Industry 4.0 Management:
A Hundred Years in the Making

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Industry 4.0, or the fourth Industrial Revolution, is the integration of new technologies - Artificial Intelligence, Internet of Things, smart devices and more - into all aspects of the economy. In particular the implementation of algorithmic management offers rewards and controversy. As with previous revolutions, Industry 4.0 comes with the promise of more productivity but also carries the risk of harmful social change. Current implementations of Industry 4.0 and its associated technologies have undermined workers' security, de-skilled jobs, and reduced autonomy, as well as giving employers unprecedented access to their workers' lives.

The successful implementation of Industry 4.0 will require new investment in unfamiliar technologies. These new technologies, while offer new potential, can also have negative impact on workers, potentially damaging long term returns.   It therefore becomes reasonable to ask: at what point do those costs outweigh the potential benefits for the worker?

By reviewing the historical case of Scientific Management and current implementations of Industry 4.0, this paper will suggest a direction for making Industry 4.0 more sustainable.

Keywords: Scientific Management; Industry 4.0; Management.

Introduction

This paper[1] proposes that the managerial changes that Industry 4.0 ushers in, especially those relating to algorithmic management (AM), are an extension of principles of scientific management (SM) (Kellogg, Valentine, and Christin 2020). There is a direct line between SM, Taylorism, and Industry 4.0. Industry 4.0 allows those principles to extend further and be applied more efficiently.

This paper will focus on AM as an aspect of Industry 4.0. It is important to note that AM could not be as effective as it is without many other technologies that make up Industry 4.0. It is also important to understand that Industry 4.0 is not only a collection of technologies, but it also incorporates how they are used and the work relations they support or undermine. The paper will then go on to discuss SM and how it has shaped modern management practice

History

SM was developed during a time of significant change in labour relations and a time of labour regulation reform. Labour unions were emerging and exerting power over the workplace (Devinat, 1926). SM was one of a number of strategies adopted by business owners to regain control over the workplace (Nelson, 1980).

SM was a tool that could be used by owners to transfer control from workers to managers. Before SM, work was managed by supervisors who were generally the most senior and experienced shop floor workers and were considered to be closely allied with the workforce rather than the owners (Devinat, 1926). SM created a new class of worker: the professional manager. These new managers were more closely aligned with the owners than senior tradesmen (Wagner-Tsukamoto, 2007). Taylor intended for SM to bring managers and workers closer. However, its implementation and the resulting transfer of power from workers to managers had the opposite effect, creating a barrier between them (Wagner-Tsukamoto, 2007). This transfer of power was part of the reason for SM's success (Schachter, 2010).

Industry 4.0 plays a similar role to SM in the balance of power over the workplace and labour processes. The conflict over power at the workplace that SM was part of, has continued

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[1] The author would like to acknowledge the advice and assistance of his supervisor, Dr David Haynes of Edinburgh Napier University, in the writing of this work.

to this day. Industry 4.0 is part of that conflict. SM didn't change the legal standing of workers, but today there is a trend of reducing the rights and protections of workers by the use of the gig economy, for instance, where workers' legal status is less than that of regular employees (Steinberger, 2017). This reduces the costs of labour and shifts risk from business to the workers (Huws, 2016). This makes the workforce in terms of rights and protections more closely resemble workers at the start of the 20th century, who had fewer rights and could be more easily dismissed (Devinat, 1926; Cunningham-Parmeter, 2016).

Industry 4.0 continues the trend of extending the ability of managers to monitor workers, but also makes it easier to hide decision making behind the opacity of algorithms (Boewe and Schulten, 2017). Industry 4.0 may evolve new technologies, but its implementation is a continuation of management practices that long pre-date it.

The link between SM and modern management has been well established. It has shaped both academic thought and management practice far beyond the realm of the factory floor (Schachter, 2010; Parker and Jeacle, 2019). The success of SM has been linked to socio-political developments that have been mirrored in the workplace. The expansion of SM beyond the factory was in part due to technological developments (Parker and Jeacle, 2019). Some scholars have suggested that Taylor himself would not have supported Taylorism; ultimately his vision of managers and workers becoming closer did not survive alongside SM (Taksa, 1992; Wagner-Tsukamoto, 2007).

SM has had a lasting impact and influence on the workplace. The common use of the term "Taylorism" and the associated changes it implies is striking evidence of that (Fischer and Sirianni, 1994). Taylorism is associated with de-skilling, increased monitoring and reduced worker autonomy.
Industry 4.0 recreates the political relationships between workers and managers in a manner consistent with SM (Cullinane and Cushen, 2019; Galière, 2020).

Industry 4.0

While there are many descriptions of Industry 4.0, they tend to fall into two broad categories. The first is the vision put forward by its supporters: the Industry 4.0 agenda. Supporters say the changes will offer more worker flexibility and autonomy (Duggan *et al.*, 2020). A study of its impact on employees based in Australia showed that Industry 4.0 can create an improved working environment by reducing repetitive tasks, increasing safety, and

being more ergonomic (Ejsmont, 2021). Critics of Industry 4.0 say it creates inhumane working conditions and undermines workers' rights (Rosenblat, Kneese and Boyd, 2014; Boewe and Schulten, 2017). Two examples of the impact of Industry 4.0 are given below.

Customer benefits of tailored recommendations and next or same day delivery are featured of online retail made possible by Industry 4.0 technology. The use of Industry 4.0 technologies has allowed Amazon to dominate the online retail space. Amazon has created an electronic panopticon from which it can draw vast amounts of data (Boewe and Schulten, 2017). This data is then used to manage workers' performance, assign tasks, and in some cases, make the decision to fire staff.

Uber monitors its workers using an array of different methods, including customer rating. These ratings are of vital importance because if a driver's rating drops too low their access to the app and therefore their ability to work will be limited (Möhlmann and Henfridsson, 2019). Uber also monitors the service drivers give as well as the route drivers take and places restrictions on the type of vehicle that they can use (Steinberger, 2017).

It is clear that Industry 4.0, when implemented, is more than just a group of technologies, but also incorporates management practices and even replaces some supervisory functions entirely (Todolí-Signes, 2020).

Scientific Management

Scientific Management (SM) was developed by Frederick Taylor at the start of the 20th century. SM was intended to apply the precision of engineering methods to the management of labour (Nelson, 1980). Its implementation required a specialist manager to undertake careful observations, and collect data relating to the timings of tasks and resources used (Nelson, 1980; Wagner-Tsukamoto, 2007).

The specialist manager would develop a series of rules for how the work should be carried out, assign tasks, and calculate pay rates, responsibilities that would have previously been carried out by the most senior shop floor worker. This use of a professional manager, not necessarily skilled in the work they were overseeing, was a considerable break from earlier practices (Nelson, 1980). An important effect of the implementation of SM was the transfer of control from workers to management. While it is unclear if this was intended by Taylor, it became a feature of management practices that were developed from SM. It therefore involved

the use of data for optimal task assignment and calculation of pay rates, and the transfer of control from workers to managers.

Modern Practice

Industry 4.0 does not come with its own set of management practices but adapts those that already exist. Algorithmic management is therefore designed to support and implement those practices. While it is possible that Industry 4.0 technologies could allow for different practices, in reality, it inherits those that already exist, which are based on the principles of SM (Parker and Jeacle, 2019; Günsel and Yamen, 2020). This does not mean that the use of new technologies will not result in any differences. For example, workers relate differently to algorithmic decisions than to human decisions, trusting an algorithm more on some decisions and likewise trusting a human more on others (Lee *et al.*, 2015; Cappelli, 2018).

Industry 4.0 can remove the human element of decision making and it is often intendent to do so. The motivations to remove humans from decision making are often to reduce error, speed decision making and remove bias (Gil *et al.*, 2020). This can have unforeseen negative consequences. For example, algorithmic decisions are often seen as having less biases than human decisions, whereas they often re-create those biases (Vidal and Menajovsky, 2019). The presence of a human manager also allows for deviation from the algorithm when required, something an algorithmic manager cannot do. One real-world example was a terror attack, where Uber was heavily criticised for failing to deactivate surge pricing implemented by the algorithm, resulting in a dramatic fee increase for those fleeing the area (Cox, 2017).

One of the limitations of SM is that its scope is limited to single sites. While SM can be implemented in different places, each implementation is separate. Industry 4.0 allows for single incident of management practices to be implemented across geographically dispersed workers (Curchod *et al.*, 2020).

Sustainable Industry 4.0

Industry 4.0 not does come with its own set of management practices but uses and adapts those that already exist. The algorithmic manager is designed to support and implement these practices, re-enforcing and embedding them. This would suggest more monitoring, less autonomy, and more risk for workers (Todolí-Signes, 2020).

Amazon has often been criticised for the way in which its algorithmic management can extract every ounce of effort from workers, leaving them sleeping in their cars between shifts rather than returning home (Bruder, 2017). Uber has used its technology to avoid regulation and oversight making it even harder for workers to protect themselves (Wong, 2017).

These trends go against the idea of sustainable employment as set out by the United Nations. This conflict mirrors the debate that surrounded the implementation of SM at the turn of the 20th century (United Nations, no date). Defenders of Industry 4.0, like the past defenders of SM, argue that it would have benefits for workers as well as businesses. The ultimate form that SM took, however, failed to deliver on that promise (Nelson, 1980). Industry 4.0 faces a similar debate. It holds a promise of sustainable development but delivering on that promise is not a given: it will need to be fought for.

The use of Taylorisation and Scientific Management suggest that winning the public debate is insufficient: real action is required. Sound regulation of data collection and algorithmic management is vital, but also transparency and the ability for workers to enforce protections. Ultimately, there will be a need to develop management practices not rooted in SM, for Industry 4.0 to reach its sustainability potential. While there exists a wide range of management practices, in reality, those that dominate have their roots in SM, and the development of Industry 4.0 does not appear to be any different.

The problem is not that Industry 4.0 cannot support sustainable employment; but how to ensure that it will support those goals.

References

Boewe, J. and Schulten, J. (2017) "The long struggle of the Amazon employees," *The Rosa-Luxemburg-Stiftung, Brussels Office*. rosalux.eu. Available at: https://www.rosalux.eu/kontext/controllers/document.php/385.1/b/acf33d.pdf.

Bruder, J. (2017) "Living in cars, working for Amazon: meet America's new nomads," *The Guardian*, 2 December. Available at: http://www.theguardian.com/commentisfree/2017/dec/02/nomadland-living-in-cars-working-amazon (Accessed: April 29, 2022).

Cappelli, P. (2018) *Are Algorithms Good Managers?*, *Human Resource Executive*. Available at: https://hrexecutive.com/are-algorithms-good-managers/ (Accessed: December 14, 2020).

Cox, J. (2017) "London terror attack: Uber slammed for being slow to turn off 'surge pricing' after rampage," *Independent*. Available at: https://www.independent.co.uk/news/uk/home-news/london-terror-attack-uber-criticised-surge-pricing-after-london-bridge-black-cab-a7772246.html.

Cullinane, N. and Cushen, J. (2019) "Applying Scientific Management to Modern Employment Relations and HRM," in *Elgar Introduction to Theories of Human Resources and Employment Relations*. Edward Elgar Publishing.

Cunningham-Parmeter, K. (2016) "From Amazon to Uber: Defining employment in the modern economy," *Boston University Law Review*. HeinOnline, 96, p. 1673.

Curchod, C. *et al.* (2020) "Working for an Algorithm: Power Asymmetries and Agency in Online Work Settings," *Administrative science quarterly*. SAGE Publications Inc, 65(3), pp. 644–676.

Devinat, P. (1926) "The American Labour Movement and Scientific Management," *International Labour Review*. HeinOnline, 13, p. 461.

Duggan, J. *et al.* (2020) "Algorithmic management and app-work in the gig economy: A research agenda for employment relations and HRM," *Human Resource Management Journal*. Wiley Online Library, 30(1), pp. 114–132.

Ejsmont, K. (2021) "The impact of industry 4.0 on employees—insights from Australia," *Sustainability: Science Practice and Policy*. MDPI AG, 13(6), p. 3095.

Fischer, F. and Sirianni, C. (1994) *Critical Studies in Organization and Bureaucracy*. Temple University Press.

Galière, S. (2020) "When food-delivery platform workers consent to algorithmic management: a Foucauldian perspective," *New technology, work and employment*. Wiley, (ntwe.12177). doi: 10.1111/ntwe.12177.

Gil, D. *et al.* (2020) "AI for Management: An Overview," in Canals, J. and Heukamp, F. (eds.) *The Future of Management in an AI World: Redefining Purpose and Strategy in the Fourth Industrial Revolution*. Cham: Springer International Publishing, pp. 3–19.

Günsel, A. and Yamen, M. (2020) "Digital Taylorism as an Answer to the Requirements of the New Era," in *Agile Business Leadership Methods for Industry 4.0*. Emerald Publishing Limited, p. 88.

Huws, U. (2016) "The rise of platform labour: a fair 'sharing economy' or virtual Wild West," *Protecting employment rights in an increasingly digital labour market. Policy briefing Labour in the digital economy.*

Lee, M. K. *et al.* (2015) "Working with Machines: The Impact of Algorithmic and Data-Driven Management on Human Workers," in *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. New York, NY, USA: Association for Computing Machinery (CHI '15), pp. 1603–1612.

Möhlmann, M. and Henfridsson, O. (2019) "What people hate about being managed by algorithms, according to a study of Uber drivers," *Harvard business review*. researchgate.net, 30. Available at: https://www.researchgate.net/profile/Mareike_Moehlmann2/publication/336347030_What_People_Hate_About_Being_Managed_by_Algorithms_According_to_a_Study_of_Uber_Drivers/links/5d9cb62e299bf1c36301e91d/What-People-Hate-About-Being-Managed-by-Algorithms-According-to-a-Study-of-Uber-Drivers.pdf.

Nelson, D. (1980) "Frederick W. Taylor and the rise of scientific management." Madison: University of Wisconsin.

Parker, L. D. and Jeacle, I. (2019) "The Construction of the Efficient Office: Scientific Management, Accountability, and the Neo-Liberal State," *Contemporary Accounting Research*, 36(3), pp. 1883–1926.

Rosenblat, A., Kneese, T. and Boyd, D. (2014) "Workplace Surveillance," *Open Society Foundations' Future*. doi: 10.2139/ssrn.2536605.

Schachter, H. L. (2010) "The role played by Frederick Taylor in the rise of the academic management fields," *Journal of Management History*, 16(4), pp. 437–448.

Steinberger, B. Z. (2017) "Redefining employee in the gig economy: Shielding workers from the Uber model," *Fordham Journal of Corporate & Financial Law*. HeinOnline, 23, p. 577.

Taksa, L. (1992) "Scientific Management: Technique or Cultural Ideology?," *Indian Journal of Industrial Relations*, 34(3), pp. 365–395.

Todolí-Signes, A. (2020) "Complying with the First Law of Robotics: An Analysis of the Occupational Risks Associated with Work Directed by an Algorithm/Artificial Intelligence," *Artificial Intelligence (January 20, 2020)*. doi: 10.2139/ssrn.3522406.

United Nations (no date) *THE 17 GOALS, Sustainable Development*. Available at: https://sdgs.un.org/goals (Accessed: April 27, 2022).

Vidal, M. F. and Menajovsky, J. (2019) *Algorithm Bias in Credit Scoring: What's Inside the Black Box?*, *CGAP*. Available at: https://www.cgap.org/blog/algorithm-bias-credit-scoring-whats-inside-black-box (Accessed: December 14, 2020).

Wagner-Tsukamoto, S. (2007) "An Institutional Economic Reconstruction of Scientific Management: On the Lost Theoretical Logic of Taylorism," *AMRO*. Academy of Management, 32(1), pp. 105–117.

Wong, J. C. (2017) "Greyball: how Uber used secret software to dodge the law," *The Guardian*, 4 March. Available at: http://www.theguardian.com/technology/2017/mar/03/uber-secret-program-greyball-resignation-ed-baker (Accessed: April 29, 2022).