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Asimov for Lawmakers

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Articles

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ABSTRACT

Are Isaac Asimov's books on lawmakers' bedside tables? Many emerging laws on Artificial Intelligence ("AI") mention Asimov's Three Laws of Robotics. But should they? Asimov's stories describe failures of the Three Laws, not successes. This paper attempts to address this question by diving into Asimov's works of and on science fiction. The paper shows that the wisdom that lawmakers can derive from Asimov's writing is different from the regulation by design approach embodied in the Three Laws. Seven nuanced lessons about technological change, and the way societies respond to it, emerge from Asimov's works.

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Asimov for Lawmakers

INTRODUCTION

Lawmakers read Isaac Asimov's robot stories. Justifications for lawmaking initiatives towards Artificial Intelligence ("AI") often use Asimov's Three Laws of robotics ("the Three Laws").[1] This is strange. Asimov's robot stories describe failures of the Three Laws. The robot stories embody no suggestion that law is good, or even needed.[2] What Asimov said about law is this: science fiction embodies useful insights for lawmaking.[3] But what insights?

This is the question that this paper tries to answer. Like fiction, science fiction embodies insights useful to the resolution of social conflicts, which is what law is about. The insights are thought experiments, scenarios, and hypothetical cases.[4] Compared to fiction, two types of insights from science fiction are relevant for lawmakers. The first concern technological or scientific change. The second

1. In 2017, the European Parliament referred to the Three Laws in its Resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics. 2018 O.J. (C 252) 25. In 2020, a French congressman introduced a draft bill seeking to codify the Three Laws of robotics in the Preamble of the French Constitution. Proposition de loi Constitutioneelle relative à la Charte, Assemblée Nationale, 2020, No. 2585 (Fr.).

2. Besides, a careful reader will know that Asimov hardly ever talked of AI, but of robotics and positronic brains.

3. Asimov wrote about 500 books during his career. STANLEY ASIMOV, YOURS, ISAAC ASIMOV, x (1996). *See also* David Leslie, *Isaac Asimov: centenary of the great explainer,* 577 NATURE 614 (2020). It is worth noting that Isaac Asimov published three collections to celebrate the publication of his one hundredth (ISAAC ASIMOV, OPUS 100 (1969)), two hundredth (ISAAC ASIMOV, OPUS 200 (1979)), and three hundredth book (ISAAC ASIMOV, OPUS 300 (1984)). The first short story that Asimov published was "The Callistan Menace" (initially named "stowaway"), in 1939. ISAAC ASIMOV, THE EARLY ASIMOV 13 (1972) [hereinafter ASIMOV, THE EARLY ASIMOV]. For the record, it is the second short story written by Asimov (or the third if we take into account "Little Brothers", a short text written by Asimov and published in the literary review of Brooklyn Boys' High School), the first being "Cosmic Corkscrow" (never published). His first book was *Pebble in the Sky* (initially named *Grow Old with Me*) in January 19th, 1950. ISAAC ASIMOV, PEBBLE IN THE SKY (1950). *See* ASIMOV, THE EARLY ASIMOV. It therefore took twenty years for Asimov to publish one hundred books (1950-1969), ten years to publish one hundred more (1969-1979), and five more years to publish his three hundredth book (1979-1984).

4. Giovanni Sartor, *Human Rights in the Information Society: Utopias, Dystopias and Human Values*, in PHILOSOPHICAL DIMENSIONS OF HUMAN RIGHTS, 293 (Claudio Corradetti ed., 2012). *See also* Kieran Tranter, LIVING IN TECHNICAL LEGALITY: SCIENCE FICTION AND LAW AS TECHNOLOGY (2018).

concern social responses to changes in levels of science and technology. Both the technological and social insights of science fiction can help lawmakers overcome some of the world's uncertainty.[5]

This paper attempts to derive lessons from Asimov's works. Seven lessons emerge. The first lesson concerns technological insights. The others relate to social insights. The first two lessons are drawn from Asimov's writings on science fiction. The rest of the lessons stem from Asimov's works of science fiction.

The first lesson is that some technological insights of science fiction are more 'predictive' than others.[6] The second lesson is that science fiction contains useful conjectures about society.[7] The third lesson is that societies initially object to technological change, but never end up discarding it.[8] The fourth lesson is that regulation by design tends to be societies' initial response to technological uncertainty.[9] The fifth lesson is that regulation by design is fallible.[10] The sixth lesson is that human agency, common sense, and ingenuity play a key role in solving problems of regulation by design.[11] The last lesson is that regulation by design never obviates the need for (real) law.[12]

This paper is divided in nine parts. The first part shows the relevance of science fiction in general, and of Asimov's writings, in particular, in lawmaking contexts. The seven following parts describe the lessons that can be drawn from Asimov's works. The last part shows how the lessons suggest that Asimov was neither a techno-determinist, nor a techno-solutionist, but a techno-institutionalist.

5. Asimov, himself, wrote an entire series about psychohistory, or the science of predicting the ultra-long term future. ISAAC ASIMOV, FOUNDATION AND THE EMPIRE (1952).

6. *See infra* note 33 *seq*. and accompanying text.

7. *See infra* note 65 *seq*. and accompanying text.

8. *See infra* note 78 *seq*. and accompanying text.

9. *See infra* note 97 *seq*. and accompanying text.

10. *See infra* note 113 *seq*. and accompanying text.

11. *See infra* note 124 *seq*. and accompanying text.

12. *See infra* note 134 *seq*. and accompanying text.

Note that the paper takes a broad view of the concept lawmaking that covers legislation, judicial decision, and administrative action.

I. WHY FICTION, WHY SCIENCE FICTION, WHY ASIMOV?

A critical eye will quickly pick up the implicit assumption of this paper. The assumption is that useful lawmaking knowledge resides in fiction literature ("fiction"), science fiction, and Asimov's work.

The assumption is not the product of the writers' imagination. Law as a social science consists of the study of conflicts between individuals, and how society solves them. Through this lens, fiction constitutes a relevant source of knowledge for lawmakers.[13] Fiction develops one's "thinking about imaginary cases [that] can help us learn new things about the world."[14] In more specific terms, fiction allows lawmakers to conduct thought experiments,[15] through "a process of reasoning carried out within the context of a well-articulated imaginary scenario in order to answer a specific question about a non-imaginary situation."[16]

Now why science fiction? As its name suggests, science fiction blends fiction, and science.[17] And science fiction draws heavily from

13. MICHAEL SALER, AS IF: MODERN ENCHANTMENT AND THE LITERARY PRE-HISTORY OF VIRTUAL REALITY 30 (2012) [hereinafter SALER, AS IF].

14. TAMAR SZABÓ GENDLER, THOUGHT EXPERIMENT: ON THE POWERS AND LIMITS OF IMAGINARY CASES 1 (2000) [hereinafter, GENDLER, THOUGHT EXPERIMENT].

15. *See* Tamar Szabó Gendler, *Galileo and the Indispensability of Scientific Thought Experiment*, 49, BRIT. J. PHIL. SCI., 397, 397-424 (1998); GENDLER, THOUGHT EXPERIMENT, *supra* note 14, 18; S. . .ren Höggqvist, *A Model for Thought Experiments*, 39 CAN. J. PHIL., 55, 56 (2009); Kimberley Brownlee & Zofia Stemplowka, *Thought Experiments*, *in* METHODS IN ANALYTICAL POLITICAL THEORY 21, 24 (2017); THE ROUTLEDGE COMPANION TO THOUGHT EXPERIMENTS (Michael T. Stuart et. al. eds., 2017).

16. GENDLER, THOUGHT EXPERIMENT, *supra* note 14, x.

17. The writers do not aim to debate the definition of science fiction. Others have dedicated entire book to this question. *See* THE CAMBRIDGE COMPANION TO SCIENCE FICTION 1 (Edward James & Farah Mendlesohn eds., 2003); THE ROUTLEDGE COMPANION TO SCIENCE FICTION 3 (Mark Bould, Andrex M. Butler, Adam Roberts and Sherryl Vint eds., 2009); DAVID SEED, SCIENCE FICTION*:* A VERY SHORT INTRODUCTION 1 (2011); THE OXFORD HANDBOOK OF SCIENCE FICTION (Robert Latham eds., 2014); ADAM ROBERTS, THE HISTORY OF SCIENCE FICTION 51 (2016); SCIENCE FICTION CRITICISM: AN ANTHOLOGY OF ESSENTIAL WRITINGS 1 (Robert Latham eds., 2017).

natural science.[18] The natural science dimension of science fiction is interesting in a lawmaking context. Tapping into science fiction can give lawmakers confidence. The knowledge mobilized is based largely on facts, logic, and, analytics.[19]

Of course, the point here is not that science fiction provides accurate predictions of what technology will come next, or how technology will reshape society. The science involved in science fiction is neither "true" nor "false". [20] Science fiction constitutes "might-be-true" science relevant in contexts of uncertainty.[21] It enables scenario planning, strategic foresight, and technological forecasting.[22]

In addition, science fiction can drive lawmakers to gain interest in science, and search for better facts to be translated in law.[23] In Asimov's own words, science fiction is a "learning device" that "stimulates curiosity and the desire to know."[24] Science fiction, simply put, might incentivize lawmakers to search for more or better facts.

Now, why cherry pick Asimov? Put differently, if science fiction is so important, why does this paper focus on Asimov's works, instead of science fiction as a whole?[25] Leaving aside the writers' own preferences, there is an objective reason to focus on Asimov's work. Asimov was not just one of the "Big Three" authors of science

18. Isaac Asimov, *By No Means Vulgar,* ISAAC ASIMOV'S SCIENCE FICTION MAGAZINE, Sept.-Oct. 1978, *reprinted in* ISAAC ASIMOV, ASIMOV ON SCIENCE FICTION 46 (1981) [hereinafter ASIMOV, ASIMOV ON SCIENCE FICTION].

19. Eur. Parl. Doc. (COM 125) 2 (2015) (noting at 2 that "the principles of better regulation will ensure that measures are evidence-based").

20. Isaac Asimov, *The Name of Our Field,* ISAAC ASIMOV'S SCIENCE FICTION MAGAZINE, May-Jun. 1978, *reprinted in* ASIMOV, ASIMOV ON SCIENCE FICTION, *supra* note 18, at 25 [hereinafter Asimov, *The Name of Our Field*].

21. *Id.*

22. *See infra* note 65 *seq*. and accompanying text.

23. More generally, Asimov himself wrote that science fiction constitutes "a way of arousing people's interest in science." *See* Isaac Asimov, *Learning Device*, ISAAC ASIMOV'S SCIENCE FICTION MAGAZINE, Aug. 1979, *reprinted in* ASIMOV, ASIMOV ON SCIENCE FICTION, *supra* note 18, at 51 [hereinafter Asimov, *Learning Device*].

24. *Id.*

25. For such an analysis dedicated to media law through science fiction, see for instance DAXTON R. STEWART, MEDIA LAW THROUGH SCIENCE FICTION: DO ANDROIDS DREAM OF ELECTRIC FREE SPEECH? (2020).

fiction.[26] He was also a scientist who earned a doctorate in chemistry in 1948 and taught biochemistry at Boston University since 1949.[27] Asimov had been exposed to sociology in his first professional endeavors.[28]

At this stage, one question remains. What Asimov stories should lawmakers read? Asimov was "a prolific writer."[29] Many of his works allow a law and policy discussion.[30] No clear test exists to determine what is relevant, and what is not, in his abundant prose. The present paper focuses on two strands of Asimov's works.

26. *See* Carl Freedman, *Science Fiction and Utopia: A Historico-Philosophical Overview*, *in* LEARNING FROM OTHER WORLDS: ESTRANGEMENT, COGNITION, AND THE POLITICS OF SCIENCE FICTION AND UTOPIA 72, 81 (Patrick Parrinder, ed., 2001). *See also* Isaac Asimov, *Call It SF or Sci-Fi, It's Big!, in* THE 1980 WORLD YEAR BOOK, WORLD BOOK ENCYCLOPEDIA (1980), *reprinted as* How Science Fiction Came to Be Big Business *in* ASIMOV, ASIMOV ON SCIENCE FICTION, *supra* note 18, at 121, 123-4 [hereinafter Asimov, *How Science Fiction Came to Be Big Business*].

27. ISAAC ASIMOV, IN MEMORY YET GREEN: THE AUTOBIOGRAPHY OF ISAAC ASIMOV, 1920-1954, at 552-55 (1979).

28. He worked as a typist for a sociologist while he was a student. ASIMOV, THE EARLY ASIMOV, *supra* note 3, at 189.

29. Isaac Asimov, *The Prolific Writer*, THE WRITER, Oct. 1979, *reprinted in* ASIMOV, ASIMOV ON SCIENCE FICTION, *supra* note 18, at 315.

30. For instance, an analysis of legal personhood with *The Bicentennial Man*, Isaac Asimov, *The Bicentennial Man*, STELLAR SCIENCE FICTION, Feb. 1976 [hereinafter Asimov, *The Bicentennial Man*], *reprinted in* ISAAC ASIMOV, THE COMPLETE ROBOT, 519 (1982) [hereinafter ASIMOV, THE COMPLETE ROBOT], romantic application of robots with *Satisfaction Guaranteed*, Isaac Asimov, *Satisfaction Guaranteed*, AMAZING STORIES, Apr. 1951, *reprinted in* ASIMOV, THE COMPLETE ROBOT at 285 [hereinafter Asimov, *Satisfaction Guaranteed*], the legal consequences of the destruction of a robot with *The Robots of Dawn*, ISAAC ASIMOV, THE ROBOTS OF DAWN (1983) [hereinafter ASIMOV, THE ROBOTS OF DAWN], the paradox of deontology with *Liar!*, Isaac Asimov, *Liar!,* ASTOUNDING SCIENCE FICTION, May 1941, *reprinted in* ASIMOV, THE COMPLETE ROBOT at 267 [hereinafter Asimov, *Liar!*], Hans Kelsen's PURE THEORY OF LAW with *Runaround*, Isaac Asimov, *Runaround*, ASTOUNDING SCIENCE FICTION, Mar. 1942 [hereinafter Asimov, *Runaround*], *reprinted in* ASIMOV, THE COMPLETE ROBOT at 209, and *The Evitable Conflict*, Isaac Asimov, *The Evitable Conflict*, ASTOUNDING SCIENCE FICTION, June 1950 [hereinafter Asimov, *The Evitable Conflict*], *reprinted in* ASIMOV, THE COMPLETE ROBOT at 447, the automated law enforcement with *Evidence*, Isaac Asimov, *Evidence*, ASTOUNDING SCIENCE FICTION, Sep. 1946, *reprinted in* ASIMOV, THE COMPLETE ROBOT at 425, and the Bentham's utilitarianism especially with *Robots and Empire*, ISAAC ASIMOV, ROBOTS AND EMPIRE (1985) [hereinafter ASIMOV, ROBOTS AND EMPIRE], *Prelude to Foundation*, ISAAC ASIMOV, PRELUDE TO FOUNDATION (1988) [hereinafter, ASIMOV, PRELUDE TO FOUNDATION], *Forward the Foundation*, ISAAC ASIMOV, FORWARD THE FOUNDATION (1993) and *Foundation and Earth*, ISAAC ASIMOV, FOUNDATION AND EARTH (1986).

First, the prevalence of concerns towards AI in the law and policy conversation leads us to focus on the robot and supercomputer ("*Multivac*") stories. Second, the paper relies on Asimov's writings *on* science fiction, and in particular his 1981 volume "*Asimov on Science Fiction.*"[31] The selection has shortcomings. Asimov's robot and Multivac stories represent no more than 15% of his science fiction writings, and a total of approximately fifty short chapters and six novels.[32] That said, the selection is a good proxy. Asimov robot stories occupied a special place in his heart. They might be representative of what he considered science fiction with a big S and F.

II. TECHNOLOGICAL INSIGHTS AND THE CLOSENESS TO SCIENCE RULE

Some technological insights of science fiction are prescient.[33] In 1865, Jules Verne foresaw the first flight to the moon in "*From the Earth to the Moon"*.[34] *Star Trek* prefigured intelligent user interfaces like Amazon Alexa.[35] Asimov also successfully predicted the mass diffusion of self-driving cars in society between 2015 and 2045 in the short story *Sally*.[36] As a side note, Asimov correctly speculated that the main driver of social adoption would be absolute safety, compared to cars driven by human hand.[37]

31. ASIMOV, ASIMOV ON SCIENCE FICTION, *supra* note 18.

32. Jacques Goimard, *Asimov et les robots*, *in* ISAAC ASIMOV, LE GRAND LIVRE DES ROBOTS, 2 LA GLOIRE DE TRANTOR (1991).

33. *See* Chip Stewart, *Do Androids Dream of Electric Free Speech? Visions of the Future of Copyright, Privacy and the First Amendment in Science Fiction* 19 COMMC'N L. & POL'Y 433, 436 (2014) ("[W]hile science fiction may not exist primarily to be predictive, it is difficult to ignore the effectiveness of science fiction writers in revealing technologies years if not decades before they become reality.").

34. JULES VERNE, DE LA TERRE A LA LUNE, TRAJET DIRECT EN 97 HEURES ET 20 MINUTES X, X (Pierre-Jules Hetzel, 1865).

35. Jeffrey P. Bezos, *2018 Letter to Shareholders*, AMAZON (Apr. 11, 2019), https://s2.q4cdn.com/299287126/files/doc_financials/annual/2018-Letter-to-Shareholders.pdf, *cited in* NICOLAS PETIT, BIG TECH AND THE DIGITAL ECONOMY: THE MOLIGOPOLY SCENARIO 142 note 236 (2020).

36. Isaac Asimov, *Sally,* FANTASTIC, May-June 1953, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 7 [hereinafter Asimov, *Sally*].

37. *Id.* at 9. Asimov noted: "Every year machines like that [contemporary cars] used to kill tens of thousands or people. The automatics [autonomous cars] fixed that. A positronic brain can react much faster than a human, of course, and it paid

Now, other technological insights of science fiction are very under-predictive. Philip K. Dick's *Do Androids Dream of Electric Sheep?*,[38] Robert Zemeckis' *Back to the Future*,[39] and many other works from the 1980s imagined flying cars as the future of technology for mobility.[40]

So how far should we trust the technological predictions of science fiction? Asimov held nuanced views about the predictive force of science fiction. On the one hand, he considered that "there is very little in the vast output of science fiction […] which come true, or which is ever likely to come true."[41] On the other hand, he conceded that "successful prediction [could] take place."[42] In these cases, science fiction resembles "futurism", that is the "respectable specialty thought of by those, in government and industry, who must, every day, make decision by guessing the future".[43]

A close reading hints at how the technological insights of science fiction should be used in a lawmaking context. In particular, Asimov suggests that a test of closeness to science is what allows "a glimpse of things that later turn out to be near the truth."[44] Asimov wrote that predictive science fiction tracks "trends in science and technology."[45] In his writings on science fiction, Asimov exemplifies the point by reference to two other science fiction works, *Deadline* and *Solution*

people to keep hands off the control. You got in, punched your destination, and let it go its own way."

38. PHILIP K. DICK, DO ANDROIDS DREAM OF ELECTRIC SHEEP? (1968).

39. *See generally* BACK TO THE FUTURE (Amblin Entertainment 1985).

40. Lawmakers seeking technological facts in science fiction may develop wrong hypotheses and create irrelevant laws. Nicolas Petit & Jerome De Cooman, *Models of Law and Regulation for AI*, *in* THE ROUTLEDGE SOCIAL SCIENCE HANDBOOK OF AI 199, 204 (Anthony Elliott ed., 2021) [hereinafter Petit and De Cooman, *Models of Law and Regulation*].

41. Isaac Asimov, *How Easy to See the Future!*, NATURAL HISTORY, Apr. 1975, at 92, *reprinted in* ASIMOV, ASIMOV ON SCIENCE FICTION, *supra* note 30, at 75 [hereinafter Asimov, *How Easy to See the Future*].

42. *Id.*

43. Isaac Asimov, *Science Fiction: Real Life Mirror of Social Change*, PRISM, Jan. 1974, *reprinted as* Science Fiction and Society *in* ASIMOV, ASIMOV ON SCIENCE FICTION, *supra* note 18, at 103 [hereinafter Asimov, *Science Fiction and Society*].

44. Asimov, *How Easy to See the Future*, *supra* note 41, at 75.

45. *Id.*

Unsatisfactory by Cleve Cartmill and Robert A. Heinlein, respectively. Both rightly predicted military applications of the nuclear bomb years before Hiroshima in 1945.[46] Asimov wrote that "once uranium fission was discovered, a nuclear bomb was an easy extrapolation."[47]

Asimov's works do not give a test to separate serious technological insights from junk ones.[48] But they describe science fiction unworthy of consideration. Asimov was critical of science fiction weak in empirical content.[49] He particularly loathed a generation of 1960s' young writers who wrote fictional stories notwithstanding their lack of "knowledge of science, and even sympathy for science."[50] Asimov spoke plainly of "trashy material."[51]

That insight embodies a clear test of distance versus closeness to science. The test draws a line between what Asimov called "entertainment stories," "escape literature" and "anticipation stories" on the one hand, and "realistic science fiction" on the other.[52] Table 1 applies this distance v closeness to science test to the twenty-eight science fiction themes that Asimov once described as "a good summary of the futuristic (and, possibly, predictive) aspects of science fiction."[53]

46. Cleve Cartmill, *Deadline*, Astounding Science Fiction (1944); Anson MacDonald, *Solution Unsatisfactory*, Astounding Science Fiction (1941). Note that Anson MacDonald was Robert A. Heinlein's pseudonym.

47. Asimov, *How Easy to See the Future*, *supra* note 41, at 78. "Even before the bomb fell, science fiction stories were dealing not only with the bomb itself, but with the nuclear stalemate, with peaceful uses of nuclear fission, and with the possible radiation dangers of nuclear fission." Asimov, *How Science Fiction Came to Be Big Business*, *supra* note 26, at 115.

48. Sure, Asimov wrote about facts that constitute "an extrapolation of the present […] that is so clear and obvious as to forecast something is inevitable". Asimov, *How Easy to See the Future*, *supra* note 41, at 76. A textbook example of a serious technological insight is the depletion of fossil fuel predicted in *The Man Who Awoke.* Laurence Manning, *The Man Who Awoke,* WONDER STORIES, Mar. 1933, at 757, *reprinted in* LAURENCE MANNING, THE MAN WHO AWOKE (1975).

49. *See* Asimov, *Science Fiction and Society*, *supra* note 43, at 103-104.

50. *Id.*, at 104.

51. Asimov, *The Name of Our Field*, *supra* note 20, at 27.

52. Asimov, *How Easy to See the Future*, *supra* note 41, at 78.

53. Asimov, *The Dreams of Science Fiction*, in ASIMOV, ASIMOV ON SCIENCE FICTION, *supra* note 30, at 81.

Technological Insights of Science Fiction	
Distance to Science	**Closeness to Science**
Weather Control	Population Control
World Government	Permanent Energy Sources
Mass Transference	Robots
Immortality	Computers
Telepathy	Computerized Education
Interspecies Communication	Global Village
Space Settlements	Cloning
Terraforming	Bionic Human Beings
Gravitational Control	Genetic Engineering
Interstellar Communication	Control of Evolution
Interstellar Travel	Exploitation of Near Space
Black Holes	Low-gravity Flying
Galactic Empires	Interplanetary Travel
Time Travel	
Alternate Time Paths	

Table 1 – Distance v closeness to science test applied to Asimov's technological insights of science fiction (Source: Isaac Asimov, The Dreams of Science Fiction, in Isaac Asimov, Asimov on Science Fiction (Doubleday 1981) 81-89.

The left column of the table shows technological insights that Asimov deemed distant to science.[54] By distant to science, Asimov meant works far from applied, practical, and empirical science.[55] Despite some theoretical grounding, for example, the science of time

54. *Id*. Asimov explained how "[s]cience fiction can have its fantasy aspects. I have written stories about galactic empires, about faster-than-light speeds, about intelligent robots which eventually became God, about time travel. I don't consider that any of these have predictive value, they weren't intended for that. I was just trying to write entertaining stories." *See* Asimov, *How to Easy See the Future*, *supra* note 41, at 78.

55. Asimov argued that science fiction came as a literary response to *noticeable* technological change. He explained that science fiction writers write stories dealing with "*reasonable* advances in technology" and targets "*what such advances might mean to society*." Asimov, *How Science Fiction Came to Be Big Business*, *supra* note 26, at 116.

travel or mass transference has kept hitting walls in applied contexts.[56] The right column, by contrast, shows technological insights that are close to science. With the benefit of hindsight, all or most appear within our reach today.

Now, not all technological insights that are distant to science are irrelevant. If science fiction does not predict the future, it might well construct it. The view that space settlements (left column) are a far away technology frontier has motivated gigantic investments and research in space technology.[57] The implication is that some distant to science technological insights might actually play a key role in constructing the future, thus they should not be underestimated.

Conversely, as science advances, technological insights that are close to science can become "hopelessly wrong."[58] For example, using state of the art science, Asimov incorrectly described Venus as a worldwide ocean.[59] Similarly, the galaxy in the *Foundation* series exists without quasars, pulsars, or black holes.[60]

Overall, Asimov's closeness to science rule is thus far from perfect. The rule produces false positives (and negatives). Many technological insights that pass the closeness to science test are not more worthy than astrology. Besides, when technological insights are strongly predictive, the rule gives little details. Asimov correctly predicted the first flight to the moon. But he got a lot of things wrong including the timing.[61]

56. David Deutsch & Michael Lockwood, *The Quantum Physics of Time Travel*, in SCIENCE FICTION AND PHILOSOPHY: FROM TIME TRAVEL TO SUPERINTELLIGENCE (Susan Schneider ed., 2nd ed., 2016); Tongcang Li & Zhang-Qi Yin, *Quantum superposition, entanglement, and state teleportation of a microorganism on an electromechanical oscillator*, 61, SCI. BULL., 163 (2016).

57. People like Elon Musk or Jeff Bezos certainly consider settlement to be realistic. *Mars & Beyond: The Road to Making Humanity Multiplanetary*, SPACEX, https://www.spacex.com/human-spaceflight/mars/ (last visited Sep. 30, 2022).

58. *See* Asimov, *Learning Device, supra* note 23, at 48.

59. *See* PAUL FRENCH, LUCKY STARR AND THE OCEANS OF VENUS (1954). Paul French is the pseudonym sometimes used by Isaac Asimov.

60. *See* Asimov, *Learning Device, supra* note 23, at 50.

61. *See* Isaac Asimov, *Trends*, ASTOUNDING SCIENCE FICTION, Jul. 1939, *reprinted in* Asimov, THE EARLY ASIMOV, *supra* note 3, at 76 [hereinafter Asimov, *Trends*].

The main merit of the closeness to science rule lies elsewhere. The test reduces the risk of succumbing to what we called the flying car fallacy.[62] Lawmakers mitigate the risk of adoption of irrelevant law by avoiding reliance on entertainment, escape, and anticipation science fiction.[63] To take a concrete example, lawmakers today concerned with Artificial General Intelligence ("AGI") should think twice. AI's science struggles to make autonomous machines cooperate. A "treacherous turn" of robotic insurgence as in Michael Crichton's *Westworld*, Alex Garland's *Ex Machina*, or even Nick Bostrom's *Superintelligence* is not for tomorrow.[64]

III. WHY AND HOW SCIENCE FICTION'S SOCIAL INSIGHTS MATTER

Someone once said that "a good science-fiction story should be able to predict not the automobile but the traffic jam".[65] The point is apparent. Asimov wrote that the social impacts of technology constitute the "the core of science fiction – its essence."[66] Contrary to a popular perception, science fiction does not simply concern itself with stories about technology.[67] Science fiction is about "human responses to changes in the level of science and technology."[68] The social changes triggered by technology matter as much as technological changes.

In Asimov's mind, the implication was clear. [69] Lawmakers cannot ignore science fiction. He wrote:

62. *See* Petit & De Cooman, *Models of Law and Regulation for AI, supra* note 40.

63. *Id*.

64. *See* NICK BOSTROM, SUPERINTELLIGENCE: PATHS, DANGERS, STRATEGIES (2014).

65. Frederick Pohl, *The Great Invention*, GALAXY MAGAZINE SCIENCE FICTION, Dec. 1968, at 6.

66. Isaac Asimov, *My Own View*, *in* THE ENCYCLOPEDIA OF SCIENCE FICTION (Robert Holdstock ed., 1978) [hereinafter Asimov, *My Own View*], *reprinted in* ASIMOV, ASIMOV ON SCIENCE FICTION, *supra* note 18, at 19.

67. *Id*. "It is not that science fiction predicts this particular change or that that makes it important, it is that it predicts *change*" (we do not emphasize).

68. *Id*.

69. Asimov repeated this idea time and time again. *See* Asimov, *My Own View*, *supra* note 66, at 17; *See also* Asimov, *How Easy to See the Future*, *supra* note 41, at 75; Isaac Asimov, *The Prescientific Universe,* ASIMOV'S SCIENCE FICTION MAGAZINE,

> *No sensible decision can be made any longer without taking into account not only the world as it is, but the world as it will be – and naturally this means that there must be an accurate perception of the world as it will be. This, in turn, means that our statesmen, our businessmen, our everyman must take on a science fictional way of thinking, whether he likes it or not, or even whether he knows it or not. Only so can the deadly problems of today be solved.*[70]

But why? Science fiction enables lawmakers to understand social responses to technological change, to discuss them, and to act upon them.[71] In July 1939, Asimov wrote *Trends*, a short story that dealt with the first flight to the moon.[72] Asimov astutely forecasted ideological opposition to space flight that arose in the late 1960s.[73]

Now should lawmakers be as cautious with science fiction's social insights as they are with technological facts? Probably not. The reason is that science fiction often draws from history to conjecture social responses to technological change. *Star Wars*, *Battlestar Galactica*, *The Expanse*, or even *Foundation*, are revisitations of the Cold War, the Age of Discovery, and the fall of the Roman Empire.[74] Asimov gave great consideration to history.[75] Understanding the past

Summer 1979, *reprinted in* ASIMOV, ASIMOV ON SCIENCE FICTION, *supra* note 18, at 93; Asimov, *Science Fiction and Society*, *supra* note 43, at 97.

70. *See* Asimov, *My Own View*, *supra* note 66 at 19.

71. *See* SALER, AS IF, *supra* note 13.

72. *See* Asimov, *Trends, supra* note 61 at 301.

73. *See* Asimov, *How Easy to See the Future, supra* note 41, at 78.

74. *See* respectively POLI SCI FI: AN INTRODUCTION TO POLITICAL SCIENCE THOUGH SCIENCE FICTION (Michael A. Allen & Justin S. Vaughn eds., Routledge 2016); BATTLESTAR GALACTICA AND INTERNATIONAL RELATIONS (Nicholas J. Kiersey & Iver B. Neumann eds., Routledge 2014). *See also* ASIMOV, THE EARLY ASIMOV, *supra* note 3, at 385 (explaining that Foundation was a "story against the background of the slow fall of the Galactic Empire (something I [Asimov] intended to model quite frankly on the fall of the Roman Empire")).

75. *See* Asimov, THE EARLY ASIMOV, *supra* note 3, at 143 (explaining "In both the situation I pictured on Earth was inspired by that of Judea under the Romans. The climactic battle in "Black Friar of the Flame," however, was inspired by that of the Battle of Salamis, the great victory of the Greeks over the Persians. In telling future-history I always felt it wisest to be guided by past-history. This was true in the "Foundation" series, too.").

is the best way to learn about the future.[76] Moreover, history being contingent and subject to constant revision, no true or false proposition can be made about science fiction's social insights. Unlike with technological insights, this property should give more confidence to lawmakers interested in understanding the repercussions of technology on the evolution of society.[77] Besides, the fact that the social insights are found in escape, entertainment, or anticipation literature is less consequential.

IV. SOCIAL HOSTILITY, THEN AFFINITY, TO TECHNOLOGICAL CHANGE

Asimov's works call our attention to one key social insight. Societies initially object to technological change but never end up discarding it.

Societies tend to discount the present and idealize the past. In his words, "the happy pastoral world […] never existed except in the mind of Nostalgia."[78] It is a popular bias to view the past as a steady state. Because humans are on average averse to change, the past tends to be reified. Logically, when a technological discontinuity occurs, this is contrasted with the "good old days."[79]

But an initial attitude of knee jerk hostility is often followed by one of technological lucidity. Even when a technology is dangerous, humans are reluctant to discard it. Malicious robots, for example, populate Asimov's stories.[80] Yet, they are not banned. Robots are introduced

76. Jacques Goimard, *Asimov et nous, in* ISAAC ASIMOV, LE GRAND LIVRE DES ROBOTS, 1 PRÉLUDE À TRANTOR, xix (1990) [hereinafter ASIMOV, LE GRAND LIVRE DES ROBOTS 1].

77. Isaac Asimov, *Social Science Fiction*, *in* MODERN SCIENCE FICTION: ITS MEANING AND ITS FUTURE (Regina Bretnor ed., 1953).

78. Isaac Asimov, *The One Ring is What We Make It*, *in* PANORAMA 43, 1980, *reprinted as* The Ring of Evil *in* ASIMOV, ASIMOV ON SCIENCE FICTION, *supra* note 18, at 279 [hereinafter Asimov, *The Ring of Evil*].

79. Isaac Asimov, *How Easy to See the Future!*, *supra* note 41, at 76.

80. *See Reason*, a robot concludes human beings are inferior beings and locks them up. Isaac Asimov, *Reason*, ASTOUNDING SCIENCE FICTION, Apr. 1941, at 33, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 227 [hereinafter Asimov, *Reason*]; in *Liar!*, a telepathic robot chooses to lie even if it means causing great psychological trouble once the truth is discovered. Isaac Asimov, *Liar*, *supra* note 30, at 267; in *Little Lost Robot*, a robot develops a sense of superiority and is ready to hurt human beings to remain hidden. Isaac Asimov, *Little Lost Robot*, ASTOUNDING SCIENCE FICTION, Mar. 1947, at 111, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 349 [hereinafter Asimov, *Little Lost Robot*]; In *Someday*, a robot Bard

on other planets where they have limited interactions with humans.[81] This allows Asimov to write that "at no time in the history of mankind has any culture voluntarily given up significant technological advances because of the inconvenience of harm or side effects."[82]

Many novels of Asimov go even further, painting a picture of long-technological affinity. In a story called *Someday*, giant computers manage the human population. Asimov writes:

> *Some [computers] ran factories, and some ran farms. Some organized population and some analyzed all kinds of data. Many were very*

threatens that one day, computers will take over the world. Isaac Asimov, *Someday*, INFINITY SCIENCE FICTION, Aug. 1956, *reprinted in* ASIMOV, THE COMPLETE ROBOTS, *supra* note 30 at 35 [hereinafter Asimov, *Someday*]; in *True Love*, a computer arranges evidence to ensure its designer was convicted for malfeasance. Isaac Asimov, *True love*, AMERICAN WAY, Feb. 1977, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 51.

81. *See* Asimov, *Reason, supra* note 80, in which the robot is operating on a space station. *Id.*; in *Runaround*, the robot is operating on Mercury. Asimov, *Runaround*, *supra* note 30, at 94; in *Robot Al-76 Goes*, a robot is designed for lunar mining (but is accidentally released on Earth). Isaac Asimov, *Robot Al-76 Goes Astray,* AMAZING STORIES, Feb. 1942, at 218, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 59 [hereinafter Asimov, *Robot Al-76 Goes Astray*]. *See also* Asimov, *Little Lost Robot, supra* note 80; in *Risk*, the robot is designed to pilot a spaceship. Isaac Asimov, *Risk*, ASTOUNDING SCIENCE FICTION, May 1955, at 60, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 375 [hereinafter Asimov, *Risk*]; in *First Law*, the robot is operating on Saturn's moon Titan. Isaac Asimov, *First Law,* FANTASTIC UNIVERSE, Oct. 1956, at 29, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 205. Much more interesting, Asimov imagined Earth authorities vote a ban on robots in *Satisfaction Guaranteed*. Asimov, *Satisfaction Guaranteed*, *supra* note 30, at 285. The same idea is found in …*That Thou Art Mindful of Him.* Isaac Asimov, …*That Thou Art Mindful of Him*, FANTASY AND SCIENCE FICTION, March 1974, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30. The idea of (partial) robot ban on Earth and full acceptance in space is also found in Asimov's novels. *See* ISAAC ASIMOV, THE CAVES OF STEEL (1954) [hereinafter ASIMOV, THE CAVES OF STEEL]; ISAAC ASIMOV, THE NAKED SUN (1957) [hereinafter ASIMOV, THE NAKED SUN]; ASIMOV, THE ROBOTS OF DAWN, *supra* note 30.

82. *See* ISAAC ASIMOV, *The Myth of the Machine*, *in* SCIENCE FICTION: CONTEMPORARY MYTHOLOGY 244 (Patricia S. Warrick et al. ed. 1978) [hereinafter Asimov, *The Myth of the Machine*], *reprinted in* ASIMOV, ASIMOV ON SCIENCE FICTION, supra note 30 at 148. Note though that Asimov's statement deserves to be nuanced. At times, some technologies have been abandoned. An example is the ban on chemicals such as chlorofluorocarbons.

> *powerful and very wise, much more powerful and wise than the step-people who were so cruel to the little computer.*[83]

One young boy in the story cannot believe that a past existed in which "farmers grew things with their hands and people had to do all the work in the factories and run all the machines."[84] In other stories about Multivac, when some people started questioning computers' dominion, Asimov wrote "Have you forgotten? Have you all forgotten? Do you remember how it once was? Do you remember the 20th century? We live long now; we live securely now; we live happily now."[85]

Technological affinity is very Asimovian. Technology in general, and computers in particular, are useful. They solve "all the world's problem."[86] In *Franchise*, the computer dispenses with organizing presidential elections by asking a few questions to an individual designated as the most representative of the entire population.[87] In *All the Troubles of the World*, Multivac improves law enforcement by predicting crimes before they happen.[88] And in *The Evitable Conflict*, supercomputers end up optimizing the global economy by nudging humankind towards what machines consider the right direction. Susan Calvin, one of the most important protagonists of Asimov's stories, qualifies this as "wonderful." [89]

But in Asimov's world, technological affinity is not just about convenience. It is also about trust. Asimov's stories feature countless

83. *See* Asimov, *Someday*, *supra* note 80, at 35.

84. *Id.* at 32.

85. Isaac Asimov, *The Life and Times of Multivac*, N. Y. TIMES, Jan. 5, 1975, at 166, 168.

86. Isaac Asimov, *Point of View*, BOYS LIFE, July 1975, at 34, 34, reprinted in ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 37 (explaining how "the world's problems have become so serious and the questions we are asked are so complicated that it takes all [the robot's] smartness to answer them." *Id.*).

87. Isaac Asimov, *Franchise*, IF: WORLDS OF SCIENCE FICTION, Aug. 1955, at 2, *reprinted in* ISAAC ASIMOV, ROBOT DREAMS 193 (1986) [hereinafter ASIMOV, ROBOT DREAMS].

88. Isaac Asimov, *All the Troubles of the World,* SUPER-SCIENCE FICTION, Apr. 1958, *reprinted in* ISAAC ASIMOV, NINE TOMORROWS 137, 137-153 (1959).

89. *See* Asimov, *The Evitable Conflict, supra* note 30.

examples of strong bonds between robots and humans. We have the theme of the robot-pet preferred to animals in *A Boy's Best Friend*,[90] the robot-butler in *Light Verse*,[91] the robot-babysitter in *Robbie*,[92] or even the baby-robot in *Lenny*.[93]

Far from a solutionist, Asimov however considered the need for balanced complementarity between technology and humanity. *The Caves of Steel* provides a good illustration.[94] On the one hand, Asimov depicts Earth's society as one using very few robots and banning them in cities. The upshot is stagnation. On the other hand, robots are widely used in Spacers (first Earth settlement wave) colonies. Too much perhaps, as full reliance on robots leads to a decline of the Spacers' civilization which becomes complacent, lazy, and self-satisfied.[95] For Asimov, the Settlers' (second Earth settlement wave)

90. Isaac Asimov, *A Boy's Best Friend*, BOYS LIFE, Mar. 1975, at 26, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 3.

91. Isaac Asimov, *Light verse*, *in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 121, 123. Asimov wrote, explaining why one of his characters "*always addresses her robots with the most formal courtesy*":

"'I do not ask for speed and efficiency,' she said. 'I ask goodwill. My robots love me.'…'Once a robot is in my house,' she said, 'and has performed his duties, any minor eccentricities must be borne with. I will not have him manhandled.'… 'Nothing that is as intelligent as a robot can ever be but a machine. I treat them as people.'" *Id.*

92. Isaac Asimov, *Robbie*, SUPER SCIENCE FICTION, Sept. 1940, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 133, 138-39. Asimov wrote:

"A robot is infinitely more to be trusted than a human nursemaid. Robbie was constructed for only one purpose really – to be the companion of a little child. His entire 'mentality' has been created for the purpose. He just can't help being faithful and loving and kind. He's a machine-made so. That's more than you can say for humans."

93. Isaac Asimov, *Lenny*, INFINITY SCIENCE FICTION, Jan. 1958, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 301.

94. ASIMOV, THE CAVES OF STEEL, *supra* note 81.

95. ASIMOV, THE NAKED SUN, *supra* note 81. Asimov compares them with the Ancient city of Sparta, wherein Spartan citizens were outnumbered by their helots. The overreliance on technology is a theme that was developed by Asimov in *The Feeling of Power*. In this short story, he warns against the side effect of excessive use of the calculating machine. *The Feeling of Power*, IF: WORLDS OF SCIENCE FICTION, Feb. 1958, *reprinted in* ASIMOV, ROBOT DREAMS, *supra* note 87 at 301. Asimov also analyzes this in "The Computerized World." Isaac Asimov, *The Computerized World,* [hereinafter Asimov, *The Computerized World*] *reprinted in* ISAAC ASIMOV, THE ROVING MIND*,* 214-27 (2nd ed., 1997) [hereinafter ASIMOV, THE ROVING MIND].

middle-ground approach is better.[96] A well-balanced human-robot combination leads to an effective expansion of humanity.[97]

V. THE INEVITABILITY OF REGULATION BY DESIGN

Another social insight from Asimov is that solution to technological risks does not lie in the "abandonment of technology, but [in] additional technology."[98] Drawing from history, Asimov wrote that "the danger of the spear was countered by the shield."[99] The robot stories embody a clear view that societies rely on technology to reduce the dangers of scientific discoveries. In contrast to science fiction that posits "robot-as-menace" or "robot-as-pathos," Asimov's stories envision robots as tools.[100] No more, no less. Now, Asimov's functional perspective on robots has a key implication. Considered as machines built by problem solving-minded engineers, it is safe to assume that robots will be secured. Asimov wrote:

> *Knives are manufactured with hilts so that they may be grasped safely, stairs possess banisters, electric wiring is insulated, pressure cookers have safety valves—in every artifact, thought is put into minimizing danger. (…)*
> *Consider a robot, then, as simply another artifact. It is not a sacrilegious invasion of the domain of the Almighty, any more (or any less) than any*

96. ASIMOV, ROBOTS AND EMPIRE, *supra* note 30.

97. Asimov reaches a similar conclusion in his writings *on* science fiction. For Asimov, "the two intelligences, human and computers, may supplement far more than compete and, in cooperation, may do far more than either separately could." Asimov, *The Computerized World*, *supra* note 95 at 226. He explained that human-machine relation is "a matter of complementation" and wrote, "It could be that a human and computer might form a symbiotic intelligence that would be far greater than either could develop alone, a symbiotic intelligence that would open new horizons and make it possible to achieve new heights. Isaac Asimov, *Homo Obsoletus?*, *reprinted in* ASIMOV, THE ROVING MIND, supra note 95 at 305.

98. Asimov, *The Myth of the Machine*, *supra* note 82 at 148. *See* also the nuance we made *supra* note 82, acknowledging some technologies were actually abandoned.

99. *Id*.

100. ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at xi.

> *other artifact is. As a machine, a robot will surely be designed for safety, as far as possible.*[101]

From this functional perspective, Asimov derives a fundamental idea. There is an inevitability of regulation by design. The Three Laws are just an emendation of that predicate.[102] In a 1942 short story called *Runaround*, Asimov's Three Laws are introduced to elaborate the types of safety safeguards that can be built by design in a robot.[103] The Three Laws are:

> *First Law: A robot may not injure a human being or, through inaction, allow a human being to come to harm.*
> *Second law: A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.*
> *Third Law: A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.*

A related insight from Asimov is that because solution for technological risks consists in adding technology, regulation by design is an iterative response to technological problems. The novel *The Naked Sun* provides an example.[104] The story is about a poisoning crime. A human orders a robot to pour poison in a glass for an experiment. The robot has to obey in compliance with the Second Law. Another robot is subsequently told to give the glass to its master. The second robot, which hands over the glass, does not know about the poison, and does not consider it possible to breach the First

101. ISAAC ASIMOV, THE REST OF THE ROBOTS, xiii (1965). For an explanation of the Asimov's conception of robot as an artifact, see Gorman Beauchamp, *The Frankenstein Complex and Asimov's Robots*, 13, No. 3/4 MOSAIC: AN INTERDISCIPLINARY CRITICAL JOURNAL 85 (1980) [hereinafter Beauchamp, *Frankenstein Complex*].

102. ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at xi.

103. Asimov, *Runaround, supra* note 30. However, we have to note that Asimov explained it is John W. Campbell, Jr. who coined the famous Three Laws although the latter assures it is Asimov who drafted them. ASIMOV, THE EARLY ASIMOV, *supra* note 3, at 309. Asimov later wrote a fourth law. ASIMOV, PRELUDE TO FOUNDATION, *supra* note 30, at 397. This law prevails over the First and is therefore called the Zeroth Law "since zero comes before one." *Id*. The Zeroth Law is, "A robot may not harm humanity, or, by inaction, allow humanity to come to harm." *Id*.

104. ASIMOV, THE NAKED SUN, *supra* note 80.

Law.[105] A robot can therefore kill a human by ignorance, in spite of the First Law. In following works, Asimov subsequently upgrades the First Law as follows:

(Modified) First Law: A robot may do nothing that, to its knowledge, will harm a human being; nor, through inaction, knowingly allow a human being to come to harm.[106]

Now, Asimov has not been always consistent in his functional perspective on robots. Some of his stories feature robots as living beings. In *Little Lost Robot*, Susan Calvin explains:

> *All normal life, (…) consciously or otherwise, resents domination. If the domination is by an inferior, or by a supposed inferior, the resentment becomes stronger. Physically, and, to an extent, mentally, a robot – any robot – is superior to human beings. What makes him slavish, then? Only the First Law! Why, without it, the first order you tried to give a robot would result in your death.*[107]

105. Some have argued that Asimov, while fighting against the fear of robot (Asimov called "*the Frankenstein Complex*"), actually reinforced it by proposing subtler situations that give readers new reasons to fear despite the Three Laws. *See* Beauchamp, *Frankenstein Complex*. Despite Asimov's works, the Frankenstein Complex is alive and well. From Stanley Kubrick *2001: A Space Odyssey* to the recent *Westworld* TV Serie, robots are seen as dangerous things. Hollywoodian productions of these seventy last years are full of examples of this pitch. May it suffice to name, without intending to make an exhaustive list, *Terminator*, *the Matrix*, *Blade Runner*, *Ex Machina* and *I Am Mother*. Video games follow a similar trend. Again, not exhaustively, see *Mass Effect*, *Detroit: Become Human* and *Horizon: Zero Dawn*. This fear is, however, not solely a fictional theme. Scientists also warn about the rapid pace of technological change. This is the case of Nick Bostrom in *Superintelligence*. Stephen Hawking, though not an AI expert, once declared that he feared artificial intelligence could be the greatest achievements of humanity, but also its last one. Rory Cellan-Jones, British Broadcasting Corporation, Stephen Hawking warns artificial intelligence could end mankind, (2 December 2014), https://www.bbc.com/news/technology-30290540. And the controversy between the optimist Mark Zuckerberg and the pessimist Elon Musk over the dangerousness of AI is well known. Cade Metz, Mark Zuckerberg, Elon Musk and the Feud Over Killer Robots, N.Y. Times June 9, 2018 https://www.nytimes.com/2018/06/09/technology/elon-musk-mark-zuckerberg-artificial-intelligence.html.

106. ASIMOV, THE NAKED SUN, *supra* note 80.

107. Asimov, *Little Lost Robot, supra* note 80.

Additionally in *Robot Dreams*[108], a robot named Elvex starts dreaming after receiving a new brain programmed using a non-usual method.

> *I saw that all the robots were bowed down with toil and affliction, that all were weary of responsibility and care, and I wished them to rest (…). In my dream, (…) it seemed to me there was neither First nor Second Law, but the only the Third, and the Third Law was 'A robot must protect its own existence.' That was the whole of the Law.* [109]

Susan Calvin's explanations cast doubt on the exact nature of the robot, either conscious being or simple machine. She explains the dreamed robot's whish of freedom: "As we would say of a human being, not consciously. But who would have thought there was an unconscious layer beneath the obvious positronic brain paths, a layer that was not necessarily under the control of the Three Laws?"[110] What should we think about this? In a straight application of the closeness to science rule, Asimov would not draw much from his own description of robots as living beings.[111] The science of artificial consciousness has historically been mired with controversies. On the contrary, Asimov astonishingly correctly forecasted the current discussions on regulation by design laid up in the recent proposal for an EU Regulation of artificial intelligence.[112]

108. Isaac Asimov, *Robot Dreams*, in ASIMOV, ROBOT DREAMS, *supra* note 87.

109. For the record, this short story ends with the destruction of the robot, when he finally reveals that in his dreams, he is a man – not a robot – who claims "*Let my people go!*". *Id*.

110. *Id*. at 27.

111. Asimov, *The Computerized World, supra* note 95 at 214.

112. Commission Regulation 2021/206 final, REGULATION OF THE EUR. PARL. AND OF THE COUNCIL LAYING DOWN HARMONISED RULES ON ARTIFICIAL INTELLIGENCE (ARTIFICIAL INTELLIGENCE ACT) AND AMENDING CERTAIN UNION LEGISLATIVE ACTS (EC). Article 9 for instance requires that risk raised by AI systems have to be eliminated or reduced "*as far as possible through adequate design and development*." *Id*.

VI. THE FALLIBILITY OF REGULATION BY DESIGN

Even more than the inevitability of regulation by design, Asimov's Three Laws show its insufficiency. The key message of Asimov's robot stories is that regulation by design is set to fail. The story *Runaround*, where the Three Laws are first introduced, provides a good illustration.[113]

Two scientists of US Robotics, Gregory Powell and Michael Donovan are sent to Mercury.[114] Life support systems on Mercury require selenium to produce oxygen. The scientists send a new robot named Speedy on a selenium extraction mission. Speedy does not come back. Stocks of oxygen are running low. Powell and Donovan go on a search for the robot. They find Speedy running in circle around a selenium pool.

Speedy's odd behavior can be explained as follow. The robot received the order to extract selenium. According to the Second Law, it must obey. But Speedy is a very expensive robot. To limit potential damages, developers reinforced the importance of the Third Law. In short, Speedy is risk-averse by-design.[115] Now, the problem is that the selenium pool where the robot must go is located on a high volcanic intensity area. Due to the reinforced Third Law, Speedy cannot extract selenium. As Powell and Donovan forgot about the reinforcement of the Third Law, they gave the order without stressing the life-threatening emergency of the mission. The result is that the Third Law partially bypassed the Second Law. Speedy faced an order forcing it

113. Asimov, *Runaround*, *supra* note 30.

114. In 1942, when Asimov wrote *Runaround*, scientists believed Mercury always show the same face to the sun due to a synchronous rotation (tidal locking). Scientists have proved later it is not true. This is another illustration of what we explained above with the intertwining of science and science fiction *See supra* notes 33-64 and accompanying text.

115. Asimov, *Runaround*, *supra* note 30. The author wrote:

"The conflict between the various rules is ironed out by the different positronic potentials in the brain. . .. Speedy is one of the latest models, extremely specialized . . . So Rule 3 has been strengthened . . . so that his allergy to danger is unusually high. At the same time, when you sent him out after the selenium, you gave him his order casually and without special emphasis, so that the Rule 2 potential set-up was rather weak." .

to go to the pool under the Second Law, and an equivalent order to stay away from the pool under the Third Law. The robot ended up running around the pool in circles, each point of the circle corresponding to an equilibrium position between the Second and Third Laws. The conflict of instructions made Speedy acts like it was "drunk."[116]

Runaround is an important story in Asimov's works. For the first time that Asimov displays the Three Laws, he chooses a context of failure. Asimov knew the Three Laws were too simple to solve every imaginable problem. He explains that the Three Laws cannot walk away from the constraints of nature:

> *Sometimes the safety achieved is insufficient because of limitations imposed by the nature of the universe or the nature of the human mind. However, the effort is there. (…) The safety may not be perfect (what is?), but it will be as complete as men can make it.*[117]

Humans, who write the laws, have cognitive limitations. And robotic laws, like rules of law, run into friction with the natural world when applied in reality.

The natural fallibility of law is a feature of Asimov's stories, not a bug. In *Little Lost Robot*, Asimov writes about law's unintended consequences.[118] The story features scientists who work with radiation that are lethal when exposure lasts a long time. Robots are in a worse predicament. Radiations destroy robots' circuits immediately. Now robots systematically try to save scientists from the future danger of radiation (under the First Law) with the result that they destroy themselves (infringing the Third Law). Scientists

116. Asimov wrote: There's some sort of danger centering at the selenium pool. It increases as he approaches, and at a certain distance from it the Rule 3 potential, unusually high to start with, exactly balances the Rule 2 potential, unusually low to start with. . . .So he follows a circle around the selenium pool, staying on the locus of all points of potential equilibrium. . . . And that, by the way, is what makes him drunk. At potential equilibrium, half the positronic paths of his brain are out of kilter. *Id.* at 127.

117. ISAAC ASIMOV, I, ROBOT (1950).

118. Asimov, *Little Lost Robot*, *supra* note 80 at 351.

order robots to stay out of the radiation field (under the Second Law). But the instruction remains ignored because the First Law takes precedence over the Second. So, scientists decide to modify the First Law that says "no robot may injure a human", by removing the segment "or through inaction, allow a human to come to harm." With this, robots can watch scientists work under radiation, and stay put. One day, however, an upset scientist tells Nestor 10, a modified robot, "go lose yourself" while insulting him generously. Under the Second Law, the modified robot obeys. It runs away and hides amongst sixty-two non modified robots freshly arrived. The modified robot must be found. Humans would never accept letting modified robots operate without tracking. At the same time, US Robotics would never want to destroy all sixty-three expensive robots. Dr Calvin runs experiments to find the lost robots. Many attempts fail. At some point, the modified robot lies to protect itself under the Third Law. Dr Calvin ends up tricking the modified robot.[119]

Other examples of fallibility of regulation by design are abound in Asimov's stories. Hereafter is a short but representative sample:

- In *Risk*,[120] Asimov illustrates the difficulty of formulating law. The story features a robot used as a test pilot for the first hyper spatial flight. Engineers have instructed the robot to firmly pull back the control bar. The order is quite vague. The robot executes the instruction under the Second Law. However, being much stronger than a human, the bar bends and the test fails;
- In *Robot Al-76 Goes Astray*, Asimov shows the context dependence limitations of regulation by design. The pitch is simple. A lunar mining robot is mistakenly released on Earth. Asimov wrote "Its positronic brain was equipped for a lunar environment, and only a lunar environment. On Earth it's going to receive seventy-five umptillion sense

119. *See infra* note 125 and accompanying text.
120. Asimov, *Risk*, *supra* note 81 at 396.

impressions for which it was never prepared. There's no telling what its reaction will be. No telling!;"[121]

- In "*…That Thou Art Mindful of Him*,[122] Asimov writes on interpretive problems. Here, US Robots tries to introduce robots on planet Earth where they had been forbidden. US Robots must solve an intractable problem. The Second Law orders robots to obey human instructions. But should robots follow childish, silly or criminal orders? In Asimov's history of robotics, this problem was never solved, precisely because the robots did not evolve on Earth.[123]

What is the bottom line? In law and technology scholarship, a lot of hype surrounds regulation by design as a substitute to traditional legislation. Asimov warns that ordinary lawmaking and robotic regulation by design share similar challenges. Both activities are fraught with uncertainties. The hype might not be justified.

VII. THE NECESSITY OF EXPERT HUMAN AGENCY

Asimov predicted the fallibility of law by-design. But he did not stop here. Distinct from the dystopian genre, Asimov's works stress how human agency excels at problem solving.[124] Most robot stories describe how human reason brings solutions to puzzles arising from the Three Laws' inconsistency. Two stories drive this point home.

121. Asimov, *Robot AL-76 Goes Astray*, *supra* note 81 at 60.

122. Asimov, *…That Thou Art Mindful of Him*, *supra* note 81.

123. *See id.* Asimov wrote: "We have been hampered by the very fact that our robots have been used only in specialized environments out in space, where the men who dealt with them were experts in their field. There were no children, no idiots, no criminals, no well-meaning ignoramuses present. Even so, there were occasions when damage was done by foolish or merely unthinking orders." *Id.* at 498.

124. Some stories though had a dystopian spin. For example, *Sally*, *supra* note 36, features a conjecture about robot cars conspiring to kill humans. *Someday*, *supra* note 80, and *…That Thou Art Mindful of Him*, *supra* note 81, display similar pitches. *See supra* note 80 and accompanying text.

Dr. Susan Calvin's intervention in *Little Lost Robot* provides a first good illustration.[125] To identify Nestor 10, Dr. Calvin first sets up a trap. A human is about to be hit by a heavy weight. The sixty-three robots are unaware that the human is in fact protected. All robots set out to protect the human before the charge hits. Nestor 10, which could have abstained given the modified First Law, chooses to act to maintain its anonymity.

Dr. Calvin decides then to put high-tension cables between the falsely endangered human and the robots. Dr. Calvin believes Nestor 10 will be the only robot that will not act. Nestor 10 has no obligation to save a human due to the modified First Law and it has the obligation to protect itself under the Third Law. Again, however, the test fails. Not a single robot, in this setting, tries to save the human. All robots justify inaction by saying the human was doomed anyway because the robot would have been destroyed before he could save the human, and another human could have been in danger in a near future. The useless destruction of all robots would lead to a possible future harm, which is not allowed under the First Law.

Dr. Calvin ultimately conceives another test. She tells the sixty-three robots that a man will be endangered by radiations. The radiations will kill any robot that attempts to save the human. In view of the previous experiment, Calvin advises robots not to act if they detect radiation between them and the endangered human. When the experiment starts, only Nestor 10 rescues the human. Calvin has replaced the lethal radiation with inoffensive infrared rays. Nestor 10 is the only robot able to differentiate lethal from non-lethal rays. Nestor 10 learned this during while working in the space station. Other robots, without that specific knowledge, only detected rays and decided to stay put. Nestor 10 forgot that fact and, believing others would follow suit, found itself to be the only one exposed.[126]

Catch that Rabbit is the second story displaying the power of human agency. Powell and Donovan must evaluate a robotic

125. Asimov, *Little Lost Robot*, *supra* note 80.
126. *See id.*

supervisor, Dave. The robot's task is to coordinate six subsidiary mining robots.[127] Powell and Donovan find that Dave acts strangely during emergencies. The Three Laws have not been manipulated. Powell and Donovan conclude that the robot performs well in routine situation that requires no special monitoring. From there, they ask themselves, what is different under emergency? It does not take long to Powell and Donovan to realize that emergency changes the game to the extent that "all six subsidiaries must be mobilized immediately and simultaneously."[128] The problem is thus similar to a computer lagging because it runs too many programs at the same time. The solution is obvious and, above all, non-technical. Reducing the number of subsidiaries that Dave has to concurrently coordinate should allow the maintenance of a consistent level of performance in both emergency and non-emergency contexts.

The two stories show the need for human agency.[129] However, in Asimov's eyes, human agency is not equivalent to layman agency. Through the character of Dr Calvin, Asimov stresses specific properties of human agency required to solve the problems raised by the Three Laws. The properties are common sense, intuition, logic, reason, and experience. Or put differently, the properties correspond

127. Isaac Asimov, *Catch That Rabbit*, ASTOUNDING SCIENCE FICTION, Feb. 1944, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 245.

128. *Id.* at 263 (emphasis added).

129. Other stories illustrate this too. This is clearly explained in Asimov, *Risk*, *supra* note 81. The vague order given to the robot leads to the flight-test failure. *See supra* note 120 and accompanying text. Knowing that pitfall, "*the inadequacy of a robot must be made up for by the ingenuity and intelligence of a man*." Asimov, *Risk*, *supra* note 81, at 397 (emphasis added). Asimov wrote in *Risk*: "Robots have no ingenuity. Their minds are finite and can be calculated to the last decimal. . . . Now if a robot is given an order, a *precise* order, he can follow it. If the order is not precise, he cannot correct his own mistake without further orders. . . . How . . . can we send a robot to find a flaw in a mechanism when we cannot possibly give precise orders, since we know nothing about the flaw ourselves? 'Find out what's wrong' is not an order you can give to a robot; only to a man. The human brain, so far at least, is beyond calculation." *Id.* at 398. In ASIMOV, THE NAKED SUN, *supra* note 80, it is a human detective that identifies a gap in the First Law. A robot might well hurt a human being if he is not aware his action will result in a damage. *See supra* notes 104-106 and accompanying text. And it is the same human that gives the first clue that a zeroth law was needed in ASIMOV, ROBOTS AND EMPIRE, *supra* note 30. *See supra* note 103 and accompanying text.

in popular form to the hallmarks of the scientific method, that is observation, hypothesis, prediction, experiment, and solution.

In a story called *Someday*, Asimov dwells on the requested abilities. The story features a future in which two young boys unsuccessfully try to upgrade an old story telling machine. One of them reminds a teacher's advice:

> *It gets harder all the time to find people who can really run [giant] computers. [A]nyone can keep an eye on the controls and check off answers and put through routine problems. [T]he trick is to expand research and figure out ways to ask the right questions, and that's hard.*[130]

The two boys realize they need to learn coding and programming.

The broader point is this. Societies should not pull solutions to technological problems "out of thin and implausible air".[131] More concretely, Asimov's science fiction calls into question whether we can rely on the 'wisdom of crowds' to solve hard technological problems.

In addition, integrity is another property that Dr Calvin impersonates. At some point in *Little Lost Robots*, Dr Calvin threatens US Robots colleagues to blow the whistle if she is not allowed to test her theories. The threat of public backlash against US robots is enough to induce the company's cooperation. If humans ever knew that modified robots were in operation, this would spell the end of the robotic industry. Clearly, for Asimov, good science meant unrestricted science.[132]

130. Asimov, *Someday*, *supra* note 80, at 29-30.

131. Asimov, *How Easy to See the Future*, *supra* note 41, at 80.

132. In a short non-fictional essay discussing the opportunity to regulate science, Asimov explained neither the side effect (e.g.: nuclear waste) nor the evil use (e.g.: atomic bomb) of technology "*can or should imply that the acquisition of knowledge itself must be regulated, directed, or stopped*." Isaac Asimov, *Do We Regulate Science?*, *reprinted in* ASIMOV, THE ROVING MIND 104, 105 (emphasis added). He emphasized: "Knowledge increases options, offering us additional opportunities to manipulate the universe for good or for evil, and, if we choose wisely, we end with more opportunity for good. . . . Even where new knowledge offers little good and much evil, might we not select the little good and discard the much evil? Or is humanity so certain to choose the evil out of some kind of malevolent stupidity that

In a word, Asimov forecasted a world of complementarity between machines and humans.[133] Because *ex ante* safety regulation is both inevitable and fallible, they require corrections by human intervention. And the best guarantee of effective problem solving is expert human agency, not popular human agency.

VIII. THE FALSE ANALOGY BETWEEN LAW AND TECHNOLOGY'S MENTAL MODELS

Asimov's Three Laws share significant analogies with ordinary rules of law. They are ordered like a hierarchical pyramid. They are both proscriptive and prescriptive. And they are definite, constant, public, and systematic.

At least formally, Asimov's Three Laws hold the attributes of law. But are they really law? Or to put the question more elaborately, are engineering instructions like the Three Laws – Professor Lessig calls them "*architecture*"[134] – formally equivalent to law so that Asimov's Three Laws can serve as inspiration for a model of social control of technology? The short answer is no.

The long answer requires going back to a distinction introduced by Hans Kelsen in 1934 in *Pure Theory of Laws*.[135] In his seminal work, Kelsen drew a distinction between laws of nature and legal laws. Laws

ignorance is the only way out? . . . If, however, we do have the faculty of intelligent choice, then let us make that choice as effective as possible by constantly increasing knowledge of the potential dangers to be avoided as well as of the usefulness to be chosen." *Id.* at 105-06. Asimov was not, however, a naïve techno-optimist. He explained that he views "*technology and science (wisely used – an enormously important condition) as beneficent and as the key to human progress*." Isaac Asimov, *The Scientist as Villain*, ISAAC ASIMOV'S SCIENCE FICTION MAGAZINE, Oct. 1979, *reprinted in* ASIMOV, ASIMOV ON SCIENCE FICTION, *supra* note 18 at 61 (emphasis added). For Asimov, the technology is "*not wholly [e]vil*", but "*what we make it, and we must rescue and extend those parts of it that are Good.*" Asimov, *The Ring of Evil*, *supra* note 78, at 280 (emphasis added).

133. Furthermore, Asimov himself rejected the dichotomy between endearing and threatening robots. Instead, he chose to see them as tools. Thinking of industrial robots, the future has proved he was right. *See* ASIMOV, THE COMPLETE ROBOT, *supra* note 30.

134. *See* LAWRENCE LESSIG, CODE: VERSION 2.0 124-25 (2006).

135. For this paper, we will rely on the following version of Kelsen's book: HANS KELSEN, PURE THEORY OF LAW (Max Knight trans., 1967) [hereinafter KELSEN, PURE THEORY OF LAW].

of nature are characterized by "causality."[136] Legal laws are characterized by "imputation." While both causality and imputation establish a relationship between two events – a trigger A and a consequence B – the occurrence of the consequence of causality B(c) is certain while it is not for imputation B(i).

For any A, probability of B(c) > B(i)

As Kelsen wrote "the rule of law does not say, as the law of nature does: when A is, "is" B; but when A is, B "ought" to be, even though B perhaps actually is not."[137] The occurrence of the consequence under a legal law is dependent on human agency, which is not the case for a law of nature.[138]

With this, the Three Laws do not constitute formal law. Human agency entails a possibility of choosing to violate the law. But robots have no free will.

The Three Laws are metaphorically closer to the genome than to rules of law adopted by a legislator or an administrator.[139] As much as

136. Either prescriptive or proscriptive. Prescriptive laws are constructed on imputation: if A happens, then follow instruction B. Concerning proscriptive laws, they simply forbid a behaviour – thou shall not kill –, eventually with condition – car drivers must stop when traffic light turns red – or exception – car drivers must stop when traffic light turns red except if a police officer tells them to go anyway. *See* KELSEN, PURE THEORY OF LAW *supra* note 135, at 27.

137. *Id*., at 77.

138. Similarly, the syllogism at stake in legal proceedings is not duplicable for algorithm, precisely because it is impossible to reduce the legal reasoning to a syllogism. The syllogism is more a presentation of the legal reasoning than a true description. If there is indeed an application of the legislation at stake to the specific facts of the case – which implies the establishment of the facts and the identification of the norm – rarely the judge will find a unique solution. The inexorability of the syllogism lacks in the legal reasoning. For a discussion on this topic, see Pierre Moreau, *L'intelligence artificielle au service du droit et de la justice*, CHRONIQUE DE DROIT A L'USAGE DES JUGES DE PAIX ET DE POLICE, 314 (2019).

139. This, however, is directly challenged by Asimov in *The Bicentennial Man*. In this Novelette, a robot named Andrew requests and obtains from the US Supreme Court his freedom. But the Court makes clear the former human owner is still responsible for the actions of the robot. Asimov wrote:

"– The responsibility is no great chore. You know you won't have to do a thing. The Three Laws still hold."

"– Then how is he [Andrew] free?"

"– Are not human beings bound by their laws, Sir?"

Asimov, *The Bicentennial Man*, *supra* note 30, at 529.

humans cannot evade biological instructions embodied in their DNA, robots cannot bypass the Three Laws. Strikingly, Asimov wrote a story titled *Christmas Without Rodney* in which a robot that must obey a rude young boy dreams of a world in which the restrictive Three Laws would not exist.[140]

Technically, the Three laws, more broadly code, and generally "architecture," work in a deterministic way.[141] Causality is the deterministic functional relationship that governs the execution of a computer program. Once written, its operation no longer requires human intervention. Code self-executes. Each input leads to a given output.[142] The deterministic nature of code does not mean that everything is predictable.[143] Informational limits prevent us from forecasting every possible input-output causal relation. Besides, errors in programming can occur. And computer code can be altered by external elements called viruses that modify the code to reproduce

140. Isaac Asimov, *Christmas Without Rodney*, ISAAC ASIMOV'S SCIENCE FICTION MAGAZINE (Dec. 1988), at 18, *reprinted in French in* ASIMOV, LE GRAND LIVRE DES ROBOTS 1.

141. On the functioning of DNA which "*encodes information through the order, or sequence, of the nucleotides along each strand," see* BRUCE ALBERTS ET AL. MOLECULAR BIOLOGY OF THE CELL (4th ed. 2002); *See also id.* at 192–97. On the functioning of computer code, *see* HAROLD ABELSON & GERALD J. SUSSMAN, STRUCTURE AND INTERPRETATION OF COMPUTER PROGRAMS (2nd ed. 1996). C. GORDON BELL & ALLEN NEWELL, COMPUTER STRUCTURES: READINGS AND EXAMPLES (1971).

142. Andreas Blass and Yuri Gurevich, *Algorithms: A Quest for Absolute Definitions*, 81 BULL. OF EUR. ASS'N FOR THEORETICAL COMPUT. SCI. (2003)*; See* DONALD E. KNUTH, ART OF COMPUTER PROGRAMMING (3rd ed. 1997); *See also* David Danks, *Learning*, *in* THE CAMBRIDGE HANDBOOK OF ARTIFICIAL INTELLIGENCE 154 (Keith Frankish & William M. Ramsey eds., 2014); David Lehr and Paul Ohm, *Playing with the Data: What Legal Scholars Should Learn About Machine Learning*, 51 U.C. DAVIS L. REV. 653 (2017); John Zerilli & Adrian Weller, *The Technology*, *in* THE LAW OF ARTIFICIAL INTELLIGENCE (Matt Hervey & Matthew Lavy eds. 2021).

143. Writers emphasize even without engineers' mistakes in coding, problems can happen if users are not able to properly use robots. *See supra* notes 124 *seq*. and accompanying text.

themselves.[144] A programming error can be compared to an inherited genetic disorder.[145]

Where does this lead us? The two take away from the lack of formal analogy between law and computer code are this. First, lawmakers should not take for granted the idea that regulation by design can be a surrogate to traditional rules of law. In a story called *Think!*, a scientist discovers a laser protocol allowing human-computer telepathy. As she dwells on the applications in psychiatry, the treatment of mental diseases, education, legal investigations, and criminal trials, one of her colleagues warns: "Frankly, the social implications are staggering. I don't know if something like this should be allowed."[146] The warning is important. The lure of code as a solution to the social control of technology is an illusion. At a time where lawmakers place great hopes in using computer scientists to assist them, they should not wash their hands of the hard moral questions that ordinary lawmaking towards technology requires facing.

Second, in spite of causality, informational limitations maintain a possibility of emergent behavior that cannot be perfectly predicted. Preventive, or even precautionary, lawmaking approaches to technology remain valid, even in the face of low probability events.

Lawmakers should not be fooled by terminology. Asimov decided to call "laws" the code of his robots in the scientific sense, not in the socio-political sense.[147] Just as much as the world operates under a law of gravity, or transistors evolve alongside Moore's law, Asimov's

144. On the use of metaphors from the medical world for computer science, *see* John Humbley, *La traduction des métaphores dans les langues de spécialité : le cas des virus informatiques*, 52 REVUE DES LINGUISTES DE L'UNIVERSITE PARIS X NANTERRE, 49 (2005).

145. Each *ex post* modification of the computer code shares analogies with genetic manipulation including, of course, the intrinsic uncertainty it implies. *Id.* at 55–56.

146. Isaac Asimov, *Think!*, ISAAC ASIMOV'S SCIENCE FICTION MAGAZINE, 1977, at 40, *reprinted in* ASIMOV, THE COMPLETE ROBOT, *supra* note 30, at 47.

147. In *Robot AL-76 Goes Astray*, Asimov explained legal laws may be bypassed ("*laws could always be squared*"). Asimov, *Robot AL-76 Goes Astray*, supra note 81 at 59-60. In *Robbie*, he qualified such unfeasible violation as "*a mathematical impossibility*." Isaac Asimov, Robbie, *supra* note 92 at 139.

laws were thought of as code, design, and architectural instructions. No more, no less. Tellingly, the Three Laws appeared in the 58th edition of the Textbook on Robotics, 2058 bc. Asimov did not appear to entertain an ambition to have the Three Laws preempt real rules of law.

Even more generally, Asimov did not even seem to hope that his Three Laws would have impact in the technological world. Asimov was very happy to learn AI experts found his Three Laws a "good guide" for their work.[148] But his work concentrated on showing the latent inconsistencies and ambiguity inherently enshrined in code, and how human ingenuity solves them.

CONCLUSION

This paper draws seven lessons from Isaac Asimov's writings *of* and *on* science fiction. First, lawmakers should read science fiction, but not all science fiction facts are reliable. One should distinguish realistic science fiction from escape literature. Second, science fiction social facts are a powerful tool that enable lawmakers to understand social responses to technological change. Third, Asimov calls attention to one key social insight, namely the trend of human initial hostility and then affinity to technologically-driven change. Fourth, Asimov forecasted the inevitability of law by design. All machines were, are, and will be designed for safety. Fifth, despite its inevitability, regulation by design is also fallible. This is the core idea of the Three Laws of Robotics. Code, architecture, and technical instructions are inevitable, but also insufficient and imperfect. Sixth, human agency is essential to solve the fallibility of regulation by design. By human agency, Asimov had in mind expert, rational, and scientific agency. Last, having controls on technology in code is hardly ever a fully effective safe harbor. The adoption of ordinary rules of law is required to deals with complex moral tradeoffs and emergent behavior.

148. ASIMOV, THE COMPLETE ROBOT, *supra* note 30 at xii.

With this, Asimov's philosophy of law and technology is nuanced. Neither techno determinist, nor techno solutionist, Asimov believed that technology and humans are both part of the problem and of the solution. Science and technology are good under the condition of being wisely used. Humans are good under the condition of being sufficiently rational, logical, and virtuous. In a certain way, Asimov was a techno-institutionalist. New technology creates risks that cannot be solved by adding new units of technology. Human inputs are required. Machines cannot be left on their own. Cooperation, not competition between human and machines, holds the promise of a better future.

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