

Robots in the Boardroom: Artificial Intelligence and Corporate Law

Florian Möslein*

Due to its rapid technological development, artificial intelligence will enter corporate boardrooms in the very near future. This paper explores the interplay between artificial intelligence and corporate law, and analyzes how the two fit together. Do current corporate law rules match the challenges posed by artificial intelligence, or do they need to be adapted? More specifically, it focuses on the directors of corporations. We consider the extent to which human directors should be allowed – or required – to rely on artificial intelligence. Moreover, technology will probably soon offer the possibility of artificial intelligence not only supporting directors, but even replacing them. Another question is therefore whether or not such a replacement is legally admissible. At any rate, the legal strategies currently adopted by corporate law are tailored to human directors. This chapter tests whether those strategies would still be suitable for boardrooms filled with robo-directors. It concludes that corporate law is highly relevant for the use of artificial intelligence in corporations, but that it will also need to be adapted to the challenges posed by this technology. In that sense, the interplay between artificial intelligence and corporate law promises to be dynamic in both directions.

Introduction

Back in 2014, the media reported that Deep Knowledge Ventures, a Hong Kong-based venture capital firm, had appointed an algorithm named *Vital* (Validating Investment Tool for Advancing Life Sciences) to its board of directors. According to these reports, the algorithm was given the right to “vote on whether the firm makes an investment in a specific company or not”, just like the other – human – members of the board.¹ *Vital* was appointed because of its ability to “automate due diligence and use historical data-sets to uncover trends that are not immediately obvious to humans surveying top-line data”.² For instance, *Vital* helped to approve two investment decisions, namely those to fund Insilico Medicine, an enterprise which develops computer-assisted methods for drug discovery in aging research, and Pathway Pharmaceuticals, which selects and rates personalized cancer therapies on the basis of a platform technology.³ Despite this impressive track record, *Vital* admittedly was not yet artificially intelligent in the proper sense.⁴ In fact, the algorithm will soon have to retire, since

* Prof. Dr. Florian Möslein, Dipl.-Kfm., LL.M. (London), is Professor of Law at the Philipps-Universität Marburg. He is director of the Institute of Commercial, Business and Labor Law and holds the Chair for Civil Law, German and European Business Law.

¹ R. WILE, “A Venture Capital Firm Just Named an Algorithm to its Board of Directors”, Business Insider, May 13, 2014, available at <http://www.businessinsider.com/vital-named-to-board-2014-5?IR=T>.

² E. ZOLFAGHARIFARD, “Would you take orders from a Robot? An artificial intelligence becomes the world's first company director”, Daily Mail, May 19, 2014, available at <http://www.dailymail.co.uk/sciencetech/article-2632920/Would-orders-ROBOT-Artificial-intelligence-world-s-company-director-Japan.html>.

³ For more details, cf. the public release of the Biogerontology Research Foundation, “Deep Knowledge Ventures announces new investment fund for life sciences and aging research”, EurekAlert!, December 16, 2015, available at https://www.eurekalert.org/pub_releases/2015-12/brf-dkv121515.php.

⁴ According to a collaborator at Deep Knowledge Ventures, “it's not what you'd call AI at this stage, but that is the long-term goal”, cf. R. WILE (n. 1).

a much more intelligent *Vital 2.0* is due to be launched in the second half of 2017.⁵ Moreover, *Vital* was initially not granted an equal vote on all financial decisions made by the company. Legally speaking, it has not even acquired the status of corporate director under the corporate laws of Hong Kong. It is simply treated “as a member of [the] board with observer status” by its fellow (human) directors.⁶ Nevertheless, *Vital* has widely been acknowledged as the “world’s first artificial intelligence company director”.⁷

In any event, *Vital*’s (quasi) appointment to the board marks an important if not fundamental step for corporate law. On the one hand, it demonstrates the impact of artificial intelligence on corporate decision-making. Where business decisions need to be taken on the basis of numerous and complex sets of data, computer algorithms are increasingly superior to humans in taking such decisions, particularly if artificial intelligence and machine learning allow those algorithms to permanently improve their respective capabilities. In fact, artificial intelligence is increasingly being used to support management decisions across many business sectors, above all in the financial industry.⁸ Computational progress and digitalization will therefore inevitably lead to corporate directors being supported – if not replaced – by artificial intelligence. *Dmitry Kaminskiy*, founding partner of Deep Knowledge Ventures and the human mind that created *Vital*, estimates that most duties in typical corporations will be automated within five to ten years, and that artificial intelligence systems will, at least in some cases, be able to make decisions themselves, without any human support.⁹ Robo-directors, it seems, are about to take over corporate boards on a broad scale: “The day may come when robo-boards and robo-managers play a part in augmenting human governance boards in driving decisions and executing digital strategies”.¹⁰

Corporate law, on the other hand, is about to face substantial challenges as a result of these technological advances. After all, decisions made by corporate directors are counted among the key topics of that area of law. Once robo-directors enter the boardroom and are able to vote in board decisions, corporate law will have to cope with novel, unprecedented types of legal questions. So far, its legal strategies to regulate, steer and control corporate decision-making are tailored to human decision-makers, not to algorithms or artificial intelligence. If artificial intelligence is wired differently to human intelligence – which seems quite likely, given its persistently different analytical structure – then those traditional corporate law rules may no longer fit new business realities with robo-directors present in the boardroom. For instance, corporate laws unanimously demand that directors undertake the core duty to act

⁵ N. BURRIDGE, “Artificial intelligence gets a seat in the boardroom”, *Nikkei Asian Review*, May 10, 2017, available at <http://asia.nikkei.com/Business/Companies/Artificial-intelligence-gets-a-seat-in-the-boardroom>.

⁶ See N. BURRIDGE (previous n.), citing *Dmitry Kaminskiy*, founding management partner of Deep Knowledge Ventures.

⁷ Cf. the title of E. ZOLFAGHARIFARD (n. 2).

⁸ N. BURRIDGE (n. 6). See also E. BRYNJOLFSSON/A. MCAFEE, “The Business of Artificial Intelligence”, *Harvard Business Review*, July 18, 2017, available at <https://hbr.org/cover-story/2017/07/the-business-of-artificial-intelligence>.

⁹ Cf. again N. BURRIDGE (n. 6).

¹⁰ M. HILB, “Toward an Integrated Framework for Governance of Digitalization”, in: id. (ed.), *Governance of Digitalization* (2017), p. 11, at 20; more extensively T. FEATHERSTONE, “Governance in the new machine age”, Australian Institute of Company Directors, March 24, 2017, available at <https://aicd.companydirectors.com.au/advocacy/governance-leadership-centre/governance-driving-performance/governance-in-the-new-machine-age>.

honestly and in good faith.¹¹ Robo-directors such as *Vital*, however, are credited with making more logical decisions than human directors.¹² That duty, which is based on human beliefs and incentives, does not fit well with these decision-making patterns of robo-directors. In consequence, the rise of artificial intelligence requires corporate law to reconsider some of its key rules in order to test their suitability for artificially intelligent directors. The emergence of decentralized autonomous organizations (DAOs) will challenge corporate law even further. These organizations are run according to rules encoded as computer programs (so-called smart contracts); these rules, as well as their transaction record maintained on a blockchain, mean that they are therefore able to operate entirely without human involvement.¹³ However, even the legal status of DAOs remains unclear so far.¹⁴ Some argue that the idea of an entirely autonomous business entity “directly conflicts with the architecture and gatekeeping functions of our current legal frameworks”.¹⁵ On the other hand, promises of an entirely “digital jurisdiction” in which they can operate¹⁶ seem unrealistic, since experience has already shown that such organizations are prone to human abuse in spite of their algorithm-based setting.¹⁷ In fact, lawyers, regulators and legal scholars will have to figure out whether and how existing legal rules can be applied to these fundamentally new technological phenomena, or whether new rules will have to be set.¹⁸ For instance, the Securities and Exchange Commission has recently made clear that tokens raised in Initial Coin Offerings by DAOs may be securities, and are therefore subject to federal securities laws.¹⁹ In a similar vein, corporate law will arguably also continue to play a role in terms of artificial intelligence and decentralized autonomous organizations, but it will have to respond to these technological challenges.

¹¹ See, for instance, M. EISENBERG, “The Duty of Good Faith in Corporate Law”, *31 Del. J. Corp. L.* (2006), p. 1; L. STRINE/ L. HAMERMESH/ R. BALOTTI/ J. GORRIS, “Loyalty’s Core Demand: The Defining Role Of Good Faith in Corporation Law”, *98 Geo. L. Rev.* (2010), p. 629 (both with regard to US corporate law).

¹² Cf. N. BURRIDGE (n. 6), citing *Dmitry Kaminskiy*, founding management partner of Deep Knowledge Ventures.

¹³ For more extensive descriptions, see for instance H. DIEDRICH, *Ethereum*, 2016, pp. 180-186; M. SWAN, *Blockchain: Blueprint for a New Economy*, 2015, p. xx.

¹⁴ Cf. N. POPPER, “A Venture Fund With Plenty of Virtual Capital, but No Capitalist”, *New York Times*, May 21, 2016, available at <https://www.nytimes.com/2016/05/22/business/dealbook/crypto-ether-bitcoin-currency.html>; see also H. DIEDRICH (previous n.), p. 184 *et seq.*

¹⁵ H. DIEDRICH (n. 13), p. 184; citing C. CHOI; more extensively A: WRIGHT/P. DE FILIPPI, “Decentralized Blockchain Technology and the Rise of Lex Cryptographia”, Working Paper, 2015, available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2580664.

¹⁶ This is the stated goal of Aragon Networks, a DAO that will let organizations opt into it and use its services, also providing a built-in governance system; see L. CUENDE/ J. IZQUIERDO, “Aragon Network – A Decentralized Infrastructure for Value Exchange”, White Paper, April 20, 2017, p. 16, available at <https://github.com/aragon/whitepaper/blob/master/Aragon%20Whitepaper.pdf>: “The Aragon Network (AN) will be the first decentralized autonomous organization whose goal is to act as a digital jurisdiction that makes it extremely easy and friendly for organizations, entrepreneurs and investors to operate”.

¹⁷ In 2016, an investor-directed venture capital fund run as a DAO (and called “The DAO”) was hacked and one third of its funds was drained; see more extensively N. POPPER, “A Hacking of More Than \$50 Million Dashes Hopes in the World of Virtual Currency”, *New York Times*, June 17, 2016, available at <https://www.nytimes.com/2016/06/18/business/dealbook/hacker-may-have-removed-more-than-50-million-from-experimental-cybercurrency-project.html>.

¹⁸ H. DIEDRICH (n. 13), p. 185; similar considerations, at the time with respect to the challenges of cyberspace: L. LESSIG, “The Law of the Horse: What Cyberlaw Might Teach”, *113 Harv. L. Rev.* (1999), p. 501.

¹⁹ SECURITIES AND EXCHANGE COMMISSION, “Report of Investigation Pursuant to Section 21(a) of the Securities Exchange Act of 1934: The DAO”, Release No. 81207, July 25, 2017, available at <https://www.sec.gov/litigation/investreport/34-81207.pdf>.

So far, however, corporate law has not kept pace with these advances in artificial intelligence and computer algorithms. While the general challenges of digitalization are being increasingly (albeit still hesitantly, given their impact) discussed, the debate is largely based on an overly narrow understanding of digitalization. For instance, a prominent expert group, established by the European Commission in May 2014 to help advise on issues of company law, based its recent *Report on digitalisation in company law* on the following definition: “By ‘digitalisation’ we mean the representation of communication in writing or sound by electronic means, and the concept thus concerns electronic communication [...]”.²⁰ An in-depth analysis requested by the European Parliament’s Committee on Legal Affairs has taken a very similar approach.²¹ Restricting digitalization to just electronic communication (some sort of telephone or fax message 4.0, so to say), however, inevitably results in ignoring the challenges of algorithms and artificial intelligence.

My claim is that these latter challenges are much more fundamental for corporate law than those of electronic communication. While I agree that digitalization fundamentally changes businesses and that legal scholars therefore need to focus on these changes and their impact on corporate law, I assume that digitalization has many additional facets than those currently being discussed, and that algorithms and artificial intelligence do in fact count among its core drivers.²² The core research question therefore aims to examine the intersection of artificial intelligence and corporate law, and asks how the two fit together. Do current corporate law rules match the challenges of artificial intelligence, or do they need to be adapted? More specifically, I will focus on the corporate law rules regulating directors and their business decisions. This contribution is divided into four parts. I begin with a general overview of corporate law in order to analyze where artificial intelligence fits in; it will show that its importance is greatest where directors are concerned. In part II, I explore the role of artificial intelligence as a supportive tool. To what extent should human directors be allowed to rely on artificial intelligence? Or could they even be compelled by corporate law to make use of it? Part III goes further, by assuming that artificial intelligence has the potential not only to support, but also to replace, human directors. While this scenario is technically imaginable, the question is whether or such a replacement is legally permissible. The final Part, III, will then test the suitability of current legal strategies of corporate law for robo-directors. I conclude that corporate law is highly relevant for the use of artificial intelligence, but that it will also require various adaptations and refinements in order to cope with the challenges posed by artificial intelligence.

I. Artificial Intelligence and the Anatomy of Corporate Law

²⁰ INFORMAL COMPANY LAW EXPERT GROUP (ICLEG), “Report on digitalisation in company law”, March 2016, available at http://ec.europa.eu/justice/civil/files/company-law/icleg-report-on-digitalisation-24-march-2016_en.pdf, p. 6 (para 1.1.).

²¹ V. KNAPP, “What are the issues relating to digitalisation in company law?”, June 2016, available at [http://www.europarl.europa.eu/RegData/etudes/IDAN/2016/556961/IPOL_IDA\(2016\)556961_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/IDAN/2016/556961/IPOL_IDA(2016)556961_EN.pdf); see also U. BERTSCHINGER, “Aktienrecht im digitalen Zeitalter”, in: Rechtswissenschaftliche Abteilung der Universität St. Gallen (ed.), *Recht im digitalen Zeitalter – Festgabe Schweizerischer Juristentag*, 2015, p. 167.

²² Very few publications have so far taken a similar slant. See, however, L. LOPUCKI, “Algorithmic Entities”, 95 *Washington University Law Review (Forthcoming)*, Working Paper available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2954173; similar, but with a focus on contract law: L. SCHOLZ, “Algorithmic Contracts”, 20 *Stanford Technology Law Review (Forthcoming 2017)*, Working Paper available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2747701.

To begin with, we need to more precisely consider the specific points at which artificial intelligence enters the realm of corporate law. This analysis requires a brief sketch of corporate law and its regulatory functions. In turn, such a description requires some basic understanding of the nature of corporations. It is helpful to build these considerations on the leading comparative overview of corporate law, a book authored by nearly a dozen international experts in the field, recently published in its third edition and entitled “The Anatomy of Corporate Law”.²³ In order to carry this biological metaphor further, we need to analyze which body parts of the corporation would be most affected if corporate bodies were to incorporate artificial intelligence.

1. Corporate Bodies

Corporations are legal entities that are separate and distinct from their owners. Whereas in an economic perspective, corporations are simply vehicles for investors to jointly operate their businesses, they are in legal discourse commonly referred to as legal persons. This means that they enjoy similar rights and duties to those possessed by human individuals and are able, for instance, to enter into contracts, to own assets and to sue and be sued. Even though many of their specific features depend upon the applicable legal framework, which differs between jurisdictions, corporate bodies are nonetheless characterized by a common structure that applies irrespective of jurisdictions. The authors of the “Anatomy” name five basic legal characteristics shared by corporations all over the world.²⁴ Firstly, corporations have a separate legal personality, which not only enables them to enjoy rights and duties, but also separates their patrimony from the assets that are personally owned by the shareholders.²⁵ A second characteristic is their limited liability: while the creditors of a corporation can make claims against the assets owned by said corporation, they are not able to make claims against assets held individually by the corporation’s shareholders.²⁶ The third feature closely interacts with these first two. It consists of the transferability of shares, which makes the operation of a corporation’s business independent of changes in the ownership of its shares.²⁷ A fourth, particularly important, characteristic is the delegation of management to a board of directors. The board is periodically elected by the corporation’s shareholders, and has principal authority over the corporation’s affairs because it is assigned responsibility for all but the most fundamental decisions. The fifth and final characteristic consists of investor ownership, which means that both the right to vote, and thereby the right to participate in control and the right

²³ J. ARMOUR/L. ENRIQUES et al., *The Anatomy of Corporate Law: A Comparative and Functional Approach* (3rd edn., Oxford University Press 2017).

²⁴ More extensively on the following: J. ARMOUR/ L. ENRIQUES et al., *The Anatomy of Corporate Law* (previous n.), pp. 5-15.

²⁵ This asset partitioning (or “entity shielding”) includes aspects, namely creditor priority and liquidation protection, which are both central to organizational law, see H. HANSMANN/ R. KRAAKMAN, “The Essential Role of Organizational Law”, *110 Yale Law Journal* (2000), p. 387 *et seq.*; cf. also H. HANSMANN/ R. KRAAKMAN/ R. SQUIRE, “Law and the Rise of the Firm”, *119 Harvard Law Review* (2006), p. 1335 *et seq.*

²⁶ Most importantly, limited liability thereby makes investment diversification possible, cf. H. MANNE, “Our Two Corporation Systems: Law and Economics”, *53 Virginia Law Review* (1967), p. 259, 262.

²⁷ If there were no liquidation protection or limited liability, the value of shares would depend on the creditworthiness of the corporation’s shareholders, which would in turn constitute a major impediment for the transferability of shares, cf. P. HALPERN/ M. TREBILCOCK/ S. TURNBULL, “An Economic Analysis of Limited Liability in Corporation Law”, *30 University of Toronto Law Journal* (1980), pp. 117, 136-138.

to receive distributed profits, are typically proportional to the amount of capital contributed to the firm.

2. Functions of Corporate Law

For corporate bodies, law obviously plays a vital role. As legal entities, they owe their very existence to the applicable legal framework: “A principal function of corporate law is to provide business enterprises with a legal form that possesses these five core attributes”.²⁸ If the law did not provide such a form, corporations would not even be able to come into being. Yet, the provision of a legal form is not limited to the single act of bestowing legal personality; it also requires rules to establish the basic structure of the corporation. In addition, however, corporate law has a second function, which aims at “facilitating coordination between participants in the corporate enterprise”, thereby “reducing the ongoing costs of organizing business through the corporate form”.²⁹ Otherwise, this coordination within corporations would risk being hampered by so-called principal-agent problems, which arise whenever one party (the “principal”) relies upon the actions taken by another party (the “agent”) that affect the former party’s welfare. In such situations, the principal may worry that the agent is not acting in the principal’s interest, but rather in his own.³⁰ In corporations, three such agency relationships are prevalent: (1.) between the firm’s owner and its hired managers, (2.) between majority shareholders and minority shareholders and (3.) between the firm and other parties, like creditors, employees and customers.³¹ The key conflict within the first agency relationship has appropriately been described by *Adam Smith* in his magnum opus ‘The Wealth of Nations’: “The directors of such companies”, he wrote, “being the managers rather of other people’s money rather than of their own, it cannot well be expected that they should watch over it with the same anxious vigilance with which partners in a private company watch over their own [...] Negligence and profusion, therefore, must always prevail, more or less, in the management of the affairs of such a company”.³² In general, the delegation of decision-making power to an agent creates the risk that this agent will be disloyal or incompetent.³³ Corporate law, in turn, follows a number of different legal strategies to mitigate these agency problems, namely by providing for constraints or incentives, or by attributing appointment or decision rights. For instance, directors are subject to corporate law duties, which prohibit certain forms of self-interested behavior.³⁴

3. Incorporation of Artificial Intelligence into Corporations

²⁸ J. ARMOUR/ L. ENRIQUES et al., *The Anatomy of Corporate Law* (n. 23), p. 1.

²⁹ *Ibid.*, p. 2.

³⁰ *Ibid.*, p. 29; see also M. JENSEN/ W. MECKLING, “Theory of the Firm: Managerial behavior, agency costs and ownership structure”, 3 *Journal of Financial Economics* (1976), pp. 305 et seq.

³¹ *Ibid.*, p. 29; cf also R. BAHAR/ A. MORAND, “Taking conflict of interest in corporate law seriously – direct and indirect rules addressing the agency problem”, in: A. Peters/ L. Handschin (eds.) *Conflict of Interest in Global, Public and Corporate Governance* (2012), 308.

³² A. SMITH, “An Inquiry into the Nature and Causes of the Wealth of Nations” (1778, quoted from the edition edited by R. Campbell/ A. Todd, 1976, vol. 2), p. 741, at para. 18.

³³ Cf. A. CAHN/ D. DONALD, *Comparative Corporate Law* (2010), p. 299.

³⁴ Described extensively, for instance, in the contributions in A. Paolini (ed.), *Research Handbook on Directors’ Duties* (2014).

Into which part of this basic structure of corporations can artificial intelligence be incorporated? Which body part of their anatomy does it affect? The answer to this requires some thought about the nature of artificial intelligence. As with the difficulties of figuring out the universally applicable characteristics of corporations, however, the definition of artificial intelligence is intricate. Back in 1955, some of the pioneers in artificial intelligence described the process as “that of making a machine behave in ways that would be called intelligent if a human were so behaving”.³⁵ Even though this reference to human intelligence has often been criticized as misleading in various respects,³⁶ that description at least clarifies that artificial intelligence could theoretically support or even replace any human being within corporate bodies, namely directors, shareholders or other parties, like creditors, employees and customers.

Today, the various techniques and tools of artificial intelligence are manifold and include, for instance, symbolic logic, artificial neural networks, fuzzy systems, evolutionary computing, intelligent agents and probabilistic reasoning models.³⁷ Since the tasks undertaken by these tools include the coordination of data delivery, the analysis of data trends, the provision of forecasts, the development of data consistency, the quantification of uncertainty, the anticipation of users’ data needs, the provision of information to users in the most appropriate form and the suggestion of courses of action, the most important impact of artificial intelligence is arguably its support for or even replacement of human decision-making, particularly under conditions of uncertainty.³⁸ Above all, artificial intelligence helps to make decisions. Decision-making requires data, often in large amounts. The more complex a decision, the more data is needed to make the decision on an informed, rational basis.³⁹ Since computers, algorithms and artificial intelligence are particularly well-suited to process “big data”, they are able to contribute to improve decision-making.⁴⁰ To be more precise, artificial intelligence can reduce uncertainties of any kind (not just about the future) by making predictions, that is, by translating large amounts of data into small, manageable chunks.⁴¹

³⁵ J. MCCARTHY/ M. MINSKY/ N. ROCHESTER/ C. SHANNON, “A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence”, 1955, available at <http://www-formal.stanford.edu/jmc/history/dartmouth/dartmouth.html>.

³⁶ For instance, human intelligence is in itself difficult to define; moreover, machines can also perform tasks that humans are unable to perform; see J. KAPLAN, *Artificial Intelligence* (2016), pp. 1-4.

³⁷ More extensively, for instance, in L. Jain/ P. de Wilde (eds.), *Practical Applications of Computational Intelligence Techniques* (2001); L. Jain/ N. Martin (eds.), *Fusion of Neural Networks, Fuzzy Sets and Genetic Algorithms* (1999).

³⁸ Cf. G. PHILIPPS-WREN/L. JAIN, “Artificial Intelligence for Decision Making”, in: B. Gabrys/ R.J. Howlett/ L. Jain (eds.), *Knowledge-Based Intelligent Information and Engineering Systems* (2006), pp. 531-536.

³⁹ In more detail on decision-making and complexity: J. Cook/ M. Noyes/ Y. Masakowski (eds.), *Decision Making in Complex Environments* (2007); H. Qudrat-Ullah/ J. Spector/ P. Davidsen (eds.), *Complex Decision Making: Theory and Practice* (2010); R. GRÜNIG/ R. KÜHN, *Successful Decision-making: A Systematic Approach to Complex Problems* (2nd ed. 2009).

⁴⁰ A.-E. Hassanien et al. (eds.), *Big Data in Complex Systems: Challenges and Opportunities* (2015); S. KUDYBA, *Big Data, Mining, and Analytics – Components of Strategic Decision Making* (2014).

⁴¹ A. AGRAWAL/ J. GANS/ A. GOLDFARB, “Exploring the Impact of Artificial Intelligence: Prediction versus Judgment”, Working Paper (2016), available at <https://www.aeaweb.org/conference/2017/preliminary/1426?page=2&per-page=50>; see also ids., “How AI Will Change the Way We Make Decisions”, *Harvard Business Review*, July 26, 2017, available at <https://hbr.org/2017/07/how-ai-will-change-the-way-we-make-decisions>.

As artificial intelligence could support or replace any human being in a corporate body, it is therefore most likely to be employed where the most complex decisions need to be taken within corporations. While shareholders and other stakeholders also take decisions – shareholders make decisions on investments and divestments, as well as voting in general meetings, while other stakeholders make decisions on contracting with the corporation – the main decision center of the corporation (its brain, so to speak) is certainly located within the board of directors. As a consequence of delegating management to the board, directors have principal authority over the corporation’s affairs, and are assigned responsibility for all but the most fundamental decisions; not only does daily management form part of their responsibilities, but also strategic business decisions.⁴² It is precisely these strategic business decisions that are concurrently the most complex ones that have to be taken within corporations. For instance, they usually include many different options. In comparison, the decisions of shareholders and other stakeholders are typically less complex, at least in the sense that they are usually binary, with a choice between just two alternatives (to invest or to divest, to vote yes or no, to contract or not to contract within the corporation, etc.). In any event, since they also include questions of day-to-day management, the decisions to be taken by the board of directors quantitatively outweigh those to be taken by other persons involved. The corporative organ most closely resembling a human brain is therefore the board of directors.⁴³ In consequence, artificial intelligence appears to be most likely to play a significant role in boardroom decisions; this is why robo-directors are increasingly being discussed in modern business practice, and not robo-shareholders or robo-stakeholders.

II. Support of Corporate Directors by Artificial Intelligence

Recent literature on artificial intelligence distinguishes three different forms, namely assisted, augmented and autonomous artificial intelligence.⁴⁴ The difference between these forms comes from the allocation of decision rights between man and machine. In the assisted artificial intelligence stage, machines execute certain specific tasks, but decision rights remain solely with human beings; in the second stage, augmented artificial intelligence, humans and machines share decision rights and learn from each other; and in the third and final stage, autonomous artificial intelligence, machines ultimately take over all decision rights, either because humans increasingly trust the machines’ abilities to decide, or because decisions have to be taken so quickly or require so many data that humans are simply unable to decide. This tripartite distinction – which in fact is more like a continuum – can also be applied to the use of artificial intelligence in corporations. For this purpose, we can condense the assisted and augmented artificial intelligence categories into one, and distinguish this from autonomous artificial intelligence. The dividing line is then between the support and the replacement of corporate directors by machines. Whereas in the first case, only certain (if any) decision rights

⁴² See, for instance, with respect to US law: S. BAINBRIDGE, *Corporation Law and Economics* (2002), p. 194 *et seq.*; F. GEVURTZ, *Corporation Law* (2nd ed. 2010), pp. 190-195.

⁴³ With respect to UK company law, cf. Lord Denning’s leading statement at *HL Bolton (Engineering) Co Ltd v TJ Graham and Sons Ltd*, (1956) All ER 624, at 630: “A company may in many ways be likened to a human body. It has a brain and nerve centre which controls what it does. It also has hands which hold the tools and act in accordance with directions from the centre. Some of the people in the company are mere servants and agents who are nothing more than hands to do the work and cannot be said to represent the mind or will. Others are directors and managers who represent the directing mind and will of the company, and control what it does”.

⁴⁴ A. RAO, “AI everywhere / nowhere part 3 – AI is AAAI (Assisted-Augmented-Autonomous Intelligence)”, May 20, 2016, available at <http://usblogs.pwc.com/emerging-technology/ai-everywhere-nowhere-part-3-ai-is-aaai-assisted-augmented-autonomous-intelligence/>.

are delegated, artificial intelligence replaces human directors in the latter case. Beginning with the support of corporate directors by artificial intelligence, we need to answer two different questions, namely whether directors should have authority to delegate decision-making powers to artificial intelligence (see below sub 1.) and, on the other hand, whether they might even be under an obligation to do so (see below, sub 2.).

1. Directors' Authority to Delegate to Artificial Intelligence

As can be seen by a review of the law, so far neither case law nor codebooks deal with the question of whether directors can delegate decision rights to artificial intelligence. A question with which corporate laws had to cope with, however, concerned the delegation of tasks to employees or to third parties, and one can draw analogies. In a similar vein, the "import" of rules from agency law has been discussed with respect to algorithmic contracting, since algorithms effectively act in a similar manner to human agents, regardless of their legal qualification (or "personhood").⁴⁵

As a matter of fact, delegating tasks is not strictly prohibited, since directors are simply not able to complete them all by themselves.⁴⁶ However, many national corporate laws require a clause to be included in the respective corporation's articles of association.⁴⁷ While such clauses are widespread, they usually refer to human delegates, meaning that the issue of whether or not task delegation to artificial intelligence is permitted is open to their interpretation. Under current UK company law, for instance, the Model Articles provide that:

"5. (1) Subject to the articles, the directors may delegate any of the powers which are conferred on them under the articles-

- (a) to such person or committee;
- (b) by such means (including by power of attorney);
- (c) to such an extent;
- (d) in relation to such matters or territories; and
- (e) on such terms and conditions;

as they think fit".⁴⁸

While this provision obviously leaves ample scope for delegation, it is debatable whether it could also be used for tasks to be delegated to artificial intelligence. On the basis of a literal

⁴⁵ L. SCHOLZ (n. 22), at p. 134-138; see also S. CHOPRA/ L. WHITE, "Artificial Agents and the Contracting Problem: A Solution Via an Agency Analysis", *U. Ill. J. L. Tech. & Pol'y*, Fall 2009, at pp. 363, 365 *et seq.*; A. BELLIA, "Contracting with Electronic Agents", *50 Emory L. J.* (2001), pp. 1047, 1048.

⁴⁶ S. GRUNDMANN, *European Company Law* (2nd ed. 2012), p. 267 ("In all countries, tasks are of course split in reality"); cf. also H. FLEISCHER, "Zur Leitungsaufgabe des Vorstands im Aktienrecht", *Zeitschrift für Wirtschaftsrecht (ZIP)* 2003, p. 1, at p. 7 *et seq.* ("schon aus Gründen der Leitungskapazität bis zu einem gewissen Grade unumgänglich").

⁴⁷ In Italy, for instance, Art. 2381 para. 2 CC ("Se lo statuto o l'assemblea lo consentono, il consiglio di amministrazione può delegare proprie attribuzioni ad un comitato esecutivo composto da alcuni dei suoi componenti, o ad uno o più dei suoi componenti"); in Switzerland, Art. 716b para. 1 OR ("Die Statuten können den Verwaltungsrat ermächtigen, die Geschäftsführung nach Massgabe eines Organisationsreglementes ganz oder zum Teil an einzelne Mitglieder oder an Dritte zu übertragen"); for a broader comparative overview cf. F. MÖSLEIN, *Grenzen unternehmerischer Leitungsmacht im marktoffenen Verband* (2007), p. 35.

⁴⁸ Cf., also on the previous provision in Table A Article 72: D. KENSHAW, *Company Law in Context* (2012), pp. 192-194.

interpretation, machines are neither people nor committees, meaning that, at most, assisted artificial intelligence could be employed. In this case, decision rights would remain solely with human directors. The rationale of that provision, however, is to enable management to be efficiently organized; this rationale would therefore seem to justify a broader interpretation, which also allows delegation to machines. The same teleological reasoning could probably be applied in other jurisdictions with respect to provisions either in the law or in the articles, so that the delegation of decision rights to artificial intelligence is at least not entirely prohibited from the outset.

Whilst the delegation of decision rights is therefore permitted to some extent, corporate law restricts this authority to delegate by requiring directors to manage the business of the company themselves. In the New Zealand case of *Dairy Containers v NZI Bank*, for instance, Thomas J elaborated that “it is the fundamental task of the directors to manage the business of the company. Theirs is the power and the responsibility of that management. To manage the company effectively, of course, the must necessarily delegate much of their power to executives of the company, especially in respect of its day to day operation. [...] The directors may delegate powers and functions, using that term in a broad sense, but they cannot delegate the management function itself”.⁴⁹ Accordingly, US corporate law does not allow directors “to delegate duties which lie at the heart of the management of the corporation”.⁵⁰ In other words, the core management decisions must always remain with the board of directors.⁵¹ While most corporate laws do not define more precisely what those core decisions include,⁵² the same vague limit can also be applied to the delegation of decision rights to artificial intelligence. Even if decision rights are delegated to machines, human directors must always maintain the ultimate management function themselves.

Moreover, directors still have a duty to supervise the accomplishment of the delegated tasks: “Whilst directors are entitled (subject to the articles of association of the company) to delegate particular functions to those below them in the management chain, and to trust in their competence and integrity to a reasonable extent, the exercise of the power of delegation does not absolve a director from the duty to supervise the discharge of the delegated functions”.⁵³ More specifically, directors have to instruct, supervise and control the persons to whom they have delegated tasks, although the precise requirements of this duty are not

⁴⁹ *Dairy Containers Ltd v NZI Bank Ltd* [1995] 2 NZLR 30, at p. 79 *et seq.*

⁵⁰ In *Re Bally's Grand Derivative Litigation*, 23 Del.J.Corp.L., p. 677, at p. 686.

⁵¹ Cf. also JONATHAN PARKER J, in *Re Barings plc (No. 5)* [1999] 1 BCLC p. 489: “Directors have, both collectively and individually, a continuing duty to acquire and maintain a sufficient knowledge and understanding of the company’s business to enable them properly to discharge their duties as directors”. In more detail on both cases: P. MÄNTYSAARI, *Comparative Corporate Governance* (2005), pp. 225 *et seq.*

⁵² Swiss corporate law, for example, is a bit more explicit: while Art. 716b para. 1 OR prohibits the delegation of the “Oberleitung” (key management of the corporation), the legislative materials define this term in more detail: “Oberleitung bedeutet ein Dreifaches, nämlich Entwicklung der strategischen Ziele der Gesellschaft, Festlegung der Mittel, um diese Ziele zu erreichen, und Kontrolle [...] im Hinblick auf die Verfolgung der festgelegten Ziele” (development of strategic goals, determination of the means to reach these goals and control with respect to the pursuit of these goals), see P. FORSTMOSER/A. MEYER-HAYOZ/P. NOBEL, *Schweizerisches Aktienrecht* (1996), §30, para. 31; cf. also U. BERTSCHINGER, *Arbeitsteilung und aktienrechtliche Verantwortlichkeit* (1999); A. KAMMERER, *Die unübertragbaren und unentziehbaren Kernkompetenzen des Verwaltungsrates* (1997); P. BÖCKLI, *Die unentziehbaren Kernkompetenzen des Verwaltungsrates* (1994).

⁵³ See again JONATHAN PARKER J, in *Re Barings plc (No. 5)* [1999] 1 BCLC, p. 489.

precisely defined and differ from jurisdiction to jurisdiction.⁵⁴ Both the vagueness and inconsistency of these duties make it difficult to draw analogies with respect to the supervision of artificial intelligence, but it would seem that directors are required to carefully consider which robot to employ and which tasks to assign; moreover, supervision would also seem to require that humans double check any decisions made by artificial intelligence. Directors must at least generally oversee the selection and activities of robots, algorithms and artificial intelligence devices. Already, this duty requires them to have a basic understanding of how these devices operate. Even though they do not understand their coding in every detail, they should at least be able to understand the technical guidelines that drive these machines.

Similar objective standards apply when directors delegate the gathering of information to third parties: “A director may not assert his ignorance as an excuse for his nonfeasance”.⁵⁵ In other instances, the law explicitly formulates more specific duties for the overseeing of algorithms, namely with respect to algorithmic trading: German law, for instance, requires securities companies operating algorithmic trading to operate systems and risk controls to ensure that (1.) its trading systems are resilient, have sufficient capacity and are subject to appropriate trade thresholds and trading ceilings; (2.) the transmission of erroneous orders, as well as systems malfunctions which could cause disturbances on the markets, are avoided; (3.) its trading systems cannot be used for a purpose contrary to those against market abuse or those of the trading place in which they is operating.⁵⁶ In substance, similar standards can be applied to corporate directors when they employ algorithms to perform management tasks and delegate decision rights to them. They will have to ensure that these systems are stable, that they do not cause fundamental management errors and that their decisions comply with the applicable laws and regulations.⁵⁷

2. Do Directors Have a Duty to Delegate to Artificial Intelligence?

While corporate law therefore *allows* directors to delegate decision rights to algorithms, albeit with certain restrictions, one can also consider the inverse question: could directors also *be required* to do so, at least under certain circumstances? Since permission does not equal obligation, this question might seem a little awkward at first sight. Corporate law, however, requires directors to act on an informed basis. If artificial intelligence has superior information processing capabilities, due to its ability to make predictions by translating large sets of data into small, manageable chunks (see above, sub. I., at n. 41), then the duty to act on an informed basis may well evolve into the duty to obtain such predictions made by artificially intelligent devices.

⁵⁴ More extensively, with respect to German, UK and US law: H. FLEISCHER, “Vorstandsverantwortlichkeit und Fehlverhalten von Unternehmensangehörigen - Von der Einzelüberwachung zur Errichtung einer Compliance-Organisation”, *Die Aktiengesellschaft (AG) 2003*, p. 291, at pp. 292-298.

⁵⁵ W. KNEPPER/ D. BAILEY, *Liability of Corporate Officers and Directors* (7th ed. 2002), at § 2.09; for a comparative overview see F. MÖSLEIN (n. 46), pp. 135-138.

⁵⁶ Cf. § 33 para. 1a WpHG. In general on algorithmic trading and its legal regulation: A. FLECKNER, “Regulating Trading Practices”, in: N. Moloney/ E. Ferran/ J. Payne (eds.), *The Oxford Handbook of Financial Regulation* (2015), p. 596, at pp. 619-623.

⁵⁷ In a similar vein, the same standards can also be applied to robo-advisors based on algorithmic decisions, cf. F. MÖSLEIN/ A. LORDT, “Rechtsfragen des Robo Advice”, *Zeitschrift für Wirtschaftsrecht (ZIP) 2017*, p. 793, at p. 803.

Yet, directors do not have the duty to gather every piece of information available, or to maximize the informed basis on which they take their decisions. After all, the collection of information also involves costs, and striking a balance between these costs and using the information concerned is in itself an entrepreneurial decision.⁵⁸ It should, at least in principle, be left to directors rather than being scrutinized by the courts: “The amount of information that is prudent to have before a decision is made is itself a business judgment of the very type that courts are institutionally poorly equipped to make”.⁵⁹ Nonetheless, most corporate law jurisdictions stipulate certain minimum requirements for information gathering. For instance, in the famous US case *Smith v. van Gorkom*, the finding that directors’ duties had been breached was solely based on the insufficient preparation of the respective board decision, not on its substance; it was held that this decision “was not the product of an informed business judgment”.⁶⁰ Similar requirements are formulated, inter alia, in English case law,⁶¹ in French legal doctrine,⁶² and in the Italian codifications of corporate law.⁶³ The standard of care differs, however. While it seems relatively strict in Italy, Austria and Switzerland, it appears more generous in English case law (as well as in US corporate law):⁶⁴ “Their negligence must not be the omission to take all possible care; it must be much more blameable than that; it must be in a business sense culpable of gross negligence”.⁶⁵ In a similar vein, the German Stock Corporation Act (AktG) stipulates that directors shall not be deemed to have violated their duty of care if, at the time of taking the entrepreneurial decision, they had good reason to assume that they were acting on the basis of adequate information for the benefit of the

⁵⁸ In more detail, based on a comparative overview F. MÖSLEIN (n. 46), pp. 131-134.

⁵⁹ In *Re RJR Nabisco, Inc. Shareholders Litigation*, [1989] WL 7036, para. 19 (per Chancellor Allen).

⁶⁰ *Smith v van Gorkom*, 488 A.2d 858; from the abundance of (partly critical) case reviews cf., for instance, L. HERZEL/L. KATZ, “Smith v. Van Gorkom: The Business of Judging Business Judgment”, 41 *Bus. Law.* (1986), p. 1187; D. FISCHER, “The Business Judgement Rule and the Trans Union Case”, 40 *Bus. Law.* (1985), p. 1437; B. MANNING, “Reflections and Practical Tips on Life in the Boardroom after Van Gorkom”, 41 *Bus. Law.* (1985), p. 1; K. CHITTUR, “The Corporate Director’s Standard of Care: Past, Present, Future”, 10 *Del.J.Corp.* (1985), p. 505; more recently J. MACEY, “Smith v. Van Gorkom: Insights About C.E.O.s, Corporate Law Rules, and the Jurisdictional Competition for Corporate Charter”, 96 *Northwestern University Law Review* (2002), p. 607; L. STOUT, “In Praise of Procedure: An Economic and Behavioral Defense of Smith v. Van Gorkom and the Business Judgment Rule”, 96 *Northwestern University Law Review* (2002), p. 673.

⁶¹ Cf., for instance, *Dorchester Finance Co. v Stebbing*, [1989] BCLC 498; similar: *Land Credit Co of Ireland v Lord Fermoy*, [1870] LR 5 Ch App 763; *Selangor United Rubber Estates Ltd. v Cradock* (no 3), [1968] 2 All ER 1073, at 1095 and 1121-1123. Similar for Swiss law BGE 108 V 199, at 203 (“Das setzt u.a. voraus, daß der Verwaltungsrat die ihm unterbreiteten Berichte kritisch liest, nötigenfalls ergänzende Auskünfte verlangt und bei Irrtümern oder Unregelmäßigkeiten einschreitet”); cf. also FORSTMOSER/MEIER-HAYOZ/NOBEL (n. 52), at § 28, para. 68; A. GRASS, *Business Judgment Rule* (1998), pp. 87-90.

⁶² D. SCHMIDT, “La responsabilité des membres du conseil d’administration”, *Droit et Patrimoine* 1995, 45 (46): “On attend du conseil d’administration qu’il prenne ses décisions après mûre réflexion, après avoir obtenu et analysé les informations nécessaires et après avoir recueilli les avis d’experts”; less clearly: S. HADJI-ARTINIAN, *La faute de gestion* (2001), p. 220; E. SCHOLASTIQUE, *Devoir de Diligence des administrateurs de sociétés – Droits français et anglais* (1998), p. 212 *et seq.*

⁶³ Cf. Art. 2381 Abs. 6 CC (“gli amministratori sono tenuti ad agire in modo informato”); in more detail C. GRANELLI, “La responsabilità civile degli organi di gestione alla luce della riforma delle società di capitali”, *Le Società* 2003, 1565, at 1568.

⁶⁴ Cf. again the comparative overview in F. MÖSLEIN (n. 46), p. 133 *et seq.*

⁶⁵ *Lagunas Nitrate Co v Lagunas Syndicate*, [1899] 2 Ch 392, at 435. With respect to US corporate law, cf. GEVURTZ, *Corporation Law*, 2nd ed. 2010, pp. 284-286.

company.⁶⁶ It is therefore only in exceptional cases – those in which directors act unreasonably – that the courts scrutinize the decision of directors in terms of the amount effort they put into the gathering and the processing of information.

As long as the use of artificial intelligence is not widespread with respect to business decisions, it seems difficult to establish that directors who do not take advantage of such devices are acting unreasonably. At least, the computer systems needed to operate them are still expensive, adapting them to the needs of specific companies requires thorough and burdensome preparation and their predictions may not be superior to human predictions in every case. In this present state of affairs, a director's duty to delegate the processing of (certain) information to artificial intelligence devices therefore seems difficult to establish.⁶⁷ Technological progress develops at such a rapid pace, however, that this duty is not unlikely to develop in the near future. The more artificial intelligence spreads in corporate boardrooms, the more its use will develop into a widely accepted standard of directors' behavior. When this point is reached, it will seem increasingly unreasonable to deviate from that standard; it will therefore ultimately become likely that these directors will be deemed to have violated their duty of care. A concurrent development can already be observed today with respect to the storage and handling of information. Information governance is increasingly qualified as an additional task to be undertaken by the board of directors, with manifold specifications in various areas (e.g., the strategic definition of IT targets and IT resources, the organization of the IT department, communication on IT topics and the monitoring of IT compliance and security).⁶⁸ In a very similar vein, the governance of artificial intelligence is likely to develop as an additional task for the board of directors.

III. The Replacement of Corporate Directors by Artificial Intelligence

Looking further into the future, one could even imagine that human directors will not only be supported, but also replaced, by robo-directors. Such a development would conform to the stage of autonomous artificial intelligence, in which machines take over all decision rights, either because humans increasingly trust the machines' abilities to decide, or because decisions have to be taken so quickly or require so much data that humans are simply unable to decide (see already above, sub II. at n. 44). On a more general level, historians and philosophers suggest that once artificial intelligence surpasses human intelligence, it might

⁶⁶ § 93 para. 1 AktG ("Eine Pflichtverletzung liegt nicht vor, wenn das Vorstandsmitglied bei einer unternehmerischen Entscheidung vernünftigerweise annehmen durfte, auf der Grundlage angemessener Information zum Wohle der Gesellschaft zu handeln"); in more detail: R. FREITAG/S. KORCH, "Die Angemessenheit der Information im Rahmen der Business Judgment Rule (§ 93 Abs. 1 S. 2 AktG)", *Zeitschrift für Wirtschaftsrecht (ZIP)* 2012, p. 2281; K. PETERS, "Angemessene Informationsbasis als Voraussetzung pflichtgemäßen Vorstandshandelns", *Die Aktiengesellschaft (AG)* 2010, p. 811, at p. 812; S. H. SCHNEIDER, Informationspflichten und Informationssystemeinrichtungspflichten im Aktienkonzern (2006), at pp. 89 *et seq.*, 91; *id.*, "Unternehmerische Entscheidungen" als Anwendungsvoraussetzung für die Business Judgment Rule", *Der Betrieb (DB)* 2005, 707, at 708; M. ROTH, Unternehmerisches Ermessen und Haftung des Vorstands (2001), pp. 80 *et seq.*; J. SEMLER, "Entscheidungen und Ermessen im Aktienrecht", *Festschrift for Peter Ulmer* (2003), p. 627, at 632 *et seq.*; H. FLEISCHER, "Die "Business Judgment Rule" im Spiegel von Rechtsvergleichung und Rechtsökonomie", in: *Festschrift for H. Wiedemann* (2002), p. 827, at p. 840 *et seq.*

⁶⁷ More generally on information management within corporations and on its relevance for directors' duties: J. RODEWALT, "Informationsmanagement im Unternehmen als Instrument zur Vermeidung von Organhaftung", *GmbH-Rundschau (GmbHR)* 2014, p. 639, at p. 643.

⁶⁸ R. MÜLLER, "Digitalization Decisions at Board Level", in: M. Hilb (ed.), *Governance of Digitization* (2017), p. 43.

simply exterminate mankind.⁶⁹ Whether the world will indeed be run by “robot overlords”,⁷⁰ however, is at least as debatable as whether companies will be run by robo-directors. Economists argue, for instance, that even though artificial intelligence may well be superior at making predictions, humans need to make judgments. They need to work out the benefits and costs of different decisions in different situations, since this in turn requires “an understanding of what your organization cares about most, what it benefits from, and what could go wrong”.⁷¹ While artificial intelligence may be able to learn from experience, it is still unable to exercise this sort of judgment, at least for the foreseeable future.⁷² Furthermore, creativity and innovation are widely regarded as specifically human qualities, and artificial intelligence experts are in disagreement as to whether creative or innovative machines will ever exist, or whether artificial intelligence just does not have this potential.⁷³ Since decisions at board level are often of a strategic nature, however, it is precisely abilities such as these that play a pivotal role, at least in concurrence with predictions. On the other hand, one can well imagine that there will be individual companies in specific branches of the economy – the finance industry, for instance – where predictions will prevail, at least with regard to single board positions within these companies. As a result, it seems conceivable that some companies (like Deep Knowledge Ventures) will have an interest in appointing robo-directors (like *Vital*) to their boards, at least alongside human directors. Whether this is legally permissible, however, is an open question. Remember that *Vital* has only been treated “as a member of [the] board with observer status” by its fellow human directors, but has never fully acquired that legal status.⁷⁴

As mentioned above, human directors may delegate decision rights to machines, but they must always keep the ultimate management function for themselves (see above, sub II.1.). Whether machines can themselves become directors, however, is a different issue, depending on a disparate set of legal rules. What is relevant here is the legal regime for the appointment of directors. Corporate laws usually stipulate certain requirements to be satisfied by potential directors, while some sector-specific laws add further preconditions. With respect to credit institutions and investment firms, for instance, the European Capital Requirements Directive provides that “members of the management body shall at all times be of sufficiently good repute and possess sufficient knowledge, skills and experience to perform their duties”.⁷⁵ Since this provision is obviously tailored to human directors, it seems questionable whether robo-advisors could potentially fulfill these conditions. While they may indeed gather sufficient knowledge, skills and experience, the “good repute” seems particularly difficult for a machine to acquire.

⁶⁹ Cf. Y. HARARI, *Homo Deus: A Brief History of Tomorrow*, 2016; N. BOSTROM, *Superintelligence – Paths, Dangers, Strategies*, 2014.

⁷⁰ J. SENIOR, “Review: ‘Homo Deus’ Foresees a Godlike Future. (Ignore the Techno-Overlords)”, *New York Times*, February 15, 2017, available at <https://www.nytimes.com/2017/02/15/books/review-homo-deus-yuval-noah-harari.html>.

⁷¹ A. AGRAWAL/ J. GANS/ A. GOLDFARB, *Harvard Business Review*, July 26, 2017 (n. 41).

⁷² A. AGRAWAL/ J. GANS/ A. GOLDFARB, Working Paper (n. 41), at p. 15 *et seq.*

⁷³ More extensively, for instance, in the IBM report “The quest for AI creativity”, available at <https://www.ibm.com/watson/advantage-reports/future-of-artificial-intelligence/ai-creativity.html>.

⁷⁴ See reference above, at n. 6.

⁷⁵ Art. 91 Directive 2013/36/EU on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms (Capital Requirements Directive), of June 26, 2013, OJ EU 2013 L 176/338.

On a more general level, corporate laws usually presuppose that only “persons” can become directors. Whether it is only natural persons – or also legal or corporate persons – that qualify, however, differs from jurisdiction to jurisdiction (and sometimes also within the same jurisdiction). Under UK law, for instance, at least one director of a company must be a natural person.⁷⁶ The relevant Act currently permits corporate directors to hold office in a company as additional directors, but this rule is unlikely to endure. The UK Parliament passed legislation in 2015⁷⁷ to amend the Act in order to ban corporate directors outright,⁷⁸ although these amendments have not yet been brought into force. Nonetheless, even the current requirement to have at least one director who is a natural person prevents a nonhuman autonomous system from taking exclusive control of a company.⁷⁹ Similar restrictions also apply elsewhere. Under German corporate law, § 6 para 2 GmbHG only allows natural persons to act as directors of an LLC; the same restriction applies in stock corporations, according to § 93 para. 3 AktG. Similar provisions have been challenged on constitutional grounds, however, since they restrict the fundamental right of legal persons to exercise a trade or profession.⁸⁰ At present, it is difficult to predict whether the German Constitutional Court will also require legal persons to be permitted as corporate directors. Furthermore, US corporate law requires corporate directors to be human beings.⁸¹ On the other hand, there are at least some states that do not stipulate the requirement for corporate officers to be human beings, but only generally refer to “persons”.⁸² In these states, a legal entity, if represented by one of its authorized officers, could at least serve as an officer of a corporation. Other jurisdictions are less restrictive, allowing legal entities to have a seat on a corporate board of directors.⁸³

In cases such as these, or those in which legal entities are at least allowed to serve as corporate officers, autonomous artificial intelligence systems would be able to take such a position if they qualified as a legal entity. This qualification, however, is in turn the subject of intensive

⁷⁶ Companies Act, 2006, c. 46, §§ 154, 155

⁷⁷ Small Business Enterprise and Employment Act, 2015, c. 26, § 87 (UK).

⁷⁸ Companies Act, 2006, § 156A; exceptions may be provided for, however, under § 156B.

⁷⁹ In more detail S. BAYERN/ T. BURRI/ T. GRANT/ D. HÄUSERMANN/ F. MÖSLEIN/ R. WILLIAMS, “Company Law and Autonomous Systems: A Blueprint for Lawyers, Entrepreneurs, and Regulators”, *9 Hastings Science and Technology Law Journal* (2017), p. 135, at p. 149.

⁸⁰ In a recent decision, the German Constitutional Court decided that a similar provision did not violate the fundamental rights of legal persons, see Bundesverfassungsgericht [BVerfG][Federal Constitutional Court], *Neue Juristische Wochenschrift (NJW)*, 2016, p. 930. On potential consequences, particularly with respect to § 6 para. 2 GmbHG cf. M. GEHRLEIN, “Leitung einer juristischen Person durch juristische Personen?”, *Neue Zeitschrift für Gesellschaftsrecht (NZG)*, 2016, p. 566.

⁸¹ See, e.g., Delaware General Corporation Law Section 141(b) (“The board of directors of a corporation shall consist of one or more members, each of whom shall be a natural person”) and California Corporations Code Section 164 (“Directors” means natural persons designated in the articles as such or elected by the incorporators and natural persons designated, elected or appointed by any other name or title to act as directors, and their successors”).

⁸² Cf., e.g., Delaware General Corporation Law Section 142(a) and California Corporations Code Section 312(a); different, however, is the Model Business Corporation Act, which provides in its Section 8.40(b) that “the board of directors may elect individuals to fill one or more offices of the corporation”, and specifies in Section 1.40(13) that “‘Individual’ means a natural person”.

⁸³ One example is Liechtenstein, cf. Art. 180 para. 1 Personen- und Gesellschaftsrecht (PGR); in more detail INTERNATIONAL MONETARY FUND, “Liechtenstein: Detailed Assessment Report on Anti-Money Laundering and Combating the Financing of Terrorism”, IMF Country Report No. 08/87, 2008, p. 24, available at <http://www.imf.org/en/Publications/CR/Issues/2016/12/31/Liechtenstein-Detailed-Assessment-Report-on-Anti-Money-Laundering-and-Combating-the-21775>.

debate – consider the recent discussion on the introduction of “e-persons” at the European level,⁸⁴ as well as the long continuing debate among legal philosophers on the personhood of artificial intelligence.⁸⁵ Yet, recent comparative work has shown that at least some jurisdictions offer possibilities for the creation of company structures that might provide functional and adaptive legal “housing” for artificial intelligence and autonomous systems.⁸⁶ If a suitable legal framework is chosen, robots may therefore indeed be appointed as “true” legal directors. Many national corporate laws, however, restrict that possibility, and so far no single robot has been reported to effectively be acting as a director in this legal sense. But, due to both technological progress and regulatory competition between jurisdictions, it does not seem inconceivable that this might change in the not-too-distant future.

IV. The Suitability of Corporate Legal Strategies for Robo-directors

If any national corporate law permits robots to be appointed as directors, an entirely new set of questions will arise. Corporate law will face the fundamental question of whether the legal strategies that it has developed for human agency relationships are still suitable for robots acting as agents. In fact, the same question becomes relevant whenever machines take decisions in agency relationships – for instance, when robo-advisors take investment decisions –⁸⁷ and similar issues also arise when management decisions are simply delegated to directors. But when robots legally act as directors, the anatomy of corporate law itself threatens to become dysfunctional, and its legal strategies are therefore most provocatively called into question.

More precisely, such dysfunctionality can take two possible different forms. Some legal strategies are likely to miss the mark, while others are likely to become redundant. On the one hand, the incentive strategy is doomed if robo-directors are incentivized by different things to human directors. Even if it is difficult to speculate about the potential incentives for artificial intelligence at the present stage of its technological development, these respective

⁸⁴ EUROPEAN PARLIAMENT (Committee on Legal Affairs, Rapporteur: Mady Delvaux), Report with recommendation to the Commission on Civil Law Rules on Robotics, 2015/2103 (INL), 27 January 2017, at para. 59: “Calls on the Commission, when carrying out an impact assessment of its future legislative instrument, to explore, analyze and consider implications of all possible legal solutions, such as: [...] f) creating a specific legal status for robots in the long run, so that at least the most sophisticated autonomous robots could be established as having the status of electronic persons responsible for making good any damage they may cause, and possibly applying electronic personality to cases where robots make autonomous decisions or otherwise interact with third parties independently”.

⁸⁵ In this sense already L. SOLUM, “Legal Personhood for Artificial Intelligences”, *70 North Carolina Law Review* (1992), p. 1231. Cf. also the lively debate in Germany: G. TEUBNER, “Elektronische Agenten und große Menschenaffen: Zur Ausweitung des Akteurstatus in Recht und Politik”, *27 Zeitschrift für Rechtssoziologie* (2006), p. 5; M.-C. GRUBER, “Was spricht gegen Maschinenrechte?”, in: J. Bung/ S. Ziemann (eds.), *Autonome Automaten*, 2015, p. 191; L. PHILIPPS, “Gibt es ein Recht auch für ein Volk von künstlichen Wesen, wenn sie nur Verstand haben?”, in: *Festschrift für Arthur Kaufmann*, 1989, p. 119, at pp. 119-126.

⁸⁶ S. BAYERN/ T. BURRI/ T. GRANT/ D. HÄUSERMANN/ F. MÖSLEIN/ R. WILLIAMS, “Company Law and Autonomous Systems: A Blueprint for Lawyers, Entrepreneurs, and Regulators”, *9 Hastings Science and Technology Law Journal* (2017), p. 135; see also (with respect to US corporate law): S. BAYERN, “The Implications of Modern Business-Entity Law for the Regulation of Autonomous Systems”, *19 Stan. Tech. L. Rev.* (2015), p. 93; id., “Of Bitcoins, Independently Wealthy Software, and the Zero-Member LLC”, *108 Nw. U. L. Rev.* (2014), p. 1485, at pp. 1495–1500.

⁸⁷ Cf. F. MÖSLEIN/ A. LORDT, “Rechtsfragen des Robo Advice”, *Zeitschrift für Wirtschaftsrecht (ZIP)* 2017, p. 793, at pp. 801 *et seq.*

differences do not seem unlikely. Since machines cannot become insolvent, for instance, it is questionable as whether they would try to avoid personal liability as much as humans. Liability regimes (and the liability of directors in particular) could therefore turn out to be largely ineffective if machines do not suffer financial loss.⁸⁸ On the other hand, a pay-for-performance regime, which pays agents for successfully advancing their principal's interests, is unlikely to serve its purpose if artificially intelligent machines neither earn money nor work towards the objective of doing so. On the other hand, such machines will be less inclined to divert corporate assets, opportunities or information for personal gain. In the same vein, a breach of their fiduciary duty of loyalty is unlikely.⁸⁹ More generally, in the world of robo-directors, the legal rules on the conflicts of interest faced by directors would lose significance, inasmuch as robots do not make decisions based on personal interest.

The interests and incentives of artificial intelligence, it should be added, depend on their respective coding and machine learning. Since it is possible to program computers to avoid personal financial loss or to maximize personal profit, one can envisage robo-directors with implemented loss aversion or implemented risk appetite. As opposed to humans, such character traits are not natural for robots, however: all depends on their codes and their algorithms. Furthermore, robo-directors can be programmed to comply with all applicable legal rules.⁹⁰ Yet, they are not necessarily programmed in this manner. Their fundamental difference to human directors therefore stems from the fact that the future rule compliance of robo-directors is much more easily foreseeable from the outset, namely by through a straightforward analysis of their code and algorithm. This difference, in turn, is likely to affect the legal strategies that corporate law can apply to robo-directors. Whereas ex-post strategies (such as the control of directorial behavior by way of directors' duties) will presumably lose significance, ex-ante strategies will conversely gain importance.⁹¹ For instance, robo-specific appointment requirements may well emerge as the regulatory strategy of choice. In particular, such rules could include a requirement for respective algorithms and codes to safeguard for rule-compliant behavior. This shift from ex-post to ex-ante regulatory strategies would involve various far-reaching changes for the whole anatomy of corporate law. Firstly, its specific rules on directors' behavior will effectively be transferred from the law into algorithmic codes. Secondly, the abstract control of these algorithms will largely replace the concrete control of situation-specific behavior. Thirdly, entirely different enforcement mechanisms will be required, simply because the control of algorithms requires a comprehensive technical know-how that can neither be expected from shareholders, nomination committees or supervisory boards, nor from courts specializing in corporate law. The control of algorithms by state agencies has already been postulated in other contexts.⁹²

⁸⁸ Similar considerations have been made with respect to criminal sanctions, cf. G. HALLEVY, *Liability for Crimes Involving Artificial Intelligence Systems*, 2014, pp. 212 *et seq.*

⁸⁹ On that duty (and its functions) in general, for example, F. EASTERBROOK/ D. FISCHER, *The Economic Structure of Corporate Law*, 1996, pp. 90-93.

⁹⁰ Cf. H. EIDENMÜLLER, "The Rise of Robots and the Law of Humans", Working Paper 2017, available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2941001, at p. 13: "Robots can be programmed to conform to rules but they cannot follow rules".

⁹¹ Similar, with respect to robo-advisors and their fiduciary duties: F. MÖSLEIN/ A. LORDT, "Rechtsfragen des Robo Advice", *Zeitschrift für Wirtschaftsrecht (ZIP)* 2017, p. 793, at pp. 802 *et seq.*

⁹² See, for instance, J. KROLL/ J. HUEY/ S. BAROCAS/ E. FELTEN/ J. REIDENBERG/ D. ROBINSON/ H. YU, "Accountable Algorithms", *165 Univ. of Penn. L. Rev. (Forthcoming 2017)*, Working paper available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2765268; see also the contributions presented at the international conference on "Governing Algorithms", which took place May 16-17, 2013 at New York University,

In the realm of corporate law, however, a similar approach would seem to endanger private autonomy and entrepreneurial flexibility, which are so fundamental within this area of law. The development of suitable legal strategies for robo-directors will therefore become a crucial challenge for future corporate law debates.

V. Conclusion

With the rapid development of artificial intelligence, the corporate world is about to enter a period of exponential change. In a recent large-scale survey by the World Economic Forum's Global Agenda Council on the Future of Software and Society, which aimed to predict the dates on which game-changing technologies will become mainstream, nearly half of the respondents expect the first artificially intelligent machine to be on the board of directors of a business as early as 2025.⁹³ This technology-driven change will partly be influenced by the framework of corporate law, but will also itself inevitably influence the well-functioning of corporate law.

After having explored some fundamentals about corporate bodies and the functions of corporate law, we have seen that artificial intelligence is most likely to be employed at the level of corporate boards, where the most complex corporate decisions need to be taken. We then determined that directors are allowed to delegate decision rights to artificial intelligence, but that various restrictions apply. Human directors must always maintain the ultimate management function for themselves; they also need to generally oversee both the selection and activities of robots, algorithms and artificial intelligence devices. More specifically, they will have to ensure that these systems are stable, that they do not cause fundamental management errors, and that their decisions comply with the applicable laws and regulations. On the other hand, we have seen that under certain circumstances, directors can inversely be required to obtain assistance from artificial intelligence. Corporate law requires directors to act on an informed basis. If artificial intelligence has superior information processing capabilities, this duty may ultimately develop into the duty to obtain predictions made by such devices. However, the courts only scrutinize the decision of directors as to how much effort they have put into the gathering and processing of information in exceptional cases. As long as the use of artificial intelligence is not widespread with respect to business decisions, the duty to delegate information processing to such devices is therefore unlikely to be established. In the long run, however, the rapid development of artificial intelligence may even give rise to the question of whether artificial intelligence can not only assist, but even replace, human directors. The legal admissibility of such a replacement depends on the rules governing the appointment of directors. According to many jurisdictions, these rules require directors to be "natural persons". Some jurisdictions are less restrictive, allowing legal entities to have a seat on corporate boards. If corporate law also offered possibilities for the creation of company structures that provide legal housing for artificial intelligence, these devices might indeed be able to be appointed as directors in the legal sense. Consequently, corporate law will face the fundamental question as to whether the legal strategies designed for human agency relationships are also suited to robo-directors. We have seen that some of these strategies

see <http://governingalgorithms.org>; reprinted in the special issue of *41 Science, Technology & Human Values (2016)*, pp. 3 *et seq.*

⁹³ WORLD ECONOMIC FORUM'S GLOBAL AGENDA COUNCIL ON THE FUTURE OF SOFTWARE AND SOCIETY, "Deep Shift – Technology Tipping Points and Societal Impact", Survey Report, September 2014, available at http://www3.weforum.org/docs/WEF_GAC15_Technological_Tipping_Points_report_2015.pdf, at p. 21.

are likely to either miss the mark or to become redundant if robo-directors act on different incentives to human directors. Since those incentives depend on the algorithms of robo-directors, the legal strategies of corporate law will change. They will focus on the ex-ante control of algorithms instead of the ex-post control of directorial behavior. If state agencies are entrusted with that control, then this shift has the potential to undermine private autonomy and entrepreneurial freedom. Designing legal rules for robots in the boardroom is therefore a delicate task, and it is likely to affect the anatomy of corporate law in a very fundamental way. After all, corporate law is not only highly relevant for the use of artificial intelligence in corporations; it will also need to be adapted to the challenges posed by that technology.