Social Implications of Technological Disruptions: A Transdisciplinary Cybernetics Science and Occupational Science Perspective

Pedro H. Albuquerque
Aix Marseille Univ, CNRS, AMSE
Marseille, France
ACCELERATION & ADAPTATION
Aix-en-Provence, France
ORCID 0000-0002-5034-3082

Sophie Albuquerque
Université de Sherbrooke, CdRV, CIUSSS de l'Estrie – CHUS
Sherbrooke, Canada
Aix Marseille Univ, SMPM
Marseille, France
ACCELERATION & ADAPTATION
Aix-en-Provence, France
ORCID 0000-0001-7797-5218

Abstract*—In this article we argue that the disruptive social implications of skill-replacing technological innovations are determined neither by human characteristics, such as "low skills" or "low cognition," nor by task characteristics, such as "routine," as it is typically assumed in the predominant economics and management science literature, but by the cybernetic characteristics of the innovations. We also propose that the negative effects of technological disruptions on human well-being cannot be fully understood without the use of a transdisciplinary approach involving cybernetics science and occupational science, and that it is urgent that policymakers look beyond their narrow effects on productivity and on the labor force, and consider instead the complexity of the interactions between cybernetic technologies and meaningful human occupations. We offer as an example the case of the fast adoption of online food delivery services and of remote work technologies during the COVID-19 pandemic. Ethical implications are derived from the arguments.

***Keywords* — technological disruptions, technological innovations, cybernetics science, occupational science, labor and nonlabor occupations**

The project leading to this publication has received funding from the French government under the "France 2030" investment plan managed by the French National Research Agency (reference: ANR-17-EURE-0020) and from the Excellence Initiative of Aix-Marseille University - A*MIDEX.

I. Introduction

In this article we employ a transdisciplinary cybernetics science and occupational science perspective to argue that the social implications of technological disruptions due to skill-replacing technological innovations are defined by the cybernetic characteristics of the innovations, and not by human characteristics, such as "low skills" and "low cognition," nor by task characteristics, such as "routine," as it is usually assumed in predominant economics and management science approaches. We also propose that it is of the essence to broaden the study of the effects of skill-replacing technologies beyond a productivist and economistic approach by considering their effects on the form, function and meaning of labor and nonlabor human occupations. We propose therefore that implications of technological disruptions on human well-being cannot be fully understood without the use of a transdisciplinary approach involving cybernetics science and occupational science. We ask the reader to keep in mind that, in the context of this article and when used alone, the term "occupation" means, as defined in the occupational science literature, any kind of labor or nonlabor human occupation.

The article is organized as follows: in the "Human Skills, Cybernetics and Occupations" section, we present our thesis' arguments. In the "Online Food Delivery and Remote Work: A COVID-19 Pandemic Case Study" section we offer applications of our thesis. In the "The Future of Technology and of Occupations" section, we speculate on the dangers of a limited and narrow understanding of the social implications of technological disruptions, and derive ethical implications. Finally, we summarize the contributions of the article and perspectives for future research in the "Conclusions" section.

II. Human Skills, Cybernetics and Occupations

A. Automatic and Autonomous Systems

Among the latest contributions to the understanding of technological change, one that we believe to have been somewhat overlooked in the economics and management science literature is the importance of cybernetics science in the analysis of the social implications of technological innovations and technological disruptions. The existing economics and management science literature is unquestionably aware of the developments in robotics, machine learning and artificial intelligence [1]. We think however that a more careful look into cybernetics is necessary to improve the understanding of how skill-replacing technologies affect societies.

We adopt here a broad definition of cybernetics that includes all fields of study related to automatic or autonomous systems, therefore encompassing subjects such as automation, machine learning and artificial intelligence. All these fields, even though sometimes following different epistemological approaches, are equivalent in what concerns their effects on social phenomena. That is because they are all related to the study and creation of self-governing technological innovations that, due to their automatic or autonomous nature and accelerated development pace, have been associated with increasingly disruptive socio-economic effects [2]. These technologies typically follow algorithms, which can range from static to adaptive, and simple (e.g. automation) to complex (e.g. artificial intelligence).

As examples, consider a standard elevator that embodies static and simple cybernetics (automatic technologies), and a self-driving vehicle that embodies adaptive and complex cybernetics (autonomous or intelligent technologies). Both are capable of disrupting the socio-economic fabric, but the latter, due to its decision-making capabilities, must be designed and certified following uniquely broad and stringent ethical standards [3]. Notice also from these examples that technological disruptions are assumed here to always have the potential to impact society positively or negatively, the outcome being a function not of the technology itself, but of how it is utilized and managed: an automatic elevator and a self-driving vehicle can suppress the jobs of operators, but can also extend the availability of services to a large range of contexts and users.

B. Cybernetic Characteristics of Technological Innovations

The predominant economics and management science literature on skill-replacing technologies sees in human characteristics ("low skills," "low cognition") or in task characteristics ("routine") the determinants of technological impacts on society [4], [5], [6], [7], [8], [9]. We disagree with these predominant perspectives. For us, it is the cybernetic characteristics of skill-replacing technologies (their ability to self-govern in order to replace human skills) that determine their socio-economic effects.

Most of the current economics and management scholarship on the socio-economic effects of technological innovations turns around the disputes between so-called skill-biased technical change (SBTC) and routine-biased technical change (RBTC) approaches [10]. Both approaches were however developed in hindsight as explanations to changes in data patterns that previous theories could not predict. They also suffer from reductionism and poorly defined core concepts, as they try to fit qualitative concepts to available quantitative data instead of admitting that quantitative data that fit the qualitative concepts can only be obtained by excessive proxying. This happens because, in those fields, research based on quantitative methodologies are frequently seen as superior to those employing qualitative methodologies [11]. In the cases of SBTC and RBTC, skills tend to be measured merely through quantifiable dimensions of training, education or experience, while task routinization tends to be measured using data from narrowly defined sources based on industry and labor government surveys designed to achieve objectives not necessarily related to technology studies.

Take NASA's Perseverance rover, a self-governed, complex, adaptive and learning-capable cybernetic system [12] as an example of the problems mentioned above. The rover does not replace hypothetical astronauts in the exploration of Mars because astronauts have low skills or low cognition, or because of the routine nature of the tasks they perform. It does it because Perseverance embodies a broad range of cybernetic characteristics that fully and adequately replace specialized human skills needed for the tasks involved in planetary exploration, and despite the fact that those tasks are arguably of a routine nature. In reality, due to their breadth and complexity, those routine tasks do not fit well into typical measures of task routinization based on categorical proxying for labor, as used in economics and management studies.

This point is driven home using as an example the recent rise of large language models (LLM) that deliver cognitive automation [13]. One could argue convincingly that these models only perform routine tasks. But routine and complex, although being two different characteristics of tasks, can easily coexist. Many of the routine tasks a LLM perform can be daunting for the average human due to their complexity, for example, text translation in unusual languages, or rewriting a text competently in different styles. Because core concepts such as task routinization are poorly defined in the economics and management literature, they cannot adequately represent rigorously defined cybernetics-based concepts, such as algorithmic routine, measuring instead some misleadingly similar concept, for example, task simplicity, which is then inappropriately used as a proxy for the measurement of task routinization.

Moreover, human and task characteristics specify the context that precedes a technological innovation, therefore they cannot be the determinants of the skill-replacement process. A skill-replacing technological innovation, on the other hand, is the new element in a preexistent context, therefore its cybernetic (self-governing) characteristics must be the determinants of the skill-replacement process. In summary, we propose the following:

Proposition 1: the replacement of human skills by a skill-replacing technology is not caused by human characteristics (such as low skills) nor by task characteristics (such as routine or simplicity) but by the cybernetic (self-governing) characteristics of the skill-replacing technology in a given context.

C. Human Skills, Tasks, and Occupations

Another contribution of this article is that we introduce knowledge from occupational science into the analysis. The broadest meaning of the word occupation is that it is an activity in which one engages. Collectively, occupations are defined as "the combination of everything that people do

throughout their lives" [14], p. 117. As such, they constitute the fabric of everyday living and determine the way in which humans occupy their space-time continuum and use their skill set to accumulate experiences over a life course. Furthermore, they provide personal and social meaning and identities through humans' interactions with their environment [15].

For instance, occupations can be categorized as maintenance occupations (structuring everyday life), work occupations (production-based occupations resulting in a compensation), play occupations (exploratory and cultural activities), and recreational occupations (involving relaxation and rest) [16].

What do we mean by that? Firstly, consider that labor is just one type of occupation among many types of occupations, meaning that occupational choice studies need to consider how humans allocate their time between labor and nonlabor occupations. Secondly, consider also how improvements in skill-replacing technologies will render many meaningful labor occupations forever out of reach of most humans, and that, under a well-being perspective, the time freed up because of the disappearance of these occupations shall be reallocated not only among other labor occupations, but also among nonlabor occupations.

For example, consider a dishwasher. It replaces human skills related to dish washing, reducing the amount of time humans devote to housekeeping as an occupation. By doing so, it allows humans to devote more time to other nonlabor occupations, such as watching movies or sleeping.

Notice that human skills, and the tasks and occupations that they support, are environment and meaning-making dependent [17]. As examples of nonlabor occupation technological disruptions, consider how senior people may remain unable to use smartphones for the rest of their lives, while young people may find themselves in an embarrassing situation when asked to use a vintage rotary phone. In both cases, technological characteristics are alien to humans' contextual skills, differently disrupting human occupations.

In addition, an occupational science perspective allows us to go beyond the productivist perspective about "how much output is obtained" with labor occupations, e.g. [18], p. 329. Keeping in mind that skills are needed to perform tasks [4], and that occupations refer to groups of tasks [19], p. 34, this broader approach allows for a better understanding of how technological innovations can create supportive or disruptive environments for humans as life resources [14], [17], and how they affect their well-being. Therefore, with the help of the occupational substrates taxonomy [20], we state the following:

Proposition 2: technological innovations destruct, disrupt, or create human occupations depending on the characteristics of the technologies, altering the form (how it is done), function (purpose) and meaning (human experience) of these occupations.

As an example, consider target shooting as a labor occupation (producing nourishment) or as a nonlabor occupation (leisure). Some humans may find meaning in those occupations. Under a labor occupation perspective, a rifle is a technological innovation when compared to a crossbow, and the invention of a cyber-shooter (a shooting robot) may lead to the disappearance of target shooting as a labor occupation. Nonetheless, under an existing leisure perspective, the crossbow and the rifle are just different technological artifacts used in different sports, and in a sports context a cyber-shooter is useless as a technological innovation. In addition, target shooting for nourishment could still be performed as a labor occupation, as long as it provides meaning or function to the human shooter, despite the availability of cyber-shooters. At the same time, cyber-shooting could become a new sport, as humans may play and compete using shooting robots as proxies.

In summary, in order to better understand the socio-economic effects of technological innovations, it is essential to look beyond their effects on productivity and on the labor force, and to consider the complexity of the interactions between cybernetic technologies and human occupations. In particular, skill-replacing technologies allow artifacts and processes to perform increasingly complex tasks as alternatives to humans, disrupting the form, function and meaning of human occupations, with the potential, if unmanaged, to reduce human well-being.

III. Online Food Delivery and Remote Work: A COVID-19 Pandemic Case Study

As an application of Proposition 1, consider how the previous availability of online food delivery (OFD) services before the COVID-19 pandemic [21] created the right conditions for the explosive growth of OFD services during the pandemic, as lockdowns were imposed. The pandemic was naturally a major factor concerning the disruption of dine out restaurant services, but the availability of OFD services also contributed to the intensity and speed of the disruption [22]. Using the predominant economics and management paradigm, one would propose that the contribution of technological innovations such as OFD services to the disruption of dine out restaurants was caused or by low-skill workers (according to the SBTC approach) or by the routine nature of the tasks involved in dine out restaurants (according to the RBTC approach). It is nonetheless clear that the intensity of the disruption was not caused by either (think gourmet restaurants as a clear example). Proposition 1 offers an alternative answer to the source of the disruption: OFD technologies were disruptive because of the cybernetic characteristics of these skill-replacing technologies that were well adapted to the context of the COVID-19 pandemic.

Now, as an application of Proposition 2, consider the fast adoption of remote work technologies during the pandemic. It provides a good example of how important it is to look beyond labor when studying technological disruptions. Analysis of available survey data about the phenomenon in the US indicated that: (a) there was a significant increase in the number of employees using technology to work from home during the pandemic; (b) commuting to work was negatively correlated to remote work, as expected; (c) remote work was more prevalent where COVID-19 infection rates where higher; (d) young employees were more likely to remote work; (e) remote work was more prevalent in information sectors of the economy; and (f) industries that adopted remote work more intensely were also the ones that recurred the least to layoffs or furloughs [23].

Although the study as usual concentrates most of its attention on labor, it is evident from its results that nonlabor occupations have played a role during the pandemic. For example, younger employees were probably more exposed to remote technologies and remote nonlabor occupations (consider as an example remote dating) before the pandemic started, making the transition to remote work more natural than for older employees.

The COVID-19 pandemic has also been associated with broad social phenomena that has deeply changed perceptions about the role of work in the ensemble of human occupations. Stylized examples of social shifts in perceptions are the Great Resignation [24], [25], which represents a rising trend of more highly valuing meaningful nonlabor and labor occupations independently of pay, and the quiet quitting [26], a loss of motivation at work due to decreasing levels of occupational meaning. These trends are believed to have started before the pandemic, but remote work seems to have triggered mass reevaluation of meaning and an acceleration of the trends, due in large part to the effects of remote work on the reevaluation of the importance of nonlabor activities.

Periods of remote work have also put in evidence human social needs embedded in meaningful work activities that are only indirectly connected to productivity or financial compensation but that lead to improvements in well-being, for example, socialization routines at the workplace (such as informal brainstorming by the coffee machine) or the need for physical interactions with coworkers. On the other hand, remote working can create labor and nonlabor occupational benefits such as reduced hours of tedious commuting and flexible schedules that allow for health-related activities such as workout routines and home cooking. Some studies have identified trade-offs that favor flexible arrangements combining some remote work with some physical interactions at the workplace as the most beneficial under a well-being perspective for the employee but also under a productivist perspective for the firm [27].

IV. The Future of Technology and of Occupations

In this section we offer a few arguments of a speculative and ethical nature. We beg to disagree with the typical optimistic neoliberal economics and management perspective on the future of technological disruptions [1], [28]. We believe instead that the development of cybernetic technologies will continue to accelerate, and that the social implications of skill-replacing technologies may become, if unmanaged, increasingly detrimental to well-being, as it becomes

humanly impossible to continuously adapt to broader, faster and more frequent technological disruptions. Even if disruptions can have many positive effects, it will not compensate for the asymmetric nature of the negative effects, as humans are normally risk averse, assigning more weight to losses than to equivalent gains [29].

In addition, in the words of Economics Nobel laureate Robert Solow, "if a small class of owners of wealth – and it is small – comes to collect a growing share of the national income, it is likely to dominate the society in other ways as well" [30]. There is by now ample evidence that this is happening, as technological control is held by a few cyber-entrepreneurs, suggesting that we should heed Solow's alert. And the wealth concentration resulting from the ownership of skill-replacement technologies is paired with the disruption or destruction of ever larger amounts of meaningful occupations, at an accelerating speed, without necessarily or always providing meaningful labor or nonlabor occupations as alternatives to humans, therefore with increasingly negative consequences for their well-being.

Finally, attributing the malaise caused by unregulated technological innovations to hard-to-define human characteristics (such as low skills) or occupational components (such as routine tasks) is dangerous, as this argument can be ideologically appropriated to turn attention away from the necessary regulation of cybernetic technologies towards the unfair characterization of the victims of negative disruptions as the only ones responsible for their own unfortunate fate. If this is true, we should not be surprised if the result is widespread rage against the machine and the resurrection of Luddism.

V. Conclusions

In this article we introduced knowledge from cybernetics science and occupational science into the analysis of technological disruption to broaden its scope beyond the predominant productivist and economistic labor paradigms and towards a comprehensive meaningful occupations framework. We offered two propositions: the first one establishes that it is the cybernetic (self-governing) characteristics of skill-replacing technologies that drive technological disruptions, and not human characteristics (such as low skills) or task characteristics (such as routine). The second one states that technological innovations affect form, function and meaning of all types of human occupations. To illustrate the two propositions, we presented a case study based on the growth of online food delivery services and of remote work during the COVID-19 pandemic. Finally, we suggested that the current state of social affairs may not be politically and socially sustainable. As disruptions seem to happen at an accelerating pace, policymakers may need to urgently broaden their perspectives with the help of a transdisciplinary cybernetics science and occupational science approach. We plan to address this matter in more details in our future investigations.

References

[1] E. Brynjolfsson, D. Rock, and C. Syverson, "Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics," in *The economics of artificial intelligence: An agenda*, University of Chicago Press, 2018, pp. 23–57. Accessed: Apr. 11, 2022. [Online]. Available: https://www.nber.org/books-and-chapters/economics-artificial-intelligence-agenda/artificial-intelligence-and-modern-productivity-paradox-clash-expectations-and-statistics

[2] L. Grinin and A. Grinin, "The cybernetic revolution and the future of technologies," in *The 21st century singularity and global futures*, A. V. Korotayev and D. J. LePoire, Eds., in World-Systems Evolution and Global Futures. Cham: Springer International Publishing, 2020, pp. 377–396. doi: 10.1007/978-3-030-33730-8_17.

[3] J. C. Havens and A. Hessami, "From principles and standards to certification," *Computer*, vol. 52, no. 4, pp. 69–72, Apr. 2019, doi: 10.1109/MC.2019.2902002.

[4] D. H. Autor, F. Levy, and R. J. Murnane, "The skill content of recent technological change: An empirical exploration," *The Quarterly Journal of Economics*, vol. 118, no. 4, pp. 1279–1333, Nov. 2003, doi: 10.1162/003355303322552801.

[5] D. Acemoglu and D. Autor, “Skills, tasks and technologies: Implications for employment and earnings,” in *Handbook of Labor Economics*, Elsevier, 2011, pp. 1043–1171. doi: 10.1016/S0169-7218(11)02410-5.
[6] G. L. Violante, “Skill-biased technical change,” in *The New Palgrave Dictionary of Economics*, London: Palgrave Macmillan UK, 2016, pp. 1–6. doi: 10.1057/978-1-349-95121-5_2388-1.
[7] G. M. Cortes, N. Jaimovich, and H. E. Siu, “Disappearing routine jobs: Who, how, and why?,” *Journal of Monetary Economics*, vol. 91, pp. 69–87, Nov. 2017, doi: 10.1016/j.jmoneco.2017.09.006.
[8] D. Acemoglu and P. Restrepo, “Robots and jobs: Evidence from US labor markets,” *Journal of Political Economy*, vol. 128, no. 6, pp. 2188–2244, 2020, doi: 10.1086/705716.
[9] N. Jaimovich and H. E. Siu, “Job polarization and jobless recoveries,” *The Review of Economics and Statistics*, vol. 102, no. 1, pp. 129–147, Mar. 2020, doi: 10.1162/rest_a_00875.
[10] J. Staccioli and M. E. Virgillito, “The present, past, and future of labor-saving technologies,” 2020. [Online]. Available: http://hdl.handle.net/10419/243495
[11] A. Lenger, “The rejection of qualitative research methods in economics,” *Journal of Economic Issues*, vol. 53, no. 4, pp. 946–965, Oct. 2019, doi: 10.1080/00213624.2019.1657748.
[12] N. Abcouwer *et al.*, “Machine learning based path planning for improved rover navigation,” in *2021 IEEE Aerospace Conference (50100)*, Big Sky, MT, USA: IEEE, Mar. 2021, pp. 1–9. doi: 10.1109/AERO50100.2021.9438337.
[13] A. Korinek, “Language models and cognitive automation for economic research,” 17923, 2023. Accessed: Apr. 18, 2023. [Online]. Available: https://cepr.org/publications/dp17923
[14] A. A. Wilcock and C. Hocking, *An occupational perspective of health*, 3rd ed. Thorofare, NJ: SLACK Incorporated, 2015.
[15] C. H. Christiansen, “Defining lives: Occupation as identity: An essay on competence, coherence, and the creation of meaning,” *The American Journal of Occupational Therapy*, vol. 53, no. 6, pp. 547–558, Nov. 1999, doi: 10.5014/ajot.53.6.547.
[16] D. Persson, L.-K. Erlandsson, M. Eklund, and S. Iwarsson, “Value dimensions, meaning, and complexity in human occupation - A tentative structure for analysis,” *Scandinavian Journal of Occupational Therapy*, vol. 8, no. 1, pp. 7–18, Jan. 2001, doi: 10.1080/11038120119727.
[17] G. D. Rowles, “Place in occupational science: A life course perspective on the role of environmental context in the quest for meaning,” *Journal of Occupational Science*, vol. 15, no. 3, pp. 127–135, 2008, doi: 10.1080/14427591.2008.9686622.
[18] C. Syverson, “What determines productivity?,” *Journal of Economic Literature*, vol. 49, no. 2, pp. 326–365, Jun. 2011, doi: 10.1257/jel.49.2.326.
[19] M. Law, H. Polatajko, S. Baptiste, and E. Townsend, “Core concepts of occupational therapy.,” in *Enabling occupation: An occupational therapy perspective*, E. Townsend, Ed., Ottawa: Canadian Association of Occupational Therapists, 2002.
[20] F. A. Clark *et al.*, “Occupational science: Academic innovation in the service of occupational therapy’s future,” *The American Journal of Occupational Therapy*, vol. 45, no. 4, pp. 300–310, Apr. 1991, doi: 10.5014/ajot.45.4.300.
[21] M. A. Khan, “Technological disruptions in restaurant services: Impact of innovations and delivery services,” *Journal of Hospitality & Tourism Research*, vol. 44, no. 5, pp. 715–732, Jun. 2020, doi: 10.1177/1096348020908636.
[22] D. Gavilan, A. Balderas-Cejudo, S. Fernández-Lores, and G. Martinez-Navarro, “Innovation in online food delivery: Learnings from COVID-19,” *International Journal of Gastronomy and Food Science*, vol. 24, p. 100330, Jul. 2021, doi: 10.1016/j.ijgfs.2021.100330.
[23] E. Brynjolfsson, J. J. Horton, A. Ozimek, D. Rock, G. Sharma, and H.-Y. TuYe, “COVID-19 and remote work: An early look at US data.” in Working Paper Series. National Bureau of Economic Research, Jun. 2020. doi: 10.3386/w27344.

[24] A. Cohen, “How to quit your job in the great post-pandemic resignation boom,” *Bloomberg.com*, May 10, 2021. Accessed: Mar. 22, 2023. [Online]. Available: https://www.bloomberg.com/news/articles/2021-05-10/quit-your-job-how-to-resign-after-covid-pandemic
[25] A. C. Klotz, “The Great Resignation Is still here, but whether it stays Is up to leaders,” *The OECD Forum Network*, Jun. 03, 2022. http://www.oecd-forum.org/posts/the-great-resignation-is-still-here-but-whether-it-stays-is-up-to-leaders (accessed Mar. 22, 2023).
[26] J. Lord, “Quiet quitting is a new name for an old method of industrial action,” *The Conversation*, Sep. 09, 2022. http://theconversation.com/quiet-quitting-is-a-new-name-for-an-old-method-of-industrial-action-189752 (accessed Mar. 22, 2023).
[27] J. J. de Klerk, M. Joubert, and H. F. Mosca, “Is working from home the new workplace panacea? Lessons from the COVID-19 pandemic for the future world of work,” *SA Journal of Industrial Psychology*, vol. 47, no. 1, pp. 1–14, 2021, doi: 10.4102/sajip.v47i0.1883.
[28] B. Eichengreen, “Secular stagnation: The long view,” *American Economic Review*, vol. 105, no. 5, pp. 66–70, May 2015, doi: 10.1257/aer.p20151104.
[29] D. Kahneman and A. Tversky, “The psychology of preferences,” *Scientific American*, vol. 246, no. 1, pp. 160–173, 1982, Accessed: Apr. 18, 2023. [Online]. Available: https://www.jstor.org/stable/24966506
[30] R. M. Solow, “Thomas Piketty is right,” *The New Republic*, Apr. 23, 2014. Accessed: Mar. 20, 2022. [Online]. Available: https://newrepublic.com/article/117429/capital-twenty-first-century-thomas-piketty-reviewed