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# Use of AI by Financial Players: The Emerging Evidence

Law Working Paper N° 623/2022
January 2022

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ETH Zurich and ECGI

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https://doi.org/10.67929/ecgi-law-623-2022

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## Abstract

Financial supervisors as well as financial intermediaries increasingly rely on AI. However, little remains known about the scope and pervasiveness of this evolution.

There is emerging evidence of financial supervisors relying on AI to monitor financial intermediaries. Using annual reports as a benchmark, we show that the European Central Bank as well as French and German financial supervisors started referring to AI-use in 2017, with their principal brethren following up in 2018 and 2019. However, the provision of AI-specific information dried-up in 2020 and 2021.

There is also evidence of financial intermediaries using AI for risk management and compliance purposes. This is especially noticeable in the contractual, litigation and sentencing areas. However, the available data remains circumstantial, making it hard to quantify the magnitude of this evolution.


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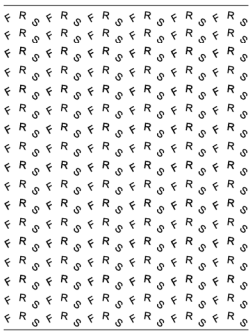

Keywords: compliance, financial supervision, investor protection, systemic risk, use of artificial intelligence.

JEL Classifications: G18, K20, K22, K40, L22



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07 January 2022



(FRS) FUTURE RESILIENT SYSTEMS

# Use of AI by Financial Players
# The Emerging Evidence

#6

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# 1 ABSTRACT

Financial supervisors as well as financial intermediaries increasingly rely on AI. However, little remains known about the scope and pervasiveness of this evolution.

There is emerging evidence of financial supervisors relying on AI to monitor financial intermediaries. Using annual reports as a benchmark, we show that the European Central Bank as well as French and German financial supervisors started referring to AI-use in 2017, with their principal brethren following up in 2018 and 2019. However, the provision of AI-specific information dried-up in 2020 and 2021.

There is also evidence of financial intermediaries using AI for risk management and compliance purposes. This is especially noticeable in the contractual, litigation and sentencing areas. However, the available data remains circumstantial, making it hard to quantify the magnitude of this evolution.

Key Words: *compliance, financial supervision, investor protection, systemic risk, use of artificial intelligence.*

## 2. FINANCIAL RISKS AND AI

Fundamentally, financial supervision aims at minimizing the impact of financial crisis (systemic risk) and protecting investors against intermediary-specific hazards (systematic risk). Properly implemented, this approach should strengthen the soundness of financial institutions and boost investor confidence.

1. From a practical perspective, *systemic risks* are difficult to deal with.

To begin with, they include many variables—from liquidity, leverage, concentration, and size factors, to interactions between market participants and regulators. In addition, their materialization (a financial crisis) tends to be determined by the way initial losses are handled.

The 2008 credit crisis provides a good example of the difficulties one faces when it comes to preventing single institution failures from evolving into a breakdown of the entire financial system. Central banks had to inject trillions of dollars in credit markets to prevent them to collapse in the face of falling asset prices.

2. To prepare for such contingencies, financial supervisors *model the interactions* among financial actors in financial crisis situations. On that basis, they adjust the design of regulatory barriers to entry via market access authorization and capital requirements.

Admittedly, many financial risks remain not well known or simply not recognized – including so-called "elephants in the room".[1] This has led policymakers to focus on limiting the build-up of systemic risks and the management of its manifestation rather than on adopting preventive measures. For example, the 2008 credit crisis prompted G-20 nations to

[1] Nick Gogerty, *The Nature of Value: How to Invest in the Adaptive Economy* (2014).

reform the so-called Basel capital requirements and to constrain the use of internal models to calculate them.

However, these are minimal requirements and they only apply to internationally active banks. More importantly, they raise moral hazard and scope issues. To begin with, their drafters are the very entities that guarantee bank liabilities. In addition, adopting a global approach to financial market regulation may well exacerbate rather than diminish risk. Finally, the requirements rely on a risk-weighting system that ignores the magnitude of accumulated risks.

3. *Systematic risks* are dealt with via compliance requirements that target intermediary-specific hazards.

Here too, banks are subject to capital requirements for market, credit and operational risk. In addition, retail investors are protected by so-called rules of conduct, that subject financial intermediaries to information requirements as well as duties of care and loyalty.

4. Policy-makers are *increasingly aware* of the role artificial intelligence can play for both systemic and systematic purposes.

Basically, artificial intelligence (a term coined by John McCarthy in 1956) relies on computer algorithms that improve automatically through experience (machine learning). Artificial intelligence (AI) technology is progressively put to use in the private sector as well as in the supervisory area.

When it comes to financial supervision, AI-use is expected to decrease regulatory enforcement costs while providing technology-advanced players with opportunities to game the regulatory system.[2]

[2] See Gérard Hertig, *The Political Economy of AI-Driven Financial Supervision*, FRS Working Paper # 5 (October 2021).

5. There is specific evidence of financial intermediaries increasingly relying on AI. For example, 70% of financial firms report the use machine learning to predict cash flow events, adjust credit scores and detect fraud.[3] More recently, they have started to rely on AI for risk management, trading, portfolio management, advisory services and compliance purposes.[4]

Here, we will assess financial intermediaries' use of AI based on surveys and evidence in the contractual, intellectual property and litigation area.

When it comes to financial supervision, we will evaluate AI-use by tracking references to AI in annual supervisory reports. This is a somewhat embryonic way to proceed. However, the approach is appropriate in view of the emerging nature of AI-technology making it relatively easy to identify whether or not AI is being used.

6. On the downside, AI may have a highly disruptive effect on the economy and society. In particular, some warn that AI-use could lead to the creation of super firms – hubs of wealth and knowledge –, which could have detrimental effects on the wider economy.

AI-use may also widen the gap between developed and developing countries, and boost the need for workers with certain skills while rendering others redundant. This trend could have far-reaching consequences for the labor market, in particular by pushing down wages. Experts also warn of its potential when it comes to increasing inequality and shrinking the tax base.

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[3] Sameer Maskey, *How Artificial Intelligence Is Helping Financial Institutions*, December 5, 2018 (available at www.forbes.com).

[4] See International Organization of Securities Commission, *The Use of Artificial Intelligence and Machine Learning by Market Intermediaries and Asset Managers*, Final Report (September 2021), available at https://www.iosco.org/library/pubdocs/pdf/IOSCOPD684.pdf

# 3. USE OF AI BY FINANCIAL PLAYERS

As indicated above, supervisory authorities' references to AI in their annual reports is an indicator of their AI-use (Section 3.1). When it comes to financial intermediaries, AI-use will be evaluated based on surveys and sector-specific information (Section 3.2).

## 3.1 SUPERVISORY ANNUAL REPORTS

There is almost no reference to AI in annual supervisory reports for the years prior to 2016.

One can reasonably infer from this omission that supervisory authorities did pay no or limited attention to AI, respectively did not deem their AI-use worth a mention in their annual reports.

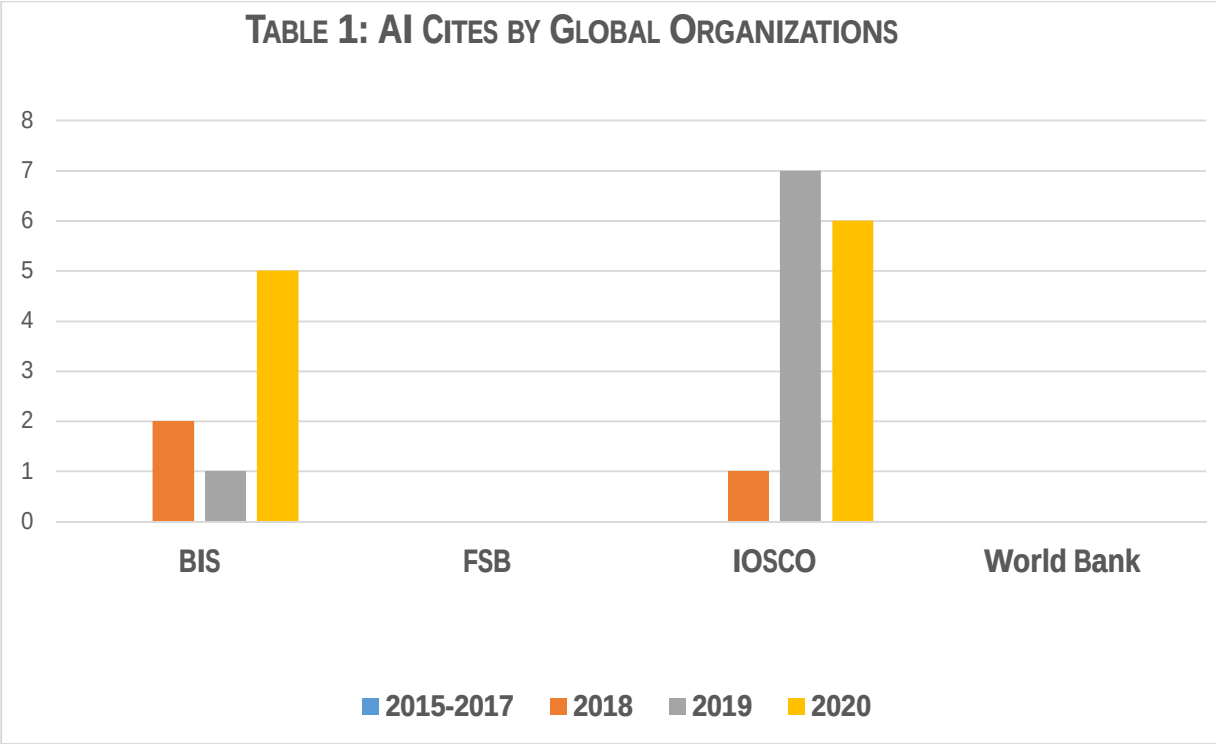
By contrast, there is evidence of increasing AI-reliance in 2017-2020 supervisory reports. This Section 'quantifies' this evolution on the basis of AI cites.

1. Various global organizations with supervisory influence or activities started mentioning AI with their 2019 Annual Reports (Table 1).

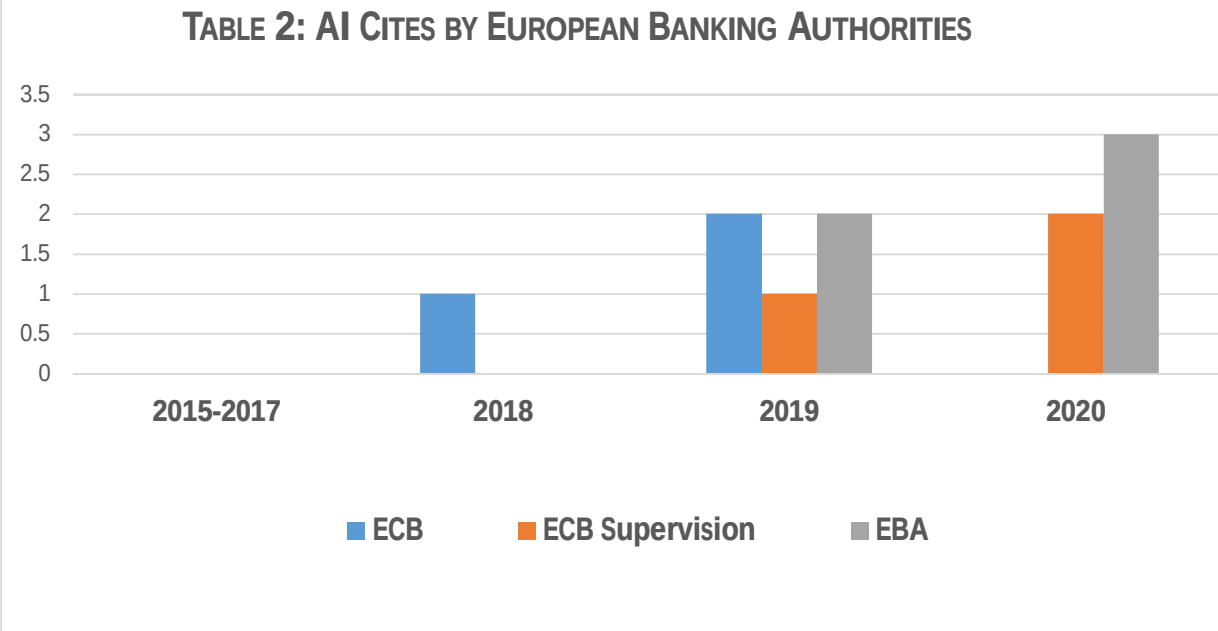
In particular, the Bank for International Settlements (BIS), mentioned AI twice in its 2019 report and five times in its 2020 report.

Similarly, the International Organization of Securities Commissions (IOSCO) referred to AI seven times in its 2019 report and six times in its 2020 report.

On the other hand, organizations such as the World Bank and the Financial Stability Board have yet to mention AI in their annual reports.

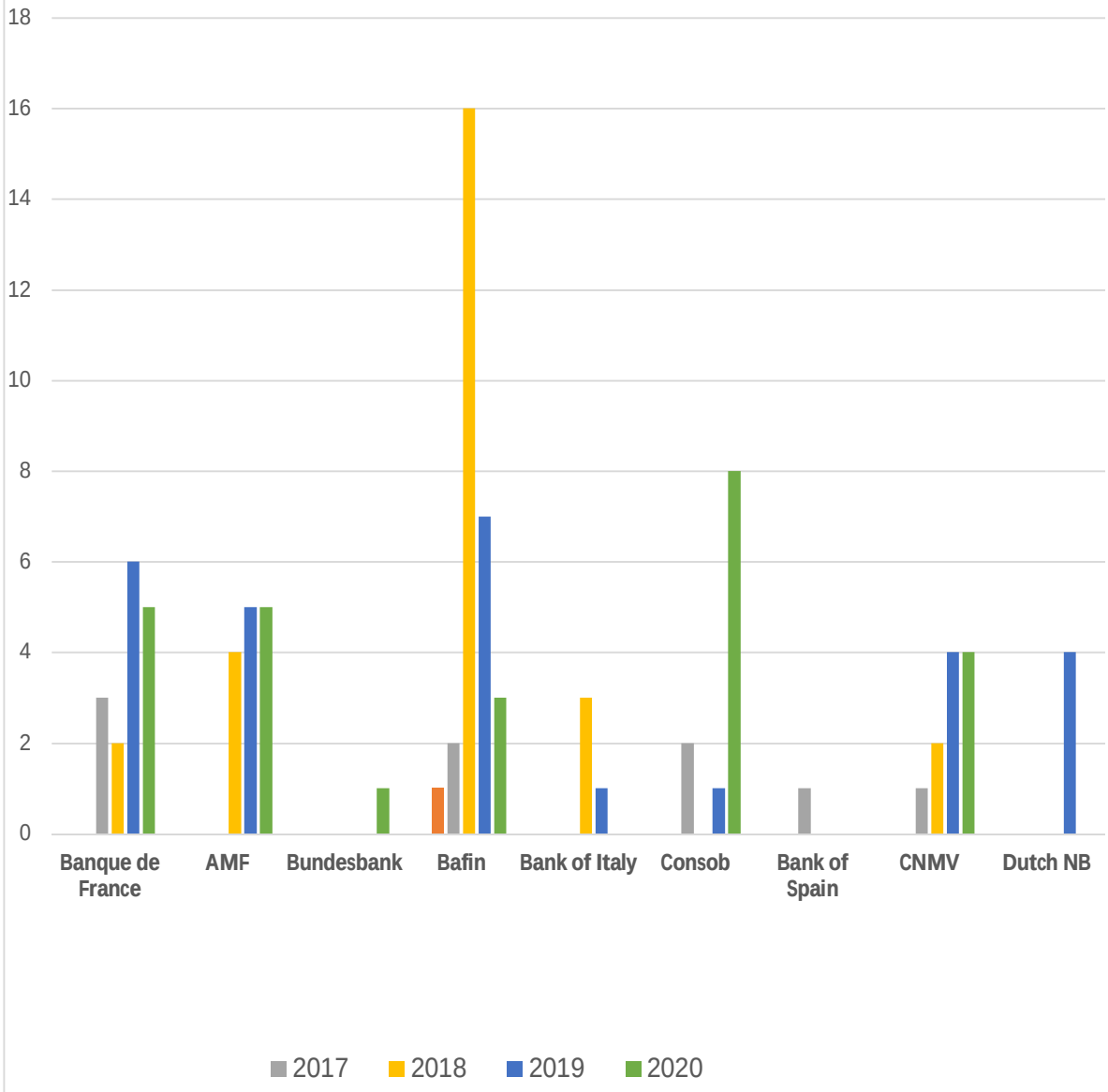



2. For their part, the European Central Bank (ECB) and the European Banking Authority (EBA) have slowly but increasingly referred to AI since 2018, respectively 2019 (Table 2).

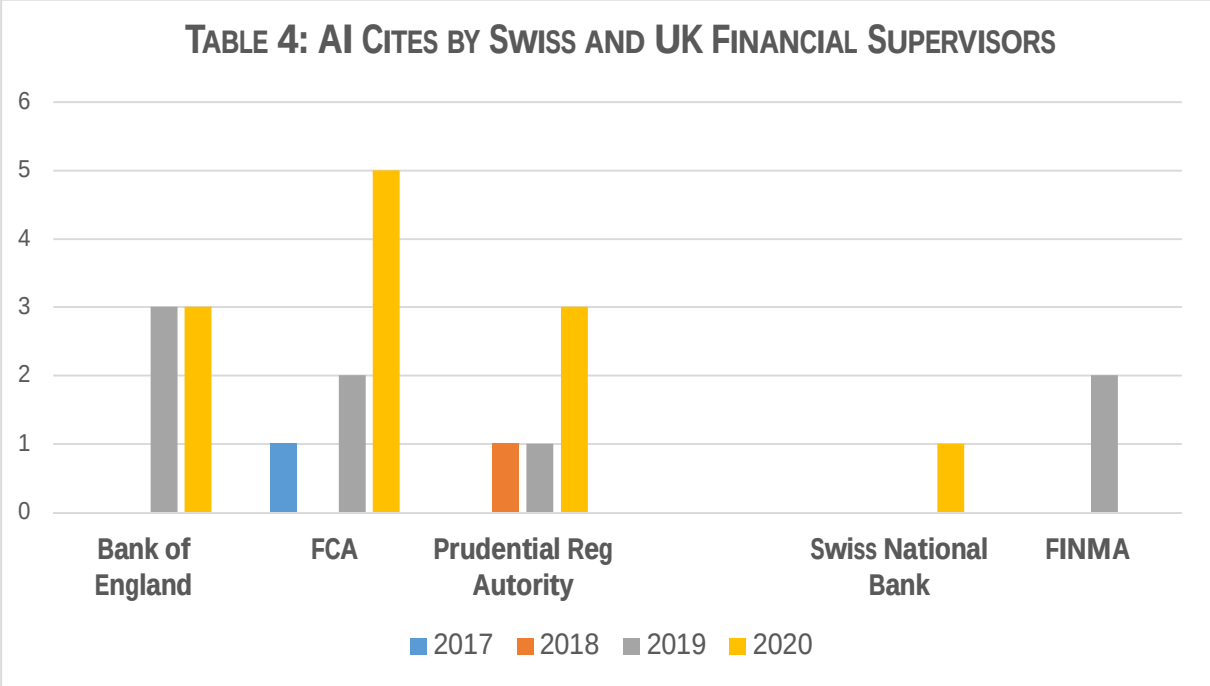


3. At the EU Member state level, overall AI cites have also been increasing. Financial authorities in Germany and France refer to AI more often than the EBA and ECB, whereas Italy, the Netherland and Spain are more in line with the latter institutions (Table 3).

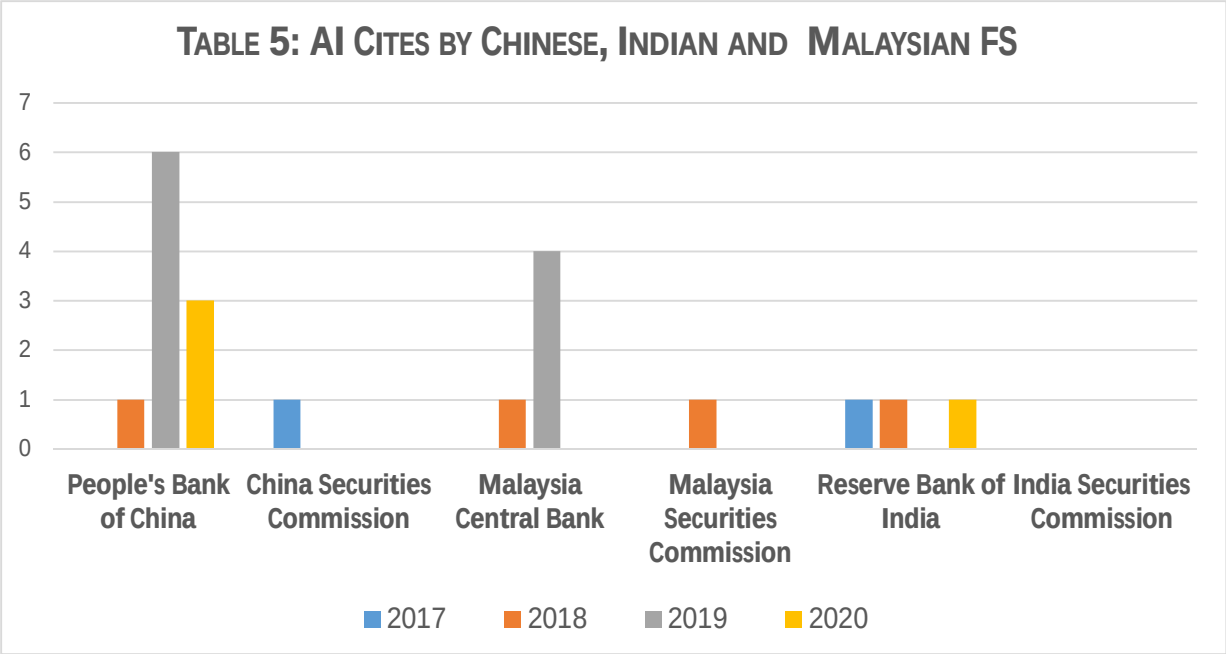
**TABLE 3: AI CITES BY EU MS FINANCIAL SUPERVISORS**



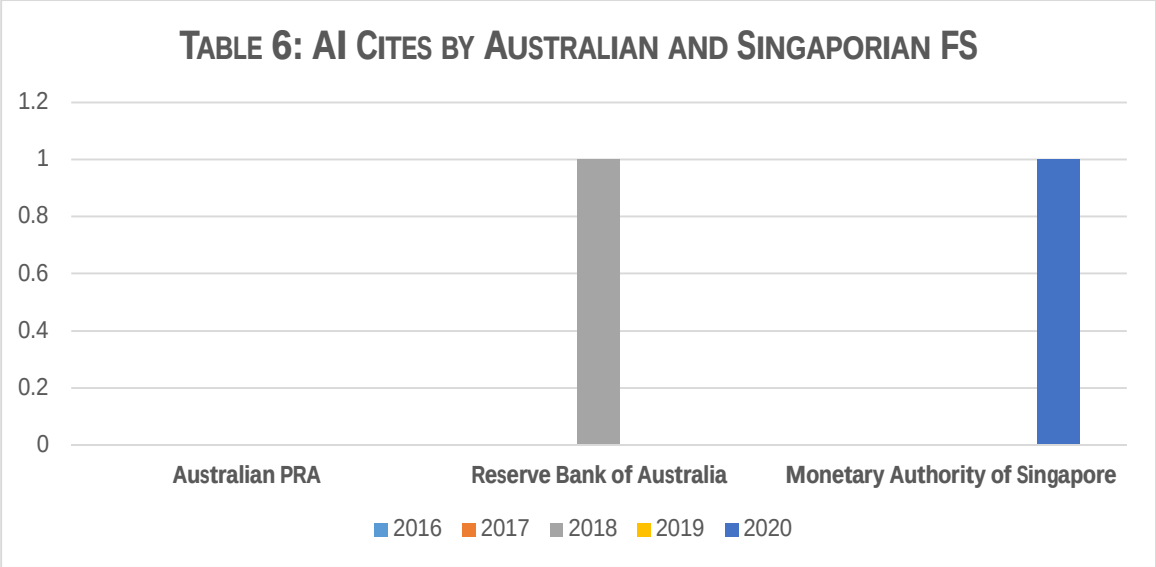
When it comes to European states that are not EU Members, the picture is similar for the UK, but significantly below the EU 2017-2020 average for Switzerland (Table 4).



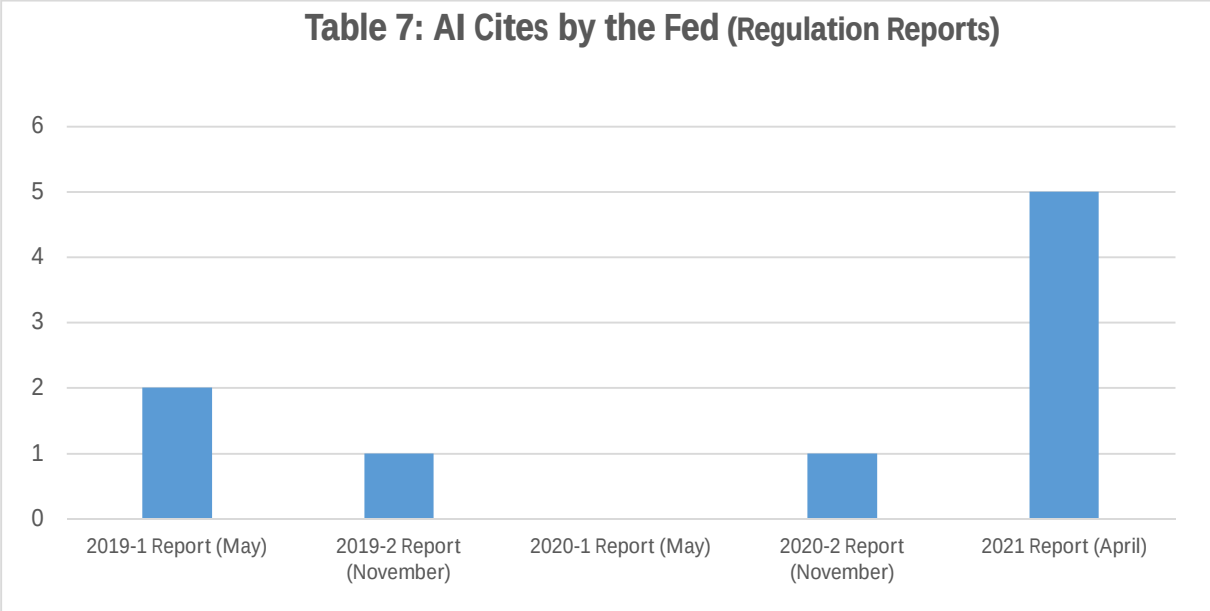

5. When it comes to Asia, AI mentions by financial supervisors also essentially occur over the 2018-2020 period. China was a rather prolific contributor, especially by comparison to India (Table 5).



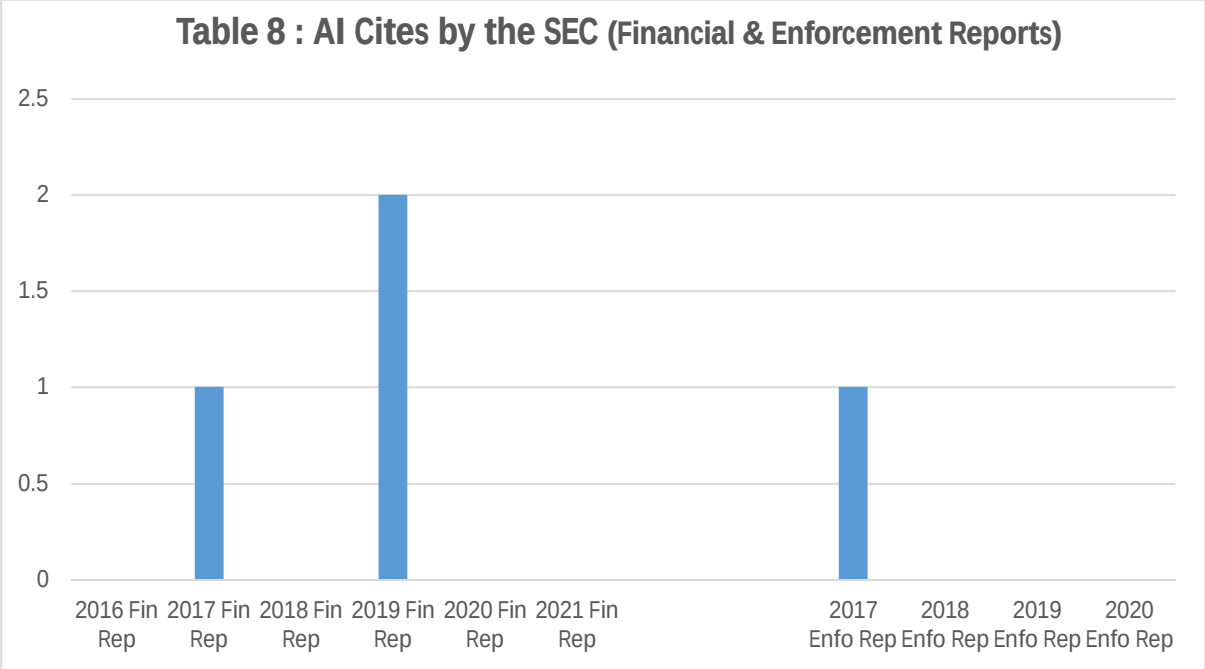
On the other hand, Australian and Singaporean financial supervisors have proved rather minimalist in mentioning AI.




6. In North America, the US Federal Reserve Board (Fed) has recently significantly increased the references to AI in its financial supervision reports. This evolution goes hand-in-hand with US banks using AI in a growing number of areas, in particular fraud monitoring, customer service, trading, and loan underwriting.



By contrast, the Securities and Exchange Commission (SEC) mentioned AI once (2017) in its Enforcement Reports and twice (2017 and 2019) in its Financial Reports. It did not refer to AI in its 2020 and 2021 Reports.




The Fed's AI references are in line with its increasing importance from a monetary and banking perspective. On the other hand, the SEC's (recent) omissions are surprising. Given its investor protection mission, one would expect the SEC to significantly rely on AI for enforcement purposes; yet, the SEC did not mention AI in its 2020 Report, even though it undertook 715 enforcement actions during the reporting period.

Unlike US authorities, Canada's Office of the Superintendent of Financial Institutions did not mentioned AI at all in its 2015-2019 Annual Reports. However, it alluded to the completion of a survey of AI use by financial institutions in its 2019-2020 Annual Report..

In short, while they may remain parsimonious, AI references are getting more numerous in financial supervisors' Annual Reports.

## 3.2 PRIVATE SECTOR EVIDENCE

### 3.21 Industry Level AI Reliance

The public sector evolution is in line with, and possibly driven by the private sector increasingly relying on AI.

For example, a 2021 survey shows that AI is used to conduct business by 51% of Asia Pacific respondents, whereas 82% of European, Middle East & African respondents perceive AI as a core component of their business strategy.[5] A leading professional services firm is thus expecting AI-use to generate a 14% raise in global GDP by 2030.[6]

To be sure, these numbers are not necessarily representative of the situation at the enforcement or industry level. For example, a 2019 study by the Association of Certified Fraud Examiners found that a mere 13% of the surveyed companies were using AI to tackle financial crime.

More generally, the time and utility values of AI still differ significantly across industries. Marketers are heavy users of AI, with 61% of them identifying AI as the most important aspect of their data strategy. AI use is still in development mode in the automotive, telecom and financial services sectors, with around 30% of firms having adopted one or more AI technologies. This percentage drops to 12% for the travel and tourism industries, which are among the least digitized sectors.

Looking forward, Table 9 quantifies the sectorial impact of AI technologies for the 2017-2030 period.

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[5] London Stock Exchange Group, *The Defining Moment for Data Scientists, Artificial Intelligence and Machine Learning Ready to Change Finance* (2021) at 51.

[6] PWC, *The Macroeconomic Impact of Artificial Intelligence* (February 2018), available at https://www.pwc.co.uk/economic-services/assets/macroeconomic-impact-of-ai-technical-report-feb-18.pdf.

| Table 9: AI Impact 2017-2030 / Index Scores by Industries | | | |
|---|---|---|---|
| | **Personalization** | **Time Saved** | **Utility/ Quality** |
| Energy, Utilities and Mining | 1.0 | 2.0 | 3.1 |
| Manufacturing and Construction | 1.9 | 1.7 | 3.7 |
| Consumer Goods, Accommodation and Food services | 2.9 | 2.6 | 3.1 |
| Transports and Logistics | 3.4 | 2.9 | 3.0 |
| Technology, Media and Communications | 2.2 | 2.6 | 3.1 |
| **Financial and Professional Services** | **2.8** | **2.4** | **3.5** |
| Health, Education and Other Public and Personal Services | 4.3 | 3.0 | 3.7 |

*Source: PwC, The Macro-Economic Impact of AI (February 2018)*.[7]

### 3.22 Firm Level AI Reliance

AI is expected to become play an increasingly pervasive role, moving from being a contributor to operations to driving revenues.[8]

1. For example, a 2019 survey by the Bank of England and the Financial Conduct Authority shows that 57% of financial intermediaries are using AI applications for risk management and compliance purposes.[9] Similarly, there is evidence of AI already replacing humans when it comes to

[7] Available at https://www.pwc.co.uk/economic-services/assets/macroeconomic-impact-of-ai-technical-report-feb-18.pdf

[8] Protiviti, *Competing in the Cognitive Age*, available at https://www.protiviti.com/sites/default/files/ united_states/insights/ai-ml-global-study-protiviti.pdf

[9] Speech by James Proudman, *Managing Machines: The Governance of Artificial Intelligence*, available at https://www.bankofengland.co.uk/speech/2019/james-proudman.

processing loan applications, advising clients, engaging in financial trading or detecting fraudulent transactions.[10]

2. Financial market participants generally face data availability, quality, privacy and processing as well as reconciliation challenges.

This is an environment where AI can significantly contribute to the conduct of business and compliance. For example, AI is already allowing for the automation of 64% of data collection and 70% of data processing tasks.[11]

3. Fundamentally, this means that financial market participants are increasingly able to move from largely historical analysis to continuous monitoring and, ideally, real-time decision making.

At the same time, using AI requires financial market participants to 1) engage into significant technology investments and 2) adopt a scientific approach to dealing with large, unstructured data sets.

4. From a practical perspective, AI support is gradually permitting executives to allocate more time to complex issues and to areas where human judgment matters. Conversely, they can largely rely on data-driven mechanisms for the taking of routine and frequent transactions.

The same is true for auditors, a key component of the supervisory chain: they increasingly rely on AI to perform financial robustness and compliance investigations.[12]

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[10] Chi Chan et al., *AI Applications in Financial Services* 2019, available at www.oliverwyman.com.

[11] Bernard Marr, *The 4 Biggest Trends In Big Data And Analytics Right For 2021*, Forbes, Feb 22, 2021 (available at https://www.forbes.com/sites/bernardmarr/2021/02/22/the-4-biggest-trends-in-big-data-and-analytics-right-for-2021/?sh=49dc36347df8).

[12] See e.g. Karen Kroll, *Using Artificial Intelligence in Internal Audit: The Future is Now*, March 18, 2021, available at https://internalaudit360.com/using-artificial-intelligence-in-internal-audit-the-future-is-now/.

More generally, the across-the-board use of AI for financial reporting purposes,[13] is allowing auditors to move from manually collected/historical information analysis to continuous monitoring that feeds real-time decision-making (Table 9).

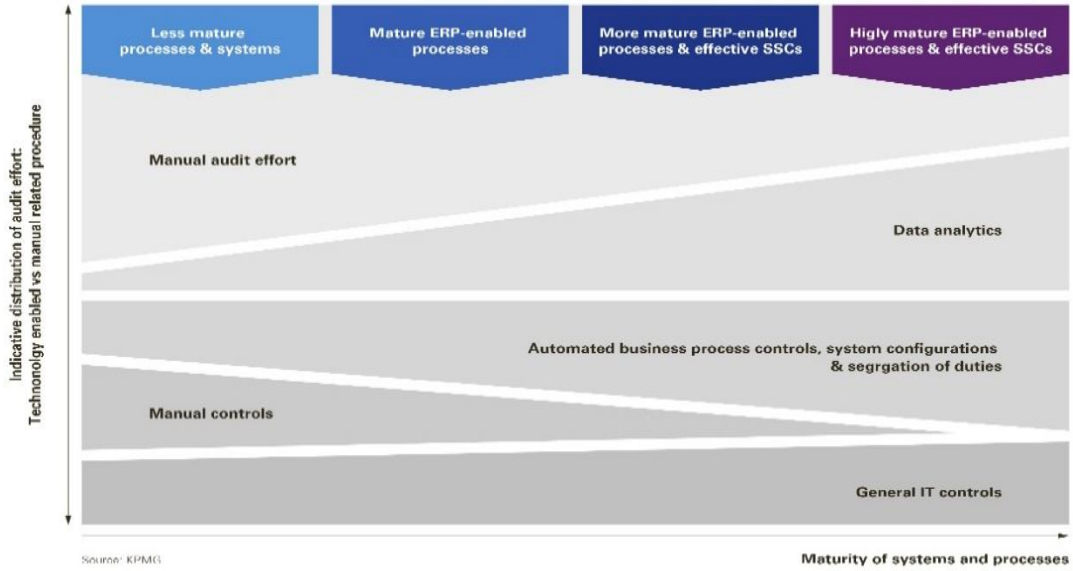



**Table 9: Distribution of Audit Effort**

Source: KPMG (https://home.kpmg/ch/en/home/insights/2021/06/audit-transformation.html)

5. As for any technological revolution, doubts are still lingering about the benefits of AI-use across the board.

However, one should not under-estimate the positive spillover effects of AI-use. For example, there is survey evidence of managers in AI-relying firms to be more receptive to audit adjustments when auditors rely on AI.[14]

[13] See W*orldwide Spending on Artificial Intelligence Systems Will Grow to Nearly $35.8 Billion in 2019*, available at: https://www.businesswire.com/news/home/20190311005093/en.

[14] Cassandra Estep, Emily E. Griffith and Nikki MacKenzie, *How Do Financial Executives Respond to the Use of Artificial Intelligence in Financial Reporting and Auditing?* (Working Paper 2021) available at https://ssrn.com/abstract=3974946 or http://dx.doi.org/10.2139/ssrn.3974946.

6. More specifically, there is evidence of AI playing an increasing role when it comes to contracts. Here, the freedom to contract principle, which extends to contract amendment and enforcement, tends to facilitate this extension.

Admittedly, AI-reliance could further polarize asymmetrical relationships,[15] in particular when it comes to 'weaker parties' such as consumers and employees.

However, this risk is manageable by mandating the use of standardized AI-software for contract drafting and amendment.

7. AI-driven decision-making is also gaining ground in the intellectual property and competition area.

Hence, the US Patent and Trademark Office is currently automating its patentability assessment process. AI-identification of those patent applications most likely to succeed should reduce the examiner's information disadvantage and the room for error, while enabling her to focus on the most value-adding submissions.[16]

Similarly, antitrust authorities more and more rely on AI to oversee market behavior.[17]

8. Finally, and most importantly, AI is increasingly relevant in the compliance and litigation area—even though the dominant view still is that

[15] See e.g. Florian Martin-Bariteau and Marina Pavlovic, *AI and Contract Law*, in Florian Martin-Bariteau & Teresa Scassa Eds., Artificial Intelligence and the Law in Canada (Toronto 2021).

[16] Logan Brown, Reid Pezewski and Jeremy Straub, *Determining Sentencing Recommendations and Patentability Using a Machine Learning Trained Expert System*, available at https://arxiv.org/ftp/arxiv/papers/2108/2108.04088.pdf.

[17] Cary Coglianese and Alicia Lai, *Antitrust by Algorithm*, available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3985553.

technology cannot fully replace the human perspective in the area of judgment.[18] For example, UNESCO is offering an online AI-course to engage judicial operators around the world in a discussion about AI-use and its impact on the rule of law.[19]

More specifically, there is evidence of US judges switching from checking sentencing guidelines to taking into account a software-driven recommendation.[20] The next step could be the replacement of judicial by AI sentencing,[21] due to its decision consistency and recidivism prediction advantages.[22]

Similar debates took place in England and Wales,[23] but there they resulted in the 2020 Sentencing Act forbidding computerized sentencing.

[18] Tobias Pachlatko, *Automating the auditor: a glimpse into the future*, available at https://home.kpmg/ch/fr/blogs/home/posts/2021/10/automating-the-auditor.html.

[19] See https://en.unesco.org/artificial-intelligence/mooc-judges.

[20] Mathis Schwarze and Julian Roberts, *Reconciling Artificial and Human Intelligence: Supplementing Not Supplanting the Sentencing Judge*, forthcoming in Jesper Ryberg and Julian Roberts Eds., *Sentencing and Artificial Intelligence*, Studies in Penal Theory and Philosophy New York 2021.

[21] Compare Mirko Bagaric and Gabrielle Wolf, *Sentencing by Computer, Enhancing Sentencing Transparency and Predictability, and (Possibly) Bridging the Gap between Sentencing Knowledge and Practice*, 25 George Mason Law Review 653 (2018); Lance B. Eliot, *On Confining AI-Based Robo-Judges to the Lower Courts*, available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3961079; Mathis Schwarze and Julian Roberts, above FN 11.

[22] Noel L. Hillman, *The Use of Artificial Intelligence in Gauging the Risk of Recidivism*, The Judges' Journal (January 1, 2019), https://www.americanbar.org/groups/judicial/publications/judges_journal/2019/winter/the-use-artificial-intelligence-gauging-risk-recidivism/#10.

[23] Andrew Ashworth and Julian V. Roberts, *Sentencing Guidelines: Exploring the English Model*, Oxford Scholarship on Line (2013).

By contrast, AI-sentencing is paid less attention in so-called 'civil law' jurisdictions.[24] This could be due to the continued predominance of penal codes granting courts a larger degree of discretion.[25]

In any event, AI already facilitates discovery analysis[26] and case outcomes prediction.[27] Moreover, it is making arbitration more affordable, thus providing a commonly available alternative to courts.

9. This evolution raises the question of AI's overall adjudication role. Should AI become the default litigation mechanism or be limited to judicial guidance?[28]

This debate is already ongoing when it comes to criminal cases. [29] For some, AI could generally substitute judges, whereas others suggest we first get a better understanding of the unfair outcome risks.

More generally, there is an awareness of AI-driven law enforcement potentially affecting citizens' rights across-the-board.[30]

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[24] Julian V. Roberts and Lyndon Harris, *Sentencing Guidelines Outside the United States*, in The Oxford Handbook of Sentencing and Corrections, Oxford University Press (2012).

[25] Compare Charles W. Ostrom, Brian J. Ostrom and Matthew Kleiman, *Judges and Discrimination: Assessing the Theory and Practice of Criminal Sentencing* (2004), available at https://www.ojp.gov/pdffiles1/nij/grants/204024.pdf (judicial discretion has been constrained by the creation of sentencing guidelines).

[26] Don Farrands, *Artificial Intelligence and Litigation – Future Possibilities*, 9 Journal of Civil Litigation and Practice 3 (2020).

[27] D. Arditi and O. B. Tokdemir, 13 *A Comparison of Case-based Reasoning and Artificial Neural Networks*, 13 Journal of Computing in Civil Enginering 162 (1999).

[28] Julian V. Roberts and Lyndon Harris, *Sentencing Guidelines Outside the United States*, in Cassia Spohn and Pauline K. Brennan Eds, Handbook on Sentencing Policies and Practices in the 21st Century, Routledge 2020

[29] Raluca Enescu, *Simplified Procedures in Criminal Matters and the Risk of Judicial Errors: The Case of Penal Errors in Germany*, 10 Journal on European History of Law 182 (2019).

[30] White Paper on Artificial Intelligence – A European Approach to Excellence and Trust COM(2020) 65 final, February 19, 2020.

## 4. REGULATORY DEVELOPMENTS

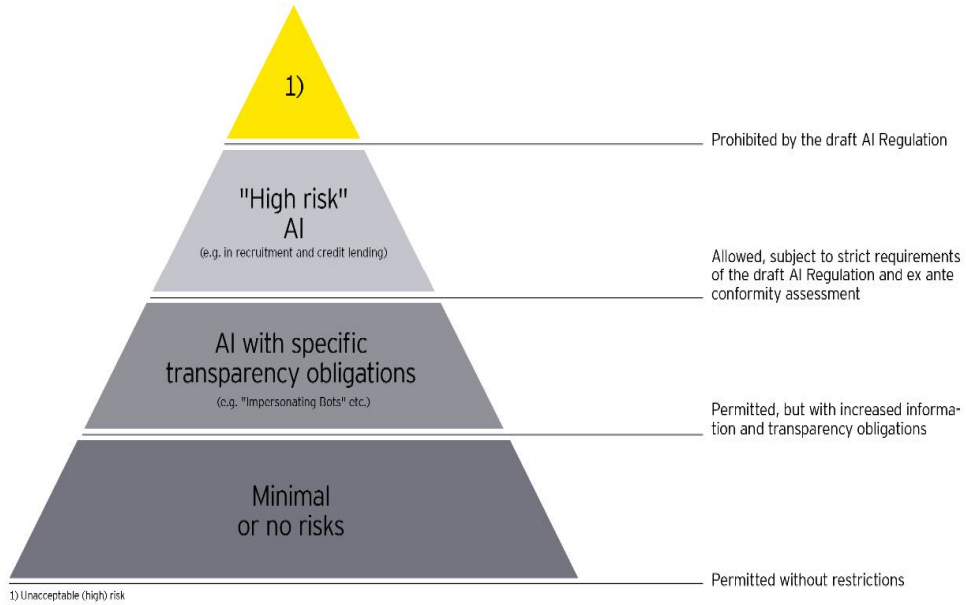
The European Commission (EC) is the first governmental body to issue draft regulation specifically targeting the use of AI.

1. For the EC, AI must be regulated to ensure its compatibility with fundamental rights and facilitate enforcement actions.[31] Its 2021 Proposal complements the *General Data Protection Regulation*[32] and aims at promoting trust in the use of AI for public administration.

More specifically, the Proposal deals with AI systems according to their level of risk: *ex ante* conformity assessments for high-risk systems, compliance with transparency requirements for lower-risk systems.

AI

AI risk categorization




Source: EY Switzerland

[31] Proposal for an EU Regulation on AI, COM(2021) 206 final, April 21, 2021.

[32] Regulation (EU) 2016/679, OJ L 119, May 4, 2016 and OJ L 127, May 23, 2018.

AI systems providing 'Know Your Customer' tools, or designed to assess the creditworthiness of individuals, are considered *high-risk* systems. The Proposal thus subjects their operators to risk management, cybersecurity and human oversight requirements.

Operators should also provide borrowers and investors with comprehensive disclosure, in particular when it comes to data accuracy and quality, governance, traceability and robustness.

2. The EC Proposal is facing significant criticism.[33] Credit institutions, in particular, object to having their AI-systems verified by supervisory authorities that are not subject to third party validation for their own AI-systems.

The objection is valid: if they are not properly 'trained', supervisory AI-systems may misunderstand market movements. This risk is especially relevant for 1) the detection of subtle differences among human participants and 2) differentiating 'active' contributors from 'passive' followers. Hence, third party validation is definitely worth considering.

There is also evidence of firms across industries having difficulties to bring their AI-systems up to operational speed. In a 2020 McKinsey survey,[34] 48% of the firms were acknowledging regulatory-compliance risks and merely 38% reported to be actively working on addressing them.

However, the up side is that those firms expecting the highest returns from AI are also the ones most engaged in risk-mitigation practices, which may contain operational risks within acceptable parameters.

[33] See e.g. Michael Veale and Frederik Z. Borgesius, *Demystifying the Draft EU Artificial Intelligence Act*, 4 Computer Law Review International 97 (2021).

[34] McKinsey, *Global Survey, The State of AI in 2020*,

3. The EC Proposal is also criticized for its 'cognitive bias'[35] provisions only dealing with logic, probability reasoning and heuristic failures.

This is a valid point too. It could make sense to complement the Proposal with provisions on stereotyping (associating a characteristic with a group), bandwagon (do something primarily because others do) and priming[36] (exposure to one stimulus influences the response to a subsequent stimulus).

4. From an overall perspective, it remains prudent to constrain supervisory use of AI. To begin with, the relevant data may not yet be available.

More importantly, *status quo* preferences may bring policymakers to frame AI-driven supervision in ways that favor risk avoidance over risk seeking.[37]

Humans can tackle this type of 'bounded rationality'[38] issues. On the other hand, given the multitude of behavioral factors that systematically affect

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[35] See the path breaking contribution by Herbert A. Simon, *A behavioral model of rational choice* 69 Quarterly Journal of Economics 99 (1955) and A. Tversky and Daniel Kahneman, *Judgment under Uncertainty: Heuristics and Biases*, 185 Science 1124 (1974).

More recently, see J. E. Hans Korteling and Alexander Toet, A., *Cognitive biases*, Encyclopedia of Behavioral Neuroscience, 2d ed (2020), Elsevier Science; Ari Ezra Waldman, *Cognitive Biases, Dark Patterns, and the 'Privacy Paradox'* 31 Current Issues in Psychology 105 (2020).

Whether cognitive biases reflect errors in judgment or rational deviations from logical thought is controversial; see e.g. Gerd Gigerenzer, *How to Make Cognitive Illusions Disappear: Beyond Heuristics and Biases*, 2 European Review of Social Psychology 83 (1991).

[36] See Daniel C. Molden, *Understanding Priming Effects in Social Psychology: What is 'Social Priming' and How Does it Occur?*, 32 Social Cognition 1 (2014).

[37] See Amos Tversky and Daniel Kahneman, *The Framing of Decisions and the Psychology of Choice*, 211 Science 453 (1981); Jonathan Mercer, *Prospect Theory and Political Science*, 8 Annual Review of Political Science 1 (2005).

[38] See Herbert A. Simon, *A Behavioral Model of Rational Choice*, 69 Quarterly Journal of Economics 99 (1955); id., *Bounded Rationality in Social Science: Today and Tomorrow,* 1 Mind and Society 25 (2000).

managerial choices, AI-driven systems are not yet[39] capable of fully mimic humans. In other words, the cognitive abilities of AI systems still differ from those of biological systems.[40]

5. This 'imperfection' has its advantages. In a non-AI world, managerial ego and over-confidence often leads banks to take exposures that affect their sensitivity to a financial crisis,[41] whereas investor risk aversion increases in the wake of financial crises.[42]

AI-driven systems being immune to such cognitive distortions, they are good candidates for mitigating them.

Similarly, there is evidence of financial supervisors engaging in herding behavior[43] and collectively underestimating the probability that observed outcomes merely reflect good luck.[44]

Here again, these cognitive effects can be mitigated by AI-driven systems.

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[39] See Daniel Kahneman, *Comment on Artificial Intelligence and Behavioral Economics*, in Ajay Agrawal, Joshua Gans, and Avi Goldfarb Eds., *The Economics of Artificial Intelligence: An Agenda* (2019).

[40] Hans J.E. Korteling, G. C. van de Boer-Visschedijk, R. A. M. Blankendaal, R. C. Boonekamp and A. R. Eikelboom, *Human- versus Artificial Intelligence*, Frontiers in Artificial Intelligence, March 25, 2021, available at https://www.frontiersin.org/articles/10.3389/frai.2021.622364/full

[41] Po-Hsin Ho, Chia-Wei Huang, Chih-Young Lin, Ju-Fang Yen, *CEO Overconfidence and Financial Crisis: Evidence from Bank Lending and Leverage*, 120 Journal of Financial Economics 194 (2016).

[42] Luigi Guiso, Paola Sapienza and Luigi Zingales, *Time Varying Risk Aversion*, 128 Journal of Financial Economics 403 (2018).

[43] Tanmai Bansal, *Behavioral Finance and Covid-19: Cognitive Errors that Determine the Financial Future,* available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3595749.

[44] Anjan Thakor, *Banking, Financial Crises and Behavioral Finance: Lending Booms, Smart Bankers, and Financial Crises*, 105 American Economic Review, Papers & Proceedings 305 (2015).

6. Operational risk, i.e. the risk of loss due to inadequate internal processes or external events, is another candidate for AI-driven regulation.

At the present time, business line managers are generally in charge of dealing with this risk. However, financial intermediaries also rely on autonomous risk management units and independent reviews.

AI-driven systems permit to replace this so-called "three lines of defense"[45] model with a one-step "consider the opposite"[46] approach.

Conceptually, this procedure should make managers aware of their cognitive bias.[47] In practice, however, elaborate training methods are still needed to ensuring for the mitigation of this bias.[48]

## 4. THE FUTURE OF AI-DRIVEN SUPERVISION

AI-driven decision-making remains prone to erroneous assumptions, build-in bias, data incompleteness and validation deficiencies.

These deficiencies result in AI-driven supervision remaining incomplete. However, human supervision is incomplete too. In addition, AI-driven supervision has a higher completeness potential than human supervision.

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[45] The Institute of Internal Auditors, *The Three Lines of Defense in Effective Risk Management and Control* (January 2013).

[46] Hal R. Arkes, David Faust, Thomas J. Guilmette and Kathleen Hart, *Eliminating the Hindsight Bias*, 73 Journal of Applied Psychology 305 (1988); Thomas Mussweiler, Fritz Strack and Thomas Pfeiffer, *Overcoming the Inevitable Anchoring Effect: Considering the Opposite Compensates for Selective Accessibility*, 26 Personality and Social Psychology Bulletin 1142 (2000).

[47] See Baruch Fischoff, *Debiasing*, in Daniel Kahneman, Paul Slovic, and Amos Tversky (Editors), *Judgment under Uncertainty: Heuristics and Biases*, 1982 Cambridge University Press 422.

1982 Richard P Larrick, *Debiasing*, in Derek J. Koehler and Nigel Harvey (Editors), 2004 *Blackwell Handbook of Judgment and Decision Making* 316.

[48] Jackie M. Poos, Karel van den Bosch and Christian P. Janssen, *Battling Bias: Effects of Training and Training Context*, 111 Computers and Education 101 (2017).

It logically follows that the supervisory role of AI will continue to increase. The open question is: up to which point?

For political and uncertainty reasons, we can expect supervisory authorities to retain strategic, review and ‘scandals’ competences. Beyond that, the financial ‘supervision’ universe is up for grabs.

Acknowledgment

This work is an outcome of the Future Resilient Systems project at the Singapore-ETH Centre (SEC) supported by the National Research Foundation, Prime Minister’s Office, Singapore under its Campus for Research Excellence and Technological Enterprise (CREATE) programme.

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Publisher: Singapore-ETH Centre
© Singapore-ETH Centre, January 2022

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