ТРГОВИНСКО ПРАВО И АРБИТРАЖЕ

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ROBOTS IN LAW

Abstract

Robots and robotic technologies have revolutionised factories and warehouses. Like all engineered systems, robots serve the purpose they have been designed for. First-generation robots can be easily integrated into traditional principal-agent concepts. The liability assessment changes dramatically once robots become collaborative or so autonomous that they almost unpredictable. The paper assesses various scenarios where robotics affects behavioural patterns

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of humans. This includes robo-advisors, industrial robots, collaborative surgical robots and autonomous vehicles. U.S. jurisprudence on Da Vinci robots will be explored to shed light on the interface between product liability and malpractice claims, between strict liability and liability conditioned on negligence. Autonomous vehicles challenge established beliefs about the human ability to take charge in an emergency scenario, as ethics require. In fleshing out civil liability rules for autonomous cars, cost externalisation and risk distribution considerations should be controlling. This ushers in the question whether product liability should be supplemented by liability for car companies as they introduce a vehicle inherently dangerous into traffic.

Key words: *Robotics, Civil Liability, Robo-advisors, Industrial and Collaborative Surgical Robots, Autonomous Vehicles.*

I Robots – A New Species in Law?

1. The State of Art

Robots and robotic technologies have long left the research laboratories to enter the world of humans.[1] Robots play an important role in industry.[2] Medical robots are used for minimally invasive surgery where only an interaction with a physical person will assure the success of the operation.[3] Service robots are used for dispensing care for the elderly in order to counter a shortage of labour.[4] Judges are discovering the benefits of artificial intelligence for the administration of justice.[5] Law firms have realised that the 'advo-robot' is

1 N.M. Richards/W.D. Smart, in: R. Galo/A.M. Froomkin/I. Kerr, Robot Law (Edward Elgar Publishing, Cheltenham 2016), 3.

2 See Industrial Federation of Robotics, Press Release 7 February 2018, Robot density rises globally (available at https://ifr.org/ifr-press-releases/news/robot-density-rises-globally).

3 See the cases: Landgericht (Regional Court) Hannover, Judgment of 10 January 2011 (19 O 161/97), BeckRS 2011, 22342; Oberlandesgericht (Higher Regional Court), Judgment of 7 December 2004, NJW-RR 2005, 173 et seq. ('Robodoc'). Press Release, Erstmals in Berlin und Brandenburg: Roboter assistiert bei Speiseröhrentumor-OP, Rechtsdepesche für das Gesundheitswesen 2015, 268. For a cross-border scenario with telemedicine and robots: B.M. Dickens/R.J. Cook, Legal and ethical issues in telemedicine and robotics, 94 Int'l. J. Gynecology and Obstetrics 73 (74 et seq.) (2006).

4 Frankfurter Allgemeine Zeitung online, 14 October 2017, Hoffnung auf Technik – Künstliche Intelligenz soll Menschen bei Behinderung helfen (available at *http://www.faz.net/aktuell/wirtschaft/kuenstliche-intelligenz/hoffnung-auf-technik-kuenstliche-intelligenz-soll-menschen-mit-behinderung-helfen-15246054.html*).

5 J.-P. Buyle/A. Van Den Branden, in: H. Jacquemin/A. de Streel (eds.), L'Intelligence artificielle et le Droit (Larcier Collection du CRIDS Brussels 2017), 259 (at p. 286 et seq.).

capable of dispensing legal advice online.[6] Likewise, a 'robo-professor' is thought to deliver seminars and lectures,[7] presumably at lower cost than its human counterpart. As artificial intelligence is developing,[8] so is the autonomous robot, capable of handling situations allegedly unforeseen by its developers.[9] Autonomously moving ship[10] or cars[11] challenge traditional legal thinking. They also invite analysis whether the robot's degree of autonomy might exonerate its designer from direct liability.[12]

The International Organization for Standardization (ISO) distinguishes industrial robots from service robots. An industrial robot is "an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which can be either fixed in place or mobile for use or in industrial application".[13] Service robots are not used for industrial automation application. They have been developed for non-commercial use by lay

6 See B. Kobayashi/L. Ribstein, Law's Information Revolution, 53 Ariz. L. Rev. 1169 (1193) (2011) (on automated legal advice); Beck-aktuell, Roboter-Anwalt berät bei Kündigungen, becklink 2008420 (23 November 2017). For an assessment of ‚legal robots' in the context of corporate taxation: M. Burr, Die Entwicklung von Legal Robots am Beispiel der grunderwerbsteuerlichen Konzernklausel, Betriebs-Berater 8/2018, 476 et seq.

7 Frankfurter Allgemeine Zeitung online, 22 October 2017, Roboter als Dozent – Ist das der Professor von morgen? (available at *http://www.faz.net/aktuell/beruf-chance/campus/roboter-als-dozent-ist-das-der-professor-von-morgen-15254645.html*).

8 See the studies in H. Jacquemin/A. de Streel (eds.), supra sub FN 5.

9 For a detailed assessment of the ethical issues of autonomous driving: Federal Ministry of Transport and Digital Infrastructure, Ethics Commission, Automated and Connected Driving, Report 2017, at p. 10 et seq. (available at: *https://www.bmvi.de/SharedDocs/EN/publications/report-ethics-commission.pdf?__blob=publicationFile*).

10 Deutschlandfunk online 12 September 2017, Selbstfahrende Schiffe – Ohne Crew auf dem Meer (available at *http://www.deutschlandfunk.de/selbstfahrende-schiffe-ohne-crew-auf-dem-meer.676.de.html?dram:article_id=395682*).

11 See L. Bütfeld et al., Using Virtual Reality to Assess Ethical Decisions in Road Traffic Scenarios: Applicability of Value-of-Life-Based Models and Influences of Time Pressure, 11 Frontiers in Behavioral Neuroscience (July 2017 – Article 122).

12 See analytical survey by N. Nevejans, Règles Européennes de Droit Civil en Robotique, Étude pour la commission des affaires juridiques du Parlément européen PE 571,379 (2016), p. 18 et seq. (available at *http://www.europarl.europa.eu/RegData/etudes/STUD/2016/571379/IPOL_STU(2016)571379_FR.pdf*), and U.Pagallo, The Laws of Robots (Springer Dordrecht 2013), at p. 35 et seq., who insists that a general responsibility for a robot should be used as a starting-point for legal analysis.

13 ISO 8373:2012 (Definition of Industrial Robot) (available at *https://ifr.org/img/office/Industrial_Robots_2016_Chapter_1_2.pdf*).

persons, or for commercial tasks, operated by properly trained personnel.[14] Service robots function with a 'degree of autonomy', i.e. the "ability to perform intended tasks … without human intervention".[15] The first-generation robots do not require human-robot interaction. Collaborative robots do.[16] The most sophisticated robots, including autonomously driving vehicles[17], are guided by artificial intelligence. They are capable of "…perform[ing] functions that are generally associated with human intelligence such as reasoning and learning".[18] A robot's artificial intelligence builds on a "knowledge-based system", i.e. an "*information processing system* that provides for solving problems in a particular *domain* or application area by drawing *inferences* from a *knowledge base*",[19] including the ability to collect and refine knowledge and process acquired information.[20]

A "robot army" has come to revolutionise factories and warehouses,[21] ushering in both, benefits and tragedy. Industrial robots have killed workers in the assembly-line.[22] Autonomous cars are reported to cause (lethal) accidents.[23] A Chinese autonomous language robot went out of its way, physically

14 See International Federation of Robotics, Service Robots (Classification of service robots by application areas) (2016) (available at *https://ifr.org/img/office/Service_Robots_2016_Chapter_1_2.pdf*).

15 Ibid. See also International Federation of Robotics, Press Release 11 October 2017, Why service robots are booming worldwide (available at *https://ifr.org/ifr-press-releases/news/why-service-robots-are-booming-worldwide*).

16 See infra sub II.3.

17 See infra, sub III.

18 See Definition in ISO/IEC 2382-28.01.02:1995 (en) (available at *https://www.iso.org/obp/ui/#iso:std:iso-iec:2382:-28:ed-1:v1:en*).

19 ISO/IEC 2382-28.01.05:1995 (en) (available at *https://www.iso.org/obp/ui/#iso:std:iso-iec:2382:-28:ed-1:v1:en*).

20 See ISO/IEC 2382-28.01.09:1995 (en) (Knowledge acquisition) and ISO/IEC 2382-28.01.10:1995 (en (Cognitive Modeling) (available at *https://www.iso.org/obp/ui/#iso:std:iso-iec:2382:-28:ed-1:v1:en*).

21 Financial Times online 17 November 2017, Robot army is transforming the global workplace (available at *https://www.ft.com/content/f04128de-c4a5-11e7-b2bb-322b2cb39656*).

22 The Independent online 15 March 2017, Robot 'goes rogue and kills woman on Michigan car parts production line' (available at http://www.independent.co.uk/news/world/americas/robot-killed-woman-wanda-holbrook-car-parts-factory-michigan-ventra-ionia-mains-federal-lawsuit-100-a7630591.html); Complaint and Jury Demand, Holbrook v. Prodomax Automation Ltd. et al., U.S. District Court, W.D. Michigan, Case No. 1:17-CV (filed, 7 March 2017, available at *https://www.courthousenews.com/wp-content/uploads/2017/03/RobotDeath.pdf*).

23 Class Action Calls TESLA Self-Driving Software 'Dangerous', Sheikh v. Tesla, Inc., 36 (24) Westlaw J. Automotive 2 (2017); J. Fowler, Comment - Trailblazing An Industry: The Potential Effects and Defects of Autonomous Vehicles and the Need for Legislation in Texas, 49 Tex. Tech. L. Rev. 903 et seq. (2017), and infra sub III.

attacking bystanders.[24] These incidents contribute to the uneasiness about "killer robots",[25] inviting analysis whether regulatory intervention for protective measures is apposite. Robo-advisors do not cause the loss of lives, but bad advice may generate substantial losses of investor money.[26] From a theoretical point of view, the borderline between autonomous and semi-autonomous robots, between direct human intervention and mere oversight, is very appealing. But in the real world, human action may even interfere with the operation of autonomous robots and their artificial intelligence: Blockchain technology has come to be combined with artificial intelligence. Swarms of autonomous robots will be coordinated via blockchains[27] to optimise e.g. transports[28] or agricultural tasks.[29] In this scenario, the robot may well be autonomous, while its activity is triggered by the operation of a human-made blockchain.

In 2017, the European Parliament called for a common definition of 'smart autonomous robots' in order to prepare the ground for a charter on robotics.[30] According to a Resolution of the European Parliament 'smart autonomous robots' are capable of acquiring autonomy through sensors by exchanging data and analysing them.[31] This capacity enables 'smart autonomous robots' to learn and interact so that they can adapt to the environment. In reflecting on civil law liability, the Resolution observes that physical damages caused by 'non-human agents' do not justify *per se* restrictions on recove-

24 Z. Mou, Robot attacks visitor during demonstration, China Daily online 18 November 2016 (available *http://www.chinadaily.com.cn/china/2016-11/18/content_27425304.htm*).

25 J. Markoff/C. Cain Miller, As Robotics Advances, Worries of Killer Robots Rise, New York Times online 16 June 2014 (available at *https://www.nytimes.com/2014/06/17/upshot/danger-robots-working.html*).

26 See infra sub II.1.

27 E. Castelló Ferrer, The blockchain: a new framework for robotic swarm systems (2016) (available at *https://arxiv.org/pdf/1608.00695.pdf*).

28 J. Chen/M. Gauci/R. Groß, A Strategy for Transporting Tall Objects with a Swarm of Miniature Robots, 2013 IEEE International Conference on Robotics and Automation (ICRA), Karlsruhe/Germany 6-10 May 2013 (available at *https://naturalrobotics.group.shef.ac.uk/publications/2013-icra-chen.pdf*).

29 See L. Emmi et al., New Trends for Agriculture: Integration and Assessment of a Real Fleet of Robots, 2014 The Scientific World Journal 1 (7 et seq.); S. Yaghoubi et al., Autonomous Robots for Agricultural Tasks and Farm Assignment and Future Trends in Agro Robots, 13 (3) Int'l. J. Mechanical & Mechatronics Engineering 1 (4) (2013).

30 European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL) (available at *http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P8-TA-2017-0051+0+DOC+XML+V0//EN*).

31 See definition and classification of 'smart robots' in the Annex to the Resolution: Recommendations as to the Content of the Proposal Requested.

ring damages.[32] It appears to adhere to a master-servant concept when it emphasises the need for uninterrupted human control over intelligent machines. But the Parliament stops short of explicitly addressing the role of those who actually put a 'smart autonomous robot' to work. It insists on the "interoperability of network-connected autonomous robots",[33] and invites the Commission to weigh strict liability against a risk management approach, supplemented by a mandatory insurance scheme into which the producer of the 'smart autonomous robot' will be required to pay.[34]

2. Outline of the Paper

At the outset, robots – like all engineered systems – operate to serve the purpose they have been designed for.[35] As long as their activities can be integrated into traditional control theory, lawyers have no difficulty in integrating them into a principal-agent relationship.[36] As a corollary, established concepts of foreseeability are likely to accommodate the fall-out from robotics, even if the cooperation between human beings and the robot-machine intensifies.[37] This argumentative pattern, however, is likely to fall apart as soon as (autonomous) robots become "unpredictable by design".[38]

This paper distinguishes financial loss from physical injury caused by robots. In the financial services industry, computer-generated information is intended to play a decisive role in determining investors' strategies. The analysis will then focus on the degree of human collaboration with robots.[39] While industrial robots have a long tradition of separating human from robot action, medical robots introduce a delicate interface between robots and humans. Robot-assisted surgery combines the skills of a surgeon with robot autonomy. Reference will be made to the jurisprudence of U.S. courts which

32 Ibid. sub 'Civil law liability'.

33 Annex to the Resolution: Recommendations as to the Content of the Proposal Requested (sub: 'interoperability, access to code and intellectual property rights).

34 See Resolution (General principles concerning the development of robotics and artificial intelligence for civil use), sub 3.

35 B. Walker Smith, in: R. Galo/A.M. Froomkin/I. Kerr, supra sub FN 1, 78 (83 et seq.).

36 Id., at p. 84. See also A. Lowenthal, Beyond Robo-Advisers – Thinking About the Next Wave of Artificial Advisers, 19 (6) Fintech L. Rep. NL 2 (December 2016).

37 B. Walker Smith, in: R. Galo/A.M. Froomkin/I. Kerr, supra sub FN 1, 78 (at 85 et seq.).

38 J. Millar/I. Kerr, in: R. Galo/A.M. Froomkin/I. Kerr, supra sub FN 1, 102 (107).

39 See S. Chopra/L.F. White, A Legal Theory for Autonomous Artificial Agents (The University of Michigan Press Ann Arbor 2011), p.8 et seq., on the interaction between humans and robots ('agents'), and N. Nevejans, Traité de Droit et d'Éthique de la Robotique Civile (LEH Édition Bordeaux 2017), at p. 140 et seq.

have addressed the overlap between product liability and malpractice scenarios, between strict liability and liability predicated upon of finding of – at least – negligence. Contrary to surgical robots, autonomous vehicles challenge established beliefs about the residual human capacity to take charge in an emergency scenario. A final section will emphasise the need to focus on the interface between civil liability rules, cost externalisation and risk distribution considerations.

II Robot-assisted Activities

1. Robo-Advice

Digitisation is shaking the foundations of financial advice exclusively given by human beings. Cost considerations have come to drive the financial services industry into exploring the potential of algorithm-generated advice.[40] Automated advice is seen as a vehicle for bringing investment advice to consumers who have been underserved by traditional advice patterns[41]. 'Robo-advisors' stand also for a new type of digital wealth management where mathematical algorithms generate proposals for investment opportunities which translate into digitally managed online portfolios.[42] Conceptually, two forms of algorithm-generated information are about to assume a decisive role in advising investors.[43] The borderline is the degree of human intervention in the counselling process while advising companies make market information on investment opportunities available to their customers. In an advisor-assisted scenario investment advice is supplied through digital channels.[44] The personal advisor retrieves all relevant business information from an algorithm-

40 See WeltN24 online 13 December 2016, K. Seibel, "Deutsche Bank schickt Roboter in den Fondsverkauf" (available at *https://www.welt.de/wirtschaft/webwelt/article160234741/Deutsche-Bank-schickt-Roboter-in-den-Fondsverkauf.html*).

41 United Kingdom Financial Conduct Authority (FCA), Robo Advice: an FCA perspective, Speech by Bob Ferguson, London 11 October 2017 (available at *https://www.fca.org.uk/news/speeches/robo-advice-fca-perspective*).

42 See the case studies by R. Schwinn/E.G.S. Teo, in: D. Lee Kuo Chen/R..H. Deng, Handbook of Blockchain, Digital Finance, and Inclusion Vol. 2 (Academic Press London 2018), 481 (484 et seq.), Deloitte, The Expansion of Robo-Advisory in Wealth Management (August 2016) (available at *https://www2.deloitte.com/content/dam/Deloitte/de/Documents/financial-services/Deloitte-Robo-safe.pdf*); Neue Zürcher Zeitung online 8 September 2017, M. Ferber, „Blechkollegen in der Bank" (available at *https://www.nzz.ch/finanzen/robo-advisory-blechkollegen-in-der-bank-ld.1315087*), and

43 B. Nicoletti, The Future of Fintech – Integrating Finance and Technology in Financial Services (Palgrave/Macmillan/Springer Cham 2017), 141 et seq.

44 UK FCA Robo Advice, supra sub FN 41.

based search mechanism which reflects specific customer profiles and produces best suitable investment strategies.[45] Thus personal advice is combined with information generated from a digital platform into which information on investment opportunities is fed. Conversely, a fully automated robo-advisor feeds investor information into a model portfolio and will then produce an algorithm-based package of recommendations for investment strategies.[46] From the perspective of digital technology, the outcome of this process very much resembles the autonomous, digitised matching-process now practised by some crowdfunding platforms.[47] In fact, this is a robo-distribution of investment opportunities based on digitised investor information and corresponding risk preferences translated into algorithms arranged by a financial services company.[48] Wealth management with robot-assisted services is a rapidly consolidating market where investment companies manage a portfolio of 73bn US $ with the assistance of robo-advisors.[49] The fully automated robo-distribution of investment opportunities supports portfolio management by artificial intelligence.[50] It is intended to produce both, long-term cost reductions for the industry and a yet more efficient allocation of personal portfolios.[51]

The U.S. Securities and Exchange Commission (SEC) takes a cautious approach towards robo-advisors. It notes that some investment firms operate 'hybrid' advisory schemes which combine contact with a 'physical' professional with the automated search scheme generating information on investment

45 Ibid.

46 See Press Release (13 November 2017) from Julius Bär Group Ltd. (Switzerland), E. Johnson, FinTech: robots that might change your (financial) life) (available at *https://www.juliusbaer.com/group/en/news-detail-page/item/fintech-robots-that-might-change-your-financial-life/*).

47 See Financial Times online 9 December 2016, FCA proposes tougher rules for peer-to-peer lending (available at https://www.ft.com/content/ae38b8c9-a44f-3bff-8c26-ee15940705e4); Lending Crowd, Automated Investments with Autobid (Blog 12 June 2015, available at *https://www.lendingcrowd.com/blog/automated-investments-autobid/*).

48 For a comprehensive survey see New Zealand Financial Market Authority, Consultation Paper: Proposed exemption to facilitate personalised robo-advice (Wellington June 2017) (available at *https://fma.govt.nz/assets/Consultations/170621-Consultation-paper-Robo-advice-exemption.pdf*).

49 World Economic Forum/Deloitte, Beyond Fintech: A Pragmatic Assessment of Disruptive Potential in Financial Services (August 2017), sub 3.5 (Investment Management) (available at *http://www3.weforum.org/docs/Beyond_Fintech_-_A_Pragmatic_Assessment_of_Disruptive_Potential_in_Financial_Services*.pdf).

50 See B. Nicoletti, supra sub FN 43, 143 et seq.

51 See Homepage of Betterment, Inc., explaining robo-advisors ("What is a Robo-Advisor? – You can thank automation for more efficiency, more peace of mind, and lower costs" (13 October 2014).) (available at *https://www.betterment.com/resources/personal-finance/goals-and-advice/what-is-a-roboadvisor/*).

opportunities.[52] The SEC emphasises that potential investors should scrutinise the focus of a specific automated investment programme before they sign up.[53] Ultimately, this is a question about whether potential (consumer-) investors have obtained sufficient information before they make a judgement in favour of robo-advisory. From the practitioner's perspective, this is an issue of private contracting. Investment firms applying robo-advisory systems will have to examine to what extent liability risks can be reduced by supplying adequate warnings about investment strategies and risks prior to signing the contract. If disclaimers about the risks of automated portfolio management enter into the standard terms of the contract, courts may eventually be asked to examine whether (consumer-) investor will not be unduly disadvantaged.

Somewhat implicitly, the SEC acknowledges that the law on artificial intelligence in robo-advisory schemes rests on two prongs: Private contracting may hedge liability risks anticipated by the investment advisory companies. But from a practical perspective, licensing requirement under capital market regulations may come to play a more important role in accommodating potential shortcomings of artificial intelligence by regulation. Investment advisors in the U.S. have to register with the SEC or state authorities. It is noteworthy that the duty to register is not predicated on the degree of 'human' intervention or participation when investment advice is dispensed. Rather, the registration requirement is triggered by the very fact that an investment management company operates a system of automated robo-advice. This approach is dictated by regulatory difficulties: Should robo-advisory services be offered cross-border via the internet, a United States-based investment management company is the only entity subject to SEC jurisdiction. But in the context of artificial intelligence a causation argument appears to come into play. Ultimately, it will be the mastery of a robo-advisory system tilts the scales towards registration under Investment Advisory Law. A comparable regulatory approach has been taken by New York State authorities towards investment professionals offering virtual currencies or virtual currency services: A 'bit license' has to be sought once virtual currency-related services are offered.[54] But the SEC's Investor Bulletin on robo-advisors does not answer the question whether a specific compliance is apposite if the artificial intelligence of the robo-advisory system gets out of hand. Moreover, under the current

52 U.S. SEC, Investor Bulletin: Robo-Advisers (23 April 2017, available at *https://www.sec.gov/oiea/investor-alerts-bulletins/ib_robo-advisers.html*).

53 *Ibid.*

54 See New York Codes, Rules and Regulations Title 23 Chapter I Part 200 (Virtual Currencies) (available at *https://www.dfs.ny.gov/legal/regulations/adoptions/dfsp200t.pdf*).

state of law it is unclear how courts will handle a complaint for damages under an investment contract for robo advisory-based investment.

Currently, regulatory agencies in the U.S have refrained from interfering with robo-advice by way of outright prohibition. But they attempt to flesh out the fiduciary duties by requiring investment management companies to disclose potential risk of relying on the advice emanating from an artificial intelligence-based system.[55] This is particularly apposite where investment management companies will have to undertake a due diligence exam in a robo-advisory context.[56] In February 2017, the SEC issued a Guidance for robo-advisors under the Advisers Act,[57] emphasising disclosure duties, the *ex-ante* collection of information from the potential investors and specific duties under a compliance programme.[58] The SEC requires robo-advisory companies to explain their investment strategies, the algorithmic functions and the underlying assumptions which determine the management of a customer account, i.e. the portfolio, and the risks associated therewith.[59] Moreover, the investment management company has to collect sufficient information on the investment preferences before a portfolio management contract is signed. The SEC has voiced some concern about an internet-based exchange of information. Online questionnaires have been found to be so streamlined that the scope of information on customers' investment preferences was very limited.[60] The SEC urges robot-advisory investment firms to contact potential investors before artificial intelligence gets operative.[61] Moreover, the investment companies are urged to establish automatic review systems where client responses are inconsistent.[62] Clients should also be allowed to change the strategy recommended by the robo-advisor.[63] With respect to the statutory compliance programme, investment companies are urged to monitor the operation of algorithms ex post and to evaluate the need for adjustments. Clients have to

55 See U.S. SEC, IM Guidance Update No. 2017-02, Robo-Advisers (February 2017), sub 1 (Substance and Presentation of Disclosures) (available at *https://www.sec.gov/investment/im-guidance-2017-02.pdf*), and generally M. Ji, Note – Are Robots Good Fiduciaries? Regulating Robo-Advisors under the Investment advisers Act of 1940, 117 Colum. L. Rev. 1543 (1567 et seq.) (2017).

56 Cf. M.L. Fein on robo-advisors, in: Securities Activities of Banks (Aspen Publishers, 4th ed. 2018 (Supplement), 5.04 [G].

57 The Investment Advisers Act of 1940, 15 U.S.C. § 80 b-1 et seq.

58 U.S. SEC, IM Guidance Update No. 2017-02, supra sub FN 55.

59 *bid.*

60 *Ibid.*

61 *Ibid.*

62 *Ibid.*

63 *Ibid.*

be warned if a change of the algorithmic code would materially affect their investment portfolios.[64] It is as yet unclear, how the statutory compliance duties can be calibrated with what is owed under contract law. It is equally unclear whether a breach of statutory compliance duties will automatically establish a case for damages under the law of contracts, as the SEC has not yet embarked on a comprehensive regulatory strategy towards robo-advisors. Robo-advisors are still under no (statutory) duty to disclose in-built investment biases of the algorithms or shadow commissions.[65]

Compared to their U.S. counterparts, German robo-advisory companies are operating with a substantially smaller size of portfolios.[66] In Germany, 'robo-advice' stands for a variety of business models including, advisory and brokering services or portfolio management.[67] Thus, 'robo-advice' may be covered by banking law, capital market regulation or private law duties under the Civil Code (*Bürgerliches Gesetzbuch*). Under banking law, robo-advisory services are predicated on the information solicited from the potential investor and the ability of the algorithm to accommodate the specific investment needs of the customer. Such services require a licence.[68] Under German law, robo-advisory companies are not required to operate an algorithm which excludes any discretionary decision-making by the operator.[69] Thus algorithms still operate within the statutory limits if they produce a recommendation for a specific type of investment without identifying the securities of a particular target company. Conversely, if investment advice is confined to mere brokering or agent-like activities, neither artificial intelligence nor algorithms operate as to open up discretion for distributing investment between several targets.[70] It is obvious that 'robo-advice' may only be offered if the investment company discharges specific disclosure duties which have been read into the Civil Code, depending on whether the investor is a consumer or a sophisticated, professional investor.[71] As under U.S. law, private law duties

64 *Ibid.*

65 M. Ji, 117 Colum L. Rev. 1543 (1581) (2017).

66 F. Möslein/A. Lordt, Rechtsfragen des Robo-Advice, ZIP 2017, 793 (794).

67 F. Möslein/A. Lordt, ZIP 2017, 793 (794 et seq.).

68 F. Möslein/A. Lordt, ZIP 2017, 793 (796).

69 F. Möslein/A. Lordt, ZIP 2017, 793 (796).

70 F. Möslein/A. Lordt, ZIP 2017, 793 (796 et seq.).

71 See also on the risks of increasing automation of financial advice European Securities and Markets Authority/European Banking Authority/European Insurance and Occupational Pensions Authority/Joint Committee of the European Supervisory Authorities, Joint Committee Discussion Paper on automation of financial advice (JC 2015 080), 4 December 2015 (available at *https://esas-joint-*

owed under the Civil Code will be heavily influenced by public laws on registration, licensing and supervision.[72] It is as yet unclear whether a breach of public law duties will automatically establish a breach of the underlying private law contract for robo-advisory services.

The United Kingdom Financial Conduct Authority (UK FCA) has emphasised the importance of appropriate robo advice models which exclude systemic risk selling.[73] In this context the FCA warns that firms offering the robo-advisory system cannot escape responsibility by outsourcing the development of the technology to third party suppliers.[74] In preparing its authorisation for personalised robo-advice the New Zealand Financial Markets Authority had considered a value cap on personal insurance products for consumer protection reasons,[75] but ultimately relied on personal eligibility criteria for the directors and senior managers of robo-advice services.[76]

2. Robots in Industry – Industrial Automation

Traditionally, 'industrial automation' has been defined as the process of integrating robots into manufacturing or industrial settings (integrated assembly settings).[77] The first generation of industry robots is not yet equipped with sensors to detect the presence of humans at the assembly-line where robots become operative.[78] Nonetheless, robot-related deaths are relatively

committee.europa.eu/Publications/Discussion%20Paper/20151204_JC_2015_080_discussion_paper_on_Automation_in_Financial_Advice.pdf).

72 See the plea by F. Möslein/A. Lordt, ZIP 2017, 793 (802 et seq.), to develop 'algorithmic duties of organisation'.

73 Supra sub FN 41.

74 *Ibid.*

75 New Zealand Financial Market Authority, Consultation Paper, supra sub FN 48.

76 New Zealand Financial Market Authority, Media Release MR No. 2017-44, FMA allows personalised robo-advice; applications open early 2018 (Wellington 18 October 2017) (available at https://fma.govt.nz/news-and-resources/media-releases/fma-allows-personalised-robo-advice-applications-open-early-2018/).

77 See study prepared by the Fraunhofer-Institut für System- und Innovationsforschung/Fraunhofer-Institut für Produktionstechnik und Automatisierung, Automatisierung und Robotik-Systeme – Studien zum deutschen Innovationssystem Nr. 11-2016 (Karlsruhe January 2016), at p. 23 (available at *https://www.e-fi.de/fileadmin/Innovationsstudien_2016/StuDIS_11_2016.pdf*); U.S. Department of Commerce, International Trade Administration, 2016 Top Markets Report – Industrial Automation (Washington, D.C., April 2016), at p. 3 et seq. (available at *http://internationalenergydevelopers.com/uploads/4/0/4/6/4046368/industrial_automation_top_markets_report_2016.pdf*).

78 See report in Financial Times online 2 July 2015, C. Bryant, Worker at Volkswagen plant killed in robot accident (available at https://www.ft.com/content/0c8034a6-200f-11e5-aa5a-398b2169cf79),

rare.[79] They raise issues of private law and criminal liability.[80] From the perspective of a potential product liability claim against the producer of the robot, the buyer or the injured person will only succeed if an unsuitable design of the robot or deficiencies in the training of futures users of the robot in the factory can be established. In such a case, the producer of the robot will attempt to escape liability by suggesting that the worker unduly interfered with the operation of the robot, or that training instructions were unduly disregarded by the buyer-factory. If producer liability cannot be established, the injured worker will have to rely on a claim for damages for sustained injuries against the employer under the labour contract. Thus, injuries sustained under an unforeseen malfunctioning of a first generation robot will ultimately translate into the question whether the employer has bought sufficient insurance to handle claims for workers' compensation.

Considerable attention has been devoted to increasing safety for those working in the vicinity of robots: Public authorities require factories to report any injury sustained due to a malfunctioning of the robot.[81] Specific training programmes are devised to anticipate errors in human judgment evidenced by decreasing precautions while hazardously close to the robot.[82] With respect to injury avoidance strategies, research focuses on probabilistic assessments about the likelihood of injuries, which build on insights from the history of injuri-

and analysis by V. Murashov/F. Hearl/J. Howard, Working Safely with Robot Workers: Recommendations for the New Workplace, 13 (3) J. Occup. Environ. Hyg. 1 et seq. (sub 'industrial robots') (2015).

79 Financial Times online 2 July 2015, C. Cookson, Robot-related deaths are rare and becoming rarer (available at https://www.ft.com/content/c9851cde-20b3-11e5-aa5a-398b2169cf79),

80 F.P. Hubbard, "Sophisticated Robots": Balancing Liability, Regulation and Innovation, 66 Fla. L. Rev. 1803 (1829 et seq.) (2014). For a criminal law approach to manslaughter by industrial robots: S.M. Solaiman, Corporate Manslaughter by Industrial Robots at Work: Who Should Go on Trial under the Principles of Common Law in Australia?, 35 J.L. & Com 21 (25 et seq.) (2016).

81 See e.g. U.S. Centre for Disease Control and Prevention, National Center for Occupational Safety and Health, FACE 8420, Fatal Accident Summary: Die Cast Operator Pinned by Robot (2014/2015) (available at *https://www.cdc.gov/niosh/face/in-house/full8420.html*), and the survey by the U.S. Department of Labor, Occupational Safety and Health Administration, "Search Results", giving an account on each industrial robot-related accident (available at *https://www.osha.gov/pls/imis/AccidentSearch.search?acc_keyword=%22Robot%22&keyword_list=on*).

82 See report by S. Oberer-Treitz/A. Puzik/A. Verl, Sicherheitsbewertung der Mensch-Roboter-Kooperation, 101 (9) wt Werkstatttechnik online 629 (630 et seq.) (2011) (available at *www.springer-vdi-verlag.de/libary/news/2011/09/629_63044.pdf).*

es or fatalities from industrial robots.[83] Ultimately this will translate into an update on training sessions organised by the producer of the robot and a sophistication of programming processes within the production plant.[84] Deficiencies in the programming process of the robot are likely to trigger a claim for negligence.[85] Disregard for safety instructions will result in reduction of damages awarded to an injured worker or in a total denial of a claim for compensation.

Recently, the development of 'industrial automation' has been expanded to include the digital and industrial internet of things.[86] Basically, this adds communication devices to production processes with robots, so that the control systems of a plant can optimise the use of assets, including robots. As the industry moves away from first-generation robots, collaborative robots pose a new challenge to risk reduction strategies and workers compensation schemes which have been sufficiently flexible to handle the beginnings of industrial automation. If collaborative robots are governed by artificial intelligence operating a specific communication and control system via the cloud,

83 Ibid.; M. Vasic/A. Billard, Safety issues in human-robot interactions. Proceedings - IEEE International Conference on Robotics and Automation.197 et seq. (2013) (available at *https://pdfs.semanticscholar.org/c967/d91abb76a2b908315dd8d0d4bdf86345a8f5.pdf*),and the reports by the Robotic Industries Organisation, T.M. Anandan, Robot Safety, Everything But Routine (20 August 2015) (available at *https://www.robotics.org/content-detail.cfm/Industrial-Robotics-Industry-Insights/Robot-Safety-Everything-But-Routine/content_id/5653*), and the Association for Advancing Automation, Get the Facts on Robot Safety (2 September 2015) (available at *https://www.a3automate.org/get-the-facts-on-robot-safety/*).

84 See on the increasing relevance of automation specialists: P. Ilg, Die Zeit online 24 February 2017, Ohne sie läuft in der Produktion nichts (available at *http://www.zeit.de/karriere/beruf/2017-02/automatisierungstechnik-elektroniker-beruf-ausbildung*); *http://www.zeit.de/karriere/beruf/2017-02/automatisierungstechnik-elektroniker-beruf-ausbildung*) and VDI (Verband Deutscher Ingenieure), Press Release 28 January 2914, Ohne sie läuft nichts – Ingenieure in der chemischen Produktion (available at *https://www.vdi.de/technik/fachthemen/verfahrenstechnik-und-chemieingenieurwesen/artikel/ohne-sie-laeuft-hier-nichts-ingenieure-in-der-chemischen-produktion/*).

85 Cf. Spindler, in: Spickhoff (ed.), beck-online Großkommentar (1 May 2017), § 823 BGBG No. 731; O. Keßler, Intelligente Roboter – neue Technologien im Einsatz. Voraussetzungen und Rechtsfolgen des Handelns informationstechnischer Systeme, MMR 2017, 589 (593 et seq.) (on the liability scenario for intelligent robots).

86 Crédit Suisse Equity Research Capital Goods, Global Industrial Automation – Thoughts on Digital and broader competitive trends post Hannover Messe (15 May 2017) (available at https://research-doc.credit-*suisse.com/docView?language=ENG&format=PDF&sourceid=csplus researchcp&document_id=1074773731&serialid=jQd8M7yfc%2FleL5%2Fd7Ojm3hw3jn9ccBds%2FcK3wyVC%2FJU%3D*).

traditional concepts of distribution of risk will have to be reassessed.[87] The judicial fallout from collaborative robots will be first explored in the context of medical robots or robotic surgery.

3. Medical Robots – Robotical Surgery

Since the late 1980's, surgical robots and minimally invasive surgery have entered hospitals. A surgical teleoperator system enables the surgeon to perform operations with a robotical arm which actually makes the incisions within the patient's body.[88] The surgeon looks into the body with the help of endoscopes which visualise the movements of the robotic arm.[89] Stereo visualisation ushers in a man-to-machine interface whereby the movement of the surgeon's hands at the teleoperator are translated into motions of the surgical tool tips in the patient's body.[90] The surgical robot combines, in fact, several robotical functions. A console unit consists of visualisation technology, the surgeon-user interface and a controller system.[91] In addition to the console unit a cart close to the patient includes endoscopic technology, tool manipulators and interface facilities for the surgical assistant.[92]

'Da Vinci', the most commonly used surgical robot in the United Sates, has brought innovation to medicine and to law, as many patients have made a perfect recovery and others have complained about substantial defects causing injury.[93] Case law from the United States explores the challenge to traditional notions of product liability and medical malpractice when human beings and robots are meant to cooperate,[94] magnified by evidentiary standards in court proceedings.[95] If patients cannot overcome the burden of proof

87 For a re-assessment of the traditional roles of manufacturer and user in the context of 3D-printing: J. Beck/M.D. Jacobson, 3D Printing: What Could Happen to Products Liability When Users (and Everyone Else in Between) Become Manufacturers, 18 Minn. J.L. Sci. & Tech. 143 (158 et seq.) (2017).

88 G.S. Guthart/J.K. Salisbury, Jr., The Intuitive Telesurgery System: Overview and Application, Proceedings of the 2000 IEEE International Conference on Robotics & Automation, San Francisco (2000), 618.

89 *Ibid.*

90 *Ibid.* at p. 619. See also A. Schweikard/F. Ernst, Medical Robotics (Springer Cham Heidelberg 2015), 16, 339 et seq.

91 A. Schweikard/F. Ernst, at p. 339.

92 *Ibid.*

93 F.P. Hubbard, 66 Fla. L. Rev. 1803 (1841 et seq.) (2014).

94 See infra sub II.3.

95 See M. Goldberg, The Robotic Arm Went Crazy! The Problem of Establishing Liability in a Monopolized Field, 38 Rutgers Computer & Tech. L. J. 225 (248 et seq.) (2015), commenting on Mracek

in a strict liability setting, they will adopt a breach-of-duty litigation strategy,[96] claiming that the producer did neither warn of the potential risks of the 'Da Vinci' surgical robot nor provide adequate training to potential surgeons.[97] In terms of litigation strategy, this might overplay difficulties in establishing a malpractice case against the surgeon.[98] On the other hand, once a product liability case is unsuccessful, a malpractice claim might look more promising, if the surgeons had applied minimally invasive surgery in spite of bad news on 'Da Vinci's' (temporary) deficiencies.[99] However, the courts have adopted a cautious approach towards this line of reasoning. The – injured – plaintiff cannot just rely on hearsay, instead, the pleadings must adduce evidence that there has been a breach of duties.[100] If the surgical robot malfunctions during the operation and doctors return to traditional, open surgery, this does not automatically justify a claim for compensation due to alleged malpractice.[101] Recent cases suggest that – in the cooperative scenario between the (human) surgeon and the surgical robot – product liability and malpractice claims are not mutually exclusive.[102] This leaves a complicated message for hospitals, doctors and potential plaintiffs. As the standard of care in a robot-surgery scenario is still unclear, doctors will have to observe extensive disclosure duties so that the patient's informed consent can be obtained.[103] For hospitals, legal uncertainty should result in meaningful training sessions, adequate documentation and protocols of the surgical processes[104] in order to escape from the

v. Bryn Mawr Hospital, 610 FS 2nd 401 (404) (E.D. Penn., 2009), aff'd 363 Fed.Appx. 925 (3rd. Cir., 2010).

96 See the plaintiff's pleading in Mohler v. St. Luke's Medical Center LP, 2008 WL 5384214 (Az. App. 1st, 2008).

97 See the plaintiff's argument in Silvestrini v. Intuitive Surgical, Inc., 2012 WL 380283 (E.D. La., 2012).

98 Cf. the Press Release of the American Association for Justice on 'New Robotic Surgery, Litigation Packet' in: 49-DEC Trial 57 (December 2013).

99 See plaintiff's argument in: Gonzalez Production Systems v. Martinrea International, Inc., 2015 WL 4934628 (N.D. Mich., 2015).

100 Gonzalez Production Systems v. Martinrea International, Inc., 2015 WL 4934628 (N.D. Mich., 2015).

101 See the facts in Mracek v. Bryn Mawr Hospital, 610 FS 2nd 401 (403) (E.D. Penn., 2009), and in O'Brien v. Intuitive Surgical, Inc., 2011 WL 3040479 (N.D. Ill., 2011).

102 See Reece v. Intuitive Surgical Inc., 63 FS 3d 1337 (1339 et seq.) (N.D. Ala., 2014) and Moll v. Intuitive Surgery, Inc., 2014 WL 1389652 (E.D. La., 2014).

103 Cf. J. Douglas Peters, Robots Holding the Scalpel, 48-MAY TRIAL 36 (38 et seq.) (2012).

104 See Reece v. Intuitive Surgical Inc., 63 FS 3d 1337 (1339 et seq.), and Balding v. Tarter, 2013 IL App (4th) 121030-U (Ill. App. (4th), 2013); and R. Calo, Robotics and the Lessons od Cyberlaw, 103 Cal. L. Rev. 513 (537 et seq.) (2015).

vicarious liability concept.[105] With respect to the producer, the notion of greater surgical efficiency will only hold if it is accompanied by meaningful information about potential risks of teleoperator systems.[106] This duty to inform and to warn is to overplay uncertainties about the actual role of robots in medicine.[107] It may remedy alleged shortcomings of product liability law in the context of robots. But it also appears to modernise the well-established concept of master-agent for robotic surgery. Once doctors interfere substantially with 'Da Vinci's' activities, they are taking over the role as the robot's master from its producer.[108] It would seem that duties of disclosure and care currently operate as to calibrate overlapping responsibilities of producers, hospitals and doctors. In a German case, an appeal court has rejected the argument that robotic surgery as a new technology should facilitate a *per se* claim for damages.[109]

III The Next Generation - Autonomous Vehicles

1. The Framework

Under s. 49 U.S.C. 30102 (a) (1) an " 'automated driving system' means the hardware and software that are collectively capable of performing the entire dynamic driving task on a sustained basis, regardless of whether such system is limited to a specific operational design domain".[110] A "dynamic driving task' …[consists of all] … the real time operational and tactical functions required to operate a vehicle in on-road traffic, excluding the strategic functions such as trip scheduling and selection of destinations and waypoints, and including …monitoring the driving environment via object and event detection, recognition, classification, and response preparation…".[111]

Robo-taxis are the *dernier cri* in the development of autonomous cars: Passengers will be able to 'call' for a taxi by using an app on their smartphone

105 See Payas v. Adventist Health System/sunbelt, Inc., 2018 WL 911824 (Fla. App. 2nd Dist., 2018).

106 Taylor v. Intuitive Surgical, Inc., 187 Wash.2d 743 (at p. 753 et seq.) (Wash., 2017), see also the plaintiffs' claims in Darringer v. Intuitive Surgical, Inc., 2015 WL 4623935 (N.D. Cal., 2015), and in Whitley v. Sepulveda et al., 2017 WL 3641871 (N.D. Cal., 2017).

107 Cf. *ibid.*

108 However, a surgeon's statement that he is „captain of the ship" does not affect established concepts of liability: Balding v. Tarter, 2013 IL App (4th) 121030-U (Ill. App. (4th), 2013).

109 Oberlandesgericht (Higher Regional Court) Frankfurt, judgement of 7 December 2004, NJW-RR 2005, 173 (174 et seq.).

110 49 USC 30102 (a) (1), as amended by the Self Drive Act 2017, 115th Congress (2017-2018) H.R. 3388 (available at *https://www.congress.gov/bill/115th-congress/house-bill/3388/text*).

111 49 USC §§ 30102 (a) (6), 30102 (a) (6) (C), as amended by the Self Drive Act 2017.

which transmits the desired location to the 'recipient' car.[112] By relying on the internet of things, a remote human operator will be able to step in and take over control in an emergency.[113] Current research focuses on the development of a blockchain-based infrastructure which coordinates the movements of the autonomous cars,[114] like the robots in smart farming.[115] In fact, some manufacturers are so confident about the interface between autonomous vehicles and the internet of things that they envisage cars without a steering-wheel.[116] Undoubtedly, autonomous cars pose enormous ethical challenges in dilemma situations, as algorithms will have to assess specific risk situations in actual traffic.[117] Algorithms are based on modelling human behaviour, but also on an ethical determination what risk choices are acceptable or not.[118] Regulators tend to approach this dilemma from a liability perspective.[119] Thus, various

112 Forbes online 28 February 2018, P. Lyon, Japan's First-Ever, Self-Driving Robo-Taxis Testing On Public Roads (available at *https://www.forbes.com/sites/peterlyon/2018/02/28/futuristic-self-driving-robo-taxies-testing-on-public-roads-in-japan/#c17f84f2a67c*); Japan Times online 27 February 2018, A. Beadie, Revolution looms for Japan's staid taxi sector as Uber and SoftBank vie for a piece of the action (available at *https://www.japantimes.co.jp/news/2018/02/27/business/ corporate-business/revolution-looms-japans-staid-taxi-sector-uber-softbank-vie-piece-action/*).

113 Digital Trends Blog 24 February 2018, Cars – Nissan begins fields tests of its Easy Ride driverless robo-taxi in Japan (available at *https://www.digitaltrends.com/cars/nissan-easy-ride-robo-taxi-first-tests/*); see on the importance of the internet of things for autonomous driving: D.A. Riehl, Car Minus Driver Part I, Autonomous Vehicles Driving Regulation, Liability and Policy, 73 J. Mo. B. 208 (209 et seq.) (2017).

114 See D.A. Crane/K.D. Loge/B.C. Pilz, A Survey of Legal Issues Arising from the Deployment of Autonomous and Connected Vehicles, 23 Mich. Telecomm. & Tech. L. Rev. 191 (233 et seq.) (2017), and United Kingdom Department of Transport, Press Release 13 December 2017, Highways England's intelligent network of the future (available at *https://www.gov.uk/government/news/highways-englands-intelligent-network-of-the-future*). See also Frankfurter Zeitung online 4 October 2017, Testen für das Netz der Zukunft (available at *http://www.faz.net/aktuell/wirtschaft/unternehmen/selbstfahrende-autos-testen-fuer-das-netz-der-zukunft-15226894.html*).

115 See supra, sub FN 29.

116 Frankfurter Allgemeine Zeitung online 12 January 2018, General Motors schafft das Lenkrad ab (available at *http://www.faz.net/aktuell/wirtschaft/diginomics/general-motors-schafft-das-lenkrad-ab-15392375.html*), 20 November 2017, Hier fährt der Fahrer nicht (available at *http://www.faz.net/aktuell/technik-motor/motor/smart-fortwo-robotertaxi-von-daimler-15298634.html*).

117 See supra sub FN 9.

118 L. Sütfeld/R. Gast/P. König/G. Pipa, Using Virtual Reality to Assess Ethical Decisions in Road Traffic Scenarios: Applicability of Value-of-Life-Based Models and Influences of Time Pressure, Front. Behav. Neurosc. 11:122 (2017) on modelling human moral behaviour.

119 See the assessment by Fowler, supra sub FN 23, at p. 920 et seq.; from a criminal law perspective: E. Hilgendorf, Automatisiertes Fahren und Strafrecht – der "Aschaffenburger Fall", Deutsche Richterzeitung 2/2018, 66 (67 et seq.).

liability scenarios have to be tested before ethical considerations translate into mandatory law.

Proponents of autonomous driving claim that accident rates will significantly drop.[120] In California, many manufacturers of autonomous cars perform tests in private. However, when these cars venture outside, they are not always as autonomous as they look: In 2017, nineteen out of 50 companies went 'public' and sometimes, the drivers of autonomous cars had to intervene to replace the working of artificial intelligence by human stewardship.[121] On the other hand, a preliminary analysis of accidents with autonomous vehicles in California has shown that 22 out of 26 accidents were not caused by deficiencies of the 'driving robot'.[122] Some accidents occurred while the autonomous vehicle operated on manual mode.[123] It may be too early to infer general conclusions from this assessment, but statutory insistence on human drivers being able of overruling artificial intelligence in dilemma situations may be less convincing than it looks.[124] Moreover, the possibility of human intervention reanimates the debate on the interface between human and robot action, so typical of the 'da Vinci' scenario.[125] This, in turn, may reanimate simple value-of-life models for determining algorithmic choices in dilemma situations.[126]

In December 2017, the California Department of Motor Vehicles issued new regulations on autonomous vehicles, specifying the qualifications

120 McKinsey Report, Michele Bertoncello and Dominik Wee, Ten ways autonomous driving could redefine the automotive world (June 2015) (available at *https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/ten-ways-autonomous-driving-could-redefine-the-automotive-world*).

121 Automotive News online 31 January 2018, California's latest self-driving report card signals long road ahead (available at *http://www.autonews.com/article/20180131/MOBILITY/180139947/californias-latest-self-driving-report-card-signals-long-road-ahead*).

122 F.M. Favarò et al., Examining accident reports involving autonomous vehicles in California, PLOS ONE 1 et seq. (20 September 2017, available at *http://journals.plos.org/plosone/ article?id=10.1371/journal.pone.0184952*).

123 *Ibid.*

124 As under Californian and German laws. However, California has announced that it is about to allow testing of driverless cars: see revised Regulations: Second Modified Express Terms Title 13, Div. 1, Ch.1 Article 3.7: Testing of Autonomous Vehicles (available at https://www.dmv.ca.gov/portal/wcm/connect/aa08dc20-5980-4021-a2b2-c8dec326216b/AV_Second15Day_Notice_Express_Terms.pdf?MOD=AJPERES) and The Verge online 26 February 2018, California green lights fully driverless cars for testing on public roads (available at *https://www.theverge.com-/2018/2/26/17054000/self-driving-car-california-dmv-regulations*).

125 See supra, sub II.3.

126 L. Sütfeld/R. Gast/P. König/G. Pipa, supra sub FN 118.

for test drivers of autonomous vehicles.[127] In the preceding public debate, carmakers had attempted to change the strict liability regime which rendered them liable for any defects of the autonomous car, irrespective of any intervening act.[128] The industry lobbied for a 'good driver standard', thus watering down the strict product liability scheme. The department refused to follow suit.[129] It explained that a change of the liability standard would increase risk unfairly to test drivers.[130] Moreover, a change of the liability regime was inapposite event though the driver had the chance to take over control of the car at any given time.[131] The new regulations require the test driver to participate in a training programme so that the driver "knows the limitations of the vehicle's autonomous technology".[132] The current concept behind California law on autonomous vehicles is motivated by the policy consideration that it is first and foremost the carmaker which introduces a potentially dangerous vehicle into traffic. The acceptance rate of artificial intelligence is determined by who is best qualified to reduce the risks of algorithms externalising cost.[133] Current California law appears to be unconvinced by the argument that it is the driver who operates the vehicle and hence, should be held liable. It is as yet an open question how insurance companies will be able to accommodate these legislative choices[134].

127 Available at https://www.dmv.ca.gov/portal/wcm/connect/a6ea01e0-072f-4f93-aa6c-e12b844443cc/DriverlessAV_Adopted_Regulatory_*Text.pdf?MOD=AJPERES*.

128 See Associated Press News online 15 November 2017, Michael Liedtke, California may limit liability for self-driving carmakers (available at *https://www.apnews.com/39a98dfb5bd442698de0c31126db5ae0/California-may-limit-liability-of-self-driving-carmakers*).

129 See Associated Press News online, 2 December 2017, California regulators nix rules limiting carmaker liability (available at *https://www.apnews.com/ce707c88718446c5b9b93b3180c70e6e*).

130 California Department of Vehicles – Final Statement of Reasons, § 227.20.

131 Ibid. and § 227.02 (c) of the Regulations.

132 §§ 227.18 (d), 227.22 (a) of the Regulations.

133 For an assessment of the various regulatory policy options on risk: S. Weinberg, Automated Vehicles: Strict Products; Negligence Liability and Proliferation, Illinois Business Law Journal (7 January 2016, available at *https://publish.illinois.edu/illinoisblj/2016/01/07/automated-vehicles-strict-products-liability-negligence-liability-and-proliferation/*).

134 See KPMG White Paper, Marketplace of change: Automobile insurance in the era of autonomous vehicles, p. 37 et seq. (October 2015, available at *https://assets.kpmg.com/content/dam/kpmg/pdf/2016/06/id-market-place-of-change-automobile-insurance-in-the-era-of-autonomous-vehicles.pdf*). From a consumer perspective: Consumer Watchdog, H. Rosenfeld, Self-Driving Vehicles – The Threat to Consumers, p 23 et seq. (June 2017, available at *http://docs.house.gov/meetings/IF/IF17/20170627/106182/HHRG-115-IF17-20170627-SD020.pdf*).

2. Conclusion

On March 18, 2018 an autonomous car operated by Uber caused the first pedestrian death due to self-driving technology.[135] Obviously unnoticed by the sensors of the autonomous vehicle, the victim had stepped out of the dark and crossed the street,[136] not using a near-by zebra crossing.[137] There was an emergency back-up driver, but apparently, it would have been difficult to avoid the collision either autonomously or through human intervention.[138] In the immediate aftermath of this tragic accident there was no evidence that the sensors of the autonomous car had been malfunctioning. It just seems that the autonomous car had entered an unpredictable situation, typical of road traffic.[139] Statisticians in favour of autonomous cars will be quick to point out that, in the US, an average of 16 pedestrians die in road traffic.[140]

The immediate reactions after the 18 March accident highlight the regulatory challenge in the face of robots. With varying intensity, regulators have stepped in to set up a framework for autonomous cars. Accidents with autonomous cars happen at the (theoretical) intersection between product liability and liability for operating an object, believed to be inherently and potentially dangerous.[141] Regulators and autonomous car-operating companies have insisted that an emergency back-up driver might intervene in case of immediate danger. This introduces an element of master-servant thinking into liabi-

135 New York Times online 19 March 2018, Self-Driving Uber Car Kills Pedestrian in Arizona, Where Robots Roam (available at *https://www.nytimes.com/2018/03/19/technology/uber-driverless-fatality.html*).

136 Frankfurter Allgemeine Zeitung online 20 March 2018, Zusammenstoß wäre schwer zu verhindern gewesen (available at *http://www.faz.net/aktuell/wirtschaft/unternehmen/toedlicher-uber-zusammenstoss-waere-schwer-zu-verhindern-gewesen-15502893.html*).

137 The Standard Examiner online 19 March 2018, Self-driving vehicle strikes and kills pedestrian in Arizona (available at *http://www.standard.net/Business/2018/03/19/Uber-self-driving-vehicle-hits-kills-pedestrian-in-Arizona*); Phoenix New Times online 19 March 2018, Temple Police: Uber Self-Driving Car Didn't Brake 'Significantly' Before Killing Pedestrian (available at *http://www.phoenixnewtimes.com/news/medical-cannabis-extracts-legal-in-arizona-or-not-10232352*).

138 San Francisco Chronicle online 19 March 2018, Uber halts self-driving operations after car kills Arizona pedestrian (available at *https://www.sfchronicle.com/business/article/Uber-self-driving-car-strikes-kills-pedestrian-12764464.php*).

139 Cf. New York Times online 19 March 2018, supra sub 137.

140 See Financial Times online 20 March 2018, Driverless vehicles – Self-driving cars under scrutiny after pedestrian death (available at *https://www.ft.com/content/6d328aa8-2be5-11e8-9b4b-bc4b9f08f381*).

141 See passim P. Buck-Heeb/A. Dieckmann, in: B.H. Oppermann/J. Stender-Vorwachs, Autonomes Fahren (Verlag C.H. Beck Munich 2017), 59 (62), advocating a comparable distinction in liability analysis without specifying whether they consider this is a sub-category of product liability.

lity analysis.[142] But as the 18 March accident demonstrates, the autonomous car situation is radically different from the collaborative atmosphere between a doctor and surgical robot. In an invasive surgery scenario, doctors can still intervene when something goes wrong. However, even with the presence of emergency back-up drivers a tragic accident may not be averted. The traditional foreseeability analysis of tort law cases is unhelpful in a master-servant scenario where not a defect of the product materialises, but the inherent danger of the robot put into operation by a physical person or a company.[143] Admittedly, a robot ceases to be the simple tool of a specific actor the more autonomous it gets.[144] But during the current test phase of autonomous cars, it is still the operating company which externalises its costs when it introduces autonomous cars into the real world of city traffic.[145] This argument will also hold true should autonomous cars be used for taxi or city bus services.

So far, the regulatory policy of the European Union has approached robots in law from the perspective of product safety. Directives and the respective national laws determine the framework within which a consumer or an injured party might seek damages.[146] The Resolution of the European Parliament indicates that the analysis of civil liability for robots should be informed by externalisation criteria.[147] This should also extend to blockchain technology which is to coordinate the use of artificial intelligence in production processes and the internet of things.[148] As artificial intelligence and robots

142 See S. Chopra/L.F. White, supra sub FN 39, p. 119 et seq. on 'tort liability for artificial agents'.

143 For a discussion of permissible risk in the context of Swiss law on driverless cars: N. Zurkinden, in: H. Jacquemin/A. de Streel (eds)., supra sub FN 5, 341 (350 et seq.).

144 Recital AB of the Resolution of the European Parliament, supra sub FN 30.

145 See S. Chopra/L.F. White, supra sub FN 39, at p. 189, calling for a cost-benefit analysis when employing robots (including robots with artificial intelligence), and U. Bose, The Black Box Solution to Autonomous Liability, 92 Wash. U. L. Rev. 1325 (1334 et seq.) (2015).

146 See analysis by N. Nevejans, Robotique Civile, supra sub 39, 284 et seq., commenting on Directives 2006/42/EC (Machinery), 2014/30/EU (electromagnetic compatibility (recast)), 2006/95/EC (electrical equipment designed for use within certain voltage limits) and 2005/88/EC (use of outdoor equipment).

147 See assessment by E. Palmerini, in: H. Jacquemin/A. de Streel (eds.), supra sub FN 5, 47 (69 et seq.).

148 See Alyssa Hertig, Coindesk 12 August 2016, How Blockchain Could Make Robots Swarms Smarter (available at ETCIO.com Newsletter 24 October 2017, Blockchain, Machine learning, Robotics, Artificial Intelligence and Wireless technologies will reshape digital business (available at *https://cio.economictimes.indiatimes.com/news/strategy-and-management/blockchain-machine-learning-robotics-artificial-intelligence-and-wireless-technologies-will-reshape-digital-business-in-2018/61198007*); J. Henderson, Digital Supply Chain Newsletter 24 January 2018, Blockchain, IoT, data and robotics "game changers" for supply chain industry in 2018 (available at

are difficult to integrate into traditional law concepts,[149] it has been suggested that robots should be awarded legal capacity.[150] Intellectually challenging as it is, this proposal should not obscure the major cleavage between strict product liability and the responsibility for releasing a potentially damaging robot for operation. Properly understood, 'legal capacity' of robots invites cost externalisation analysis, but no *per-se* exemption from liability.[151]

Robots and law defy a generalising approach. Obviously, the first generation of industrial robots is easier to reconcile with traditional concepts of tort law and product liability. Robo-advice and robot-assisted surgery normally allow for a clear distinction between human and robot action. Human intervention will still be able to address unforeseen crisis scenarios so that damages can be contained.[152] On the other hand, autonomous cars stand for the application of artificial intelligence which stretches traditional foreseeability analysis to the extreme.[153] Guided by probability analysis, risk scenarios should be identified where civil liability (and the duty to buy mandatory insurance) will fall on those who put a potentially harmful robot into operation.[154]

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http://www.supplychaindigital.com/technology/blockchain-iot-data-and-robotics-game-changers-supply-chain-industry-2018).

149 See C.E.A. Karnow, in: R. Galo/A.M. Froomkin/I. Kerr, supra sub FN 1, 51 (61 et seq.), on the difficulties of applying traditional tort theory to embodied machine intelligence, i.e. robots.

150 M.A. Chinen, The Co-Evolution of Autonomous Machines and Legal Responsibility, 28 Va. J.L. & Tech. 338 (at p. 386 et seq.) (2017).

151 See S. Chopra/L.F. White, supra sub FN 39, who discuss personhood for artificial agents (at p. 153 et seq.), but also emphasise the need for 'efficient risk allocation' (at p. 190), and F.P. Hubbard, in: R. Calo/A.M. Foomkin/I. Kerr (eds.), supra sub FN 1, 25 (at p. 41 et seq.), applying risk allocation criteria to the liability analysis of 'robotic automobiles).

152 See e.g. the risk assessment in the context of robo-advisors and the likelihood of materialisation of risk, in: European Securities and Markets Authority/European Banking Authority/European Insurance and Occupational Pensions Authority/Joint Committee of the European Supervisory Authorities, Report on automation of financial advice, sub no. 16 et seq. (December 2016) (available at *https://esas-joint-committee.europa.eu/Publications/Reports/EBA%20BS%202016%20422%20(JC%20SC%20CPFI%20Final%20Report%20on%20automated%20advice%20tools).pdf*).

153 See, however C.E.A. Karnow, in R. Calo/A.M. Froomkin/I. Kerr (eds.), supra sub FN 1, 51 (at p. 76 et seq.), who insists on common sense operating as a 'buffer' on machine intelligence since the increasing use of a new technology will create (new) expectations and thus render 'the behavior of autonomous robots' more predictable.

154 Cf. S. Chopra/L.F. White, supra sub FN 39, at p. 190; and U. Pagallo, supra sub FN 12, on 'robots as strict agents' and insurance implications (at p. 166 et seq., 170).