Neilson, Brett. (2020) 'The Reverse of Engineering', *South Atlantic Quarterly* 119(1): 75-93. DOI: 10.1215/00382876-8007665

# The Reverse of Engineering

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## Abstract

Insofar as planning mediates between the order of *what is* and the question of *what might be*, it is not only a matter of philosophy but also one of engineering. Particularly at a time when routines of financial speculation and pattern recognition have colonized the making of futures, planning has become a process of creating architectural opportunities from scattered corpuses of extracted data. Mindful of the importance of machine learning in such processes, this article critically grapples with the proposition that techniques of reverse engineering offer a means of cracking these future making routines and turning them toward projects of social and political amelioration. I argue that practices of reverse engineering need to articulate to radical political projects and modes of organization. Drawing on computer science studies of adversarial machine learning, I also consider the question of whether reverse engineering of machine learning techniques is technically possible. Ultimately, the article contrasts political claims for reverse engineering with what I call the reverse of engineering, or a program that entails the subordination of data to qualitatively rich futures rather than planning processes that work from the merely evidential and measurable.

## Keywords

Planning, reverse engineering, artificial intelligence, machine learning, data, capitalism

Insofar as planning mediates between the order of *what is* and the question of *what might be*, it is not only a matter of philosophy but also one of engineering. Particularly at a time when routines of financial speculation and pattern recognition have colonized the making of futures, planning has become a process of creating architectural opportunities from scattered corpuses of extracted data. From the Black Scholes equation governing the price evolution of financial derivatives to myriad forms of platform economy, the channeling of data into engines of analysis and prediction has tightened capital's grip on tomorrow. Regardless of

whether one accepts the argument that data prediction has replaced production as the motor of capitalist valorization and accumulation (see, for instance, Ascher 2016), planning has clearly become something other than a means of making or administering a socialist society. To follow Campbell Jones (2020) in speaking of "the return of economic planning," then, is not to assert a revival of the golden era of state planning or to invest in the notion that state institutions might offer a bulwark against global capital. The compatibility of planning and capitalism has been a prospect at least since the time of European fascism and the democratic experiment of the New Deal. Far from presenting polar opposites, markets and plans can both sustain powerful orthodoxies that present equilibrium or disequilibrium, depending of the school of thought to which one subscribes, as the base condition of economic and social life. Under these circumstances, it is tempting to suggest that radical political change might proceed only by cracking the codes of capital's operations and turning the resultant knowledge to emancipatory ends. This article probes the limits of such claims for reverse engineering.

Although reverse engineering has a long history, stemming in some accounts (see Kahevi and Okutmus 2015) from the Egyptian capture and reconstruction of an Assyrian chariot, claims for its radical political uses have mounted in recent decades. To be sure, there are important precedents for the idea that capital's techniques and technologies might turn to anticapitalist ends. One thinks of Vladimir Lenin's (1972) contention in the 1918 pamphlet "The Immediate Tasks of the Soviet Government" that post-revolutionary Russia should organize the study and teaching of Taylorism in order to adapt the scientific management of production to the needs of a worker-led society. However, it is with the more recent rise of computational modes of capitalism (especially those driven by the extraction and analysis of data) that claims for the radical political potential of reverse engineering have become frequent and prominent. Consider the proposal made by Leigh Phillips and Michal Rozworski (2019, 239) to "seize logistics and planning powerhouses—the Walmarts and Amazons of the world—and repurpose them for an egalitarian, ecologically rational civilization." Convinced that "a different way of doing things" is "foreshadowed in the sophisticated economic planning and long-distance cooperation already happening under capitalism" (244), these authors see the reverse engineering of corporate systems and planning devices as pivotal to the making of a socialist future. Similarly, Brian Massumi (2018, 24) suggests that the "key to revaluing value might lie in reverse engineering a dynamic that is carried to its highest power in the most advanced, and seemingly regressive, segment of the capitalist economy:

the financial markets." Massumi also offers some concrete proposals as to how to accomplish such reverse engineering. He describes work with Akseli Virtanen and others at the Economic Space Agency (www.esca.io) on repurposing blockchain and cryptocurrency technologies to create a "distributed programmable organization" capable of supporting a "*commons* of productive activity … with an ethos of collective collaboration and a certain instantiation of direct democracy" (106). More cautiously, Massumi notes that while such an initiative "offers many avenues of response to the capitalist market," the "models now existing or under development are locked in a game of whack-a-mole with it." With every blow made against capitalism, he surmises, "the familiar myopic face of one of its constitutive principles *pops up somewhere else*" (110). Clearly, there is an urgent political need to assess the prospects for reverse engineering to break out of this game and contribute to the making and design of a postcapitalist future.

At a memorable moment in Errol Morris's film *Fast, Cheap and Out of Control* (1997), roboticist Rodney Brooks recalls his plan to build a "walking machine … that is able to fall down." Brooks explains: "A well respected professor from Germany said: 'But how do you tell the robot what to do,' and my only answer was: 'I don't tell the robot what to do... I switch it on, and it does what is in its nature.'" Brooks' story queries the notion that design is an art of control. The scenario of machinery coming alive is not new. From Frankenstein's monster to more recent proclamations that information is alive (see Lash 2004), the testing of the border between the animate and inanimate has been a consistent feature of modernity. At a time of heightened attention to artificial intelligence (AI) and machine learning, it is necessary to push this logic further. Fueled by concerns about the displacement of the self-positing subject, the specter of alienation appears in a new guise. As M. Beatrice Fazi (2018) and Luciana Parisi (2019) argue in quite different terms, the subject of AI replaces consciousness with mindless computation. Cybernetic communication networks have not only absorbed physical and cognitive labor into their circuits but also learn from human culture, reducing patterns of social cooperation to datasets whose value rests in their utility for training machine learning routines for predictive analytical purposes.

Far from central planning techniques executed through the input-output analysis of the Leontief matrix, automation unleashes a form of planning that projects anticipated futures based on correlations discovered in dispersed, non-equivalent datasets. With roots in Soviet planning, the Leontief matrix was essentially a spreadsheet that tracked the dependence of each industry on all others by quantitatively representing inputs and outputs between them in

tabular form. Deployed equally by capitalist corporations and socialist states after World War II, following the move of its progenitor Wassily Leontief to the US in the 1930s, this kind of planning assumed full knowledge of flows across industrial sectors within a bound economy. By contrast, contemporary automation economies rely on data extracted from diverse sources and subject to uneven patterns of distribution and access, according to factors such as proprietary rights, connectivity, and sharing protocols. Uncertainty, partial knowledge, and competition—factors that gave rise to general equilibrium models in economic theory—doubtless play a role in making the conditions under which machine learning provides such seductive answers to questions of planning and future making. Yet these conditions, which to some extent have always been part of market dynamics, do not appear out of nowhere. They result from specific sets of relations between states, markets, and labor forces that begin to mutate in the 1970s. These changes predate the present turn to automation by almost a half century, but it is worth reviewing how the decline of the planner state set the conditions by which social engineering would slowly cede to machine dreams.

Beginning with an exploration of the circumstances that compel the movement away from central planning, this article contends that planning has become a capitalist strategy that seeks to leverage on uncertain futures by calling on algorithmic technologies to bend the production of the future around market positions. I consider the interstitial role of financial speculation in this shift and critically interrogate claims that the social appropriation of datasets, algorithms, and machine learning models through processes of reverse engineering provides a potential means of wresting the future away from capital. Indeed, such efforts are just as likely to be absorbed into the recalibration of processes of capital accumulation. To avoid such absorption, I argue, technical practices of reverse engineering need to articulate to radical political projects and modes of organization. Drawing on computer science studies of adversarial machine learning, I also consider the question of whether reverse engineering of machine learning techniques is technically possible. Ultimately, the article contrasts political claims for reverse engineering with what I call the reverse of engineering, or a program that entails the subordination of data to qualitatively rich futures rather than planning processes that work from the merely evidential and measurable.

## Farewell to the planner state

Is central planning a form of social engineering? The term social engineering has negative connotations in suggesting the application of techniques derived for the design and operation

of machines and structures to the organization of complex human interactions (or, for those who subscribe to more recent orthodoxies on the constitution of society, to associations among humans and nonhumans). Catherine Malabou (2019) argues that critique of automated systems through "the demonization of technology and the inverted valuing of the 'human' and the 'natural'" is increasingly ineffective. Yet the articulation of anti-planning positions linked with the rise of monetarist policies in the 1980s and the intellectual influence of Austrian and Chicago school economics shows that the valuing of automaticity does not necessarily yield a radical, anticapitalist politics. These programs of thought and action emphasized the functioning of markets according to a spontaneous order or catallaxy, to remember the neologism of Friedrich Hayek (1978). The mechanism of price, and not the gathering of statistics by a central agency, would furnish sufficient information and knowledge for efficient market operations. Influential particularly in Anglo-sphere varieties of neoliberalism, this stance against state intervention did not extend to all strains of post-1970s economic reform. In Germany, for instance, the ordoliberal tradition mandated state oversight of capitalist competition. Such a coordinated market economy maintained an important element of the planner state—i.e. the supposed neutrality of the state's administrative function with respect to different fractions of capital. However, the decline of central planning does not result solely from the influence of different schools of neoliberal economic thought.

To understand the move away from central planning, we need to trace transformations across different kinds of states, as this was not a tendency limited to the former first world. Across the three main types of states that emerged in the wake of World War II—the democratic social state, the socialist state, and the developmental state—we can observe common characteristics in the dissolution of planning. No doubt, it is important to keep in mind the limitations of this typology, which reflects the "three worlds" model of Cold War era, and the immense diversity and forms of hybridization that existed within and between these varieties of states (Mezzadra and Neilson 2019, chapter 3). In very general terms, there was a weakening of the state's ability to represent, aggregate, and meaningfully arbitrate between different fractions of capital—an ability that, at least according to Keynesian arguments, lay the foundations for specific forms of planning.[1] In parallel, states lost much of their capacity to guide and secure the reproduction of labor-power—a loss that needs to be understood widely in the context of feminist debates on social reproduction (Dalla Costa and James 1972; Federici 2004; Pateman 1988; Weeks 2011) as well as accounts of the decline of the

welfare state (Piven and Cloward 1997). It is at this junction between the representation of aggregate capital and the reproduction of labor-power that the crisis of central planning becomes evident. Money and finance play a prominent role in these changes, setting the conditions by which capital can control and represent modes of social cooperation in ways that both exceed state power and penetrate into its logics of operation. In this way, the decline of state planning relates to what Étienne Balibar (2013, part 3) calls the "*paradoxical organization, by the State itself, of its incapacity to resist pressures from the financial sector*." Yet to attribute these transformations to finance alone is to ignore the role of other operations of capital, not least those relating to logistics and extractive industries (Cowen 2014; Mezzadra and Neilson 2017).

In many developmental states, for instance, the crisis of planning accompanies a move away from import substitution industrialization to greater reliance on extractive enterprises such as mining and agriculture. This shift, which brings dispossession of Indigenous and peasant populations as well as reliance on logistical techniques and technologies to facilitate exports, ushers in new combinations of high finance and primitive accumulation (Mitra, Samaddar and Sen 2017). Entangled with neocolonial debt relations, neoliberal governance strategies, economic zoning, and severe difficulties in reproducing labour power according to the norm of the "free" wage, the extractive turn of the developmental state presages many aspects of contemporary data economies, at least in relation to the dependence of capital on its multiple outsides and the changing relations between profits and rents. If what I call the reverse of engineering highlights these dynamics in scenarios of automation and machine learning, accounts of postcolonial capitalism do the same for the worlds of mining and agriculture. It is important to emphasize the presence of ruptures as well as continuities between developmental strategies based on extraction of raw materials from the earth's crust and biosphere and computational techniques of data extraction that encounter and draw upon forms and practices of human cooperation and sociality (Mezzadra and Neilson 2017). The category of data colonialism proposed by Nick Couldry and Ulises A. Mejias (2018, 2) suggests the combination of "the predatory extractive practices of historical colonialism with the abstract quantification methods of computing" (see also Thatcher, O'Sullivan and Mahmoudi 2016). Yet, as Imre Szeman (2017, 444) notes, there is a "long distance to travel from the extractive labour practices documented in the photos of Sebastião Salgado to what happens when we fail to turn off the cookies on our browsers." Regardless of one's stance on

colonialism and data extraction, powerful resonances suggest that the decline of central planning links to an explosion in extractive activities.

While patterns of class struggle and globalization interrupted the ability of the social democratic state to mediate the reproduction of labor-power with the representation of aggregate capital, the socialist state's collectivization of labor as the source of property met a series of transformations it was unable to sustain. In the case of the developmental state, the turn to extractive pursuits linked the "reprimarization" of the economy to flexible political technologies of rule, heterogeneous territorial arrangements, and increasingly decentered ways of managing the relation between capital and state. Analyzing the situation in this way provides a thread that joins the crisis of state planning, which it is important to distinguish from a total withdrawal of state intervention, to the perverse forms of planning that have emerged in contemporary data economies. When future making hitches itself to technologies of automation and imaginaries of speed, prophecy, and solutionism, planning becomes perverse not only in its need to consume ever-greater volumes of data but also in its omnivorous appetite for extraction. This perversion is evident across the gamut of contemporary data extractive activities, from the flash crashes triggered by automated financial trading (Borch 2016) to the social sorting effected by credit scoring routines that identify the "unbanked" (Aitken 2017) and the race and gender bias embedded in search and predictive policing algorithms (Crawford 2016).

The analytical line that joins the decline of state planning to data economies should not obscure links between extractive undertakings and other important changes in the developmental state such as the rise of mega-cities, land grabbing, mass migrations, informality, and the growth of criminal businesses and private security industries. It is also important to guard against an interpretation that attributes the forms of planning and extraction that emerge in data economies solely to technological innovation or the capacities of computational machines. As the concept of social engineering implies, we cannot link in a linear way the use of information technology in social and economic planning to an extractivist agenda. Consider the case of Chile, where the turn from import substitution-style *desarrollismo* to an export economy oriented to the extraction of raw materials and agricultural goods was particularly violent. Before the 1973 coup, which brought Augusto Pinochet to power, the government of Salvador Allende engaged British cyberneticist Stafford Beer to design a computer-based system to manage the national economy through the monitoring and coordination of industrial production (Medina 2011). Although Allende

also nationalized the copper mining industry, this engagement registers the possibility of a compatibility between cybernetic modes of planning and the kind of socialist government that existed in Chile from 1970 to 1973. That Beer imagined this system to provide a means of decentralized planning that would involve the input of workers and change the internal workings of government suggests that politics do not map over technology in a straightforward manner.

Nonetheless, we now confront a situation in which computer engineering is central to modes of economic and political organization that rely on dispersed sets of extracted data to enable techniques of prediction and automation that reorient relations between labor forces and machinery. Data infrastructures stretch across distributed geographies of storage and mirroring that build in redundancy to regimes of securitization and incorporate technologies that can rapidly recompose and assemble datasets from information stored across different physical and virtual machines. When it comes to debates about the labor displacing capabilities of automated technologies, arguments from early political economy tend to repeat themselves (Wajcman 2017). Technical knowledge of these practices sparks fears for the substitutability of white-collar professionals whose jobs automation has thus far not threatened (LaGrandeur and Hughes 2017). Additionally, the labor of data production carried out without payment by users of social media and other digital services provides new means of harvesting the fruits of social cooperation. The extraction, agglomeration, and analysis of data have become pivotal to planning techniques that turn accumulated knowledge about populations and social relations to ends of marketing, surveillance, and logistical coordination. Under these conditions, the representation of aggregate capital falls beyond the ambit of states, although states also willingly absorb and integrate such automated systems. This does not mean we can easily identify planetary-scale digital platforms ("stacks") as the primary configurations of governance specific to automated economies, notwithstanding the compelling style in which Benjamin Bratton (2015) makes arguments in this regard. There is a need for nuanced analysis of the changing geopolitical coordinates that cross the decision-making capabilities of automated technologies with the sovereign prerogatives of states and the operations of capital, keeping in mind factors such as emerging trade wars, the emergence of China as technological power, and the new forms of polity generated by media infrastructures (Easterling 2014).

Although claims for the power, promise, and agency of data have been a familiar feature of the contemporary capitalist landscape for over a decade now, they by no means apply only to

economic planning. Industry boosters argue that the arts of data analysis and engineering will benefit many different spheres and domains, including public administration, individual lifestyles, and the human body. David Beer (2018) lists a series of features that these advocates regularly contend will result from modes of data correlation, monitoring, and planning: real-time decision-making, accessible knowledge, predictive potential, insight generation, comprehensive analytical scope, and a general quality of "smartness." Furthermore, Beer details the operations of what he calls the data gaze, turning attention to the work of data analysts and engineers whose professional and diagnostic engagement "seeks to make everything analysable and surveys its own ability to leave nothing outside its view" (127). Combined with a sense of needing to act urgently to harness an accelerating world, this analytical gaze performs a role of ordering and legitimation, adding to the perception that data engineering uncovers patterns deeply embedded in the social condition. There is a theological zeal to this search for patterns, which practitioners of reverse engineering risk to reproduce and perpetuate. However, the hunger of data economies derives less from a sense of preordainment than a conviction that these patterns provide a kind of pre-economic foundation for value. From here, it is easy to see how claims for reverse engineering can inflect political projects that seek to tackle the ubiquity of these convictions by analyzing the components and interrelationships of technical systems and articulating them to social struggles in ways that work against the ends of speculation and surveillance to which these systems are frequently turned. The remainder of this article critically assesses such claims, arguing that the question of their feasibility lies not only in their technical practicability but also in the challenge of joining the results of reverse engineering to effective modes of political organization.

## Reverse engineering

What is act of reverse engineering? In *Reverse Engineering: Mechanisms, Structures, Systems & Materials* (2013), Robert W. Messler describes reverse engineering as "the process for discovering the fundamental principles that underlie and enable a device, object, product, substance, material, structure, assembly, or system through the systematic analysis of its structure and, if possible, its function and operation" (6). Recognizing the importance of reverse engineering across society and history, Messler emphasizes the moments of teardown, dissection, inference, and deduction. For him, reverse engineering is a process of

backward problem solving that contrasts “forward engineering” in deriving inputs, parameters, and observations from outputs, data, and knowledge rather than vice versa. Other commentators emphasize how reverse engineering opens opportunities for technological cross-pollination (Wang 2011), pedagogy (Otto and Wood 2000), or improved system performance (Ingle 1994). At a certain level, the question of reverse engineering, insofar as it links to the issue of what engineers know and how they know it, raises the problem of how engineering differs from art, science, and even magic. Because reverse engineering involves the acquisition of engineering knowledge from objects that are themselves outcomes of such knowledge, it functions along a teleological trajectory. Paradoxically, then, while reverse engineering implies working backwards to understand the structure, functions, and operations of an artefact and may involve experimentation and encounters with contingency, it is a heavily goal oriented activity.

The uses envisioned for reverse engineering in contemporary activism and political life differ significantly from those rehearsed in the technical literature: military and commercial espionage, product security analysis, improvement of documentation shortcomings, etc. One area in which politically minded software designers put reverse engineering to use is in the making and operation of alternative social media. Robert W. Gehl (2014) documents and analyzes the techniques, limitations, and contradictions involved in reverse engineering mainstream social media platforms such as Facebook and Twitter. Part of Gehl’s investigation concerns the making and workings of alternative platforms such as Crabgrass, Diaspora, and Quitter—artefacts that incorporate not only elements reversed engineered from mainstream platforms but also techniques of “heterogeneous engineering” that involve “a reinterpretation of the ontological reality of a machine” (14). In this regard, Gehl refers to features such as Crabgrass’s use of the group rather than the individual as its main organizing principle. More generally, he advocates the making of “socialized media” that are “decentralized, transparent, encrypted, antiarchival, stored on free hardware, and geared toward collective politics over atomization and depth over immediacy and surfaces” (19-20). However, Gehl also recognizes that the “network effects” of social media monopolies (i.e. the way in which people use mainstream platforms because everyone else does) make “hegemonic social media’s ‘ghostly frames’ haunt any efforts to reverse engineer social media and build alternatives” (161).

The opportunities to build alternative social media initiatives into a genuinely “critical reverse engineering” occupy Gehl (2017) in a subsequent article that explores the resonances

between reverse engineering and Michel Foucault's method of genealogy. Here, the question of how reverse engineering yields not only technical knowledge but also knowledge about organizational rules and structures, errors, communication between designers, and the evolution of software is key. In "What is Enlightenment" (1984), Foucault argues that insofar as genealogy is "a historical investigation into the events that have led us to constitute ourselves and to recognize ourselves as subjects of what we are doing, thinking, saying" (45), it must pose questions about the conditions of possibility for such recognition and the making of the present. Engineering seems unable to grapple with these questions. Yet, the capacity of reverse engineering to inform projects of forensic investigation means it can verge toward such critical genealogical ends. Consider the work of London-based research group Forensic Architecture (Weizman 2017), which incorporates techniques of reverse engineering into its practice of detecting traces of violence and culpability in ruins and other sites of architectural evidence, primarily associated with war in the Middle East. The group's reconstruction of the secret Syrian torture prison known as Saydnaya involved the building of an interactive computer model based on "echo profiling" and other pieces of acoustic and visual evidence gathered from survivors. Although stemming from an epistemology that correlates data with reality, the intention and effects of this exercise were political and humanitarian, involving a collaboration with Amnesty International and boosting knowledge and concern about the Saydnaya facility in global public culture. This and other so-called good data (Daly, Devitt and Mann 2019) projects deploy reverse engineering techniques in ways answerable to activist demands and critical genealogical investigations that aim to make the present thinkable.

Things become trickier when it comes to routines of predictive analytics based on machine learning methods that train on large corpuses of extracted data and serve the ambitions of enterprises aiming to optimize operations and improve market positions. If this is a domain in which planning accords capital's operations, it is also one in which reverse engineering encounters roadblocks and dead-ends. This situation eventuates as much from a series of technical conditions as from organizational and commercial factors. Because machine learning requires large datasets to train and function, effective reverse engineering of their operations involves not only an understanding of the models and/or algorithms that they deploy but also knowledge of or access to the datasets themselves. Differently from the alternative social media platforms favored in Gehl's analysis, which reverse engineer applications that extract data from user activity, the reverse engineering of machine learning

technologies must approach data as a *prima facie* rather than a *post hoc* question. Consequently, issues of ownership and access to data become part of the process, and these introduce barriers that technical workarounds struggle to overcome.

Data access issues often occupy the ground of digital divide claims based in sociological visions of stratification, visions of media bias, or rights discourses linked to liberal conceptions of subjectivity. In the case of the reverse engineering of machine learning applications, the issues are primarily technical. The possibilities for seizing and undoing technologies of control in ways that turn them to ends of radical planning meet the blank wall of data security. Nonetheless, in the case of cloud-based machine learning services, there do exist claims for the feasibility of reverse engineering machine learning models and algorithms without access to training sets. Tramèr et al. (2016, 601) "explore *model extraction attacks*, which exploit the tension between query access and confidentiality in ML [machine learning] models." "In such attacks," they contend, "an adversary with black-box access, but no prior knowledge of an ML model's parameters or training sets" can "extract target ML models with near perfect fidelity for popular model classes including logistic regression, neural networks, and decision trees" (601).

At stake in these claims is the deployment of so-called adversarial machine learning techniques, which, as Biggio and Roli (2018) explain, derive from methods invented by spam emailers in the early 2000s to get around filtering protocols by making carefully crafted changes in the content of emails. Since that time, adversarial machine learning has evolved into a complex and multifaceted craft, usually divided into attacks that occur at training time (poisoning) and those that occur at testing (evasion). Lack of training set knowledge becomes relevant in so-called black-box attacks, where the reverse engineer supposedly has access neither to this data nor to the learning algorithm. As Biggio and Roli (2018, 320) point out, however, the success of such operations depends on the attacker having specific prior knowledge. The reverse engineer must know that an application "is designed to perform a specific task (e.g. object recognition in images, malware classification, etc.)." In addition, the attacker must know "which kind of data has been used to train" an application; for example, "if a deep network aims to discriminate among classes of animals, then it is clear that it has been trained on images of such animals." These conditions, as well as the closing of loopholes by companies aware of the possibility of such attacks, impose a tight set of parameters for the reverse engineering of machine learning processes.

The narrow margins for the reverse engineering of machine learning widen if one moves from black box scenarios to gray or white box ones; the former assuming partial knowledge of algorithms and training sets and the latter assuming complete knowledge. It also possible, as is the case in the Forensic Architecture example discussed earlier, to fill in knowledge from other sources, including technical manuals, computer science and software engineering publications, industry protocols, international standards, open data, or reports of human experiences of interfacing with machine learning technologies. Such sources can provide a basis for approximations, which may not allow reverse engineering to replicate fully the kinds of decisions or predictions AI systems make but nonetheless allow insight into their workings. In any case, the technical difficulties surrounding the reverse engineering of machine learning routines should not be seen as insurmountable, especially given the continual cat and mouse game played between hackers and security experts. Whatever the possibilities at stake, the issue remains as to how the reverse engineering of machine learning processes might articulate to projects of radical planning that seek to turn capital's codes against its drive toward accumulation and valorization. I confront this political question in the final section of the article.

## The reverse of engineering

What does it mean to speak of the reverse of engineering? The concept does not necessarily imply the undoing or negation of engineering processes, including those used in reverse engineering. The reverse of engineering is not some kind of antithesis that pushes engineering toward a dialectically given totality, where the latter is a philosophical category that posits the problem of how society understands itself. Rather, it operates beyond any dialectic and measure, attending not to techniques of planning or prediction based in the quantitative reduction of life to data but to qualitative values and forms of life, divorced from transcendental surveillance and relational in their being. Furthermore, the reverse of engineering produces a "qualitative excess" that operates "beyond the myth of equal exchange, the fairness of the market, and the rhetoric of commensuration" (Massumi 2018, 8). It creates an outside or beyond of value as defined by capital or interpreted through the lens of value-form theory. Sure, value-form theory posits a path beyond the labor theory of value by emphasizing the processual relation of the different forms of value specified by Marx (1977) in *Capital*, Vol.1—"in one moment money, the next the commodities that compose the labour process (including the commodity labour-power), the next the commodity product, and then again money—whilst always maintaining a relation in its

money form to its commodity form and vice versa" (Endnotes 2010). Yet the question of how to break this relation remains open. What I am calling the reverse of engineering neither posits the liberation of labor in a planned economy nor seeks an ontological horizon of communization separated from challenges of organization. Rather, it raises the challenge of warding away capital's tendency to capture and incorporate its multiple outsides. This process of warding away involves not only recognizing that qualitative difference is itself susceptible to logics of extraction but also devising techniques that work against such ends. The reverse of engineering is thus not a coherent political program or a general model for a new practice of planning. Rather, it evaluates and directs the workings of operations, generating modes of existence that can confront, negotiate, and possibly break capital's rule. These modes of existence can coexist with or articulate to reverse engineering techniques, but such forms of articulation must be politically constructed or organized. The reverse of engineering thus implies modes of collective being and action that are open to contestation and composed of heterogeneous tendencies. If, metaphorically speaking, reverse engineering implies opening the black box, the reverse of engineering questions this trope of secrecy and revelation.

The metaphor of the black box provides a powerful register of the opacity of many of the technical and commercial operations that propel contemporary capitalism. Whether understood as figure of the social itself (Pasquale 2015) or a node within a wider network of actors and associations that assemble the social (Callon 1986), the abstract notion of the black box describes a set of relations that can be potentially measured or specified by tracing the conversion of inputs into outputs. Reverse engineering promises a means of opening the black box to reveal secrets and processes that are otherwise inaccessible. In this sense, calling for the articulation of reverse engineering to radical political projects registers the need for a politics that grapples with technical instruments and knowledge, and, in doing so, refuses a valorization of the human based in a reactive rejection of technology. It is important to emphasize this basic point and its importance to the argument of this article. At a time when the mediation of social relations by computational machines and the data on which they run has become increasingly central to political and economic life, it would be foolish to ignore or underestimate the political potential carried by the arts of engineering.

However, there is also a need to recognize the limits of the metaphor of the black box. In an earlier article written with Sandro Mezzadra (Mezzadra and Neilson 2013), I attempt to highlight these limits by exploring the relation between the trigger and the outcome of an

operation in terms that exceed not only linear conceptions of time and causality but also political theoretical notions of performance and event. Put simply, the metaphor of the black box not only lets political theory and practice off the hook when it comes to an engagement with technical knowledge and processes but also restricts our ability to understand the relation between an operation's internal workings and its outside environment. Insofar as an operation is effectual rather than performative, it is productive of something other than itself. Inversely, insofar as it is performative rather than effectual, an operation fabricates a world in relation to its own premises. We need an approach that "brings into relief the combination of social activities, technical codes and devices that make an operation possible" but that also "allows us to look at the outcome of an operation without taking it for granted" (Mezzadra and Neilson 2013, 16). The figure of the black box obscures both these possibilities, removing the onus to identify the conditions of possibility for an operation and drawing attention away from its effects by rendering its internal workings at once crucial and unknowable. If techniques of reverse engineering allow us to open the black box, I suggest, the resulting knowledge and artefacts become politically useful only insofar as they operate in ways that engage these conditions and effects.

I will never forget the moment when my collaborator Ned Rossiter and I met with a group of computer engineers to discuss their knowledge of the enterprise resource planning system SAP, one of the most widely disseminated proprietary software platforms for business operations and management of corporate services, finance, and human capital. We had approached these programmers in the context of a research project about the software and infrastructural dimensions of logistical practices and their relevance for labor forces, populations, and the making of worlds. When our interlocutors asked why we were interested to meet with them, we commented naively that we thought they could help us "open the black box" of SAP's operations. They replied by asking "what's the black box?" This mildly surprising response made sense on reflection. Why should software engineers deeply engaged with SAP's codes, commands, and protocols consider the platform's operations obscure or unknowable? As our work on the project proceeded and we learned more about the logistical operations of SAP and similar platforms, the remark acquired more weight. By projecting our paranoias and fantasies into the black box, we were investing in the hope that understanding these operations would give us a privileged means of intervening in scenarios of labor exploitation and population management constitutive to forms of planning and enterprise in the "societies of control" (Deleuze 1992). In fact, the knowledge we gained was not

immediately useful in this regard, at least without due attention to its translation and application within contexts of labor struggle and social resistance that had heretofore produced political subjects in separation from such knowledge.

In the end, it is necessary to make a similar point about reverse engineering. However necessary the integration of engineering knowledge into repertoires of political struggle at a time when automation and data analytics begin to dominate planning imaginaries and practices, such integration cannot occur based on engineering knowledge alone. In other words, reverse engineering is not sufficient to meet the challenges faced by contemporary political action and organization. Never mind that many political movements use social media platforms or that networked forms of organization have become as ubiquitous in the world of corporations and states as in the bottom-up, autonomous tactics of the "new institutional forms" that Geert Lovink and Ned Rossiter (2018, 8) call organized networks. To articulate knowledge and artifacts derived from reverse engineering to struggles for justice and equality requires the qualitative forms of knowledge and practice that I describe as the reverse of engineering. As discussed earlier, such forms of knowledge and practice imply the seizing of tools and their deployment in contexts far from or even opposed to their initial intent or design. In my understanding, the reverse of engineering is a deeply ethical process that produces qualities and values that resist the capture and reduction perpetrated by data extraction and the economic logic of the market. When planning begins to incorporate engineered visions of the future that cannot escape the gaze of data analytics, the need for measures that work within and against these dominant methods of pattern recognition and correlation becomes acute. To recognize this need is not to call for a return to traditional modes of organization such as the trade union or party. Rather, it is a plea to leave the future open to experimental modes of activism and contestation, susceptible to contingency as much as determination, and fuller and more unknowable than data-driven predictions and automated planning techniques might hope to fathom.

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[1] I use the term fractions of capital as deployed in Marx's *Capital*, Vol. 2 (1978) to refer to independent fractions of total capital. Sablowski (2008) explains that the term *Kapitalfraktionen* does not necessarily refer to capital invested in specific economic sectors, and, even when it does, divergences and clashes of interest challenge the unity of such fractions. See Poulantzas (1973) for the classical 1970s argument about the state as an arena for competition between different fractions of capital understood as the political organization of individual capitals with interests in common. Clarke (1978) offers a critique of this position.