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Federal Electricity Commission ElCom
Technical Secretariat

Algorithmic Trading

Communication

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Contents

1 Background

The Federal Electricity Commission ElCom is responsible for the supervision of wholesale Swiss electricity trading and is committed to a transparent and fair electricity wholesale market. Whereas algorithmic trading is already firmly established in currency and stock markets, its penetration into the wholesale electricity market is a relatively recent phenomenon. For this reason, in August 2019 ElCom conducted a survey on the subject of algorithmic trading. The survey focussed on the use of algorithms in the Swiss electricity market and its use by Swiss market participants in the wholesale electricity markets of the EU. The goal of the survey was to gain an overview of the presence of trading algorithms in the Swiss wholesale electricity market. Furthermore, the survey was intended to contribute to an understanding of how the underlying risk controls and governance are handled by the electricity supply companies.

Within the framework of the survey, ElCom contacted a total of 61 market participants. Two of them are based abroad, but are very active in the Swiss short-term markets. In all, 75 percent of the market participants completed the questionnaire. Ten percent did not complete the questionnaire because, according to their own statements, they are no longer active in the wholesale electricity market. ElCom received no feedback from 15 per cent of the surveyed market participants.

The analysis of the survey revealed that the use of algorithmic trading by Swiss market participants in the wholesale electricity market is limited. Only eight of the companies that provided feedback use trading algorithms. Algorithms are used most frequently in intraday trading and primarily in the German electricity market. External solutions are preferred to in-house development. Three of the eight companies have developed algorithms themselves. However, often the responsibility for individual aspects (in particular ensuring the integrity of the market) is incorrectly viewed as belonging to the developer of the algorithm rather than the user. Furthermore, there is definitely potential for optimisation, particularly with reference to the documentation of the individual process steps, algorithm inventories and governance.

In this communication, recommendations and best practices in relation to algorithmic trading are proposed. These recommendations are non-binding, but may be helpful in the development of internal instructions and processes.

2 Introduction

Algorithmic trading is becoming increasingly important in the energy industry. As a result of the increasing, fluctuating and difficult to predict supply from renewable energy sources, participants in the market are forced to constantly adjust their electricity positions on the intraday market. In addition, digitalisation opens up new possibilities. The use of smart metering systems provides real-time consumption data from and for household and business customers. In order to keep balancing costs low, utilities also have an incentive to optimise consumption positions on the intraday market. Automation of intraday trading using algorithmic trading to balance the production and/or consumption position, in order to close open positions automatically and keep balancing costs low, reduces the costs for intraday traders and enables optimisation even without 24/7 shift operation.

As a result of the reduction in market access barriers to algorithmic trading, more smaller companies are becoming active in this environment. Despite the positive effects, such as increasing market liquidity, falling transaction costs, reduced bid-ask spreads and the resulting increased efficiency of price determination, in addition to the exclusion of human emotional and psychological factors, automated trading also involves risks which may require measures, especially if the algorithmic trading triggers extreme price movements, leads to overloading of exchange systems or damages market integrity. Because of the rapid changes in market conditions and the increasing complexity in energy trading, the lack of monitoring systems which operate correctly can cause enormous damage to businesses (which is not limited to financial damage).

The following sections describe what is meant by the term algorithmic trading, which legal basis exists in Switzerland and the EU (not exclusively), which areas of activity are emerging in the energy sector and which requirements must be met by businesses in the development, testing and validation phases, as well as risk controls and governance.

2.1 Definition of algorithmic trading

Contratto (2014, p. 145) explains, "algorithmic trade is automated, i.e. without direct human intervention, but is based on complex procedural instructions programmed by a human being and embedded in software".

With reference to the term “algorithmic trading”, ElCom relies on the definition in Directive 2014/65/EU on Markets in Financial Instruments (MiFID II). Article 4 (1) 39 MiFID II defines algorithmic trading as “trading in financial instruments where a computer algorithm automatically determines individual parameters of orders such as whether to initiate the order, the timing, price or quantity of the order or how to manage the order after its submission, with limited or no human intervention, and does not include any system that is only used for the purpose of routing orders to one or more trading venues or for the processing of orders involving no determination of any trading parameters or for the confirmation of orders or the post-trade processing of executed transactions”. In the case of these latter systems, these involve automated trading, not algorithmic trading.

ElCom therefore assumes algorithmic trading if the algorithm is able, autonomously and without human interaction, to submit orders and/or execute trades on exchange or broker platforms. In these cases the order, in particular its price, quantity and the time of entry of the order are determined by the algorithm itself.

2.2 Overview of the legal basis in the EU and in Switzerland

Under Directive (EU) No. 1227/2011 (EU REMIT Directive), the electricity supply legislation (Electricity Supply Act of 23 March 2007 [ESA; SR 734.7] and the Electricity Supply Ordinance of 14 March 2008 [ESO; SR 734.71], no explicit conditions exist for companies which use algorithmic trading. MiFID II, however, specifies a series of requirements for companies which use algorithms in their trading activity. The regulation of algorithmic trading, however, relates exclusively to financial instruments as defined according to MiFID II. Spot and intraday products such as those offered on the EPEX SPOT electricity exchange do not fall within the scope of MiFID II. Consequently, in Switzerland there is at present no binding regulation of algorithmic trading of such trading products, so regulation in MiFID II is considered in greater detail below, on a provisional basis.

The MiFID II requirements include (Financial Conduct Authority, 2018):

- A warranty of effective systems and controls, in particular to guarantee that trading systems are resilient, that trading threshold values and limits are complied with, that incorrect orders which contribute to an unregulated market are avoided and that violations of the rules of a trading platform or of Regulation (EU) No. 596/2014 on Market Abuse (EU Market Abuse Regulation) are prevented.

- The company must have implemented effective emergency provisions in order to be able to guarantee to deal with any trading system failure and to ensure that its systems are fully tested and duly monitored. In particular

    - there must be a clear and formalised governance framework;

    - compliance personnel must have a general understanding of algorithmic trading and must have contact with personnel who have the possibility of cancelling all non-executed orders;

  - the company remains fully responsible for its regulatory obligations even if the IT services are or will be outsourced;
  - the company must have available sufficient specialised personnel in the technical, law, monitoring, risk and compliance areas;
  - the company must employ automated monitoring systems to detect market manipulation;
  - the company must have available pre-trade controls with reference to price, value, trading volume, message volumes, trader permissions, and, market and credit risk limits;
  - the company must monitor its trading activities with a focus on disorderly trading and must have available effective post-trade controls.

- The systems must be fully tested (including conformity tests with the market place in which they are used) before they are put into operation. Substantial adjustments should be made only on behalf of a senior member of the personnel and only where there are pre-defined trading limits. The company must carry out specified pre-trade checks on submission of an order, monitor all of its trading activities in real time and continuously implement post-trade controls, including those relating to its market and credit risks.

- The company must have available an emergency "kill functionality" which enables the immediate deletion of all non-executed orders.

- If the company is active on an EU trading platform and operates algorithmic trading on it, it must inform the trading platform's responsible authority and the regulator.

- The company must carry out annual self-assessment and produce a validation report which covers the following:
  - algorithmic systems and strategies
  - governance and control framework
  - emergency provisions
  - stress tests
  - general conformity with the other MiFID II requirements.

With reference to the responsibility of companies which use algorithms which have been supplied by a third-party company and as a result of which the integrity of the market has been damaged, in the EU Article 4 of the Delegated Regulation (EU) 2017/589 of 19 July 2016 supplementing the Financial Market Directive expressly applies. The article states that "An *investment firm* shall remain fully responsible for its obligations […] where it outsources or procures software or hardware used in algorithmic trading activities."

In Switzerland, algorithmic trading is regulated in the Federal Act on Financial Market Infrastructures and Market Conduct in Securities and Derivatives Trading of 19 June 2015 (Financial Market Infrastructure Act, FinMIA; SR 958.1), which is based on EU legislation. With reference to preventive measures in connection with algorithmic trading, Articles 30 and 45 and Articles 30 ff. and 40 f. of the Ordinance on Financial Market Infrastructures and Market Conduct in Securities and Derivatives Trading of 25 November 2015 (Financial Market Infrastructure Ordinance, FinMIO; SR 958.11) are relevant. The ban on insider trading and market manipulation under the supervisory requirements legislation is regulated in Articles 142 and 143 FinMIA. The criminal liability for insider trading and price manipulation is defined in Article 154 f. FinMIA. It is to be assumed that in principle the operator of the algorithm is responsible for the trading activities undertaken by it. Complementary criminal liability of the company which developed the algorithm is also conceivable (e.g. as an accomplice). In any event, assessment

under criminal law is incumbent on the competent prosecution authorities, and assessment under supervisory law is, however, incumbent on the FINMA.

2.3 Use of trading algorithms in the energy sector

Trading algorithms are used primarily for the automated closing of an open position which occurs in the case of a portfolio of renewable energies, for example owing to a newly received wind or solar forecast. Also, on the demand side, “smart meters” allow "almost" real-time measurement of consumption. Updated demand forecasts could be optimised directly by trading algorithms on the intraday market. Here the main factors driving the use of algorithmic trading are the reduction of balancing costs and optimisation of the electricity position even outside normal office hours, if the cost of 24/7 shift operation is too high (Keitsch, Bornhöft, Becker & Wieland, 2017).

Another reason for the use of trading algorithms is to make profits. The growing range of short-term tradable electricity products (hourly, half-hour and quarter-hourly products), but also the different market places, increases traders' costs on the one hand, and on the other hand also opens up arbitrage possibilities between the products (for example purchase of the hourly product vs. sale of the four quarter-hour products) or between different trading venues (Keitsch et al., 2017).

In addition, trading algorithms can be used for speculative portfolio optimisation. However, this presupposes that the company has available good pricing models and is ready to take certain risks. Algorithms which enable automated market making and which first bring together internal orders (match), are another possibility, before these make their way outside onto the market. This reduces the trading volume and, accordingly, exchange and brokerage fees.

3 Possible “best practices” in the use of trading algorithms

Keitsch et al. (2017) view secure operation, high cost efficiency, high flexibility and support for multiple central markets and products as a key requirement for algorithmic trading. Security means that the algorithm always behaves as intended and that the algorithm does not result in any incorrect or unexpected conduct which could harm the company (financially, legally or in terms of its image). The algorithm should be flexibly configurable, so that its use in highly variable market situations can be rapidly optimised.

As mentioned above, algorithmic trading provides many opportunities for energy companies, but also involves risks. In what follows, recommendations and measures in connection with the development, testing and validation of trading algorithms are provided, in order to enable secure operation of trading algorithms which are used.

Possible best practices are then indicated with reference to regulations in the EU. These recommendations, which are not binding in Switzerland, may be helpful in the development of internal directives and processes.

3.1 Development phase, testing phase, validation phase and documentation of trading algorithms

In this section the focus is on measures in the development, testing and validation phases of an algorithm and on its documentation. Individual recommendations and measures on these subjects can already be found in the report on compliance of algorithmic trading on wholesale markets by the Financial Conduct Authority (FCA 2018).

Even if the algorithm is procured externally, the company should be involved in the development and testing phases or should at least obtain orderly documentation on these phases from the third-party company in order to be in a position to judge for itself how well and under what market conditions the algorithms have been tested.

3.1.1 Development phase

The design of an algorithm adheres to the following process. Initially data access is regulated and the data is prepared. Then an *ex-ante* data analysis is scheduled to identify and evaluate trading opportunities, for example, in terms of risks and profitability. If the result of the evaluation is positive, a trading signal follows. Then the execution module chooses the market and the execution strategy. There follows an *ex-post* analysis of the trades which have been carried out and reporting of the transactions and results. Each individual phase of the process should be examined and documented (Keitsch et al., 2017).

A guideline or instructions relating to the development and testing of algorithms, which is accepted and applied internally by all units, is one of the best practices for a company which uses trading algorithms. This guideline should not be restricted to the process of developing new algorithms but should also clearly define the process for modifying existing algorithms. If the algorithms are outsourced, these internal provisions should help to specify minimum requirements and critical questions to the third-party company. The guideline should be in line with the internal regulations and correspond to the company's risk appetite and behavioural expectations.

In addition to a project manager who takes responsibility for the overall development and testing phases, colleagues from different trading units should be involved. It should be ensured that all existing and relevant know-how is incorporated, that roles and responsibilities are clearly defined and that independent reviews can be conducted. The participation of traders, their superiors, risk managers, compliance managers and a member of senior management, who should formally approve the phase as the decision-maker, is essential.

3.1.2 Testing phase

An intensive testing phase and detailed documentation of all stages is indispensable in order to identify potential problems in trading algorithms, before these are fully rolled out. As stated in the Delegated Regulation (EU) 2017/589 of 19 July 2016, the requirements for tests for trading algorithms should address the potential effects of these algorithms on the fair and orderly functioning of the market.

In the testing phase it must be ensured that:

- the algorithm performs as intended;
- the algorithm remains functional and does not lead to disorderly trading even under extreme market conditions;
- the “kill functionality” always works at any time;
- the algorithm corresponds to the company's risk appetite and behavioural expectations;
- the rules of the respective trading platform are not violated;
- REMIT rules, in particular rules concerning market manipulation, are not violated;
- the trading platform's conformity test is passed. “Conformance testing should be made in order to verify that the trading systems of an investment firm communicate and interact properly with the trading systems of the trading venue or of the direct market access (DMA) provider[1] and that market data are processed correctly”

In order to be able to perform the tests, a test environment should be used which is absolutely separate from the production environment. Mainly, the traders and IT specialists should be involved, but risk managers, risk controllers and senior management should be informed by the project manager about the most important individual stages of the testing phase.

In the testing phase the first “Go Live" should also be tested. When trading algorithms are introduced it is highly advisable to use a controlled procedure in an initial stage, i.e. to carry out a test run with predefined limits for the number of orders, the number of traded products, the price, the trading volume and the number of trading venues (broker or exchange platforms) on which the orders are to be placed. In this way it can be ensured that the algorithm also behaves as intended in the production environment.

[1] DMA: Direct Market Access.

The progress of the testing phase, the market data used and the market circumstances under which the tests have taken place, should be documented in detail.

If the algorithm has been sourced externally, this should be tested internally before it is actually used, in a test environment, again on the basis of the above-mentioned criteria, because in the end the responsibility lies with the company which uses the algorithm.

Keitsch et al. (2017) describe two possibilities for testing algorithms: back testing and agent-based modelling of the market.

In the case of back testing, trading algorithms can be tested against recorded historical market processes. In order to take into account the liquidity of the market and thus to also determine a possible influence of the algorithm on the market, classical back testing alone, where only historical prices are used, should not be used; the complete historical order book data should be included in the tests. This order book data should flow into the market simulation using replay procedures, and be accelerated temporally using the tick data so as to cover a longer historical range. The advantage of this method is that the behaviour of algorithms can be tested in many real historical market situations and optimisations of the algorithm can be tested promptly and effectively in order to achieve the desired behaviour. It should not be forgotten, however, that the market situation in the energy market has changed dramatically over recent years and the historical market data may possibly be outdated. Flow Based Market Coupling or XBID , for example, represent completely new market situations.

In the case of agent-based market simulation, software agents generate a market on the basis of adaptable rules. In this market, “Liquidity Maker Agents” (which bring liquidity into the market) meet “Liquidity Taker Agents” (which extract liquidity from the market). The behaviour of the algorithm can be tested in this market. Since the scenarios are configurable, this approach makes it possible to follow the algorithm in real time in market situations which have not previously been observed. However, the large amount of time which this method requires is a disadvantage.

3.1.3 Validation phase

Before an algorithm can be productively rolled out, the entire process should be validated by all trading units concerned (trading, risk management, compliance, law, IT and back office). Ideally, throughout the entire development and testing phases, inspection points are defined and a full examination is carried out and documented at the end of each phase. These documents should be examined by an independent unit, thereby ensuring that all inspection points have been satisfactorily concluded and that the algorithm is consistent with the original specifications.

3.1.4 Documentation of algorithms

Companies which operate algorithmic trading should keep and maintain a comprehensive inventory of all algorithms, including their strategies and systems (regardless of whether the algorithm was developed in-house or externally). The following points must be clearly defined in the inventory:

- types of algorithms, trading strategies and the systems involved, operational goals, parameters of the algorithms and behavioural characteristics
- the person responsible for the algorithm and colleagues who are authorised to manage the strategy or the system
- guidelines on the conclusion of development, test and validation procedures
- technical details and system architecture
- market conditions under which the algorithms were tested
- regulatory and market place requirements in force
- a list of all risk controls (including the kill functionality) which apply to each strategy or each system, including the overall risk limit and the limits for each individual algorithm.

With reference to the types of algorithms, it should be clear whether the development of the algorithm is based on rule-based systems or on machine learning. Rule-based systems are based on explicitly

defined and static models and rules of a sector. These rules are encoded in the system in the form of “if-then-else” statements. The knowledge which is given to the algorithm does not change over the course of time. It may therefore be the case that the algorithm "stalls" if it encounters a problem for which no rules have been drafted and it is therefore unable to solve the problem; it may even go out of control. Rule-based systems can also cause other problems. It is for example difficult (if not almost impossible) to add rules to an already large knowledge base without introducing contradictory rules. Consequently the maintenance of rule-based systems may often become very costly and time-consuming.

Machine-learning systems generate their own models. This has the advantage that the models can adapt rapidly to changing trends and there is flexibility to adapt the parameters concerned. A neural net is, for example, one instance of a learning system. Although the learning process is deterministic, from a practical point of view it is almost impossible to extract the model from the internal functioning of a learning system. The reason for this is the high degree of complexity caused by the high number of dynamic parameters (e.g. weighting, bias). One natural consequence is that the learned and applied models can no longer be interpreted, explained and understood well enough by humans. It is often no longer possible to understand how these systems make their decisions (Tricentis). Learning systems are therefore often termed black boxes.

Companies which use such algorithms must be aware of this fact and must therefore pose the question of whether they can rely on a “black box” and whether and in which form such machine-learning algorithms are capable of compliance.

The inventory should try to represent the complexity of the algorithmic trading clearly and comprehensibly. It should constitute the information basis for senior management and provide evidence that the company's algorithmic trading activity is clearly identifiable and adequately monitored and that adequate risk controls are in place.

3.2 Risk controls and governance of trading algorithms

3.2.1 Risk controls

In order to identify and reduce potential trading risks in relation to algorithmic trading, all companies should implement appropriate risk controls. On the one hand this is appropriate for the company itself (operational errors due to algorithms which have gone out of control can result in high costs), and on the other hand it is intended to ensure the market integrity of the trading platforms on which the algorithms are actively used.

In Article 17 para. 1 MiFID II describes the requirements of risk controls as follows:
“An investment firm that engages in algorithmic trading shall have in place effective systems and risk controls suitable to the business it operates to ensure that its trading systems are resilient and have sufficient capacity, are subject to appropriate trading thresholds and limits and prevent the sending of erroneous orders or the systems otherwise functioning in a way that may create or contribute to a disorderly market. Such a firm shall also have in place effective systems and risk controls to ensure the trading systems cannot be used for any purpose that is contrary to Regulation (EU) No 596/2014 or to the rules of a trading venue to which it is connected. The investment firm shall have in place effective business continuity arrangements to deal with any failure of its trading systems and shall ensure its systems are fully tested and properly monitored to ensure that they meet the requirements laid down in this paragraph.”

Delegated Regulation (EU) 2017/589 of 19 July 2016 differentiates between different kinds of risk controls.

In the first place, the pre-trading controls are to be designated, i.e. controls which take place before the submission of an order in a marketplace. The pre-trading controls impose the following safeguards:

- price bands: ideally, orders which do not correspond to the fixed price parameters are automatically blocked and are not transferred to the marketplace. The price bands should be differentiated according to trading products.
- maximum order values: these are intended to prevent orders with a high order value from reaching the market.
- maximum order volumes: orders where the volume exceeds the set value should be automatically blocked and it should not be possible to place them on the market.
- upper limits for messages: an excessive number of messages on the submission, modification or cancellation of orders should be prevented from reaching the market.
- traders who are authorised to trade in specific trading instruments.

Moreover, it must be ensured from the outset that the trading system switches itself off automatically after a pre-set number of repeated transactions until the responsible person switches it on again. Clear upper limits should be specified for market and credit risks. All companies should also have available a kill functionality to deactivate trading activities in order to also be able to ensure the integrity of the market. If the company wishes to execute trading orders even if they have been blocked by the pre-trading controls, a pre-defined procedure should be applied.

In a second stage the real-time controls follow. This is a matter of monitoring the trading activity in order to highlight infringements of pre-trading upper limits in real time by means of alerts. In addition, signs of disorderly trading conditions which interfere with the market should be monitored. The monitoring is performed by the trader responsible for the algorithm or the risk manager.

Finally, companies should implement post-trading controls to monitor their trading activities and to take appropriate measures if alerts have been triggered. In extreme cases this measure should entail shutting down the trading algorithm concerned. The post-trading controls enable continuous assessment and monitoring of the company's market and credit risks. To this end, comprehensive, accurate and consistent trading and account information must be maintained. Electronic trading logs, which are coordinated with relevant third parties such as the trading department, must be maintained. It must be ensured that alerts are issued as promptly as possible if potential signs of market manipulation or infringements of the rules of the exchange occur, and that traders and risk managers carry out post-trading monitoring.

3.2.2 Governance

A strong governance framework with appropriate guidelines and clear and formalised directives including effective risk management is of fundamental importance for reducing the risks associated with algorithmic trading strategies.

Article 1 of Delegated Regulation (EU) 2017/589 of 19 July 2016 imposes the following organisational requirements on companies which operate algorithmic trading:

- Clear hierarchies and accountabilities.
- The presence of procedures for communication of information in order to seek and implement instructions efficiently and promptly.
- A separation of tasks and responsibilities between the trading department and support functions such as risk management and compliance.

Moreover, Article 9 of this Regulation provides for annual self-assessment and validation in which the algorithmic trading systems, the algorithms and the trading strategies are examined. In addition, the governance, accountabilities and approval framework are examined. Annex 1 of the Regulation provides clear criteria for the self-assessment analysis. The relevant validation report must be approved by the company's management.

Robust development, testing and roll-out processes, independent validation procedures, appropriate risk management controls and appropriate monitoring ensure a strong governance framework. Strong governance is also facilitated when senior management is involved from the beginning in the

development phase and testing phase of trading algorithms. This ensures that algorithmic trading and the potential effects on market behaviour are understood and that the necessary procedures for forwarding information promptly, and not only after the onset of a critical situation, are implemented.

Nevertheless, if a critical situation does arise, the company should have clear processes established in order to emerge positively from the crisis as a result of successful crisis management. The situation should first be identified and analysed. Then strategies must be developed to overcome the crisis and to introduce and monitor counter-measures.

A crisis management system which is intended to alleviate the escalation of an event in an emergency using prepared action plans can be of assistance. The formation of a crisis team which is deployed in an emergency and which takes on all communication tasks (in-house as well as externally) is also advisable. To protect the company from adverse effects on its image, the establishment of a communication strategy for cases of crisis is advisable. This is because corporate crises can often also have a negative media effect.

Good risk and compliance management constitutes a further requirement of governance. Ideally, a member of the compliance team should already be involved during the development and testing phase of the trading algorithms. It should focus its monitoring activity on conduct risks (e.g. market price risks) and ensure that the regulations relating to market integrity are being complied with. In addition, the members of the compliance team should understand the trading systems or trading algorithms well enough to be able to confront the traders with critical questions.

3.3 Influence of trading algorithms on the market

It is of crucial importance that the company takes into consideration the effects of its trading activity on market behaviour and the effects on general market integrity. In particular this is because some energy markets exhibit distinctly less liquidity than stock markets. If an enterprise has multiple algorithms activated, it should be ensured that their interaction has no effect on market integrity. If algorithms are sourced externally, the question arises as to how much the parameters can be customised and how many market participants are acting according to the same logic.

Delegated Regulation (EU) 2017/589 of 19 July 2016, in Article 13, requires an automated monitoring system to expose market manipulation. In this context, orders and trades should be controlled effectively, alerts and reports should be generated and, where appropriate, visualisation tools should be provided.

The type of monitoring instruments which are used depends on the size of the company, but they should ensure that they are proportionate and are tailored to the specific risks of its algorithmic trading activity.

4 Summary and outlook

Algorithmic trading is not yet well established among Swiss market participants. However, algorithmic trading will gain ground in connection with the increasing digitalisation in the energy markets. Electricity companies should take advantage of the opportunities which this brings and identify and avoid potential risks.

The above-mentioned measures for the development, testing and validation phases of an algorithm and for its documentation should constitute a basis for detecting possible risks relating to algorithmic trading promptly and for introducing the processes necessary to reduce these risks. Developments relating to artificial intelligence (AI) and machine learning are already making inroads into algorithmic trading. AI algorithms are different, since they adapt, learn and affect the environment without being programmed to do so. In the future many algorithms will be “trained” rather than “developed”. That means that in borderline cases the functioning of many algorithms will be unclear and difficult to predict and the

responsibility for the damage they do will be diffuse and difficult to apportion. AI algorithms will make the testing of algorithms an immensely great challenge (Barnett, Koshiyama & Treleaven, 2017).

From the regulatory point of view, it is clear that the regulator cannot examine each algorithm before it is productively rolled-out. In order to ensure effective supervision and to be able to take appropriate measures against flawed or fraudulent algorithmic strategies, the question arises as to whether Table 1 of the Annex to the "Implementing Acts"[2] of the EU REMIT Regulation should be extended so that all orders generated by algorithmic trading are identified. The regulator would then be able to detect orders and trades which are generated by different algorithms and to distinguish between them. The strategies applied by algorithmic traders can thus be reconstructed and evaluated more efficiently. Identification of algorithms has already been implemented in the financial markets sector.

In view of the rapidly changing landscape in relation to the possibilities of programming such algorithms, the question arises as to whether in the future algorithms should be certified before they are productively rolled out (Barnett et al., 2017). Algorithm certification should then ensure that a specific algorithm complies with one or more standards, i.e. the algorithm corresponds to the recorded requirements (correctness, completeness, consistency and accuracy) and that the standards, practices and market rules are being complied with.

The task of the regulator, in coordination with the industry, would then be to develop guidelines, standards and specialist knowledge in relation to algorithmic trading in order to create a balance between innovation, market security and integrity.

[2] Article 8 of REMIT states that the Commission defines by means of "Implementing Acts" the list of orders to be notified, the schedule and form of reporting and the persons who must report transactions.

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