DEPARTMENT OF SOCIAL SCIENCES
AND ECONOMICS

SAPIENZA
UNIVERSITÀ DI ROMA

ISSN 2532 -117X
Working papers
DIPARTIMENTO DI SCIENZE SOCIALI ED ECONOMICHE
[online]

PhD COURSE IN APPLIED SOCIAL SCIENCES WORKING PAPERS SERIES n. 13/2020

Learning algorithms as technological artefacts: between organisational change and new forms of regulation of work processes

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CF 80209930587 – P. IVA 02133771002

Learning algorithms as technological artefacts: between organisational change and new forms of regulation of work processes

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This contribution is positioned in the debate on digitisation and how both organisational processes and the regulation of work processes are changing due to introduction of digital technologies such as learning algorithms within organisations. Using the theoretical framework of organisational studies, the aim is to analyse the reasons behind the introduction of these new technological artefacts, as well as its possible implications. The result is a typology regarding the intervention of learning algorithms on work processes. Since learning algorithms are adaptive tools that can be implemented in organisations that follow different technologies, the typology could help in identify the differences concerning the impact of learning algorithms on the regulation of work processes according to changes in the technology adopted.

1. INTRODUCTION

Although there is still no definition that removes ambiguity in talking about the process of digitisation, there is no doubt that it has transformed, and it is still transforming organisational dynamics in depth. A starting assumption which it is possible to agree upon is that we are witnessing the spread of digital and information technologies – in the form of technological artefacts – used as tools for integration and coordination within organisational contexts. In particular, over the last decades has been growing the importance of data collection systems (i.e. Big Data systems) and learning algorithms (Faraj, Pachidi and Sayegh 2018). On the one side, these new technologies seem capable of reducing reality – simplifying it – to a predictive model with the aim of optimizing decision-making processes inside organisations (von Krogh 2018). On the other side, they encourage the exercise of new forms of control, which becomes both more pervasive and intrusive (Zuboff 2015).

The theoretical contribution that is presented here intends to analyse the possible implications of the introduction of these new technological artefacts in organisations. The reasons regarding their introduction will be investigated in more depth. Initially, it will be questioned the relationship between technology and organisational change (par. 2 and

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3), a classic topic in organisational studies. The question which we will try to answer to concerns the characteristics of the change produced by the introduction of technological artefacts such as learning algorithms in organisational processes. Specifically: are these devices radically changing the logic of organisational action or are they integrated into the processes without distorting them? Successively, it will be examined what is changing in the regulation of work processes and it will be propose a typology in order to classify the intervention of learning algorithms on the regulation of work processes (par. 4). Algorithmic proceduralization retains traditional characteristics in the regulation of work processes but at the same rime introduces problematic elements concerning the pervasiveness of control over work and the evaluation of workers. The final paragraph will conclude the contribution with some remarks.

2. TECHNOLOGY AND ORGANISATIONAL CHANGE: THE ROLE OF DIGITISATION

The subject concerning the relationship between technology and organisational structure has been widely debated in the field of organisational studies, to the extent that it is possible to count it among the classic themes of the discipline (Bonazzi 2008; Catino 2010). There is consensus among scholars that there is no single, universal model of organisation, but rather a plurality of possible forms. Consequently, it is useful to understand what are the variables that explain this differentiation. Some theoretical contributions have identified a fundamental typological criterion in technology and its operating procedures (Woodward 1965; Thompson 1967; Pugh and Hickson 1976).

Using technology as the main criterion allows to establish the assumption that when technology changes this has a direct influence on the organisational structure. In this sense, we can better understand why the recent debate on digitisation and its effects on technologies was quickly intercepted by organisational studies. Digitisation is described as a continuous process characterized by the diffusion and use of information and digital technologies in the form of technological artefacts. A technological artefact can be understood as "[...] the visible translation of knowledge developed inside and outside organisations. They are *a sort of crystallization of effective solutions to recurring problems*: developing and using artefacts that include these solutions allows you to share these 'filtered' forms of experience" (Masino and Zamarian 2003: 3, the italics is ours). Technological artefacts are mainly used as tools for integration and coordination of organisational processes. It is worth noting that within the literature on the subject we can identify a rift in the interpretation of the transformations produced by digitisation.

The first interpretation supports the idea that these transformations would have a disruptive nature and that they would be fostering the development of the so-called Fourth Industrial Revolution with its new production model (Schwab 2017). Other scholars - more prudently - affirm that the appearance of these transformations can be traced back at least to the Seventies, emphasizing a continuity line over the course of time and therefore rejecting the hypothesis of the disruptive change (Valenduc and Vendramin

2017; Salento 2017, 2018). The latter interpretation seems more effective in helping to understand the transformations produced by digitisation, conceiving its recent manifestations as the result of a prolonged and complex process. Furthermore, it allows to avoid the risk of falling into the trap of technological determinism, as new technologies are not interpreted as exogenous factors, but rather as the result of continuous processes of actions and decisions regarding their meaning, their diffusion, their adoption and so forth.

However, what emerges as truly new is "(…) the system's ability to process large data streams, transmitting information from each machine to large data collection devices, with the aim of processing and using them, following a process of recursive self-learning "(Salento 2018: 8). The technological artefacts we are talking about are data collection systems (Big Data systems) as well as learning algorithms[2]. The spread of the use of these tools is evident in a vast number of organisations, from private companies to public administrations, a fact which indicates their extreme adaptability. In this regard, which organisational processes they can adapt with extreme versatility to? And how these technological artefacts are able to succeed? In this sense, it may be useful to start from some classic studies in the field of organisational studies.

3. THE SENSE OF ALGORITHMS AS TECHNOLOGICAL ARTEFACTS

The spread of technological artefacts such as learning algorithms within organisations could be explained by two reasons. The first, lies in their promise - in which actors *believe* - to achieve, both in terms of effectiveness and efficiency, the maximum expression of technical rationality. With technical rationality (or, in a broad sense, technology), we refer to the analytical concept defined by Thompson (1967) as the set of activities, supported by beliefs regarding *cause-and-effect* relationships, which produce specific expected outcomes. Consequently, the technical rationality is effective when precise actions produce the expected results and is efficient when these same results are obtained with the minimum waste of available resources (optimization). However, it is very unlikely that technologies in their concrete use reach perfection: they can be effective, but not efficient at all or vice versa; or neither effective nor efficient, in the worst-case scenario. The main source of the "imperfection" of technical rationality lies in the context of *uncertainty* in which organisations normally act. As noted by Crozier and Friedberg (1978) there are "sources of uncertainty particularly pertinent to an organisation" (*ibidem*: 55), i.e. the possession of particular skills, the control of relations with the external environment (or environments), control of information and manipulation of internal organisational rules. At this stage, learning algorithms seem capable to intervene mainly on the last source of uncertainty (Tomar *et al*. 2016). While

[2] Learning algorithms can be defined as "(…) an emergent family of technologies that build on machine learning, computation, and statistical techniques, as well as rely on large data sets to generate responses, classifications, or dynamic predictions that resemble those of a knowledge worker" (Faraj, Pachidi and Sayegh 2018: 62).

the uncertainty concerning the control of information significantly complexifies the process of forming beliefs regarding *cause-and-effect* connections, at the same time actors that make decisions inside organisations have cognitive limits that prevent them to acquire and store information and to take optimal decisions (Simon 1957; March and Simon 1958). Consequently, the processes of decision-making take place in a context of bounded rationality (Simon 1957), which differs from technical rationality. Nevertheless, trying to achieve the perfection in technology is the main purpose (or, if we want, the *recurring problem*) of any complex organisation and the most functional strategy requires removing as much uncertainty as possible (Thompson 1967) in order to simplify the decision-making processes. Through their functioning, algorithms promise to reduce uncertainty to gradually achieve optimal decisions, as they can control the sources of uncertainty and overcome cognitive limits in acquiring, coding and processing information.

The second reason - a consequence of the first - is that these technological artefacts act as *procedures*. Ever since the diffusion of the scientific management, procedures have represented an effective organisational tool with the aim of "(...) *removing the chance for the operator to regulate his/her own process of action* [author's italics, translation is ours]" (Maggi 2018: 43-44). Traditionally, procedures are conceived after repeated observation of actions in a specific context that help in designing optimal models of action, which are then prescribed to workers. Learning algorithms, with the set of data which they rely on, acts as procedures: they are able to provide for a greater volume of repeated observations, instantaneously processing it and continuously re-designing the model of action, with the subtle assumption that the more the data the better the model. Better, of course, in proceduralising the means-ends chain and in aligning the processes of action of the actors towards those same ends.

Thinking about the role played by these algorithms and their functioning as procedures, one can better understand why there is little really "revolutionary" in the nature of these technological artefacts. The logic of complex organisations has always been to improve technical rationality and optimize processes, trying to remove as many sources of uncertainty as possible. In this sense, there is not much difference between the assembly line and algorithms. Both are artefacts - one mechanical, the other digital - that through repeated observation of movements and tasks improve their potential and manage to progressively eliminate the defects of technology, allowing to prescribe better procedures from the point of view of productivity.

What really changes is represented by the volume of data that can be acquired, in the reduction of system learning times and in the pervasiveness of the control carried out by the new algorithmic procedures. Above all, this latter aspect is more problematic, since it closely concerns the relationship between technical and social variables. Traditionally, the context in which it is possible to observe the results of the encounter (or clash) of these variables is the one concerning the regulation of work processes.

4. LEARNING ALGORITHMS AND REGULATION OF WORK PROCESSES

In the light of the theoretical framework previously mentioned, learning algorithms are used in organisations as technological artefacts able to *simultaneously* execute – or serve as support on[3] – functions of *coordination*, *control* and *evaluation* concerning the organisation of work processes. What is important to underline is to one side the adaptability of these tools, that can re-elaborate the same set of data for different purposes, and to the other their ability to carry out different functions simultaneously. Moreover, the functions that algorithmic systems execute are not secondary or marginal, rather strategical for what concerns work processes. Some of the main managerial functions are transferred to technological artefacts and this denotes the high level of intrusiveness of these tools. The brief illustration of the functions at issue may help in better clarifying this aspect. Coordination is the counterpart of the division of labour and acts as tool of integration of tasks and regulation of the interdependency between actors[4]. Control consists in verifying if workers follow the rules and comply with directives. Lastly, evaluation concerns the judgement – based on predetermined criteria – on the performance of workers. Even though functions of both coordination and control have been executed by traditional tools and machinery in the past (Thompson 1967; Edwards 1979), learning algorithms can intensify and potentiate their execution. Conversely, evaluation is a new competence acquired by these digital technologies, since it has traditionally been a prerogative of human managerial intelligence. Ultimately, the diffusion of learning algorithms has encouraged both the intensification of coordination and control through technological artefacts and the extension of functions, especially in regard of evaluation. Because of the intrusiveness and pervasiveness of these technological tools and their ability to take on "managerial" functions, some scholars proposed to use the term "algorithmic management" (Lee *et al*. 2015; Jarrahi and Sutherland 2018).

Nevertheless, the flexibility that characterizes learning algorithms has made them an adaptive tool that can be implemented in organisations that follow different technologies. In this sense, the "algorithmic management" can assume different connotations as a change in the technology occurs. Thus, it could be helpful to conceive a typology that takes into account the differences in the use of learning algorithms in relation to the type of technology chosen. At the same time, this typology could be useful for better understanding the implications for the regulation of work processes. Rather than a new typology, the proposal is to re-elaborating on the classical subdivision of technological variety devised by Thompson (1967). He identified three classes: long-linked technology, mediating technology and intensive technology. In particular, we will

[3] It can be argued that there is a significant difference between executing and serving as a support. However, if those who use these artefacts as support for their decision believe in their capabilities and effectiveness, the decision is *de facto* predetermined and indirectly executed by the tools.

[4] We use the term "actors" because the coordination can concern the interdependence between workers (e.g. in manufacturing), as well as between workers and consumers (e.g. in services).

focus on the first two[5]. As showed in Table 1, we distinguish between *algorithmic management* and *algorithmic matching*, that intervene on the two different technologies.

TABLE 1
TYPOLOGY OF INTERVENTION OF LEARNING ALGORITHMS ON WORK PROCESSES

	Technology supported	**Source of data**	**Evaluative criterion**
Algorithmic management	*long-linked technology*	*workers*	*productivity*
Algorithmic matching	*mediating technology*	*workers and consumers*	*productivity and reputation*

The algorithmic management serves as a support for long-linked technologies, i.e. those which reach the desired outcomes through "(…) serial interdependence in the sense that act Z can be performed only after successful completion of act Y, which in turn rests on act X, and so on" (Thompson 1967:16). Learning algorithms serve as procedures that allow serial interdependence between actions, by means of the acquisition of a continuous flow of information concerning work processes. Among the available source of data there are workers, that provide data while performing their tasks by means of digital working tools or interacting with machinery or software. The same workers are then evaluated for their performance, being assumed productivity[6] as the main evaluative criterion. It is possible to find some examples concerning the algorithmic management use, e.g. the Warehouse Management System (WMS)[7] used for work processes inside Amazon Fulfilment Centers (Cattero and D'Onofrio 2018; Delfanti 2019) or the UPS delivering system (ORION) that "drives" workers on the roadmap (Holland *et al*. 2017).

Linked to mediating technology there is algorithmic matching. Mediating technologies allow to connect users or consumers "who are or wish to be interdependent"

[5] The third one is the intensive technology and it operates when "(…) a variety of techniques is drawn upon in order to achieve a change in some specific object; but the selection, combination, and order of application are determined by feedback from the object itself" (Thompson 1967:17). Hospital and educational organisations are classical examples of organisations that operate with intensive technologies. In this paper, we will not discuss the intervention of learning algorithms on this kind of technology. Nevertheless, it is worthwhile to point out that there is much written on this topic (among others: (Obermeyer and Emanuel 2016; Simmons 2016)).

[6] Relationship between tasks assigned and fulfilled, in relation to time.

[7] As stated by a former employer of Amazon Logistics, the algorithm that track and evaluate workers' performance is called ADAPT (Associate Development and Performance Tracker) and its functioning is illustrated in detail in the document available at: https://cdn.vox-cdn.com/uploads/chorus_asset/file/16190209/amazon_terminations_documents.pdf, retrieved on September 15, 2019.

(Thompson 1967:16). In this case, algorithms operate as standard procedures with a double purpose: they facilitate the matching between supply and demand of a specific service, and they set the working framework within which workers complete their tasks. As compared to algorithmic management, data is extracted from both workers and consumers: workers provide information while performing their tasks and consumers perform this when they chose the service and after the execution of workers' performance. In fact, for algorithmic matching it is possible to identify two criteria of evaluation: productivity and reputation. The former is similar to the criteria identify for the algorithmic management – direct evaluation on performance in relation to procedures –, while the latter is the result of the re-elaboration of judgement expressed by consumers regarding the service – and therefore workers. The overall evaluation is calculated taking into account both criteria. Examples of algorithmic matching – well illustrated by empirical research – are those of Uber and Lyft: algorithmic matching serves for working assignment (matching of supply and demand), informational support and performance evaluation (Lee *et al*. 2015).

It is possible to note that in both cases workers – while completing their tasks – provide information and data that potentiate algorithmic procedures thanks to the self-learning ability of the same technological artefacts. Workers are a crucial source of data in both algorithmic management and algorithmic matching, but at the same time algorithms allow workers to access to a wide source of information, that they can use strategically[8]. Algorithms can verify the compliance with the procedures they prescribe and communicate immediately to workers the results of this constant verification. Again, this could be both a problem and an opportunity: constraints can sometimes be preferable than the responsibility for the use of discretion (Maggi 2018). Finally, we mentioned the "functional variances", i.e. the actions that distance themselves from the standard set by procedures. These variances could be interpreted – due to how algorithms are designed and programmed – in a positive or negative sense: when positive they train algorithmic system and re-define standards, but when negative they also evaluate workers. These last aspects are the most problematic. In the first case workers provide information that improve algorithmic systems, but we do not currently know to what extent this improvement is attributed to workers. One question is if learning algorithms would be as smart as they are without workers providing for information. In the other case – the negative one – moving away for standards means to be evaluated. Productivity and reputation as measured by learning algorithms are the main criterion for evaluation, but we still not know much about their effectiveness and implications (Slee 2015; Burrell 2016).

[8] Lee and colleagues (2015) show clear examples of how workers use information to help or to take advantage of each other.

5. CONCLUSION

The contribution aimed at analyzing how both the organisational processes and the regulation of work processes are changing due to introduction of digital technologies, such as learning algorithms, within organisations.

Firstly, we focused the attention on the cause of these transformation, namely the process of digitisation. The recent spread of learning algorithms within organisations is conceived by some scholars as the result of a prolonged and complex process, whose origins can be traced back to the Seventies and that steadily impacted on the organisational processes since then. In this sense, it is possible to avoid the risk of falling into the trap of technological determinism, as the development and implementation of new technologies are interpreted as endogenous factors, which resulted from continuous processes of actions and decisions within organisations regarding the meaning, the design, the diffusion and the adoption of these same technologies.

Secondly, we discussed the two main reasons behind the large diffusion of technological artefacts such as learning algorithms inside organisations. The first reason concerns the ability of these technological artefacts to achieve, both in terms of effectiveness and efficiency, the maximum expression of technical rationality. Learning algorithms promise to reduce uncertainty to gradually make – or help in making – optimal decisions, as they can control the sources of uncertainty and overcome the cognitive human limits in acquiring, coding and processing information. The second reason is that that these technological artefacts can act as procedures. Learning algorithms are used to optimise work processes, since they are able to continuously re-design themselves, reaching better organisational models which are then prescribed to workers.

Finally, we propose a typology regarding the intervention of learning algorithms on the regulation of work processes. The diffusion of learning algorithms has encouraged the intensification both of coordination and control in working contexts. Some scholars proposed to use the term "algorithmic management" (Lee *et al*. 2015; Jarrahi and Sutherland 2018), referring to the ability of learning algorithms to take on "managerial" functions. Nevertheless, the “algorithmic management” can assume different connotations as a change in the technology occurs. Re-elaborating the classical subdivision of technological variety devised by Thompson (1967), the typology has proposed the distinction between *algorithmic management* and *algorithmic matching*. The two types diverge for the source of data used to feed learning algorithms and for the evaluative criterion of workers performances and entail different implications for workers that in our opinion were not sufficiently grasped with the wider concept of “algorithmic management”.

In conclusion, it is possible to assert that learning algorithms are deeply changing work processes and they will foster further changes in the near future. Taking into account some pioneering empirical researches on the actual use of learning algorithms inside organisations, it seems that they can determine both opportunities and constraints for workers and managers. However, further empirical researches are needed in order to offer

in-depth results. In this sense, clarifying the theoretical concepts used – resorting to the classics of organizational studies – could be a useful strategy to guide research.

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