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Research on Legal Regulation of Quantitative Trading and Its Improvement Path in China

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Abstract

As a technology-driven financial innovation paradigm, quantitative trading possesses both the positive value of enhancing securities market efficiency and the potential risk of undermining market fairness, exhibiting a dual nature of efficiency empowerment and fairness challenges. Currently, China's legal regulatory framework for quantitative trading faces core dilemmas such as fragmented regulatory norms, lack of algorithm transparency oversight, inadequate cross-market collaborative supervision mechanisms, and the absence of investor compensation mechanisms. Therefore, it is imperative to address these issues by improving top-level design, strengthening process regulation, optimizing market fairness mechanisms, and enhancing accountability systems, thereby establishing a legal regulatory framework that balances innovation inclusiveness with fairness safeguards.

Keywords

Quantitative trading; Securities regulation; Compensation for damage.

1. The Fundamental Theory of Quantitative Trading

Quantitative trading is a modern trading paradigm that uses mathematical models as its logical core and computer programs as its execution center. Its core is to convert market data into standardized trading signals through algorithms, achieving a fully intelligent closed-loop process of strategy development, backtesting verification, automatic execution, and risk control. Essentially, it replaces the subjective experience judgment of traditional trading with data-driven decision-making.

Compared to traditional trading, the core features of quantitative trading are mainly reflected in three aspects: firstly, strategy modeling and verifiability, relying on theories such as statistics, machine learning, and behavioral finance to construct models. From multi factor stock selection, trend tracking, to event driven, all logic can be validated through historical data backtesting to avoid irrational biases in subjective decision-making. The second is to achieve high efficiency and low latency in execution. With the help of technologies such as hosting and microwave transmission, the response speed of orders can be compressed to microseconds. High frequency trading strategies can complete the entire process of market reception, signal generation, commission trading, and closing and exiting in milliseconds, while manual trading orders require at least a second level response from decision-making to placing orders. There is an essential gap between the two in capturing trading opportunities. The third is risk quantification and dynamic control. Through tools such as Value at Risk, Conditional Value at Risk, and stress testing, market risk, liquidity risk, and model risk are transformed into quantifiable numerical indicators. Setting a daily maximum drawdown threshold automatically triggers position reduction, or offsetting portfolio systemic risk through hedging tools to achieve accurate risk measurement and real-time prevention and control[1].

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From market practice, the current mainstream quantitative trading models can be divided into three categories: one is high-frequency trading, which focuses on low latency and small price differences, and uses strategies such as liquidity supply, order book arbitrage, and liquidity rebate trading to achieve meager single profits but extremely high trading frequency. Currently, it accounts for 30% -40% of the trading volume in China's A-share market. The second is statistical arbitrage strategy, which constructs hedging portfolios based on historical statistical patterns between assets, such as paired trading and cross period arbitrage, with the core logic being mean regression. The third is algorithmic trading, which focuses on reducing the impact of large orders on market prices. For example, the time weighted average price algorithm evenly splits orders into all day execution, and the volume weighted average price algorithm dynamically adjusts the order rhythm based on real-time trading volume. It is widely used in bulk trading for institutional investors such as public funds and insurance, avoiding significant price fluctuations caused by a single large order.

2. The Existing Problems in the Legal Regulation of Quantitative Trading in China

2.1. Fragmentation of current regulatory norms

The regulation of quantitative trading in our country presents obvious fragmented characteristics, with the core manifestation being that regulatory norms are mainly based on departmental regulations and normative documents, lacking systematic support from higher-level laws, resulting in scattered regulatory logic and low levels of rule effectiveness.

From the perspective of regulatory system, the current regulatory content directly targeting quantitative trading is mainly scattered in the departmental regulations and business rules issued by the China Securities Regulatory Commission and exchanges, such as the defining provisions of procedural trading in the "Securities and Futures Trading Settlement Rules" of the China Securities Regulatory Commission, the enumerative clauses on abnormal trading behavior in the "Trading Rules" of the Shanghai and Shenzhen Exchanges, and the "Notice on Further Regulating Relevant Matters of Quantitative Trading" issued in 2023, which puts forward requirements in terms of declaration rate, order type, information disclosure, etc. These regulations mostly focus on specific operational aspects, such as restricting the order declaration rate of high-frequency trading, requiring quantitative institutions to report algorithm strategies, but have not formed a unified regulatory framework, and even have rule conflicts, such as the recognition standards for algorithm abnormal trading, differences in the expression of exchange self-regulation rules and regulations of the China Securities Regulatory Commission, resulting in inconsistent regulatory enforcement approaches in practice.

The more core issue lies in the lack of support from higher-level laws. As the fundamental law of the securities market, the Securities Law does not explicitly include quantitative trading and algorithmic strategies in its regulatory scope. It only leaves vague space in principle clauses such as "prohibiting manipulation of the securities market" and "preventing systemic risks". It neither defines the legal attributes of quantitative trading nor establishes its basic regulatory principles and responsibility boundaries. The absence of higher-level laws and the filling of lower level laws in this model result in a lack of rigid constraints on regulatory norms. On the one hand, departmental regulations are at a lower level, making it difficult to effectively constrain cross market and cross variety trading of quantitative institutions. Especially when faced with complex behaviors such as high-frequency trading and algorithmic arbitrage, regulatory loopholes are prone to occur; On the other hand, when quantitative trading triggers civil disputes, due to the lack of clear standards for determining infringement liability in the Securities Law, courts can only refer to departmental regulations or judicial interpretations to make judgments, resulting in significant differences in the results of similar cases. This not only

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hinders the formation of stable expectations for market entities, but also weakens the authority and unity of legal regulation.

2.2. Lack of transparency regulation in algorithms

The core competitiveness of quantitative trading lies in algorithm models, and the lack of transparency regulation of algorithms in the current regulatory system has made "black box algorithms" the core dilemma of compliance review, which not only hinders regulatory penetration but also exacerbates the concealment of market risks[2].

This deficiency is first reflected in the ambiguity of algorithm disclosure requirements. The current regulations only require quantitative institutions to report the basic information of algorithm strategies, but do not specify the scope, depth, and form of disclosure: for dynamic optimization algorithms based on machine learning in high-frequency trading, their core parameters and logical iteration process belong to institutional trade secrets. Regulatory authorities have not defined the boundary between "disclosable information" and "trade secrets", nor established a hierarchical disclosure mechanism[3]. If it is required to fully disclose algorithm details, it will damage institutional innovation motivation. If only formal reporting is done, it will result in regulatory authorities being unable to determine whether the algorithm has potential flaws in manipulating the market and inducing systemic risks, leading to a formal review of compliance through reporting.

The second challenge lies in the interpretability of black box algorithms. Quantitative trading, especially high-frequency trading strategies, rely heavily on complex algorithms such as deep learning and neural networks. Their decision logic has observable input-output and untraceable intermediate processes, making it difficult for even algorithm developers to fully explain the reasons for each trading instruction, resulting in an "algorithmic black box". This puts regulatory compliance reviews in a passive position: on the one hand, it is impossible to verify whether the algorithm meets the requirements of "prohibiting market manipulation" and "fair trading" through conventional audit methods. For example, the large number of pending and canceling orders automatically triggered by the algorithm is difficult to accurately define whether it is a normal liquidity supply or fraudulent trading based solely on post event data monitoring; On the other hand, when the algorithm encounters anomalies, regulatory authorities are unable to quickly locate the root cause of the problem, making it difficult to achieve pre warning and trace responsibility in a timely manner after the risk occurs. They can only rely on self-report from quantitative institutions, and institutions may conceal algorithm defects in order to avoid responsibility, further amplifying regulatory lag错误!未找到引用源。.

This lack of transparency ultimately leads to information asymmetry between regulators and market entities. Quantitative institutions have control over the core logic of algorithms, while regulatory authorities can only infer algorithm behavior through trading data. The information gap between the two makes it difficult for compliance reviews to touch on the essence of algorithms, making it difficult to effectively prevent illegal activities such as algorithm manipulation and malicious arbitrage, as well as to proactively control algorithm risks, becoming a key bottleneck in regulating fairness in quantitative trading.

2.3. The cross market collaborative regulatory mechanism is not perfect

There is a natural contradiction between the cross market characteristics of quantitative trading and the current regulatory model of segmented supervision and market segmentation, especially in the spot and derivative markets. The lack of collaborative regulatory mechanisms leads to regulatory disconnection, leaving regulatory loopholes for quantitative arbitrage and exacerbating the cross market transmission of market risks.

Firstly, there is a lack of uniformity in regulatory standards. The spot market has clear restrictions on the order declaration rate and cancellation ratio for quantitative trading, while

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the derivative market has not set equal constraints due to different trading targets and settlement mechanisms. For example, the stock index futures market has more relaxed declaration restrictions for high-frequency trading and does not require quantitative institutions to uniformly report strategies when trading across markets. This uneven regulation provides regulatory arbitrage space for quantitative institutions. Some institutions take advantage of the rule difference between the spot and derivative markets to quickly establish positions in the derivative market and synchronize hedging in the spot market through high-frequency trading. This not only avoids regulatory constraints in a single market, but also earns risk-free profits through cross market price differences. This rule arbitrage not only undermines market fairness, but may also trigger abnormal fluctuations in both markets through price linkage.

Secondly, there is a lack of collaborative regulatory mechanisms. The current spot market is regulated by the Listing Department and the Futures Exchange of the China Securities Regulatory Commission, while the derivatives market is regulated by the Futures Department and the Futures Exchange of the China Securities Regulatory Commission. Although both belong to the China Securities Regulatory Commission system, regulatory data has not been communicated in real-time and regulatory actions lack unified coordination. Firstly, the cross market strategy of quantitative trading involves order data and position data from two markets, and under the existing mechanism, exchanges only share some post market data, which makes it difficult for regulatory authorities to detect cross market violations such as manipulating spot prices through derivative markets. Secondly, when abnormal trading occurs in a certain market, regulatory authorities find it difficult to quickly investigate whether it is related to the quantitative strategies of the derivatives market. They can only initiate risk disposal for a single market separately. This independent regulatory model cannot block the cross market transmission of risks and may exacerbate market panic due to inconsistent disposal rhythms. For example, in 2024, a quantitative institution made a huge order for stock index futures due to algorithm errors, causing a circuit breaker in the futures market, while the spot market failed to respond synchronously, resulting in heavy losses for investors due to price linkage, exposing a serious weakness in cross market collaborative supervision.

2.4. Lack of investor compensation mechanism for damages

The damage to investors caused by quantitative trading infringement is difficult to determine causality and the compensation path is unclear, resulting in a serious lack of current compensation mechanisms. It is neither effective in remedying damaged investors nor forming a deterrent constraint on quantitative institutions.

The core issue lies in the concealment and complexity of the causal relationship of quantitative trading infringement, which far exceeds the scope of traditional securities infringement identification. In traditional false statements and insider trading infringement, causality can be directly determined through the chain from infringement behavior to price fluctuations to investor losses. However, quantitative trading infringement is often manifested as market anomalies caused by algorithmic behavior, such as high-frequency trading scams that mislead market pricing through a large number of false orders, or liquidity black holes caused by algorithmic homogenization leading to stock price crashes. Investor losses are the result of collective market behavior and are difficult to directly attribute to algorithmic operations of a single quantitative institution. More importantly, the instantaneous nature and strategic complexity of quantitative trading make it difficult to prove causal relationships. Investors cannot obtain the algorithm logic and order execution data of quantitative institutions, nor can they prove that their losses are directly related to a certain algorithm behavior. For example, a decline in stock prices may be the result of overall market fluctuations, industry policy changes, or the superposition of multiple quantitative strategies. Relying solely on the individual

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strength of investors cannot prove causal relationships, and they are trapped in the dilemma of having no way to claim compensation if they cannot provide evidence[4].

The absence of a compensation mechanism is also reflected in the dual gap between rules and practice. The current Securities Law and judicial interpretations do not have specific compensation clauses for quantitative trading infringement, and can only refer to the compensation rules for market manipulation and false statements for judgment. However, there are significant differences between the two in terms of behavior determination and causality standards, resulting in a lack of clear basis for court judgments. In some cases, the court rejected investors' claims on the grounds that it could not prove the subjective fault of the quantitative institution; Some cases, due to unclear loss calculation standards, only support a small amount of compensation, and the judgment results of similar cases vary greatly. At the same time, there is also ambiguity in the definition of the subject of compensation liability. Quantitative trading involves multiple parties such as strategy developers, transaction executors, and system service providers. When algorithm defects cause losses, whether the institution bears full responsibility or can be held accountable to the algorithm supplier is not clearly stipulated in current rules, which further exacerbates the difficulty of investors' claims. The triple dilemma of difficult identification, difficult evidence, and difficult judgment renders the investor compensation mechanism virtually ineffective. It cannot compensate for the actual losses of investors, nor can it force quantitative institutions to regulate algorithmic behavior through civil compensation, weakening the remedial function and deterrent power of legal regulation.

3. The Path to Improving The Legal Regulation of Quantitative Trading in China

3.1. Improve top-level design, clarify the legal definition and regulatory principles of quantitative trading

The lack of top-level design is the root cause of current regulatory fragmentation, and the revision of the Securities Law should be the core to fill the fundamental gap in the legal regulation of quantitative trading.

Firstly, the legal definition of quantitative trading should be clearly defined in the Securities Law, distinguishing between sub types such as "algorithmic trading", "high-frequency trading", and "statistical arbitrage". By defining and listing these sub types, the constituent elements of quantitative trading should be clarified, including trading behaviors with algorithmic models as the decision-making core, computer programs as the execution carrier, and automated trading as the main feature. At the same time, simple programmatic ordering tools used by ordinary investors should be excluded to avoid overly broad or narrow regulatory scope.

Secondly, establish the regulatory principles of classified supervision, risk orientation, and fair priority. For high-risk strategies such as high-frequency trading and cross market arbitrage, strict regulatory standards should be applied, and the declaration rate limit and risk reserve requirements should be strengthened[5]. Moderate regulation should be applied to auxiliary strategies such as algorithmic trading, with a focus on standardizing order execution logic. For neutral strategies such as statistical arbitrage, the focus is on guiding standardization and encouraging them to play a role in market pricing correction. At the same time, the core principles of prohibiting algorithm manipulation, ensuring fair information access, and preventing cross market risk transmission will be included in the Basic Principles chapter of the Securities Law, providing a legal basis for the formulation of lower level laws.

In addition, it is necessary to integrate existing departmental regulations and self-discipline rules, formulate relevant management measures, and unify regulatory logic. Clarify the China Securities Regulatory Commission as the leading regulatory agency, coordinating the

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supervision of spot and derivative markets; Exchanges, China Securities Depository and Clearing Corporation and other institutions are responsible for daily monitoring and rule enforcement; Industry associations have formulated guidelines for quantitative trading business, forming a hierarchical regulatory system to address rule conflicts and fragmentation issues.

3.2. Strengthen process regulation, establish algorithm filing, real-time monitoring, and abnormal transaction circuit breaker mechanism

The core of process regulation is to solve the dilemma of "algorithmic black box" and achieve a shift from post accountability to pre prevention and intervention in quantitative trading.

Firstly, establish a hierarchical classification algorithm filing mechanism. Different from the current formal reporting, differentiated filing requirements should be set according to the strategic risk level: for high-frequency trading and machine learning complex algorithms, quantitative institutions are required to submit algorithm logic manuals, historical backtesting reports, and stress test results. For simple algorithm trading, only the strategy type and order execution method need to be reported. At the same time, a balance mechanism between protecting trade secrets and regulating the right to know should be established. Regulatory authorities have confidentiality obligations for recorded information, which can only be used for compliance review and risk monitoring, and cannot be disclosed to third parties. This not only avoids the leakage of algorithm core secrets, but also ensures regulatory penetration.

Secondly, establish a cross market real-time monitoring system. Led by the China Securities Regulatory Commission, we will integrate trading data from the Shanghai and Shenzhen Stock Exchanges, Futures Exchanges, and China Securities Depository and Clearing Corporation, establish a quantitative trading big data monitoring platform, and set core monitoring indicators such as order declaration rate, cancellation rate, cross market position linkage, algorithm strategy iteration frequency, etc[6]. Automatically trigger alerts for abnormal trading behavior, and regulatory authorities can access real-time algorithm operation logs to trace the logic of transaction instruction generation.

Thirdly, establish a circuit breaker mechanism for abnormal transactions. Drawing on the stock market circuit breaker system, a graded circuit breaker threshold is set for market anomalies caused by quantitative trading: when a certain target's price fluctuates by more than 5% or its liquidity drops by 30% due to quantitative trading, a "partial circuit breaker" is triggered, and the quantitative trading of that target is suspended for 10 minutes, allowing market sentiment to calm down; When there is a systemic anomaly across markets, a "comprehensive circuit breaker" is triggered, and quantitative trading across the entire market is suspended until regulatory authorities investigate the risk. The activation of the circuit breaker mechanism should have clear standards, be open and transparent, and avoid market panic caused by regulatory arbitrariness.

3.3. Optimize market fairness mechanism, standardize order priority and prohibit 'lightning orders'

The core of market fairness is to eliminate the opportunity squeeze of quantitative trading on ordinary investors, and it is necessary to reconstruct a fair competitive environment from the perspective of trading mechanisms.

On the one hand, standardize order priority rules to prevent technical advantages from being converted into transaction privileges[7]. Currently, some exchanges allow "host custody" users to receive market trends and execute orders faster, indirectly granting priority trading rights to quantitative institutions. In this regard, it should be clearly stated in the Securities Trading Rules that order priority is based solely on price priority and time priority, and exchanges are prohibited from providing differentiated order execution speeds through paid services. For

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hosting services, it is necessary to unify the hosting location and network latency standards to ensure that all market participants receive market data and declare orders under the same technical conditions. At the same time, the order splitting behavior of quantitative institutions is restricted, and it is prohibited to split a single large order into thousands of small orders to seize the time advantage. The declaration interval for split orders is required to be no less than 100 milliseconds, leaving a fair opportunity for ordinary investors to place orders manually.

On the other hand, it is explicitly prohibited to use "lightning commands" to block information leakage vulnerabilities. Flash instruction "refers to quantitative institutions obtaining non-public order book information from exchanges through special channels 1-3 milliseconds in advance, and then quickly placing orders for arbitrage. Essentially, it is information plundering of ordinary investors. A clause prohibiting "lightning orders" should be added to the Securities Law, clarifying that no institution shall obtain information on unexecuted orders through non-public channels. Exchanges shall synchronously disclose all order information to ensure that market data is released in real-time and uniformly to all market participants, and shall not provide information advantages to specific institutions. Quantitative institutions that violate this clause will be fined 1-10 times the transaction amount and their trading qualifications will be suspended for 6-12 months, forming a strong deterrent.

3.4. Establish a sound responsibility system, clarify the quantified liability of trading entities for violations and civil compensation pathways

The lack of a responsibility system is the key to the difficulty in holding accountable for quantified transaction infringement. It is necessary to establish a mechanism for full chain accountability and convenient compensation from three aspects: administrative responsibility, criminal responsibility, and civil responsibility.

In defining the responsibility for violations, it is necessary to clarify the division of responsibilities among multiple parties[8]. Quantitative trading involves multiple parties such as strategy developers, transaction executors, system service providers, and custodian institutions. Responsibilities should be allocated based on the principle of consistent rights and responsibilities. Quantitative institutions, as the core responsible parties, bear primary responsibility for the compliance and risk control of algorithm strategies. If market manipulation or investor losses are caused by algorithm defects, the legal representative of the institution and the person in charge of strategy development shall bear joint and several administrative responsibilities. If the system service provider provides a low latency trading system with vulnerabilities that result in abnormal order execution, they shall bear supplementary responsibility. If the exchange fails to fulfill its real-time monitoring obligations, resulting in the failure to detect violations in a timely manner, it shall bear the responsibility for regulatory negligence. At the same time, refine the application of administrative and criminal responsibilities. For intentional violations such as fraudulent transactions and algorithm manipulation, in addition to confiscating illegal gains, fines will be imposed, and those with serious circumstances will be held criminally responsible[9]; For minor violations caused by algorithmic errors, the main measures are to order rectification and suspend trading qualifications, while balancing regulatory rigidity and innovation inclusiveness.

In the path of civil compensation, it is necessary to overcome the difficulties of determining causality and providing evidence. One is to add a presumption rule for the causal relationship of quantitative trading infringement in the judicial interpretation of the Securities Law. If the quantitative institution engages in illegal algorithmic behavior and the investor's loss occurs during the existence of the behavior, it is presumed that there is a causal relationship between the two. The quantitative institution will provide evidence to prove that the loss is unrelated to their own behavior, reducing the burden of proof for investors. The second is to clarify the calculation criteria for losses, using the benchmark price difference method, based on the

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average price of the 10 trading days before the violation occurred, to calculate the difference between the actual transaction price of investors and the benchmark price as the compensation amount; For losses caused by market systemic risks, compensation shall be made after deducting the corresponding proportion. The third is to establish a linkage mechanism between advance compensation and collective litigation, drawing on the advance compensation system of the Science and Technology Innovation Board, requiring quantitative institutions to pay a quantitative trading risk reserve according to the proportion of registered capital. When infringement disputes occur, the reserve will first compensate investors for their losses. At the same time, we support investors to protect their rights through the securities collective litigation system, with the China Securities Small and Medium sized Investor Service Center representing damaged investors in filing lawsuits to reduce the cost of rights protection.

4. Conclusion

Quantitative trading, as a financial innovation product driven by technology, is not only an accelerator to improve the efficiency of the securities market, but also a risk source to challenge the bottom line of market fairness. The core issues of fragmented norms, lack of algorithmic transparency, insufficient cross market collaboration, and lack of compensation mechanisms in the current regulatory system for quantitative trading require the construction of a regulatory path that balances innovation inclusiveness and fairness protection from four dimensions: top-level design, process regulation, market mechanism, and responsibility system. The essence of fair regulation in quantitative trading is the adaptation of technical logic and legal logic. It cannot be abandoned at the expense of innovation for simple regulatory convenience, nor can it be left to its own devices, allowing the "algorithmic black box" to erode the foundation of market fairness. The future regulatory direction should shift from post accountability to full chain penetration supervision, taking the revision of the Securities Law as an opportunity to clarify the legal positioning of quantitative trading, using algorithm filing and real-time monitoring to solve the black box dilemma, optimizing order rules to eliminate technical privileges, improving the responsibility system to achieve risk recovery, and ultimately forming a regulatory pattern with controllable technology, measurable risks, and traceable responsibilities.

With the deep integration of technologies such as artificial intelligence and quantum computing with quantitative trading, new risks such as algorithm collusion and cross market algorithm manipulation will emerge in the future, and the regulatory system still needs dynamic iteration. But as long as we adhere to the core principle that fairness is the lifeline of the market and balance the relationship between innovation and regulation, we can guide quantitative trading from disorderly expansion to compliant development, making it a positive force for serving the high-quality development of the capital market and protecting the legitimate rights and interests of investors.

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