications for the working-class movement in the coming decades of the 21st century.[27]

26. There is, for example, an interesting discourse between Braverman (1974), who viewed scientific management of the workplace (aka intensified Taylorism or Fordism) and labor fragmentation and deskilling as the new realities of labor process in the late 20th century, and his critics who insisted that much of these "new phenomena" were already covered by Marx and that the revolutionary impulse for class unity and class struggle among the workers remain as valid as before.

27. I have clustered these related theoretical issues into separate headings in the list of references at the end of this paper. It would be good, for example, to critically study the works of Finn

Patterns of consumption are fast changing, especially in capitalist countries but also in urban areas of developing countries. This is spurred on by at least two related drivers. One is the immense diversity in the more conventional types of goods, due to the hyper-capacity especially of giant TNCs to produce and distribute across the globe, to localize and customize their products, and to embed the sales effort throughout the entire production process — from inception and design all the way to after-sales service. (As early as Grundrisse, Marx already provides glimpses of this inter-penetration of production and consumption via distribution and exchange.)

The other is the tremendous growth in services (such as telecomms, multimedia, trade and finance, transport and cargo handling) and goods that perform services (such as digital and online gadgets). This trend greatly telescopes the whole chain from production to distribution/exchange to consumption. Marxist political economy must analyze the phenomenon of shifting or blurring delineation between goods and services, which the OECD calls the "hybridisation of goods and services," and in particular the entire question of "information goods" (including the role of labor in their production, and the source and behavior of their value as commodities).[28]

All in all, the 3rd IR has further increased the social character of production under capitalism and the potential for humanity to meet all its basic needs in more sustainable ways. And yet, the other side of the coin, the private appropriation and monopolization of wealth, remains equally true. EDT reduces production costs to bare minimums, and achieves dramatic increases in volume, diversity, and (arguably) quality of goods and services. But EDT is unable to generate more jobs to compensate for the millions of workers that capitalism deskills and unemploys. Instead, EDT wielded by the bourgeoisie heightens the capitalist crisis of overproduction and worsens the impoverishment of the planet and its peoples.

Hanson (1979), Alena Heitlinger (1979), and Silvia Federici (2009) on social reproduction, women's rights, and state policies.

28. In 1999, I wrote an essay, "Towards a People's Alternative to 'Intellectual Property Rights'", which addressed important points on this issue using the framework of Marxist historical materialism and political economy. It was subsequently published serially in the *IBON Perspectives magazine* Vol. 1 (1999) Nos.18-20. A content outline of the essay is available at https://www.iraia.net/2017/11/07/alternative-ipr/ .

Thus, at a fundamental level, EDT intensifies the basic contradictions in capitalism by further revolutionizing the productive forces, increasing the social character of production, yet turning the capitalist relations of production even more exploitative and oppressive, with more and more victims and less and less beneficiaries.

Conclusion

Many bourgeois theorists and utopian-socialist or anarchist futurists welcome the digital era as the advent of "information society". They imagine a society where wealth is no longer exclusively found in land (as in feudal society) or in using the power of capital to extract value from labor and Mother Earth and flood the market with commodities (as in present-day capitalist society). Rather, they see the immense potentials of tapping into the endless wellsprings of knowledge to create wealth and share it with everyone.

Indeed, one obvious long-term impact of the 3rd IR is that it enables society to turn people's collective knowledge, mental labors, intricate skills, and intelligent creations into objectified form — as useful and palpable goods that can be mass-produced, yet with high fidelity if not near-perfect accuracy compared to the original. The most obvious examples are all kinds of firmware and software, scientific databases, and entire libraries and archives of digitized books, films, music and art. In the future, science and industry may mass-produce even more mind-boggling consumer and producer goods with built-in intelligence, and at minimal cost.

Under capitalism, however, such "objectified knowledge" are not free; most information goods are mass-produced by capitalists into profitable commodities. The authors or creators of the original content — as owners of "intellectual property," and often hand in hand with big business — typically get state protection and earn from royalties (a kind of rent) or from outright sale. On the other hand, producing digital copies of the original entails very minimal cost. This contradictory phenomenon under capitalism generates new issues that require analysis by Marxist political economy.

In a socialist society, the mass production of intellectual/information goods should be a welcome aspect of the collectively owned, planned and managed economy. Such goods will no longer be alienated from the proletariat and people as costly commodities or privately owned resources. Rather, they will be freely accessed and used to meet the proletarian and non-proletarian masses' growing material and cultural needs and to raise the conditions of life in society as a whole.

In further anticipation of what advanced EDTs may bring, bourgeois theorists and futurists claim that the most advanced capitalist societies are now entering (if they have not yet entered) a "post-industrial economy." At best, this is a very premature expectation. That more and more parts of the world have now entered the digital era is undeniable. But it has not enabled modern society to start phasing out industrial methods of production, much less enter a new "post-industrial" society where most material things we need are produced automatically by machines on demand.

If we consider just technological advances per se, the most definite long-term impact of EDT is that, for the first time in history, highly automated production creates the potential to provide all the basic goods and services needed to equitably sustain decent standards of living for all members of society, and likewise to incrementally respond to humanity's additional needs for higher (social and individual) development. All these are now technically possible to reach, requiring only a smaller fraction of labor and natural resources as compared to 100 years ago.

Hypothetically, the capitalist system may achieve more and more automation in the future. After all, it always strives for higher productive capacity through the introduction of improved automated machinery (all the way to AI-enabled robots). But its fundamental motive is always to pursue unhindered the circuit of capital, to produce "more and better" at less cost per unit, and thus to increase profits. The capitalist motive is not to make the workers' lives easier and their labors lighter, and certainly not to equalize the access of all members of society to the social wealth thus created.

Capitalist innovation may indeed bring some superficially positive results, such as a lighter workload and higher pay — in some industries, for some workers, some of the time. But the bigger, more prevalent, and more persistent result is the worsening fundamental problems of unemployment and crisis — as part of capitalism's laws of motion that Marx and Engels tirelessly investigated and explained in their time. After centuries of capitalism and 150 years since the *Communist Manifesto*, experience of the working class and people have repeatedly revalidated the Marxist critique of capitalism.

In a socialist society, such highly automated machines, processes and facilities should serve to greatly lighten the labors of the working class, both in the workplace and in the home, and allow more time and facilities to pursue their all-sided and long-term development as individuals, as collectives and communities, and as an entire civilization. In addition, such automation should also more effectively meet the growing material, cultural needs of the people — in terms of cheap and accessible goods and services for their daily use and also in terms of socially managed facilities for such all-sided development.

Robots and artificial intelligence are welcome additions to humanity's advance. But they will (and should) never replace human work and the human role in production, which are inherent to our humanity. Technology and human wants are neither perfect nor static. Human intervention will still be needed to fill in unavoidable gaps and to correct unexpected errors or breakdowns in automation. Also, environmental and social changes will eventually entail new products and processes, and vice versa.

Even with a comprehensively planned and balanced socialist economy, production cannot always respond automatically and perfectly to these old gaps and new demands. There will be unevenness and imperfections in the capacity of machines to supplement and complement — not to mention replace — human physical capacities, intelligence and other faculties, which after all will continue to co-evolve with technology and environment.

The living tools of Marxist theory are robust and resilient enough for us to better analyze these new trends in order to enrich and deepen our understanding of the fast-changing landscape of 21st century technologies, whether under capitalism, or as part of more advanced forces of production with which to build socialism. A truly "post-industrial era" is foreseeable only after capitalism is overthrown and replaced by a socialist society that continues to move forward into a bright communist future. #

EPILOGUE NOTE

Readers will note that this paper avoided any mention of how the various trends of the digital era apply to the Philippines; it dwelt on implications for the Third World or developing countries only at very specific points. This is intended, because we want to first establish the validity of these conclusion for the global capitalist system as a whole, before we address the unevenness — which is always present in the imperialist era, as Lenin observed.

APPENDICES

1. Karl Marx on forces and relations of production

> In the social production of their existence, men inevitably enter into definite relations, which are independent of their will, namely relations of production appropriate to a given stage in the development of their material forces of production. The totality of these relations of production constitutes the economic structure of society, the real foundation, on which arises a legal and political superstructure and to which correspond definite forms of social consciousness. The mode of production of material life conditions the general process of social, political and intellectual life. It is not the consciousness of men

> that determines their existence, but their social existence that determines their consciousness. At a certain stage of development, the material productive forces of society come into conflict with the existing relations of production or – this merely expresses the same thing in legal terms – with the property relations within the framework of which they have operated hitherto. From forms of development of the productive forces these relations turn into their fetters. Then begins an era of social revolution. The changes in the economic foundation lead sooner or later to the transformation of the whole immense superstructure.(Karl Marx, *A Contribution to the Critique of Political Economy*)

2. On new commodities in the digital economy

Ursula Huws has written two successive books on what she calls the "cybertariat".[29] In "iCapitalism and the Cybertariat: Contradictions of the Digital Economy" (2015), she says: "We have now entered a period … when new waves of commodification set in motion in earlier periods are reaching maturity. The new commodities have been generated by drawing into the market even more aspects of life that were previously outside the money economy, or at least that part of it that generates a profit for capitalists. Several such fields of accumulation have now emerged, each with a different method of commodity genesis, forming the basis of new economic sectors and exerting distinctive impacts on daily life, including labor and consumption. They include biology, art and culture, public services, and sociality."

29. *The Making of a Cybertariat: Virtual Work in a Real World* (2003) and *Labor in the Digital Economy: The Cybertariat Comes of Age* (2014).

REFERENCES

GENERAL MARXIST CRITIQUE OF CAPITALISM AND IMPERIALISM

Eaton, John. 1963. *Political Economy*. New York: International Publishers.

Dickhut, Willi. 1986. *Crises and Class Struggle*. Essen: Neuer Weg Verlag und Druck GmbH.

Lenin, V.I. 1917 (1963). *Imperialism, the Highest Stage of Capitalism*. In Collected Works Vol.1. Moscow: Progress Publishers.

Marx, Karl. 1857-58. *Foundations (Grundrisse) of the Critique of Political Economy*. Abridged text from *The Marx-Engels Reader*, 2nd ed. (1978), Robert C. Tucker (ed.)

Marx, Karl. 1863-68. *Capital*. Vols. I-III. Moscow: Progress Publishers.

Marx, Karl. 1861-63. Capital. Vol IV (*Economic Manuscripts: Theories of Surplus Value*). Moscow: Progress Publishers. https://www.marxists.org/archive/marx/works/1863/theories-surplus-value/index.htm.

Sison, Jose Ma. 2009-2015. *Peoples' Struggles against Oppression and Exploitation*. Vols. 1-4. The Netherlands: International Network for Philippine Studies.

MARXIST STUDIES ON SERVICES, INFORMATION, COMMUNICATION, LABOR ISSUES AND SOCIAL REPRODUCTION

Antunes, Ricardo. 2018. "The New Service Proletariat." *Monthly Review* 69, no. 11 (Apr). https://monthlyreview.org/2018/04/01/the-new-service-proletariat/

Auerbach, Daniel, and Brett Clark. 2016. "The Internet and Monopoly Capitalism." Review of Robert W. McChesney, *Digital Disconnect: How Capitalism Is Turning the Internet against Democracy* (New York: New Press, 2013). Monthly Review 68, no. 5 (Oct). https://monthlyreview.org/2016/10/01/the-internet-and-monopoly-capitalism/

Bhattacharya, Tithi. 2013. "What is social reproduction theory?" *Socialist Worker* website. https://socialistworker.org/2013/09/10/what-is-social-reproduction-theory

Booth, Adam. 2013. "Technology, innovation, growth, and capitalism." *In Defense of Marxism* website. (4 September) http://www.marxist.com/technology-innovation-growtn-and-capitalism.htm

Braverman, Harry. 1955. "Automation: Promise and Menace." *American Socialist* (Oct). https://www.marxists.org/archive/braverman/1955/10/automation.htm

_____. 1974, 1998 (25th Anniversary ed.). *Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century*. https://caringlabor.files.wordpress.com/2010/11/8755-labor_and_monopoly_capitalism.pdf

Clelland, Donald. 2014. "The Core of the Apple: Degrees of Monopoly and Dark Value in Global Commodity Chains." *American Sociological Association* 20, no. 1, 82-111. https://www.researchgate.net/publication/282526339_The_Core_of_the_Apple_Degrees_of_Monopoly_and_Dark_Value_in_Global_Commodity_Chains

Federici, Silvia. 2009. "The reproduction of labour-power in the global economy, Marxist theory and the unfinished feminist revolution." Reading for Jan. 27, 2009 UC Santa Cruz seminar "The Crisis of Social Reproduction and Feminist Struggle." https://caringlabor.wordpress.com/2010/10/25/silvia-federici-the-reproduction-of-labour-power-in-the-global-economy-marxist-theory-and-the-unfinished-feminist-revolution/

Foster, John Bellamy, and R. Jamil Jonna. 2014. "Beyond the Degradation of Labor: Braverman and the Structure of the U.S. Working Class." *Monthly Review* 66, no. 5 (Oct) https://monthlyreview.org/2014/10/01/beyond-the-degradation-of-labor/

Foster, John Bellamy, and Robert W. McChesney. 2015. "The Cultural Apparatus of Monopoly Capital: an Introduction." In *Media and Left*, edited by Savaş Çoban, 67-69.

Fuchs, Christian. N.d. "The Digital Labour Theory of Value and Karl Marx in the Age of Facebook, YouTube, Twitter, and Weibo." http://fuchs.uti.at/wp-content/uploads/CF_value.pdf

_____. 2016. "Digital Labor and Imperialism". *Monthly Review* 67, no. 8 (Jan). https://monthlyreview.org/2016/01/01/digital-labor-and-imperialism/

_____. 2018. "Karl Marx & Communication @ 200: Towards a Marxian Theory of Communication." https://www.triple-c.at/index.php/tripleC/article/view/987

Gough, Ian. 1972. "Marx's Theory of Productive and Unproductive Labour." *New Left Review* I/76, (November-December), 47-72. https://newleftreview.org/I/76/ian-gough-marx-s-theory-of-productive-and-unproductive-labour; http://eprints.lse.ac.uk/51144/

Hansson, Finn. 1979. "Welfare State and Reproduction of Labour Power: Notes on the Effect of State Policy on the Structure of Reproduction." *Acta Sociologica* 22, no. 2, 175-185. University of Copenhagen. Sage Publications, Ltd. https://www.jstor.org/stable/4194290

Heitlinger, Alena. 1979. "Marxist Theory of Domestic Labour and Reproduction of Labour Power," Ch. 4. In *Women and State Socialism: Sex Inequality in the Soviet Union and Czechoslovakia*. Montreal: McGill-Queens University Press. https://link.springer.com/chapter/10.1007/978-1-349-04567-9_4

Hughes, Bob. N.d. "From Useful Idiocy to Activism: a Marxist interpretation of computer development." Dept. of Electronic Media, Oxford Brookes University. http://dustormagic.net/Documents/BobHughesIdiocyFinal.pdf

http://www.marxist.com/technology-innovation-growtn-and-capitalism.htm-Huws, Ursula. 2015. “iCapitalism and the Cybertariat: Contradictions of the Digital Economy.” *Monthly Review* 66, no. 8 (Jan). https://monthlyreview.org/2015/01/01/icapitalism-and-the-cybertariat/

Levins, Richard. 2016. “A New Economy of Knowledge.” Review of Agustín Lage, *La economía del conocimiento y el socialismo*, a collection of articles mostly published in *Cuba Socialista*. Monthly Review 67, no. 11 (Apr). https://monthlyreview.org/2016/04/01/a-new-economy-of-knowledge/

LRNA. N.d. “Revolution in the Means of Production.” League of Revolutionaries for a New America. http://www.lrna.org/2-pt/555/v18ed2art4.html

McChesney, Robert. 2008. *The Political Economy of Media: Enduring Issues, Emerging Dilemmas*. New York. Monthly Review Press.

Munir, Kamal et al. 2017. “The role of intermediaries in governance of global production networks: Restructuring work relations in Pakistan's apparel industry.” *Human Relations* (August). DOI: 10.1177/0018726717722395 https://www.researchgate.net/publication/319037833_The_role_of_intermediaries_in_governance_of_global_production_networks_Restructuring_work_relations_in_Pakistan's_apparel_industry

Rigi, Jakob. N.d. “Foundations of a Marxist Theory of the Political Economy of Information: Trade Secrets and Intellectual Property, and the Production of Relative Surplus Value and the Extraction of Rent-Tribute.” Central European University, Budapest, Hungary. https://www.triple-c.at/index.php/triplec/article/view/487/667

Sartelli, Eduardo,and Marina Kabat. 2014. “Where did Braverman go wrong? A Marxist response to the politicist critiques.” Paper 5, Cad. EBAPE.BR 12, no. 4 (Oct-Dec). Rio de Janeiro. DOI: http://dx.doi.org/10.1590/1679-395115865; http://www.scielo.br/pdf/cebape/v12n4/1679-3951-cebape-12-04-00829.pdf

=Starosta, Guido. 2010. “Global Commodity Chains and the Marxian Law of Value. National University of Quilmes.” *Antipode* 42(2):433-465 (February). DOI: 10.1111/j.1467-8330.2009.00753. https://www.researchgate.net/publication/229468872_Global_Commodity_Chains_and_the_Marxian_Law_of_Value

Swidler, Eva. 2018. “Invisible Exploitation: How Capital Extracts Value Beyond Wage Labor.” *Monthly Review* 69, no.10 (March). https://monthlyreview.org/2018/03/01/invisible-exploitation/

Tregenna, Fiona. 2009. “‘Services’ in Marxian Economic Thought.” Cambridge Working Papers in Economics 0935, Faculty of Economics, University of Cambridge. https://www.repository.cam.ac.uk/bitstream/id/534127/0935.pdf/

ON THE FIRST AND SECOND INDUSTRIAL REVOLUTIONS; ECONOMIC HISTORY OF CAPITALISM

Heller, Henry. 2011. "The Industrial Revolution: Marxist Perspectives" (Ch. 6), in *The Birth of Capitalism: A 21st Century Perspective*. Pluto Press. http://www.jstor.org/stable/j.ctt183p671.10

Hobsbawm, Eric. 1999. *Industry and Empire: From 1750 to the Present Day*, revised ed. New Press.

_____. 1994. *The Age of Extremes: The Short 20th Century, 1914-1991*. London: Michael Joseph. https://libcom.org/files/Eric%20Hobsbawm%20-%20Age%20Of%20Extremes%20-%201914-1991.pdf

Maddison, Angus. 1991. "Business Cycles, Long Waves and Capitalist Development." Abbreviated version of Chapter 4 of A. Maddison, *Dynamic Forces in Capitalist Development*, Oxford University Press, 1991. http://www.ggdc.net/maddison/ARTICLES/Business_Cycles.pdf

Mandel, Ernest. 1995. *Long Waves of Capitalist Development: A Marxist Interpretation* (revised ed). London, New York: Verso. https://libcom.org/files/ernest-mandel-long-waves-of-capitalist-development-a-marxist-interpretation.pdf

ON THE THIRD AND FOURTH INDUSTRIAL REVOLUTIONS, DIGITAL DIVIDE

Craven, Patrick. 2017. "The 'Fourth Industrial Revolution' – or Socialist Revolution?" *Daily Maverick*. https://www.dailymaverick.co.za/opinionista/2017-01-05-the-fourth-industrial-revolution-or-socialist-revolution/#.WxVDUitGjDc

Internet Society. 2017. *Paths to Our Digital Future: 2017 Internet Society Global Report*. https://future.internetsociety.org/wp-content/uploads/2017/09/2017-Internet-Society-Global-Internet-Report-Paths-to-Our-Digital-Future.pdf

ITU. 2017a. "ITU releases 2017 global information and communication technology facts and figures." (July 31) http://news.itu.int/itu-releases-2017-global-information-and-communication-technology-facts-and-figures/

ITU. 2017b. *Measuring the Information Society Report*, Volume 1. https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume1.pdf

McAllum, Michael. 2016. "Making Sense of Rifkin's Third Industrial Revolution: Towards a Collaborative Age." Ph.D. Thesis, University of Wellington (New Zealand). http://research.usc.edu.au/vital/access/services/Download/usc:20301/SOURCE1?view=true

Morgan, Jacob. 2016. "What is the Fourth Industrial Revolution?" Posted on the *Forbes* website (Feb 19). https://www.forbes.com/sites/jacobmorgan/2016/02/19/what-is-the-4th-industrial-revolution/#398238d5f392

OECD. 2017. *OECD Digital Economy Outlook 2017*. Paris: OECD Publishing. http://dx.doi.org/10.1787/9789264276284-en , http://espas.eu/orbis/sites/default/files/generated/document/en/9317011e.pdf

Rifkin, Jeremy. 2011. "The Third Industrial Revolution: How Lateral Power is Transforming Energy, the Economy, and the World." *Huffington Post*. https://www.huffingtonpost.com/jeremy-rifkin/the-third-industrial-revo_b_981168.html

Schwab, Klaus. 2016. "The Fourth Industrial Revolution: what it means, how to respond." *World Economic Forum* website (Jan 14). https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

Taalbi, Josef. 2017. "Origins and Pathways of Innovation in the Third Industrial Revolution: Sweden, 1950-2013." *Lund Papers in Economic History*; No. 159. Lund: Department of Economic History, Lund University. http://portal.research.lu.se/portal/files/24520394/LUP_159.pdf

Toffler, Alvin. 1971. *Future Shock*. London: Pan Books Ltd.

_____. 1980. *The Third Wave*. New York: Bantam Books.

_____. 1990. *Power Shift*. New York: Bantam Books.

VINT. 2013. "THINGS—Internet of Business Opportunities." https://www.fr.sogeti.com/globalassets/global/downloads/reports/vint-research-1-things-internet-of-business-opportunities.pdf

VINT. 2014. "The Fourth Industrial Revolution: Things to Tighten the Link Between IT and OT." https://www.fr.sogeti.com/globalassets/global/downloads/reports/vint-research-3-the-fourth-industrial-revolution

ON THE COMPUTER INDUSTRY, INDUSTRIAL AUTOMATION, ROBOTS

(US) Congressional Research Service. 2016. *U.S. Semiconductor Manufacturing: Industry Trends, Global Competition, Federal Policy*. https://fas.org/sgp/crs/misc/R44544.pdf

Cortada, James. 2004. *The Digital Hand: How Computers Changed the Work of American Manufacturing, Transportation, and Retail Industries*. Oxford University Press. https://books.google.com.ph/books?id=0TSeKikU_S0C&printsec=frontcover#v=onepage&q&f=false

Frohm, Jörgen et al. 2008. "Levels of Automation in Manufacturing." *Ergonomia (International Journal of Ergonomics and Human Factors)* 30, no. 3. http://publications.lib.chalmers.se/records/fulltext/76667/local_76667.pdf

IFR. 2017. Executive Summary World Robotics 2017 Industrial Robots. https://ifr.org/downloads/press/Executive_Summary_WR_2017_Industrial_Robots.pdf

Stephens, Rachael. 2015. "Robots at work: The economic effects of workplace automation." *Journalist Resource* website, accessed Jun 11, 2018. https://journalistsresource.org/studies/economics/jobs/robots-at-work-the-economics-effects-of-workplace-automation

Tilley, Jonathan. 2017. "Automation, robotics, and the factory of the future." McKinsey website. Posted Sep 2017, accessed Jun 10, 2018. https://www.mckinsey.com/business-functions/operations/our-insights/automation-robotics-and-the-factory-of-the-future

Thompson, Derek. 2015. "A World Without Work." *The Atlantic*. July/August issue. https://www.theatlantic.com/magazine/archive/2015/07/world-without-work/395294/