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Smart Devices and the Capitalistic Subsumption of Knowledge: A New Function of Technology

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Abstract: *Marx claimed that the primary function of technology in a capitalistic context is that of increasing the relative surplus value and, therefore, the rate of exploitation of the labour force. However, both in the Capital and in the Grundrisse he identifies a second, derived function: that of subsumption of knowledge to the capitalistic needs. Our thesis is that, even if smart technologies keep these two fundamental functions, they have brought to light a third function: a new form of subsumption of knowledge. We will see how the latter concerns not only the production process but also our daily life, and how it is based on data, the "raw material" of knowledge. Furthermore, we will argue that this new function of technology does not result from a degeneration of capitalism, but from its essential laws of motion: the need for this new form of knowledge subsumption has been always hidden in the structural uncertainty of the process of accumulation, which has never been peacefully accepted by the capitalists. Today, the latter have the instruments to partially reduce this uncertainty, and the anguish resulting from it.*

Keywords: Marxism; the function of technology; smart technologies; capitalism; big data; subsumption of knowledge.

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Introduction

According to the International Data Corporation (IDC), the total amount of data created, captured, copied, and consumed is constantly increasing. If in 2018 global data creation reached 33 zettabytes, over the next five years up to 2025, it is projected to grow to 175 zettabytes.[1] Along with that, also the market of the Internet of Things (IoT) is getting bigger and bigger: the same forecast of the IDC estimates that, in 2025, there will be 41.6 billion connected devices, generating 79.4 zettabytes of data.

At first glance, this huge increase in the amount of generated data is surprising. However, this is no longer the case if we frame it in the capitalism's more general interest in knowledge – of which data are, we will see, the "raw material" –, which has been evident since its birth: during the 18th century, for instance, Johann Beckmann tried to codify the artisanal "know how" to improve the German productive system, and in the following century, with the First Industrial Revolution, the developments in science and technology has begun to play a crucial role in maximising profit.

In this regard, Marx also found a strict relationship between the capitalistic use of technology and its ability to exploit knowledge, showing how machinery represented an attempt to "absorb" different forms of knowledge and to use them for the exploitation of the labour force.

In this article, starting mainly from a Marxist perspective and with the help of some contemporary critical authors, we will try to make an original contribution to the analysis of the ever closer relation between technology and knowledge exploitation occurred after the digital and the Internet revolutions, by setting three main objectives:

1) Highlighting the importance of a "secondary" function of technology, that we will call "capitalistic subsumption of knowledge", in addition – but at the same time closely connected – to that of the increasing of surplus value.

[1] David Reinsel, John Gantz and John Rynding, *The Digitization of the World: From the Edge to the Core*(Needham, MA: IDC, 2018), https://www.seagate.com/files/www-content/our-story/trends/files/idc-seagate dataage-whitepaper.pdf.

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2) Showing how, with smart devices, a new form of subsumption of knowledge based on its "raw materials" (data) has emerged.

3) Showing that this new function of technology is becoming ever more relevant in capitalism.

Before starting with our work, and trying to achieve these objectives, some methodological premises are required. Firstly, this paper will not have the presumption of exposing a comprehensive theory of this new form of knowledge subsumption: future research will therefore be needed to answer the questions left open and to draw all its consequences. This work, instead, will only try to propose a new point of view on the relation between new technologies and society and the phenomenon of surveillance.

Moreover, our study will not be focused on single, national "capitalisms" – in each of which the process of knowledge subsumption assumes specific forms according to their different features –, but on the increasing interest of capital "in general" in big data. For this reason, we will only analyse the economic aspect of data subsumption, without considering the specific role and the interests of the different states (liberal, authoritarian, etc.) in this process, and their ever deeper connection with the economic sphere: these issues will have to be addressed, as we will underline in the conclusions, in future works.

"Knowledge Subsumption to Capital" as a Structural Function of Technology

Marx has been very interested in technology throughout his life, and his knowledge on this topic derived from a systematic and constant study.[2] In the latter, the debate that occurred between the end of the 18th and the beginning of the 19th century played an important part. During that period a group of intellectuals led by Beckmann tried to establish a new science called "*Technologie*"[3], conceived as a

[2] Andrea Cengia, "Per una teoria della tecnologia: Raniero Panzieri e l'analisi marxiana dei processi produttivi" (PhD diss., Università degli Studi di Padova, 2019), 2.
[3] Guido Frison, "Technical and technological innovation in Marx", *History of Economic Ideas* 1, no. 6 (1998): 303, https://doi.org/10.1080/07341518908581755.

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knowledge of the artisanal work, the workshops, and the manufactures. More specifically, they wanted to analyse the production process and separate the artisanal know-how from the immediate manual activity.[4] Even if Beckmann's project failed, it highlighted for the first time the strategies used by capital to appropriate knowledge, in this case by means of its "codification".

Marx was perfectly conscious of Beckmann's theories,[5] and, more generally, of the connection between modern technology and knowledge expropriation, as demonstrated by its use of the notion of "general intellect".[6] This concept, although it appears only once in his texts and that has probably been taken by the William Thompson's masterpiece *An Inquiry Into the Principles of the Distribution of Wealth*,[7] more specifically in the so-called "*Fragment on machines"*, has become central for some important heterodox Marxist approaches. The *Fragment* – which, in fact, is not literally a "fragment", but a part of the *Grundrisse* – has been published for the first time in Italy in 1964 in Renato Solmi's *Quaderni Rossi* and it had been enthusiastically received by some Italian thinkers (the so called "workerists"), who proposed a new, non-dogmatic, reading of Marx.[8]

Renato Panzieri tracked the basic coordinates for this new reading, while Mario Tronti and Toni Negri, precisely on the basis of the *Fragment*, went further opposing the Marx of the *Grundrisse* to that of the *Capital*.[9] In this framework, and that of the rise of the Italian students' movement "La Pantera" in 1990, Paolo Virno provided a new interpretation of the notion of general intellect, putting it at the core of his analysis of post-Fordism.[10] As underlined by Spence, his reading of this concept, developed by

[4] *Ibid*., 304.
[5] *Ibid.*
[6] Karl Marx, *Grundrisse: Foundations of the Critiqueof Political Economy (Rough Draft)* trans. Martin Nicolaus (London, UK: Penguin Books/New Left Review, 1973), 706.
[7] Matteo Pasquinelli, "On the origins of Marx's general intellect", *Radical Philosophy* 206 (2019).
[8] Massimiliano Tomba and Riccardo Bellofiore, "The 'Fragment on Machines' and the *Grundrisse*: the Workerist Reading in Question," in *Beyond Marx: Theorising the Global Labour Relations of the Twenty-First Century,* eds. Marcel van der Linden and Karl Heinz Roth, (Leiden: Brill, 2014), 346.
[9] *Ibid*., 347.

[10] Paolo Virno, "Citazioni di fronte al pericolo," *Luogo Comune* 1 (1990), 9-13.

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other exponents of the so called "post" or "neo" workerism such as Carlo Vercellone, is based on two main points:[11]

1) The general intellect is something new, or at least the result of a specific stage of capitalistic development, and not a metahistorical element.
2) It is as such a powerful and transformative force of production.

To go beyond these theses, Spence underlines that the central focus of the *Fragment* is not the general intellect, but the fixed capital.[12] We can realise this only if we do not isolate the *Fragment* from the theoretical framework of the *Grundrisse*: in these pages Marx is explaining how, during the First Industrial Revolution, both scientific and the workers' tacit knowledge[13]– in other words, the general intellect – have been "absorbed" into the machinery introduced in the production process and, in doing so, exploited by capital.

Contrary from what emerges from the readings of Virno and Vercellone – whose basic points are shared by many other post-workerists –, Spence underlines that the general intellect already existed before the Industrial Revolution and even before capitalism: exactly like the "social brain"[14], the general intellect as such is meta-historical in its form and historical in its contents. In other terms, this "collective" and "social" intelligence was already functioning and generating interpretations of natural phenomena, tacit knowledge, etc., for instance, in the Middle Age. However, it was not systematically applied by the ruling class of that time in the production of goods, it was not separated from the labour activity and, obviously, it was made up of different methods of analysis, concepts, theories, etc.[15] Capitalists too has become capable of exploiting the general intellect only after the introduction of machinery and technology in the production process, which "absorbed" and "objectified" the general

[11] Martin Spence, "Marx against Marx: A Critical Reading of the *Fragment on Machines*," *TripleC*: *Communication, Capitalism and Critique* 17, no 2 (2019): 331, https://doi.org/10.31269/triplec.v17i2.1146.
[12] *Ibid*., 330.
[13] Michael Polanyi, *The Tacit Dimension* (New York: Anchor Books, 1977).
[14] Karl Marx, *Grundrisse: Foundations of the Critiqueof Political Economy (Rough Draft)*, trans. Martin Nicolaus (London, UK: Penguin Books/New Left Review, 1973), 694.
[15] Karl Marx, *Capitale e tecnologia: Manoscritti (1861-1863)*, ed. Piero Bolchini (Rome: Editori Riuniti, 1980), 100.

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intellect, putting it at the service of the law of accumulation in the form of a "direct force of production".[16]

Similar arguments, based on a collective conception of knowledge generation, transmission and storage, can be found also in the *Capital*. For instance, Marx claims there that "a critical history of technology would show how little any of the inventions of the eighteenth century are the work of a single individual",[17] and that in the great industry "science is incorporated in it [the machine] as a nindependent power".[18] Moreover, he writes that "once discovered, the law of the deflection of a magnetic needle in the field of an electric current, or the law of the magnetization of iron by electricity, cost absolutely nothing. But the exploitation of these laws for the purposes of telegraphy, etc., necessitates costly and extensive apparatus".[19] It is in this sense that he writes that:

> "Science, generally speaking, costs the capitalist nothing, a fact that by no means 'prevents him from exploiting it. 'Alien' science is incorporated by capital just as 'alien' labour is. But 'capitalist ' appropriation and 'personal' appropriation, whether of science or of material wealth, are totally different things. Dr. Ure himself deplores the gross ignorance of mechanical science which exists among his beloved machinery-exploiting manufacturers, and Liebig can tell us about the astounding ignorance of chemistry displayed by English chemical manufacturers."[20]

Therefore, a process of what we will henceforth call "knowledge subsumption" emerges in some of the main Marxian texts as a structural function of technology in the bourgeois society. With this notion, that we have partially taken from the Marxian vocabulary,[21] we refer to the process through which knowledge is controlled, appropriated – in the sense previously described by Marx – and exploited by capital and put at the service of its laws. This function keeps a close relation with the

[16] Karl Marx, *Grundrisse*, 706.
[17] Karl Marx, *Capital: A Critique of Political Economy* trans. Ben Fowkes, vol. 1, 1867 (London, UK: Penguin Books/New Left Review, 1990), 493, note 4.
[18] *Ibid*., 799.
[19] *Ibid.,* 508-9.
[20] Marx, *Capital*, 1:508, note 23.
[21] *Ibid.,* 643*;* Karl Marx, "The Results of the Immediate Process of Production," in *Capital, A Critique of The Political Economy* (London, UK: Penguin Books/New Left Review, 1992), 1919-38.

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"classical" – and more explicit – one of increasing the relative surplus value:[22] it is only by means of its subsumption to capital through technology that the general intellect becomes useful for increasing the relative surplus value, and it is precisely for its need of maximising profit that capital is interested in subsuming knowledge. Since two functions of technology can only be kept separate analytically, whereas, in reality, they are inextricably intertwined, we will call the function of subsumption of knowledge "secondary" to underline its connection to that of increasing the relative surplus value and the general theoretical "priority" of the latter.

To sum up, in this chapter we have described technology as the main instrument for the capitalistic appropriation and exploitation of the general intellect – which we have shown to be meta-historical – and the body of knowledge it produces socially – which is, on the contrary, constantly changing –. In the next chapters we will try to argue that this close connection between "knowledge subsumption" and technology has become more relevant today, and how, in parallel with this "secondary" function that we have underlined, a new form of "knowledge subsumption" has emerged with the rise of new technologies.

The Commodification of Big Data

The era of big data has started at the beginning of the 21st century, bringing with it important changes in capitalism. According to the McKinsey Global Institute, we can talk of big data when the volume of data is such that it can no longer be registered, transmitted, and processed by means of traditional systems.[23] They are usually described with the so called "five V model", which identifies some of their key and innovative properties:[24]

[22] Marx, *Capital,* 1:429-672.
[23] Alberto Di Meglio and Anna Ferrari, *Big Data* (Rome: Treccani, 2021), chap. 1, Kindle.
[24] Andrea Fumagalli, "Per una teoria del valore-rete. Big data e processi di sussunzione," in *Datacrazia: Politica, cultura algoritmica e conflitti al tempo dei big data*, ed. Daniele Gambetta (Ladispoli: D Editore, 2018), 52-5.

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1) Volume, since the amount of collected data is hundreds of thousands of times greater than what existed in the past.
2) Velocity, since new technologies can analyse this huge amount of data much faster than in the past.
3) Variety, with which we can identify the different types of big data, metadata, and the source from which they came.
4) Veracity, which indicates the rate of accuracy and truthfulness of big data collected.
5) Value, which refers to their utility and their exchange value.

Furthermore, big data may appear structured or unstructured. Structured data are organized in a predefined scheme, as those ordered in a table; unstructured ones, instead, do not have a rigid logic structure, like those contained in texts, images, sounds, etc.[25] The latter represent around 80% of total big data collected using platforms.[26]

As Durand argues, big data are also characterised by three main features: they are continually generated, aim for high granularity and completeness, and are produced in a flexible way to be integrated with complementary sources.[27] For instance, Oracle relies on 80 "brokers" that provide the tech giant with the supplementary data required to improve the information extracted.[28]

Nonetheless, the management of this data could not be possible without a physical and digital infrastructure and a highly distributed system of data analysis, in which the figure of the "data scientist" is ever more central. He is a recent professional figure who filters big data, evaluating its veracity and relevance for subsequent analysis.[29]

Finally, concerning the usage and the analysis process of big data, a crucial role is played by the so-called "data mining", which makes it possible to find hidden patterns, correlations, or similarities and to extract useful information from a huge amount of data. In this process, techniques

[25] Di Meglio and Ferrari, *Big Data*, chap. 2.
[26] Fumagalli, "Teoria valore-rete", 58.
[27] Cédric Durand, *Techno-féodalisme: Critique De L'économie Numérique* (Paris: Zones, 2020), 76, PDF e book.
[28] *Ibid.*, 82.
[29] Di Meglio and Ferrari, *Big Data*, chap. 6.

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based on algorithms are often used, since they can generate models capable of making good predictions by means of direct or indirect correlations among data.[30]

The current relevance of big data in our society could not be understood without considering the massive commodification they have undergone in the last decades. As argued by Lukács, "for at this stage in the history of mankind there is no problem that does not ultimately lead back that question [that of the nature of commodity] and there is no solution that could not be found in the solution to the riddle of commodity-structure",[31] and this is also the case.

One of the first step that paved the way to the current massive process of commodification of big data – along with the "War on terror"[32]– has been the burst of the dot-com bubble, that has prompted the capitalists to find a new, profitable business model in the Internet sector.[33] This model was originally based on the systematic collection of a great amount of data on the general behaviour of individuals, in order to generate an adequate UPI (user profile information):[34] the unstructured big data collected by means of platforms were analysed and processed through artificial intelligence and then transformed into highly precise information about the user single user. This process guaranteed profits since data were directly used by the owner of the platform (for example Google) to provide targeted marketing services to other capitalists, and to predict with an unprecedent precision the interests and the behaviour of each single user.[35]

However, as underlined by Zuboff:

"Although advertisers were the dominant players in the early history of this new kind of

[30] *Ibid.*, chap. 3.
[31] Gyorgy Lukács, *History and Class Consciousness: Studies in Dialectics*, trans. Rodney Livingstone (Cambridge, MA: MIT Press, 1971), 83.
[32] Shoshana Zuboff, *The Age of Surveillance Capitalism:The Fight for a Human Future at the New Frontier of Power* (New York: PublicAffairs, 2019), chap. 4, EPUB
[33] Christian Fuchs and Marisol Sandoval, "Critique, Social Media and the Information Society in the Age of Capitalist Crisis," in *Critique, Social Media and the Information Society*, ed. Christian Fuchs and Marisol Sandoval (New York: Routledge, 2004), 32.
[34] Zuboff, *Surveillance Capitalism*, chap. 3.
[35] *Ibid.*

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> marketplace, there is no reason why such markets are limited to this group. The new prediction systems are only incidentally about ads, in the same way that Ford's new system of mass production was only incidentally about automobiles."[36]

Nowadays, the interest in big data and their derivatives is no longer limited to the capitalists capable of their extraction (the platforms), but they are becoming increasingly important in a wide range of different sectors. Moreover, this interest in big data is going further than the purposes of advertising: as we will see later, they are no longer extracted just to produce UPIs, but also to predict the trends of many market sectors, the behaviour of competitors, workers and machines performances, etc. In all such cases, as correctly underlined by Zuboff, the need to extract big data relies on their direct or indirect capability of providing highly probable predictions.[37]

With this new "phase" of surveillance, with the role of big data becoming increasingly fundamental for many different sectors like assurance companies, financial players, etc. (what Zuboff calls "behavioral futures markets")[38], the process of their commodification is achieving unprecedented levels and, in the next years, will steadily grow.[39]

This process – that, as we will see, is closely related to the new form of "knowledge subsumption" – can not be considered, as Zuboff does, a "rogue" degeneration of capitalism,[40] but it must be interpreted as completely coherent with its laws of motion. Let us clarify this point. This mode of production is generally based on a structural contradiction between the micro and the macro level: the division of labour inside the workplace is scientifically organised, whereas the social one is casual

[36] *Ibid.*
[37] *Ibid.,* chap. 7.
[38] *Ibid.,* chap. 3.
[39] "Forecast of Big Data market size, based on revenue, from 2011 to 2027." Statista (website), accessed May 5, 2022, https://www.statista.com/statistics/254266/global-big-data-market-forecast/
[40] Zuboff, *Surveillance Capitalism,* chap. 8.

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and irrational. In this regard, Marx writes:

> "The planned and regulated *a priori* system on which the division of labour is implemented within the workshop becomes, in the division of labour within society, an *a posteriori* necessity imposed by nature, controlling the unregulated caprice of the producers, and perceptible in the fluctuations of the barometer of market prices."[41]

Obviously, it exists a "social labour" at a "total" system level, that is the total amount of labour employed by the total capital over a certain period of time. However, there is no guarantee that the sectoral allocation of this labour corresponds to the real social need at that moment: in an economy based on competition among producers, the correspondence between these two elements can be verified just in the circulation moment. Here, the market will "check" if the labour employed over a certain period of time has an effective social utility and if the commodity produced will thus be sold or not. It means that, in capitalism, we can know if the amount of social labour is adequate to the social need just *ex-post*, not *ex-ante*, since this mode of production is not based on regulated economic plans.[42] In other terms, capitalism is structurally based on uncertainty and casualty. From a macroeconomic perspective, in fact, this contradiction can produce crisis and instability; from a microeconomic point of view (that of the single capitalist), it can cause the failure of the process of accumulation.

Marx describes the latter with the famous model "money-commodity-more commodity more money" (M-C-C'-M'): the capitalist invests a certain sum of money to buy the means of production and the labour force – which in capitalism are commodities –, extract a certain amount of surplus value and then, with the sale of the commodities produced, gains some profit.[43] Although this is an "abstract" and simplified representation of the process of accumulation which Marx exposes in the first volume of the *Capital* (part of the surplus value extracted in this way, in fact, takes the form of rent or interest and is

[41] Marx, *Capital*, 1:476.
[42] Riccardo Bellofiore, *Smith, Ricardo, Marx, Sraffa: Il lavoro nella riflessione economico-politica* (Turin: Rosenberg & Sellier, 2020), 214-5.
[43] *Ibid.*, 1:256-7.

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appropriated by the financial capital, rentiers, etc.),[44] it is sufficient to understand that each of this "metamorphoses of value" is mainly based on uncertainty: in the real process of valorisation, the transformation of M in M' is threatened, for instance, by delays in the supply chain before the beginning of the production process, human errors and bottlenecks in the process of production (C-C'), and the non-realisation of the investment in the process of circulation (C'- M').

Therefore, as also highlighted by Keynes, capitalists have a constant and morbid thirst for liquidity, but, at the same time, they must deal with its potential loss. This is the inescapable and distressing contradiction of accumulation: to obtain more money they must separate themselves from money, without the certainty of a return.[45] Contrary to what Zuboff believes, this fact has never been peacefully accepted by them: Hayek's eulogy of the "mistery of the market"[46] has never been shared by industrialists and financial investors. That is why the latter generally adopt an imitative behaviour, blindly following the "crowd":[47] from their point of view, this "mistery" has always been a source of anguish. And that is also the reason why big data and its derivatives have undergone a massive process of commodification: adequately used, they can make more probable the realisation of the investment and the maximization of profit.

Now it is clearer why the commodification of big data has not (only) been the contingent result of subjective, arbitrary decisions of some businessmen, or the consequence of a "rogue" degeneration of capitalism, but the manifestation of its structural contradictions: the seeds of pervasive surveillance and control have always been in the process of accumulation; now, with new technologies, they have been able to grow.

Nonetheless, this "dream" of a total prediction of the future collides with the fundamental

[44] Karl Marx, *Capital: A Critique of Political Economy*, trans. David Fernbach, vol. 3, 1867 (London, UK: Penguin Books/New Left Review, 1992).
[45] Gilles Dostaler and Bernard Maris, *Capitalisme Et Pulsion De Mort* (Paris: Albin Michel, 2010), 63.
[46] Zuboff, *Surveillance Capitalism,* chap. 18.
[47] Dostaler and Maris, *Capitalisme Pulsion De Mort*, 63.

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and structural contradictions of this society: on the one hand, the capitalist would like to perfectly know the future, avoid any kind of risk, and eliminate the uncertainty of the accumulation process (this is also the image evoked by Zuboff of the "project of total certainty")[48]. On the other hand, it is the accumulation as such that makes that impossible since it constantly reproduces contradictions and instability. The conditions for a crisis are constantly reproduced by this society, making it impossible to definitively eliminate both the instability and the anguish that derives from it. In a few words, the conditions of the existence of capitalism generate, at the same time, the need for big data surveillance and the limits for its effectiveness.

Now, let us analyse more specifically how this need of "certainty" manifests itself into the process of production, especially with the Industry 4.0 (I4.0) project, and in our daily life, through the smart technologies which intermediate most of our "free-time" activities.

The Capitalistic Need for Certainty: I4.0

Since 2014, the debate on the so-called "Industry 4.0" (I4.0) has started in Germany.[49] This concept refers to a triple-based program:[50]

1) Automation of many production phases.
2) Interconnection among machines and different firms.
3) Digitalisation of many processes of production.

The realisation of this program is based on new technologies like IoT, cloud computing, artificial intelligence, sensors, platforms, and robotics, employed not just to produce commodities, but also for their distribution and use.[51]

[48] Zuboff, *Surveillance Capitalism,* chap. 13.
[49] Christian Fuchs, "Industry 4.0: The Digital German Ideology," *Triple C: Communication, Capitalism & Critique* 16, no. 1 (2018): 280, https://doi.org/10.31269/triplec.v16i1.1010.
[50] Valeria Cirillo et al., "Technology vs. Workers: the Case of Italy's Industry 4.0 Factories," *Structural Change and Economics Dynamics* 56, (2021): 167, https://doi.org/10.1016/j.strueco.2020.09.007.
[51] Fuchs, "Industry 4.0", 281.

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There is a specific reason why this project started in Germany. Its economy was at the same time much more manufactory-based than other leading capitalisms (like US or UK), and much less strong in the sector of information and communication technologies. Therefore, by means of I4.0, Germany is trying to become the leading capitalism in digital innovation in a different sector from that of the US giants like Google or Microsoft. More specifically, it is trying to achieve this by means of the Industrial Internet of Things (IIoT) and other new technologies manufacturing-related.[52] This project is based both on the automation of the production process, and the implementation of smart machines: using sensors, cloud computing, and AI, many industrial assets become capable of registering, storing, and transmitting data, that is then used to watch over the activity of the labour force and to efficient the valorisation process. In fact, the German Federal Ministry of Education and Research claims that in the so-called "smart factory" "equipment, machines and single components continuously exchange information" so that "in the future many processes will be controlled and coordinated in real time over large distances".[53]

However, Germany is no longer the only capitalistic country interested in I4.0-related innovations: since 2014 Industry 4.0 has become a key strategy both in many European and extra-European countries, like the US, Japan, China, and South Korea.[54]

The project of I4.0 is often presented as part of the so-called "Fourth Industrial Revolution", since it should follow the previous ones, based on steam power, electricity, and computing automation.[55] Nonetheless, much criticism has been raised about the use of the word "revolution" in

[52] *Ibid.*, 282.
[53] Germany, Federal Ministry of Education and Research, *Zukunftsbild „Industrie 4.0"* (Bonn: Federal Ministry of Education and Research, 2015), https://www.plattform i40.de/IP/Redaktion/DE/Downloads/Publikation/zukunftsbild-industrie-4-0.pdf?__blob=publicationFile&v=4.

[54] Peter Schadt, Hans Zobel, "Under Capitalism, 'Labour-Saving' Technology Only Adds to Our Workload," *Jacobin*, February 17, 2021, https://www.jacobinmag.com/2021/02/eu-germany-digitalization-technology; Monika Kosacka-Olejnik, Rapeepan Pitakaso, "Industry 4.0: State of the Art and Research Implications," *LogForum Scientific Journal of Logistics*15, no. 4 (2019): 476, https://doi.org/10.17270/J.LOG.2019.363.
[55] Fuchs, "Industry 4.0," 281.

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relation to Industry 4.0: as underlined by Fuchs, it is weird to proclaim a technological revolution before it takes place;[56] moreover, many scholars have criticized the idea that technologies on which I4.0 is based were in radical discontinuity with the previous ones.[57]

What is sure is that most of the declarations and of the research about I4.0 and the Fourth Revolution are "imbued" with "technological fetishism",[58] starting with the belief that I4.0 will automatically guarantee economic growth and a general improvement in the labour conditions and, more generally, in everyone's life.[59] These ideological statements, in fact, do not consider the context of exploitation, social control and power asymmetries in which those technologies are embedded.[60]

The implementation of the latter in the manufacturing sector is an expression of that capitalistic "need for certainty" we have described in the previous chapter. By means of data collected by them capital tries to better control the workers, which are conceived by it an infinite source of potential errors – namely of uncertainty – and an obstacle to the perfect efficiency of the process of valorisation.[61] A striking example of that is the Manufacturing Execution System (MES), a software connected to all the smart machines and technologies in the workplace which enables both a real-time detection of the production activities, the collection of historical performance data and it also gives to the labour force specific orders about the optimal manners and times for carrying out an activity, thus inaugurating new forms of remotely non-physical control of its behaviour and performances.[62]

Nonetheless, big data's usefulness in I4.0 goes far beyond the mere control of the workers'

[56] *Ibid.*
[57] Valeria Cirillo, José M. Zayas, "Digitalizing industry? Labor, technology and work organisation: an introduction to the Forum," *Journal of Industrial and Business Economics*46 (2019): 318-9, https://doi.org/10.1007/s40812-019-00126-w.
[58] David Harvey, "The Fetish of Technology: Causes and Consequences," *Macalester International* 13, 7 (2003), http://digitalcommons.macalester.edu/macintl/vol13/iss1/7.
[59] Fuchs, "Industry 4.0," 281; Carl Hughes, Alan Southern, "The World of Work and the Crisis of Capitalism: Marx and the Fourth Industrial Revolution," *Journal of ClassicalSociology* 9, no. 1 (2019): 62, https://doi.org/10.1177/1468795X18810577.
[60] Fuchs, "Industry 4.0", 281.
[61] Lukács, *Class Consciousness*, 88-9.

[62] Fuchs, "Industry 4.0", 281.

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activity, since it is crucial in other three fundamental capitalistic processes:

1) Innovation of products and product lines.
2) Maintenance of industrial assets.
3) Enhancement of the supply chain.

Point 1) consists in employing big data to reduce the uncertainty of innovation. For instance, a capitalist can use data generated from smart products to understand the customer's fulfilment needs and his thoughts about the competitors. This data can be integrated with a further one derived from different sources, such as the social media customer's activities or those of the suppliers. In doing so, management can exploit the collected information in the design process of future products of the company, reducing the risk of a failed innovation and, therefore, the uncertainty of accumulation.[63]

Point 2) is based on the exploitation of big data to maintain the machinery system and its single components, reducing the uncertainty of failures that can cause loss of quality in the product or delays that can affect the competitiveness of the capitalist.[64] Indeed, big data derived from the sensors on heat, vibrations, and other relevant parameters, if combined with machine learning and data mining techniques, can provide not only precise information about the decline of industrial machines and its causes (what is called "diagnostic process") but also on the time of their possible failure (the so-called "prognostic process").[65]

Big data in the process 3) are employed in different ways. For instance, by using them it is possible to gain insight into delays or problems concerning the activity of the suppliers, but also to compare some of them to make strategic decisions. Moreover, capitalists can control the warehousing

[63] Mujahid M. Babu et al., "Exploring Big Data-driven Innovation in the Manufacturing Sector: Evidence from UK Firms," *Annals of Operation Research*(2021): 10-1, https://doi.org/10.1007/s10479-021-04077-1.
[64] K. M. Chain Lee, Yi Cao, and Kam Hung Ng, "Big Data Analytics for Predictive Maintenance Strategies," in *Supply Chain Management in the Big Data Era,* ed. Hing Kai Chan, Nachiappan Subramanian, and Muhammad Dan-Asabe Abdulrahman (Hershey, PA: IGI Global, 2017), 51, http://doi:10.4018/978-1-5225- 0956-1.ch004.
[65] *Ibid.*, 60-1.

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activity and, using 3D models, obtain new, more efficient configurations of existing warehouses. Finally, geolocation and traffic data can enhance and speed up the transportation of commodities: UPS, for instance, has developed an On-Road Integrated Optimization and Navigation system (Orion) to optimize the 55,000 routes in the network.[66] All this application of big data, are not only instruments to increase the maximisation of profit, but first of all strategies to reduce all the different types of uncertainty that characterise the process of accumulation, from production to circulation.

Now, let us see how big data extraction can also reduce the uncertainty outside the direct production process, briefly analysing the introduction of IoT in our daily life.

The Capitalistic Need for Certainty: Smart Technologies in Our Daily Lives

Schmidt, former CEO of Google, at the World Economic Forum of Davos in 2015 claimed that "there will be so many IP addresses, […] so many devices, sensors, things that you are wearing, things that you are interacting with, that you won't even sense it. It will be part of your presence all the time"[67] He was referring precisely to the introduction of the "Internet of Things" (IoT) in our daily life.

The latter consists of "the many uses and processes that result from giving a network address to a thing and fitting it with sensors".[68] By connecting things to the Internet by means of sensors, they gain new "abilities" or "skills", like communicating with each other and tracking people. Indeed, sensors are the components of a device or a system that detect and communicate variations in the environment:

[66] Knut Alicke et al., *Big Data and The Supply Chain: The Big Supply Chain Analytics Landscape (Part 1)* (New York, NY: McKinsey&Company, 2016), https://www.mckinsey.com/~/media/mckinsey/business%20functions/operations/our%20insights/big%20data%20and%20the%20supply%20chain%20the%20big%20supply%20chain%20analytics%20landscape%20part%201/cee032a2b5cb6d2e22c3ec7ea02159a0.pdf?shouldIndex=false.
[67] Chris Matyszczyk, "The Internet Will Vanish, Says Google's Eric Schmidt." *CNET*, January 22, 2015, https://www.cnet.com/news/the-internet-will-vanish-says-googles-schmidt/.
[68] Merces Bunz and Graham Meikle, *The Internet of Things*(Cambridge, UK: Polity Press, 2018), Introduction, Kindle.

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using them, objects become capable of collecting and transmitting data.[69]

IoT is a relevant innovation for our research, since it enables to "mediate what was not mediated before", like eating, drinking, sleeping, walking, etc.[70] All these daily activities have started to represent, thanks to smart objects and the platforms to which they are connected, new sources of big data taken from our daily life.[71] In other terms, it is no longer necessary for individuals to use digital platforms like Facebook to release data that are then registered and exploited by capital, but it is enough to carry out an activity mediated by IoT: the border between online and offline is thus increasingly disappearing, and, along with it, also the obstacles to pervasive surveillance.[72]

Nowadays everything can be fitted with sensors and linked to a digital network environment. Cars, domestic appliances like TVs or radios, watches, almost everything can become a computer capable of managing data:[73] in 2017 the number of "smart things" in the world was 8.4 billion, more than the current amount of human population.

From the point of view of capital, this has been an important development for the collection of data and for the improvement in their quality and variety, enabling to extract information about our behavioural patterns, body, personality and emotions.[74]

Roomba, the iRobot autonomous vacuum cleaner, is a striking example of how behavioural data can be captured using IoT: its business model is based on the collection of data necessary to design plants of the customers' houses, which are then sold to third parties.[75] Nest thermostat, produced by Alphabet, the Google holding company, is another example of that: it registers not only environmental data (like the humidity or the temperature in the house) and the activity of other connected objects,

[69] *Ibid.*
[70] *Ibid.*
[71] *Ibid.*
[72] *Ibid.*
[73] *Ibid.*, chap. 1; Jamali et al., *Towards the Internet of Things: Architectures, Security, and Applications* (Cham: Springer, 2020), 1.
[74] Zuboff, *Surveillance Capitalism,* chap. 8.
[75] *Ibid.*

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such as beds, cars, ovens, etc., but also data on our behavioural habits. Then, as mentioned in its terms of service, it shares this data with other smart objects or with not specified third parties.[76]

Data on body activity is becoming ever more important too. The Sleep Number bed, for instance, tracks the sleeping activity, the heartbeat frequency, the breath pace, and the movements of the customer, showing the data registered on an app called SleepIQ. "Wearable technologies" play a crucial role in this type of surveillance: smartwatches and smart clothes – such as the jacket produced by Google in partnership with Levi Strauss – are two examples of that. Health monitoring can be a source of biometric data too: during 2016 on Google Android and Apple iOS there were more than one hundred thousand apps for the health to which users gave data about kilocalories consumed, diet, lifestyle, etc.[77]

Nonetheless, the most valuable kind of data are those related to individual personality and emotions, since extremely difficult to capture and highly efficient in predicting future individuals' behaviours. "Personal virtual assistants", for instance, are designed for this, as they are tools capable of interacting with humans and potentially managing many other smart devices.[78] As claimed by the Microsoft CEO Satya Nadella: "this new category of the personal digital assistant is a runtime, a new interface. It can take text input. It can take speech input. It knows you deeply. It knows your context, your family, your work. It knows the world. It is unbounded. In other words, it's about you".[79]

If the conversation with the assistant is fluent, realistic and pleasant we will tend to prolong it. In doing so, we provide personality and emotions data not just with the content of our conversation, but also with the way in which we carry on it: vocabulary used, pronounce, time of response, intonation and

[76] *Ibid.*, chap. 1 and 7.
[77] *Ibid.*, chap. 8.
[78] *Ibid.*, chap. 9.
[79] Satya Nadella, "Microsoft Ignite 2016" (lecture, Microsoft Ignite, Atlanta, GA, September 26, 2016), https://news.microsoft.com/speeches/satya-nadella-microsoft-ignite-2016/.

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cadence, are extremely important to understand our emotions and personality.[80] Many tech companies declare that the recorded data are anonymous, but their efficient techniques of deanonymisation and the personal information contained in the conversations make it possible to precisely identify the user.[81]

Biometric and personal data collected in this way are then integrated with other ones, to obtain high-quality emotions and feelings information. The SEWA project (Automatic Sentiment Estimation in the Wild), for instance, launched by the European Commission in 2015, developed a technology capable of reading emotions to establish how they are connected to the content with which an individual is interacting in a specific moment. That has represented an important development in the field of the so-called "sentiment and emotions analysis" or "affective computing" founded by Rosalind Picard: Realeyes, the start up at the centre of the SEWA project, developed methods to analyse every expression, gesture, etc., and it is capable of understanding the feelings of people watching a video, or receiving commercial messages.[82]

All the techniques we mentioned to capture big data using smart technologies are part of the so-called "ubiquitous connectivity".[83] This expression refers to the attempt of replicating the digital experience into the physical space: in other words, by means of IoT and its sensors, "the idea is to transform any physical space, from the interior of an office building to an entire city, into a "browse-able environment" where you can see and hear everything going on in that space as it flows from thousands or billions or trillions of sensors".[84] The final purpose is that of creating a technological apparatus – what Zuboff calls "Big Other"– capable of registering and collecting any kind of variation in the physical environment, and to influence the behaviour of individuals and groups:[85] smart technologies, in fact, are

[80] Zuboff, chap. 9.
[81] *Ibid.*
[82] *Ibid.*
[83] *Ibid.*, chap. 7.

[84] Gershon Dublon, Joseph A. Paradiso, "Extra Sensory Perception," Scientific American 311, no. 1 (2014), https://doi.org/10.1038/scientificamerican0714-36.
[85] Zuboff, *Surveillance Capitalism*, chap. 13.

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used by capital as "means of behavioral modification"[86] mainly through social engineering techniques.

This technological apparatus, based on the project of an "onlife" world,[87] as underlined by Zuboff, is closely related to the need for certainty,[88] that we have demonstrated, contrary to what Zuboff says, to be structural in this mode of production. She correctly argues, in fact, that "the most predictive source of all is behavior that has already been modified to orient toward guaranteed outcomes":[89] the capitalistic "dream" of eliminating uncertainty in the process of accumulation – and, as we will see, the new form of knowledge subsumption that emerges from it – generates at the same time new powers. Through them, big tech companies aspire to control the purchases of individuals with new sophisticated methods of targeted marketing, whereas banks attempt both to predict the reliability of who applies for a loan and to inducim him to pay: the anguish of accumulation pushes capital to use this huge amount of data generated by daily technologies to reduce the structural uncertainty of profit.

The Third Function of Smart Technologies: A New Form of Knowledge Subsumption

In the first chapter we have highlighted how, in Marxist theory, an implicit and "secondary" function of technology – in addition to the "classical" one of increasing the relative surplus value – can be found: that of "subsumption of knowledge" under the needs of capital.

Smart industrial technologies too are based on these two functions: they are efficient instruments to increase the relative surplus value precisely because their functioning depends on the "absorption", in the form of fixed capital, of the current level of general intellect under the imperative of maximisation of profit. However, the fact that they can manage a huge amount of data, makes things

[86] *Ibid.*, chap. 10.
[87] Luciano Floridi, introduction to *The Onlife Manifesto: Being Human in an Hyperconnected Era*, ed. Luciano Floridi (Cham: Spinger Open, 2015), 1. With this notion we refer only to the "experience of a hyperconnected reality within which it is no longer sensible to ask whether one may be online or offline" and not to the other thesis of Floridi related to it.
[88] Zuboff, *Surveillance Capitalism*, chap. 18.
[89] *Ibid.*, chap. 10.

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more complex: through the latter, smart technologies generate – with the help of data scientists and other devices – new information both on the labour force activity and the whole valorisation process, making it available for the needs of capitalistic accumulation.

For this reason, we believe that smart things, precisely for their intrinsic features, have introduced a third, new function of technology in capitalism: an unprecedent form of subsumption of knowledge. Contrary to the "secondary" function, here it is no longer the general intellect strictly speaking (concepts, scientific laws, workers' tacit knowledge, etc.) that is controlled, appropriated and exploited by capital: data are neither information, nor knowledge, but the "raw material" of both.[90] As we have seen, in fact, if incorrectly stored, transmitted and managed, big data are completely useless: to be subsumed, they need global infrastructures of fibre-optic cables and data centres, an incredible amount of energy, the "cleaning" work of data scientists, etc..[91] As well as expensive and complex machinery are needed to the "capitalist appropriation" of the general intellect, only after this complex and expensive process data can be subsumed under the needs of capital and transformed in useful knowledge.

The case of smart technologies out of the production process is even more interesting. Within the Marxist tradition, technologies developed and sold not to be exploited in the production process have been ignored, because they are not directly and closely connected with the dynamics of surplus value. The washing machine or the vacuum cleaner, for instance, have not been developed to increase the exploitation of the labour force but to be sold in the market, exactly like any other commodity.

On the contrary, considering the perspective of this unprecedented form of knowledge subsumption, we are trying to reconsider the importance of the new "daily technologies" like

[90] Luciano Floridi, *Information: A Very Short Introduction* (Oxford, UK: Oxford University Press, 2010).
[91] Nick Srnicek, *Platform Capitalism*, (Cambridge, UK: Polity Press, 2017), chap. 2.

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smartphones, smart cars, smart homes, etc.. In the case of these devices, the new function we described above manifests itself in its "purest" form, emerging even more clearly than in the industrial IoT: daily smart devices, in fact, are not fixed capital, and they are not instruments to increase the relative surplus value. In contrast, capitalists are interested in those technologies – besides the fact that their sale guarantees profit – since they are necessary to build the "Big Other" and to intermediate our daily activities to extract new data: this new form of subsumption of knowledge does not only concern the production process but also our body activity, conversations, movements, etc. in the "free time". Actually, this process goes beyond the collection of information on what individuals do, how they interact with each other etc.: if data is defined as "a *x* being distinct from *y*, in which *x* and *y* are two uninterpreted variables, and the relation of "being distinct", as well as the domain, are left open to further interpretations"[92], then this new form of subsumption of knowledge has potentially to do with any kind of variation in the world registered by smart technologies: our house temperature, humidity of the trucks for the transportation of commodities, etc. can potentially be registered to generate new information. The latter process, however, – as we mentioned in the previous paragraph – is not automatic: many companies, for instance, collect a huge amount of data from their process of production, but they are not fully capable of exploit them because of "cultural or organisational lacks".[93] Only when data collected is then transformed into useful information – through their cleaning, labelling, etc. – we can talk about the new form of knowledge subsumption we are describing.

At this point, another distinction must be introduced. Marx exposes an important difference between the "formal" and "real" subsumption of labour under capital. The first one occurs when "capital has not yet acquired a direct control over the labour process"[94]: in this case, it formally

[92] Floridi, *Information,* 22.
[93] NewVantage Partners, A Wavestone Company, *The Quest to Achieve Data-Driven Leadership: A Progress Report on the State of Corporate Data Initiatives*, a special report published as part of the *Data and AI Leadership Executive Survey 2022* (Boston, MA: 2022), https://www.newvantage.com/_files/ugd/e5361a_ad5a8b3da8254a71807d2dccdb0844be.pdf
[94] Marx, *Capital*, 1:645.

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appropriates the surplus value generated by the exploitation of the labour force, but without changing the form of cooperation among the workers and the means of production – especially through the introduction of technology –. Instead, when capital "transforms the nature of the labour process and its actual conditions"[95], when its control on labour becomes deeper and he introduces new divisions of labour, new means of production, etc., it subsumes labour in a "real" form.

With the right precautions, we can extend this distinction – by analogy – to the "third" function of technology, at least in the case of "daily" technologies: a "formal" subsumption of knowledge through new technologies occurs when capital only extract data from our behaviour, interactions, etc., without trying to strongly influence it (what Zuboff calls the "pioneering" phase of big data surveillance).[96] When capital introduces methods such as herding, tuning and conditioning, and tries to establish a direct control on behaviours, interactions, etc. of the individual and groups, the "real" subsumption of data-driven knowledge occurs and, with it, new forms of power.[97]

Finally, as we have underlined in the previous chapters, this new function of technology has the main purpose of reducing the uncertainty which derives primarily from the structural dynamic of the accumulation process and, more generally, of capitalism. Big data subsumed through smart technologies, in fact, are used by capital both to reduce uncertainty in the working process, investments, innovation, machine breakdowns, transportation, and in the moment of the realisation of the investment, by means of the targeted marketing. Thus, the "third function" of technology is precisely the expression of an attempt, by capital, to manage the anguish of accumulation. Nonetheless, this anguish could not be completely understood without considering the fundamental laws of this society, and its structural imperative of profit maximisation.

[95] Marx, "Results Immediate Process", 1034-35.
[96] Zuboff, Surveillance capitalism, chap. 3.
[97] Ibid., *part. 3*.

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Conclusion

In this paper, we have shown how, with the introduction of smart devices, a new function of technology has emerged. If before them, the main role of the latter – in addition to increase the relative surplus value – was, in capitalism, to exploit the general intellect in the form of "fixed capital", with IoT a new form of subsumption of the "raw material" of knowledge has emerged.

We have also highlighted the differences between the two types of subsumptions, underlining how the second one concerns not only the production process but also "free time". To show that, we have described both the use of big data and smart technologies in the manufacturing sector – taking the I4.0 as an example and describing how it attempts to reduce uncertainty from the direct production line to the supply chain and the logistics – and in the daily life – giving some examples of new smart tools that intermediate our private and social activities and introducing Zuboff's notion of "Big Other" –.

Finally, in doing so, we have tried to draw attention on the important role of the current "daily" technologies, which have always been ignored in the Marxist theory, and which can be recognise only considering their new function we have highlighted, suggesting a distinction between the "formal" and the "real" subsumption of big data-driven knowledge to read the new forms of power that are arising.

However, many questions remain open. Firstly, the role of the state in this new form of knowledge subsumption should be deepened: many fundamental infrastructures – such as that of Internet – on which it is based have been built by public investments,[98] and many components of the state apparatus (secret services, political parties, etc.) in different countries cooperate with the big tech companies to obtain useful data and to have access, for instance, to cloud services.[99]

Moreover, an analysis on how the different form of the state apparatus (liberal, authoritarian,

[98] Mariana Mazzuccato, *Lo Stato innovatore* (Roma: Laterza, 2014).

[99] Zuboff, *Surveillance capitalism*, chap. 13.

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etc.) can affect this process of subsumption of knowledge will be needed: if in the West this process generally takes the form of the "Big Other", in China, for instance, it is more intertwined with the authoritarian practices of the Communist Party and state bureaucracy – even if in a very different way from how it has often been described[100]–, and it gave rise to the "Social Credit System" project.[101]

Another open question concerns the relation between this new process of subsumption and the specific characteristics of the actual oligopolistic phase of capitalism. How important is for the big tech companies to collect this huge amount of data to keep their privileged position in different markets? How they use them to obtain strategic advantages on the possible competitors? Responding to these urgent issues is essential to better understand the processes of this new form of subsumption of knowledge.

One last main open line of research concerns the risks and the dangers related to this new function of technology. As we have briefly mentioned, in fact, this unprecedented form of subsumption of knowledge is not neutral but involves many issues – in addition to the issues of *privacy* violation – not only in terms of new ways of pervasive control of the labour force, but also of new forms of intrusive and manipulative power in our daily life: the main purpose of the "Big Other" is precisely that of changing the behaviour of individuals and groups to make it more predictable, and a more systematic analysis than that carried out by Zuboff of this new power is needed.

[100] Vincent Brussee, "China's social credit score – untangling myth from reality," *MERICS*, February 11, 2022, https://merics.org/en/opinion/chinas-social-credit-score-untangling-myth-reality
[101] *Ibid.*, chap. 13;

Available online at https://www.gcasreview.com/publications-technology-and-society

References

Alicke, Knut, Christoph Glatzel, Kai Hoberg and Per-Magnus Karlsson. *Big Data and the Supply Chain: The Big Data Supply Chain Analytics Landscape (Part* 1*)*. New York, NY: McKinsey&Company, 2016. https://www.mckinsey.com/~/media/mckinsey/business%20functions/operations/our%20insights/big%20data%20and%20the%20supply%20chain%20the%20big%20supply%20chain%20analytics%20landscape%20part%201/cee032a2b5cb6d2e22c3ec7ea02159a0.pdf?shouldIndex=false

Babu, Mujahid M., Mahfuzur Rahman, Ashraful Alam and Bidit Lal Del. "Exploring Big Data-driven Innovation in the Manufacturing Sector: Evidence from UK Firms." *Annals of Operation Research* (2021): https://doi.org/10.1007/s10479-021-04077-1.

Bellofiore, Riccardo. *Smith, Ricardo, Marx, Sraffa: Il lavoro nella riflessione economico politica.* Turin: Rosenberg & Sellier, 2020.

Brussee, Vincent. "China's social credit score – untangling myth from reality." *MERICS*. February 11, 2022. https://merics.org/en/opinion/chinas-social-credit-score-untangling myth-reality

Bunz, Mercedes and Graham Meikle. *The Internet of Things.* Cambridge, UK: Polity Press, 2018. Kindle.

Cengia, Andrea. "Per una teoria della tecnologia: Raniero Panzieri e l'analisi marxiana dei processi produttivi." PhD diss., Università degli Studi di Padova, 2019.

Cirillo, Valeria, José M. Zayas. "Digitalizing industry? Labor, technology and work organisation: an introduction to the Forum." *Journal of Industrial and Business Economics* 46 (2019): 313-321. https://doi.org/10.1007/s40812-019-00126-w.

Cirillo, Valeria, Matteo Rinaldini, Jacopo Staccioli, Maria Enrica Virgillito. "Technology vs. Workers: The Case of Italy's Industry 4.0 Factories." *Structural Change and Economics Dynamics* 56, (2021): 167. https://doi.org/10.1016/j.strueco.2020.09.007.

Confessore, Nicholas. "Cambridge Analytica and Facebook: The Scandal and the Fallout so Far." *New York Times*, April 4, 2018. https://www.nytimes.com/2018/04/04/us/politics/cambridge-analytica-scandal fallout.html.

Di Meglio, Alberto and Anna Ferrari. *Big Data.* Rome: Treccani, 2021. Kindle. Dostaler, Gilles

and Bernard Maris. *Capitalisme Et Pulsion De Mort*. Paris: Albin Michel, 2010.

Dublon, Gershon, Joseph A. Paradiso. "Extra Sensory Perception." *Scientific American* 311, no. 1 (2014): 36-41. https://doi.org/10.1038/scientificamerican0714-36. Durand, Cédric. *Techno-féodalisme: Critique De L'économie Numérique*. Paris: Zones, 2020. PDF e-book.

Floridi, Luciano. *Information: A Very Short Introduction*. Oxford, UK: Oxford University Press, 2010.

Floridi, Luciano. Introduction to *The Onlife Manifesto: Being Human in a Hyperconnected Era*. Edited by Luciano Floridi. Cham: Springer, 2015.

Fuchs, Christian, and Marisol Sandoval. "Critique, Social Media and the Information Society in the Age of Capitalist Crisis." In *Critique, Social Media and the Information Society*. Edited by Christian Fuchs and Marisol Sandoval, 1-47. New York: Routledge, 2014.

Fuchs, Christian. "Industry 4.0: The Digital German Ideology." *Triple C: Communication, Capitalism & Critique* 16, no. 1 (2018): 280-89. https://doi.org/10.31269/triplec.v16i1.1010.

Fuchs, Christian. "Surveillance and Critical Theory." *Media and Communication* 3, no. 2 (2015): 6-9. https://doi.org/10.17645/mac.v3i2.207.

Fuchs, Cristian. *Communication and Capitalism: A Critical Theory*. London: University of Westminster Press, 2020.

Fumagalli, Andrea, "Per una teoria del valore-rete. Big data e processi di sussunzione," in *Datacrazia: Politica, cultura algoritmica e conflitti al tempo dei big data*, edited by Daniele Gambetta, 46-70. Ladispoli: D Editore, 2018.

Germany. Federal Ministry of Education and Research. *Zukunftsbild „Industrie 4.0"*. Bonn: Federal Ministry of Education and Research, 2015. https://www.plattform i40.de/IP/Redaktion/DE/Downloads/Publikation/zukunftsbild-industrie-4-0.pdf?__blob=publicationFile&v=4.\

Harvey, David. "The Fetish of Technology: Causes and Consequences." *Macalester International* 13, 7 (2003). http://digitalcommons.macalester.edu/macintl/vol13/iss1/7.

Hughes, Carl, Alan Southern. "The World of Work and the Crisis of Capitalism: Marx and the Fourth Industrial Revolution." *Journal of Classical Sociology* 9, no. 1 (2019): 59- 71. https://doi.org/10.1177/1468795X18810577.

Jamali, Mohammad A.J., Bahareh Bahrami, Arash Heidari, Parisa Allahverdizadeh and Farhad Norouzi. *Towards the Internet of Things: Architectures, Security, and Applications*. Cham: Springer, 2020.

Kosacka-Olejnik, Monika, Rapeepan Pitakaso. "Industry 4.0: State of the Art and Research Implications." *LogForum Scientific Journal of Logistics* 15, no. 4 (2019): 475-85. https://doi.org/10.17270/J.LOG.2019.363.

Lee, Chain, K. M. and Yi Cao, and Kam Hung Ng. "Big Data Analytics for Predictive Maintenance Strategies." In *Supply Chain Management in the Big Data Era*. Edited by Hing -Kai Chan, Nachiappan Subramanian, and Muhammad Dan-Asabe Abdulrahman, 50-74. Hershey, PA: IGI Global, 2017. http://doi:10.4018/978-1-5225-0956-1.ch004.

Luhn, P. Hans. "A Business Intelligence System." *IBM Journal of Research and Development* 2, no. 4 (1958): 314-319. https://doi.org/10.1147/rd.24.0314. Lukács, György. *History and Class Consciousness: Studies in Dialectics*. Translated by Rodney Livingstone. Cambridge, MA: MIT Press, 1971.

Karl Marx, *Grundrisse: Foundations of the Critique of Political Economy (Rough Draft)*, trans. Martin Nicolaus. London, UK: Penguin Books/New Left Review. 1973. Marx, Karl. *Capital: A Critique of Political Economy*. Translated by Ben Fowkes. Vol. 1., London: Penguin Books/New Left Review, 1990.

Marx, Karl. *Capital: A Critique of Political Economy*. Translated by David Fernbach, vol. 3, 1867 (London, UK: Penguin Books/New Left Review, 1992).

Marx, Karl. "The Results of the Immediate Process of Production." in *Capital, A Critique of The Political Economy*. London, UK: Penguin Books/New Left Review, 1990, 948- 1084.

Marx, Karl. *Capitale e tecnologia: Manoscritti (1861-1863)*. Edited by Piero Bolchini. Rome: Editori Riuniti, 1980.

Matyszczyk, Chris. "The Internet Will Vanish, Says Google's Eric Schmidt." *CNET*, January 22, 2015. https://www.cnet.com/news/the-internet-will-vanish-says-googles-schmidt/. Mazzuccato, Mariana. *Lo Stato innovatore*. Roma: Laterza, 2014.

Moro, Angelo, Matteo Rinaldini, Jacopo Staccioli, Maria E. Virgillito. "Control in the Era of Surveillance Capitalism: An Empirical Investigation of Italian Industry 4.0 Factories." *Journal of Industrial*

and Business Economics 46, (2019): 347-60. https://doi.org/10.1007/s40812-019-00120-2.

Nadella, Satya. "Microsoft Ignite 2016." Lecture, Microsoft Ignite, GE, Atlanta, September 26, 2016. https://news.microsoft.com/speeches/satya-nadella-microsoft-ignite-2016/. NewVantage Partners, A Wavestone Company. *The Quest to Achieve Data-Driven Leadership: A Progress Report on the State of Corporate Data Initiatives*. A special report published as part of the *Data and AI Leadership Executive Survey 2022*. Boston, MA: 2022. https://www.newvantage.com/_files/ugd/e5361a_ad5a8b3da8254a71807d2dccdb0844b e.pdf

Pasquinelli, Matteo. "On the origins of Marx's general intellect." *Radical Philosophy* 206 (2019): 43-56.

Polanyi, Michael. *The Tacit Dimension*. New York: Anchor Books, 1977.

Quenqua, Douglas. "Facebook Knows Better Than Anyone Else." *New York Times*, January 19, 2015. https://www.nytimes.com/2015/01/20/science/facebook-knows-you-better than-anyone-else.html.

Reinsel, David, John Gantz and John Rynding. *The Digitization of the World: From the Edge to the Core*.

Needham, MA: IDC, 2018. Accessed November 10, 2021. https://www.seagate.com/files/www-content/our-story/trends/files/idc-seagate-dataage whitepaper.pdf.

Schadt, Peter, Hans Zobel. "Under Capitalism. 'Labour-Saving' Technology Only Adds to Our Workload." *Jacobin*, February 17, 2021. https://www.jacobinmag.com/2021/02/eu germany-digitalization-technology.

Scolari, Fabio. "Toyotismo: Qualità totale per chi?." *Inchiesta*, February 4, 2017. http://www.inchiestaonline.it/osservatorio-internazionale/fabio-scolari-toyotismo qualita-totale-per-chi/.

Spence, Martin. "Marx against Marx: A Critical Reading of the *Fragment on Machines*." *TripleC: Communication, Capitalism and Critique* 17, no 2 (2019): 327-39. https://doi.org/10.31269/triplec.v17i2.1146.

Srnicek, Nick. *Platform Capitalism*. Cambridge, UK: Polity Press, 2017. EPUB. "Forecast of Big Data market size, based on revenue, from 2011 to 2027." Statista (website). Accessed May 5,

Available online at https://www.gcasreview.com/publications-technology-and-society

2022, https://www.statista.com/statistics/254266/global-big-data market-forecast/

Tomba, Massimiliano and Riccardo Bellofiore. "The 'Fragment on Machines' and the *Grundrisse*: the Workerist Reading in Question." In *Beyond Marx: Theorising the Global Labour Relations of the Twenty-First Century*. Edited by Marcel van der Linden and Karl Heinz Roth, 345-67. Leiden: Brill, 2014.

Virno, Paolo. "Citazioni di fronte al pericolo." *Luogo Comune* 1 (1990), 9-13.

Youyou, Wu, Michal Kosinski and David Stillwell. "Computer-based personality judgments are more accurate than those made by humans." *Proceedings of the National Academy of Sciences* 112, no. 4 (2015): 1036-40. https://doi.org/10.1073/pnas.1418680112.

Zuboff, Shoshana. *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power*.New York: PublicAffairs, 2019. EPUB.