Unpacking Smart Law: How Mathematics And Algorithms Are Reshaping The Legal Code In The Financial Sector

David RESTREPO AMARILES[1] & Gregory LEWKOWICZ[2]

Abstract:

The avalanche of new technologies and artificial intelligence have accelerated financial innovation, compelling the law to undergo a technological update. This phenomenon extends to the likes of regtech, suptech, regulatory big data, algorithmic supervision, etc. The study aims to demonstrate how these new instruments are, in fact, part of an overarching movement observable in numerous fields; that is, the emergence of a scientific, mathematical, algorithmic law driven by risk and technologies (classified as "Smart Law"). The authors will examine the aforementioned theoretical model and highlight the practical implications for banking and finance law. They conclude on the necessity for a structural collaboration between lawyers and engineers in order to manage the inevitable hybridization of the rule of law and its technological integration.

I. INTRODUCTION

In a well-known news article, investor Marc Andreessen wrote that software is "devouring" the world.[3] He contended that the banking and financial world is being swallowed up faster than others. The digital shift that has taken hold of financial systems for a while[4] has created an acceleration effect. Not a day goes by without a new application of computer engineering or artificial intelligence finding an outlet in the field of financial innovation. For example, it is estimated that in 2016, more than 50% of trading in financial markets was attributable to *high-frequency algorithmic trading.*[5] In 2018, portfolio management and investment

1 Professor of Law at HEC-Paris, Member of the Institute DATA IA

2 Professor at the Université libre de Bruxelles, Director of the Global Law program at the Perelman Centre

3 M. Andreessen, "Why software is eating the world", *The Wall Street Journal* (Aug. 20, 2011).

4 *See* article in L. Arena et al., "'Too Fast, Too Furious'? Trading algorithmique et instabilité des marchés

5 R.S. Miller et G. Shorter, High Frequency Trading: Overview of Recent Developments, *Congressional Research Service*, 4 avril 2016.

advisory businesses became increasingly exposed to automated "robot" advice based on automated data analysis.[6] Blockchain technology, popularized by the spread of *bitcoin* and other cryptocurrencies, is leading the return to classic banking and financial intermediation models for businesses; reinventing the public offering of savings in the form of the issuance of virtual currencies or "Initial Coin Offerings."[7]

Current technological developments, now considered applicable to Fintech, have legal implications for banking and financial regulation. Laws are forced to conform to a "technological update," adapting their form and implementation mechanisms to a technological ecosystem; having the capacity to produce petabytes of data within a nanosecond. At the global level, such adaptation results in hybridization between law and technology. This phenomenon extends into the development of regulatory technologies (RegTech)[8] or the algorithmic regulation of finance.[9] The Financial Stability Board furthers this proposition by considering the development of supervision technologies (SupTech) and its integration of current and future uses of Big Data, machine learning and artificial intelligence by regulators.[10] It would then be misleading to interpret this hybridization movement between law and technology as one particular to the banking and financial world. Rather, it is the height of a global movement observed in numerous areas of law, articulated under the acronym of "SMART"; namely, the emergence of a scientific, mathematical, algorithmic law shaped by risk and technologies (SMART Law).

This paper embraces a pragmatic perspective by considering that concepts are nothing but tools whose value depends on their strength to convey a better understanding of the world and enable action upon it. Hence, from a methodological point of view, this paper argues that SMART law is a useful concept in jurisprudence because it captures key features of the widespread and comprehensive transformation taking place in legal practice. We illustrate the relevance of the notion of SMART

6 See notably N.G. Iannarone, Computer as Confidant: Digital Investment Advice and the Fiduciary Standard, 93 Chi-Kent L. Rev. 141 (2018).

7 *See* M. Casey et al., "The Impact of Blockchain Technology on Finance: A Catalyst for Change", *Geneva Reports on the World Economy 21* (2018).

8 D.W. Arner et al., FinTech, RegTech, and the Reconceptualization of Financial Regulation, 37 Northwestern J. Int. L. & Bus. 371

9 Ph. Treleaven et B. Batrinca, Algorithmic Regulation: Automating Financial Compliance Monitoring and Regulation Using AI and Blockchain, 45 Journal of Financial Transformation 14 (2017).

10 See notably Financial Stability Board, Artificial intelligence and machine learning in financial services. Market developments and financial stability implications, FSB (Nov. 1, 2017).

law with examples in the field of banking and finance law—which is particularly affected by the process of digitization—but the main features we identify are generally meaningful also for other areas of legal practice.

The present contribution will then focus first on defining the concept of Smart law, prior to demonstrating its practical implications in banking and finance law. Finally, we conclude with some general observations from a philosophy and theory of law perspective, noting in particular the relations between the engineering sciences and the science of law.

2. THE HYPOTHESIS ON SMART LAW

The evolution of tools and techniques used by legal operators (i.e. judges, lawyers, regulators) as well as companies and legal actors (i.e. auditing firms, platforms and databases) have triggered a transformation both in the nature and operation of the law. From a theoretical standpoint, this transformation is sometimes examined, not without reason, as the beginning of a new graphical revolution and its associated effects. The development of a digital society that places emphasis on computer codes, algorithms, and autonomous systems would, from this perspective, have an impact on the law akin to the abandonment of writing on manuscripts or to the development of printing.[11] While relevant, this proposition is not specific enough to accommodate the more nuanced transformations at play. It seems that this theory must be supplemented by the hypothesis of the emergence of a *scientific, mathematical, algorithmic* law shaped by *risk and technologies* (SMART). Rather than simply describing a general revolution in society, this hypothesis defines pragmatically an empirical field whose study allows for an understanding of the overall movement that is permeating across the different branches of law. Equally, this field may be characterized as a new theoretical model that, concretely, promotes the change in law as an institution of social regulation: from a democratic to a techno-managerial model.

The *scientific* dimension of SMART law is characterized as an empirical-based approach to law, imprecisely qualified as "*evidence-based law.*"[12] This concept of a scientific law concretely means that the practice of law,

11 *See*, in the general sense, C. Herrenschmidt, *Les trois écritures. Langue, nombre, code*, Paris, Gallimard, 2007. For an application of the text to law, *see inter alia* C. Vismann*, Files: Law and Media Technology,* trad. G. Winthrop-Young, Stanford, Stanford University Press, 2008 ; Th. Vesting, *Legal Theory and The Media of Law*, Cheltenham/Northampton, Edward Elgar Publishing, 2018 ainsi que A. Garapon et J. Lassègue, *Justice digitale : révolution graphique et rupture anthropologique*, Paris, PUF, 2018.

12 *See* on this point the seminal article. J.J. Raschlinski, *Evidence-Based Law*, 96 Cornell L. Rev. 901 (2011).

and in general legal decisions, are – and must be informed – by the best available scientific knowledge.[13] As an example, this scientific approach to law is illustrative at times when "data collection and analysis [are] used to inform legal decision-making processes such as in the adoption of a new law, the choice of an applicable law, and jurisdiction in an international contract, or the election of a court to establish a company." [14]

This scientific approach is not unique to law. The term "evidence-based" was originally employed in the field of health sciences[15] for application in other disciplines such as management, marketing, or public policy. In these disciplines, an approach grounded on the best available scientific knowledge is widely conceived as a method of making decisions on the basis of quantitative data. The law behaves similarly, even in matters such as the rights of the child. In 2011, for example, the former Director of the European Union Agency for Fundamental Rights noted that progress in the field of children's rights depended on a "solid base of evidence," language that was used similarly by the European Central Bank to define its monetary policy.[16] This scientific approach to law based on empirical, and often quantitative, data then also necessitates a significant use of statistical methods of analysis and their interpretation; of which is illustrative of the second feature of the model described, the mathematical element.

This *mathematical* dimension is illustrative of the proliferation of statistical, and more generally, mathematical tools used in the field of law and regulation: the rating and ranking of legal systems or the abiding of laws by companies.[17] The increasing importance of such methods of economic analysis in law are shown in fields of contract law, consumer law, tort law, or *indubitably*, analytical methods associated with questions of Big Data in law.[18] This mathematical turn is noticeable in the fact that mathematical reasoning now appears completely admissible in law; not

13 David Restrepo Amariles & Julian McLachlan, Legal Indicators in Transnational Law Practice: A Methodological Assessment, 58 Jurimetrics Journal 163 (2018).

14 David Restrepo Amariles, « Le droit comme instrument de progrès : Sur l'idée d'ingénierie juridique », in Les grands defies du droit global 250-259, p.257 (B. Frydman & C. Bricteux eds., Bruylant, 2017).

15 See Evidence-Based Medicine Working Group, Evidence-Based Medicine: A New Approach to Teaching the Practice of Medicine, 17 J. of Am. Med. Assoc. 2420 (1992).

16 Morten Kjaerum, Director, European Union Agency for Fundamental Rights, Opening Speech at FRA Symposium 1–2 (March 12–13, 2011), http://fra.europa.eu/sites/default/files/fra_uploads/1598-MK-speech-fra-symposium2011.pdf (last visited Sept. 7, 2016).

17 David Restrepo Amariles, « Les maths du droit - Pratiques et méthodologies des indicateurs juridiques », *in* B. Deffains, M. Séjean & R. Espinosa, *Index de la sécurité juridique. Rapport pour la Fondation pour le droit continental*, Pariz, Dalloz, 2018.

18 S. Barocas & A. Selbst, *Big Data's disparate impact*, 104 Cal. L. Rev.671 (2016) ; D. Bholat, *Big data and central banks*, 55 Bank of England Quarterly Bulletin (2015).

only in the construction of concepts and their connection, but also in the context of their interpretation.[19] If the lawyer was hermetic to mathematical rationality, such that Philip Dawid spoke of lawyers as unable to manipulate mathematical figures,[20] this type of reasoning is now as pervasive across law and legal reasoning as traditional linguistic and hermeneutic techniques of legal analysis. One of the most illustrative examples of the mathematical turn concerns defining the rule of law. Without consensus among lawyers on the definition of such notion and with such variation in meaning,[21] the economists of the World Bank have decided to operationalize it through probability, by which the quality of the rule of law is conditional to the likelihood of being given the parameters $y_{j1} - y_{jK}$

175

Équation 1

$$E\left[g_j \middle| y_{j1},\ldots,y_{jK}\right] = \sum_{k=1}^{K} w_k \frac{y_{jk} - \alpha_k}{\beta_k}$$

The parameters et, as well as the variation of error are calculated for the representative indicators using by means of probability in a separate process.[22] This definition, likely used to produce the World Bank's *Rule of Law* indicator, is used by other rules of law assessment instruments such as *Standard & Poor's* sovereign debt rating.[23] Moreover, courts and tribunals have made direct reference to these types of legal measurement tools. For example, the Supreme Court of Canada relied on the *Rule of Law Index* in *Hryniak v. Mauldin* (2014) to highlight that the litigants in Canada faced relatively more barriers in accessing justice than others in developed countries, particularly in Europe. The Court, therefore, was able to rule that the principle of fair and equitable

19 David Restrepo Amariles, Legal Indicators, Global Law and Legal Pluralism: An Introduction, 47 J. Leg. Pluralism 9, 15 (2015).

20 A. Philip Dawid, *Probability and Proof – Appendix*, *in* Analysis of Evidence 3 (Terence Anderson et al. eds., 2d ed. 2005), ("pride of being innumerate").

21 B.-Z. Tamanaha, *The Rule of Law and Legal Pluralism in Development*, 3 The Hague Journal on the Rule of Law 1 (2011).

22 For a detailed analysis of this process and its relationship with the mathematical turn, see David Restrepo Amariles, « The Mathematical turn: L'indicateur Rule of Law dans la politique du développement de la Banque Mondiale », in *Gouverner par les standards et les indicateurs : De Hume au Rankings* 193-234 (Frydman, B. & A. Van Waeyenberge eds., Bruylant, 2014).

23 *See* G. Lewkowicz, « Gouverner les Etats par les indicateurs : le cas des agences de notation de crédit » *in* B. Frydman et A. Van Waeyenberge, (ed.), Gouverner par les standards et les indicateurs : De Hume aux rankings, Bruxelles, Bruylant, pp. 145 et s. ainsi que David Restrepo Amariles, « Supping with the Devil? Indicators and the Rise of Managerial Rationality in Law », 13 Int. J. L. & Context 465 (2017).

treatment underlying the proper administration of justice was not respected in practice.[24]

The *algorithmic* dimension of SMART law is, in practice, complementary to the two previous dimensions.[25] It has at least two analytically distinct roles to the model described. It participates, on the one hand, in the analysis of data; and on the other, in data implementation and enforcement. In regard to the former, the increasing digitization of available data and the production of new data in real time notably results from the constant connectivity of objects to the Internet (or the *Internet of things*); making the use of algorithms indispensable for extracting patterns, visualizations, and relevant information from the mass of data, commonly referred to as *Big Data*.

176

For example, the UK General Tax Office – Her *Majesty's Revenue and Customs* (HMRC) – has developed data analysis algorithms as part of the *Connect* computer program.[26] *Connect* pulls information from over 30 structured databases, such as payroll, credit or land registries, and unstructured databases – often using *web scraping* – including those from social networks or auction sites.[27] In order to analyze the mass of data, HMRC mobilizes – among other things – social network analysis algorithms to calculate the density between the different entities of the network.[28] Applying visualization tools, the UK tax authority then builds "*spidergrams*" to report results from the analysis and help identify the likelihood of fraud on a comparative basis. According to Mike Wells, Director of Risk and Intelligence Services at HMRC, "Over time, you get familiar with a normal person's *spidergram*. When someone is operating in the hidden economy, it [the *spidergram*] has a different shape." [29]

Graphique 1 : Représentation d'un *spidergram*

24 *Hryniak v. Mauldin*, 7 A.C.S. 24 (2014).

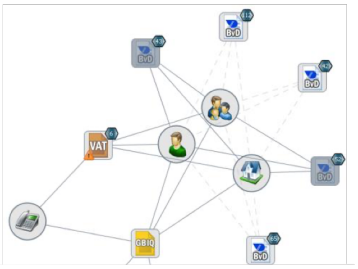
25 On the implementation of algorithm in law, *see* notably G. Chantepie, "Le droit en algorithmes ou la fin de la norme délibérée ?", *Dalloz IP/IT*, n° 10/2017, pp. 522 et s. ; S. Chassagnard-Pinet, "Les usages des algorithmes en droit : prédire ou dire le droit ?", *Dalloz IP/IT*, n° 10, 2017, pp. 495 et s.

26 Vanessa Houlder, "Ten ways HMRC can tell if you're a tax cheat," Financial Times, (Dec. 19, 2017), https://www.ft.com/content/0640f6ac-5ce9-11e7-9bc8-8055f264aa8b.

27 D. Restrepo Amariles, D., & G. Lewkowicz, « De la donnée à la décision : comment réguler par des données et des algorithmes », in E. Godet, R. Mosseri et M. Bouzeghoub (ed.), *Les Big Data à Decouvert*, Paris, CNRS édition, 2017, pp. 80-82.

28 Capgemini & HMRC, *Business Intelligence Technology helps HMRC Increase Yield*, available at https://www.capgemini.com/nl-nl/wp-content/uploads/sites/7/2017/07/hmrc_connect_final.pdf

29 Lucy Warwick-Ching and Vanessa Houlder, "Ten ways HMRC checks if you're cheating," Financial Times (Nov. 12, 2012), http://ig-legacy.ft.com/content/0f98bbc0-2db6-11e2-9988-00144feabdc0#axzz5ZH6tPg9B.



Source : Chartered Institute of Taxation[30]

The second *algorithmic* dimension corresponds to the execution and implementation of legal rules.[31] Effectively, the demand for the creation of automated execution mechanisms of legal rules stems from certain economic and social activities; which themselves are automated through algorithms. As will be illustrated in further detail, the development of algorithmic and *high frequency trading* (HFD) has led European regulators to establish *stress testing* algorithms, under regulation on market abuse[32] and the Directive regarding markets for financial instruments (Mifid 2), to evaluate *ex ante* the behaviorbehavior of algorithms operating in financial markets.[33] In the longer term, the development of autonomous vehicles[34] implies a full integration of the rules of the road codified into the software of these cars, particularly the implementation of a central algorithm for optimizing road traffic. The algorithm should render it possible to determine in real time the traffic speed of cars alongside multiple variables including pollution level, traffic density, weather conditions, priority of the vehicle, speed of other vehicles, or any relevant set of variables. Thus, speed limits would become meaningless, given that it would be executed automatically through information programmed into the car's software and received from the central optimization algorithm.

Lastly, SMART law is law driven by *risk*; and therefore, often more reflexive than one that carries intrinsic value to the rule of law, defined in a general

30 HM Revenue & Customs, Making Connections, *Connect Public Briefing File*, https://www.tax.org.uk/system/files_force/file_uploads/151218%20Connect%20Briefing_Public%20v1.0.pdf?download=1.

31 David Restrepo Amariles, « Learning algorithms: lawmakers or law-breakers? », HEC Knowledge (Apr. 2017), http://www.hec.edu/Knowledge/Business-Environment/Law-Regulation-and-Institution/Learning-algorithms-lawmakers-or-law-breakers.

32 Régulation (EU) 596/2014 Parlement européen et du Conseil concernant les abus de marché (MAR) [2014] OJ L173 and Directive (EU) 2014/57 applicable penal sanctions for market abuse (CSMAD) [2014] OJ L173.

33 Directive (EU) 2014/65 of the Parlement européen et du Conseil concernant les marchés d'instruments financiers (Mifid 2) [2014] OJ L173.

34 H. Bersini, Big Brother is driving you : Brèves réflexions d'un informaticien obtus sur la société à venir, Bruxelles, Académie Royale de Belgique, 2017.

or abstract sense. It seemingly corresponds to the adaptation of law to Ulrich Beck's "global society of risk."[35] The regulation of this so-called society of risk calls for an important change in the way the law is conceived and implemented. As Alberto Alemanno et al. note, "risk-based regulation seeks to repair market failures at the lowest possible cost."[36]Therefore, the development of an increasingly interconnected and complex society at the global level implies that the effects of a shock or failure, especially economic or technological, could lead to catastrophic societal effects on a large scale.

Legal engineering is thus used to produce risk management tools.[37] One of the most emblematic examples of this risk-based approach is the banking stress tests put in place by the European Union aimed to prevent systemic risks in the European and international financial system. We will return to this example in the second part of the paper. Presently, it is possible to identify the shift to a risk-based approach in multiple areas of legal practice, such as health, environment, transport and international business transactions;[38] all from a perspective of regulation as opposed to dispute resolution.[39] For businesses, this shift to a risk-based approach is reflected in the reinforcement and empowerment of the roles of risk management directors and chief compliance officers; though perhaps to the detriment of the legal department.[40]

Finally, the technological component of SMART law is both a consequence of the previously discussed dimensions and the means allowing their realization. The technological tools that operationalize a scientific, mathematical, algorithmic, and risk-based law come from blockchain technology and other specialized software solutions in the legal field;[41] including specific software tools that harness artificial intelligence

35 U. Beck, World Risk Society, London, Polity, 1999.

36 A. Alemanno, F. Den Butter, A. Nijsen, J. Torritu, "*Introduction*", in *Better Business Regulation in a Risk Society* 1-14 (Alemanno, Alberto ; Den Butter, Frank ; Nijsen, André ; Torritu, Jacopo eds. Springer, 2013), p. 3.

37 For concrete examples of the use of law as an instrument of risk management, *see* David Restrepo Amariles & Julian McLachlan, *loc.cit* ainsi que D. Howarth, L*aw As Engineering: Thinking About What Lawyers Do,* Edward Elgar Publishing, 2014.

38 David Restrepo Amariles & Matteo Winkler, U.S. Economic Sanctions and the Corporate Compliance of Foreign Banks, International Lawyers, soon published in 2018.

39 M. Gomez, More Risk, Better Regulation: A View from the World of Transnational Litigation, 8 Eur. J. of Risk Reg. 1 (2017).

40 David Restrepo Amariles & Matteo Winkler *supra* note 36.

41 James Grimmelmann, *Regulation by Software*, 114 Yale L. J. 1719 (2014).

research[42] and robotization.[43] This technological dimension has already been largely illustrated in the aforementioned examples. Evidently, it is fundamental to the development of SMART law, nourishing a complete reconfiguration of the functions of the State; indicative in the interpretation of States as platforms and government as services.[44]

3. MANIFESTATIONS OF SMART LAW IN BANKING AND FINANCE LAW

The emergence of SMART law, observable particularly in the field of banking and finance law, applies largely to a digitized and computerized environment. In this section, we examine two stark manifestations of SMART law, namely (1) the bank stress tests; and (2) algorithmic stress testing in algorithm trading.

3.1. BANK STRESS TESTS: THE INSTITUTIONALIZATION OF A RISK-ORIENTED SCIENTIFIC AND MATHEMATICAL APPROACH

The stress test is an exercise of simulating extreme economic and financial conditions in order to study its consequences on banks' balance sheets; thereby assessing the systemic risks for the banking sector as a whole.[45] They are specific to the European legal arsenal detailed under Directive 2020/43/EU (Directing implementing the UCITS), Directive 2011/61/EU (AIFM Directive) as well as the AMF General Regulation (Article 313-53-7, 411-79, 318-43 and 422-58) and the Commission Delegated Regulation No. 231/2013 of 19 December 2012 (AIFM Regulation).[46] The stress tests simulate the impact of a crisis case that is less likely to occur than the confidence interval chosen for the VaR.[47] This is developed on the basis of historical crises (replication of past scenarios) against a probabilistic model (based on a process of joint diffusion of different risk factors) or expert systems. The calculation is made by identifying and modelling such risks, then defining the desired confidence interval in accordance with objectives and degree of risk aversion. Stress tests also

42 Harry Surden, Machine Learning and Law, 89 Wash. L. Rev. 1 (2014);Anne Von Der Lieth Gardner, An Artificial Intelligence Approach to Legal Reasoning, *The MIT Press* (1987).

43 Ronald E. Leenes & Federica Lucivero, *Laws on Robots, Laws by Robots, Laws in Robots: Regulating Robot Behaviour by Design*, 6 Law, Innovation and Technology 194 (2014). Jack Balkin. "The Path of Robotics Law", *The Circuit: Paper 72 (2015)*, Meg L. Jones "Regulating the loop: Ironies of Automation law", *We Robot: April 4-5* (2014).

44 T. O'Reilly, *Government as a platform*, 6 Innovations 13 (2010).

45 J. Henry et C. Kok, A Macro Stress Testing Framework for Assessing Systemic Risks in the Banking Sector, European Central Bank, Occasional Paper Series N. 152 (Oct. 2013).

46 See equally instructions given by AMF N. 2011-15 (Art. 15), CESR/10-788.

47 VaR, the value at risk, is an attempt to summarize in a single measure the market risk attached to a diversified portfolio of underlying assets. This is the potential loss to the market-to-market value of a portfolio of posisions in the event of adverse market developments for a given time interval. H. Alexandre, *Banque et intermédiation financière*, Paris, Economica, 2012.

incorporate a time scale and the effects of diversification; namely, the correlation between various risk factor models. In reality, modelling risks through stress tests create "normative machines" – to quote Pauline Bégasse de Dhaem's wonderful expression[48] – that not only implement the law, but also help define new norms. By implementing choices about different risk factors and weighing them against each other, stress tests build new standards for capital requirements.

Thus, this monitoring tool is effectively a regulatory instrument for the banking sector. When institutions fail the stress test, the European Central Bank may require them to return to a recapitalization program within two weeks. In this program, institutions will need to share their plans for maintaining sufficient capital. If the plan is deemed insufficient, shareholders and subordinated creditors will be called upon to intervene financially. Results of stress tests have been made public since 2009.

180

In 2016, the Euro Banking Association conducted stress tests in 51 banking institutions across the European Union; a representation of roughly 70% of the region's assets. The worst-case scenario accounted for was a recession that would result in a 7.1% drop in the pan-European GDP over the course of 3 years and a 20% decrease in the incomes of the players in the sector with legal disputes amounting to 100 billion euros. The CET1 ratio used for these tests was 5.5%; that is to say, a bank with a capital ratio of less than 5.5% would be considered "weak." The three primary French banks, BPCE, BNP Paribas and Crédit Agricole, had a CET1 ratio that exceeded 10%; thereby, passing the test and deemed as healthy. Though the French banks have passed their stress tests, this was not the case for all institutions in the European Economic Zone. In Italy, for example, Monte Dei Paschi di Sienna held 47 billion in toxic liabilities – that is, 41% of its loan portfolio – and, therefore, had a CET1 ratio of 2.44%.[49]

We consider then the extent to which the implementation of such stress tests would render obsolete the quintessential distinction between regulation and banking supervision.[50] While banking regulation has

48 Pauline Bégasse de Dhaem « Réguler la finance globale et les banques : le cas des tests de résistance bancaire après la crise financière », *in* C. Bricteux et B. Frydman, *Les défis du droit global*, Bruxelles, Bruylant, 2018, pp. 179 et s.

49 « Stress tests bancaires : les françaises haut la main, Monte Paschi montrée du doigt », Les échos, Juillet 2016.

50 K. P. Follak, International Harmonisation of Banking Supervision and Regulation, 3 Int. Trade & Bus. L. Ann. 205, at 213, 217 (1997).

traditionally been normative and relied on specific quantitative rules, banking supervision monitors the practices of financial institutions on quality considerations.

Stress tests replace traditional methods of caution and prudence with a supervisory regime based on quantitative and objective parameters; eliminating the need for a regulator's discretion. The implementation of SMART law then has deeply transformed the banking sector, creating a shift from its traditional approach.

3.2. ALGORITHMIC STRESS TEST: REGULATING WITH DATA

The stress testing of trading algorithms illustrates the emergence of SMART law in finance law. Irène Aldrige[51] distinguishes the three modes of automatic *trading* in her study on financial markets and the use of automated processing; though only the last two actually make use of algorithms. The three modes are (1) electronic trading; (2) algorithmic trading; and (3) high frequency trading (HFT). Electronic trading is defined as traders having automated access to the trading room order books as opposed to using a broker. Algorithmic trading is the optimization of orders executed by traders. The trader remains in control of decisions to invest, but the downstream investment technique is different. Finally, HFT is the automation of decisions and execution of orders on the market at very high speeds. This type of trading is the first ever form of trading that uses entirely algorithms.

MiFID2 introduced a new regulatory regime for companies that practise algorithmic trading and/or HFT. In order to impose a licensing requirement across all market players, MiFID2 requires traders conducting HFT transactions in the EU to request certification of their algorithms. All companies performing algorithmic operations must then inform their competent authorities and the marketplace of their activities, allowing them to be subjected to a number of organizational requirements.

Companies involved in algorithmic trading will, therefore, have to establish systems, procedures, and devices to ensure their algorithms would not destabilize markets; bearing the capacity to withstand even

51 I. Aldrige, High-Frequency Trading A Practical Guide to Algorithmic Strategies and Trading Systems (2010).

moments of extreme stress.[52] They will also need to put into place business continuity plans and control mechanisms for their transactions. Their algorithms must also be "marked" in order to be identified.

The stress testing of algorithms acts as a mode of certifying the safety of trading algorithms. The objective is twofold: (1) tested algorithms should offer a sufficient standard of security with respect to economic stakes; (2) tested algorithms implement strategies that conform with the rules and applicable regulation. In this regard, stress testing should simulate the systemic environment in which algorithms run. Subject to different scenarios, its behaviour can be verified under a wide range of possibility. Ultimately, stress testing must provide both quantitative and qualitative data on the behaviour of algorithms in a variety of circumstances. The quantitative data would evaluate its conformity with established rules; while the qualitative data would evaluate its conformity with principles. The test would make it possible to demonstrate that all data required for the auditing of algorithms is produced.

182

If verifying compliance to set rules is fairly simplistic (that is, the modelling rules, then verifying that they conform with the algorithm, and finally predicting the failure of tests should it not be the case), then verifying compliance to principles may be more complex. Modelling the concept of "*high volatility*" is indeed more difficult than modelling the rules on a series of orders passed, but not executed by said algorithms. However, solutions available to date, such as the stress testing service offered by the company AlgoGuard, aims to actualize this feature. The company will provide operators, following the testing of their algorithm, a test that is able to register whether said algorithm has passed or failed.

AlgoGuard is an algorithm test service based on the competition of various algorithms within an order book. The objective is to provide investment firms with the certainty that their algorithms will behave stably on financial markets and that they meet the requirements of regulations in force.

AlgoGuard analyzes the interaction of the algorithm given by the financial institution with other competing fictitious algorithms, in order to simulate a realistic environment. The software then examines both the behaviour

52 MIFID II, art. 48.

of the algorithm under extreme circumstances (i.e. high volatility), and in periods of stability on the financial market. The software also alerts whether the algorithm tested could create problems on the market, such as price destabilization. Following the tests, AlgoGuard provides a report listing its success or failure.

The stress testing of trading algorithms illustrates, in reality, how a shift to SMART law could lead to a transformation of the law. The analysis is global and no longer casuistic. The role of the law was to deter against and to reprimand the commitment of an offence. Moreover, it reaches decisions through a casuistic case-by-case analysis. The *stress testing* of trading algorithms reconfigures the law, to a certain extent, by applying it *a priori* (it would only be implemented should the test be successful) and by adapting a specific interpretation of the law; so long as it conforms with the rules and principles are verified (behaviours or *pattern* of behaviours are not observable). This subsequently creates, in practice, a reinterpretation of a general rule as, alternatively, a set of detailed instructions that prohibit certain behaviours.

4. CONCLUSION

We have sought, within the limited framework of this study, to highlight the emergence of a new model of law that we classify as SMART Law. This scientific, mathematical, algorithmic law that is driven by risk and technology is observable in all fields of law. Banking and finance law is no exception. It could even, to a large extent, be considered at the forefront of such ongoing transformation, given the above examples of stress testing on banks and trading algorithms.

The development of SMART law carries several important consequences in terms of theory and the philosophy of law.

First, SMART law shifts the role of law from an *a posteriori* system of regulation to an *a priori* system. The challenge is often the act of preventing the commitment of offencses. This could be resolved through the direct integration of rules into technical devices; rendering it impossible to violate said rules. The rule of law then becomes entirely redundant in this environment and is instead automatic.

Second, SMART law tends to render obsolete the distinction between facts and norms, typically characteristic of legal reasoning. The law no

longer interprets cases through a debatable application of rules to facts. Instead, SMART law mechanisms presuppose an already legally -driven world where the qualification and examination of facts are entangled with the rules, becoming *de facto* indistinguishable.

Third – and consequently – code, software operations, or SMART law mechanisms would replace legal rules such that the conventional law cycle would also be disrupted. The model in which the legislator adopts a rule and is then implemented by societal actors, whose violation is then sanctioned by judges, would gradually be replaced by a process whereby consensus emerges across all stakeholders on the parameters taken to ensure compliance with the norm. In the field of HFT regulation, it is now observable that operators increasingly rely on regulatory technologies (RegTech) to ensure compliance with all obligations. The regulator itself depends increasingly on supervisory technologies (SupTech), allowing compliance control of market players. Practice has shown that the suppliers of technologies used by actors and regulators are relatively the same. The risk of a legal takeover by technological players is therefore real. Moreover, the risk of future legislators or regulators being mere producers of code or monitoring algorithms is also present.

Finally, the migration of legal norms to SMART law devices almost inevitably leads to a subversion or a significant modification of the meaning of the rule of law; given the need to properly govern mathematical or algorithmic processes. This is particularly problematic as lawyers are largely absent from the process and generally ignore the language of engineers, mathematical and computer scientists. From this perspective, it is of urgency that lawyers are given basic training on these matters. It is also necessary to foster collaboration between engineers and lawyers at all stages of development of SMART law mechanisms. The movement towards SMART law is already working to benefit both disciplines and, of course, the litigant and respect for the rule of law.

185