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**MICROSTRUCTURE INVARIANCE OF EMERGING STOCK MARKETS:
LOW LIQUIDITY COSTS**

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Relevance of the research topic

The need to take into account various deviations in the behavior of market characteristics of stocks (from the point of view of the asset pricing and market microstructure theories) arising due to high transaction costs was repeatedly noted in the messages of the Presidents of one of the leading financial associations, the American Finance Association (Stoll, 2000; O'Hara, 2003; French, 2008). Crises associated with a sharp evaporation of market liquidity are typical both for the most liquid markets (for example, the Flash Crash in May 2010 in the U.S. stock market) and for significantly less liquid emerging markets, in particular the Russian stock market (for example, the crisis in a foreign exchange market in mid-December 2014). Many researchers (e.g., Cochrane, 2004) note that it is extremely difficult to define market liquidity and study the associated effects. Over the past decades, many theoretical models have been developed to link market microstructure indicators, such as liquidity and measures of information asymmetry, to the asset pricing phenomenon (e.g., Brunnermeier and Pedersen, 2008; Easley et al., 2002).

The market microstructure invariance principles were formulated by A. Kyle and A. Obizhaeva (Kyle and Obizhaeva, 2016) and successfully confirmed for several equity markets (e.g., Kyle and Obizhaeva, 2017; Bucci et al., 2020; Bae et al., 2017). The key concept, within the context of this theory, is a bet – a meta-order to buy or sell a certain number of securities often executed intermittently over a time span. Business time reflects the event time in financial markets, and it is defined as the calendar time between bets. Liquid assets are characterized by a high number of bets per unit of time; illiquid assets have fewer bets, and business time passes slower. According to the market microstructure theory, risk transfers per one bet have approximately the same distributions for all assets when measured in units of business time. The intraday trading invariance (ITI) hypothesis formulated by Andersen et al. (2020) is the assertion that similar relationships between trading variables can be applied to transactions conducted over short intervals; to test this

hypothesis, the authors focus on the E-mini S&P 500 futures market. The ITI principles are based on a specific quantitative relationship between trading variables. In contrast to many famous alternative hypotheses (e.g., different specification of the mixture-of-distributions hypothesis), these principles imply a more realistic assumption about the endogenous response of trade size to changes in market dynamics. Thus, the approach based on the ITI provides an opportunity to analyze the scale of changes in the joint dynamic of trading variables in the Russian stock market, including during deep crashes, from a new perspective.

The authors of empirical papers in which the dynamics of trading activity variables, as well as liquidity effects, were examined in the context of asset pricing used data on stocks traded in developed markets primarily (Amihud and Mendelson, 1986; Chordia et al., 2000; Huberman and Halka, 2001; Hasbrouck and Seppi, 2001; Amihud et al., 2005; Leirvik et al., 2017). At the same time, some researchers (Brockman et al., 2009) note that emerging markets are more vulnerable to the risk of liquidity evaporation compared to developed markets. Teplova and Mikova (2019) show that market liquidity is one of the main factors responsible for the occurrence of various price anomalies in the Russian stock market. Borisenko and Gelman (2012) prove that liquidity, along with market risk, were the determinants of pricing in the Russian stock market in the period 1998-2011. Teplova and Mikova (2014a) and Teplova and Mikova (2014b) show that the consideration of trading activity and liquidity increases returns of strategies formed on the portfolio momentum effect.

Since the 1990s, when data on financial instruments became available electronically to a wide range of market participants, the analysis of the relationships between quantitative metrics characterizing news flow and various variables of market activity has become a separate direction in the field of financial economics. It is worth noting that there were no empirically tested theoretical models that assumed specific functional relationships between observed proxy variables of trading activity and various metrics of information activity for a long time. Kyle et al. (2017) were the first to apply the principles of market

microstructural invariance to study trading and information processes in the U.S. stock market. According to the information flow invariance hypothesis formulated in that paper public and private information about securities have the arrival rate proportional to the rate at which the business-time clock ticks, with a proportionality constant being the same across assets and across time. The importance of studying changes in the degree of synchronization between trading activity and various information metrics in the Russian stock market lies in the fact that over recent years (especially since the beginning of 2020), the share of private investors in the total stock volume has been continuously increasing. No less important is the study of the relationships between market liquidity, the speed of publication of financial news, and media sentiment for the sample of stocks of Chinese developers during the ongoing liquidity crisis in the Chinese real estate market during 2020–2022.

A small number of empirical papers that apply the latest theoretical developments in the field of the microstructure of financial markets (primarily in emerging markets) to study the mentioned processes associated with pricing and trading activity determined the object and subject of the study, as well as the purpose of the dissertation and its objectives.

The purpose of the study is to identify the effects of low liquidity on two emerging stock markets (Russian and Chinese ones) using the principles of market microstructure invariance.

The research objectives are as follows:

- To test the principles of market microstructure invariance at high-frequency time intervals on the sample of the most liquid Russian stocks;
- To conduct a comparative analysis of two low-frequency measures of illiquidity in the context of studying the profitability of investment strategies formed using the liquidity factor in the Russian stock market;
- To identify the degree of synchronization between trading activity on Russian stocks and the speed of dissemination of various information flows on these securities;

- To develop an information flow invariance model with subsequent testing in the emerging Chinese stock market.

The methodological basis of the study is the methods of econometric and statistical analysis, as well as methods of formalization, comparison, and generalization. To perform econometric and statistical analysis, I use the programming languages Python and R.

Gurov (2023) employs the methodology described in Kyle and Obizhaeva (2017) to estimate the expected ruble cost of implementing a bet in the Russian stock market. To extrapolate a similar estimation from the U.S. stock market (Kyle and Obizhaeva, 2016) to the Russian stock market, I scale it by the productivity-adjusted wages of finance practitioners in the local currencies. To study the effects of expected and unexpected illiquidity, I use the methodology of Amihud (2002). In particular, I assume that the logarithm of market illiquidity is the AR(1) process. As a robustness check, I consider ARMA(p,q) models, where the optimal parameters are determined by the Akaike information criterion. I find no significant biases in quantitative estimates of the effects of limited liquidity. To calculate monthly estimates of market illiquidity and market return, I employ both equal-weighting and market cap-weighting of observed security characteristics.

Teplova and Gurov (2022a) implement the Fama and MacBeth (1973) procedure to test a hypothesis about the significance of a cross-sectional illiquidity effect. The Newey and West (1987) procedure is employed to correct the standard errors. The estimates of Gibbons et al. (1989) are used to test a hypothesis that all estimates of a constant in multifactor asset pricing models for portfolios composed of stocks with different levels of liquidity are simultaneously equal to zero.

Teplova and Gurov (2022b) apply econometric methods described in Andersen et al. (2020) to test the intraday trading invariance hypothesis. To test the information flow invariance hypothesis, I use the approach presented in Kyle et al. (2017): the expected number of news articles conditional on trading activity is modelled as a negative binomial process which allows to correct for over-dispersion of news articles caused by many zeros. In addition, I use the zero-

inflation negative binomial model to alleviate the impact of over-dispersion. The OLS-based CUSUM test is used to test the stability of model parameters across a sample (Zeileis et al., 2002).

The econometric approach presented in Kyle et al. (2017) is also implemented in Gurov and Teplova (2023). In addition, to analyze the news effect and the media sentiment effect, I use the methodology described in Heston and Sinha (2018). The technique separately measures the impact of news effect, the effects of positive and negative sentiment in news on liquidity of Chinese developers' stocks. To measure the sentiment of words, I use the Loughran and McDonald (2011) dictionary based on words often used in the Form 10-K filings.

The object of the study is stocks of public Russian and Chinese companies.

The subject of the study is liquidity effects, market and information characteristics of securities traded in the emerging stock markets of Russia and China.

The research information base covers data from the Moscow Exchange, Google Trends, Thomson Reuters Eikon, Cbonds, and the RANEPA Laboratory for Analysis of Institutions and Financial Markets.

Novelty of scientific research.

First, the thesis proposes a new method for processing data on search queries provided by the Google Trends service, taking into account the imposed uploading restrictions on uploading data. One of the main restrictions is the impossibility of comparison of search volume numbers across 6 or more search queries. In addition, Google Trends shows not absolute but relative search volume numbers: all are divided by the maximum number of weekly search frequency of the most popular query as of some week, multiplied by 100 and rounded to the nearest integer over the interval from 0 to 100. The formulated procedure involves finding “a benchmark” – a search query with the maximum search volume number over the given period. Next, the remaining search queries are divided into 4 queries each, and the benchmark is added to each group. Finally, it is possible to download relative search volume numbers for all groups of queries, so all relative search

volumes are directly related to the same number (the benchmark's maximum search frequency). I also formulate the modified procedure to find relative search volume numbers; this algorithm can be used to reduce the number of zero relative search volume numbers in the sample. The methodology was used to test the intraday trading invariance hypothesis in the Russian stock market for the sample of 29 liquid stocks. The analysis is based on the assumption that institutional and retail investors tend to rely on different sources of information (the representative sources are Thomson Reuters Eikon and Google Search, respectively). I demonstrate that there is a statistically significant change in the estimates of the variable that determines the relationship between trading activity and Google search volume of the names of Russian public companies at the beginning of 2020, when the share of retail investors in the total trading activity in the Russian stock market increased significantly. When considering the information flow, approximated by the number of news articles displayed in the Thomson Reuters Eikon, I find no significant differences in quantitative estimates of the degrees of synchronization. Thus, I conclude that it was the significant increase in the share of trading activity of private investors that led to the fact that the trading flow and information flow, approximated by the relative frequencies of Google search queries, became to be better aligned with the same business time.

Second, for the first time, the theoretically justified variable of expected monetary costs of executing a bet in the Russian stock market over 2014-2018 is estimated (about 150000 rubles) without using the method of implementation shortfall (Perold, 1988), which requires information on individual bets. Following the assumption of Kyle and Obizhaeva (2017) that in equilibrium asset managers incur approximately the same monetary costs of acquiring informative signals in different equity markets, I extrapolate the value of the expected dollar costs C_{US} estimated by Kyle and Obizhaeva (2016), taking into account corrections for wages of U.S. and Russian finance professionals in local currency, as well as their productivity, expressed in the number of bets generated per unit of time. I also demonstrate for the first time that, within the framework of the theory of

invariance of market microstructure, there is a quantitative relationship between wages of financial specialists and cumulative trading activity in the corresponding stock market: an increase in trading activity by 1% is accompanied by an increase in average wages by 2/3%.

Third, the various effects of low liquidity in the Russian stock market are examined, both in the cross-section and by constructing portfolios based on ranking the past liquidity values of individual stocks. The effects of expected and unexpected liquidity are studied for the Russian stock market for the first time. I show that the premium for expected illiquidity is insignificant during 2010–2020 in most specifications. The effect of unexpected illiquidity (a decrease in the excess return of a portfolio due to the unexpected evaporation of liquidity) is, in turn, more significant. The stronger impact of the effect of unexpected illiquidity on small-cap stocks is found only for some specifications. Thus, it is impossible to make a clear conclusion that during a decrease in market liquidity, there is an increase (decrease) in demand for more (less) liquid Russian stocks (a flight-to-liquidity effect). I also test the hypothesis that the Amihud measure tends to overestimate (underestimate) the illiquidity premium for inactively (actively) traded Russian stocks compared to the corresponding estimated premia when using the $1/L$ measure, implied by the market microstructure invariance theory, in asset pricing tests. This hypothesis is based on the fact that the Amihud measure is based on the assumption that all securities have the same number of bets per day. The $1/L$ measure is based on a more realistic assumption: the expected arrival rate of bets is determined by the level of trading activity. The hypothesis that the Amihud measure overestimates the illiquidity premium for small-cap stocks is partially confirmed. At the same time, the assumption that this proxy tends to underestimate the illiquidity premium for large capitalization stocks is not confirmed.

Fourth, I analyze the dynamics of a proxy for ruble risk transferred by one bet per unit of business time (the logarithm of the trading invariant), including during times of high volatility in the Russian stock market. I demonstrate that this variable has low predictive power towards future volatility of Russian stock

returns. In terms of the model's explanatory power, the relationship between trading variables at high-frequency intervals implied by the intraday trading invariance hypothesis is found to be higher compared to the alternative specifications (the mixture-of-distributions hypotheses). The analysis also shows that the fundamental mechanism determining the average trade size as a function of changes in trading intensity did not change in the case of high market turbulence during the 2014-2018 period. The quantitative relationship between variables implied by the intraday trading invariance hypothesis remains the same: the return variation per transaction is inversely proportional to the square of the product of average trade size and price. At the same time, I show that the periods of significant decline in the RTS index were characterized by a statistically significant increase in the logarithm of trading invariant, a proxy variable of ruble risk transferred by one bet per unit of business time, and an increase in the bid-ask spread in most cases. The analysis of the predictive power of the proxy variable in relation to future market volatility at various time intervals (from several minutes to several hours) show that this metric does not have independent explanatory power towards the market dynamics of stock prices.

Fifth, I test a modified information flow invariance hypothesis at the intersection of behavioral finance and market microstructure and investigate the effects of media sentiment for a set of stocks of large Chinese developers during the liquidity crisis in the real estate sector of 2020–2022. I show that the frequency of economically significant news during this period is synchronized not with the expected calendar time between new bets but with the expected cost of transferring a risk. Also, for the mentioned segment of the Chinese stock market, I confirm the well-known prediction of behavioral finance that news with negative sentiment has a more significant impact on the liquidity of securities compared to the influence of publications with positive sentiment.

Theoretical significance. The thesis contributes to the existing literature on market microstructure. The modified market microstructural invariance hypotheses are formulated regarding intraday interactions between high-frequency trading

variables as well as relationships between trading and information metrics and are empirically tested. In the latter case, methodologies have also been proposed for testing the information flow invariance hypothesis, considering the presence of high overdispersion caused by many null observations and estimating a proxy variable for the probability of informed trading based on daily trading data. I show that the relationship between high-frequency trading variables is best described by the functional dependence proposed by the theory of market microstructure invariance. After applying various methods to reduce noise in the variables and conducting robustness checks, I demonstrate that the dispersion of log returns per transaction is proportional to the product of the average transaction size and the stock price raised to the -2 power. The alternative assumptions about the relationship between trade variables (specifications of the “mixture-of-distributions” hypothesis that do not take into account endogenous variation in average transaction size with market conditions) are not supported. In addition, the thesis contributes to the existing literature on the impact of liquidity level and risk on stock pricing. For the first time, consequences from the theory of market microstructure invariance are applied in empirical tests. For instance, following the solution of a dynamic equilibrium model of adverse selection (Kyle and Obizhaeva, 2020), I show how to obtain a theoretically justified estimate of the probability of informed trading based on daily data on bid-ask spreads and daily measures of realized return volatility and ruble trading volume.

Practical significance. The results of the study may be useful for financial regulators and investors, for whom the issues of measuring and monitoring liquidity, as well as the impact of this indicator on asset prices, are relevant. The paper also describes in detail the methodology for obtaining correct data on relative search frequencies for a wide sample of queries, which can be helpful to researchers when studying the effects of attention in both emerging and developed stock markets.

The results of the study were published in the following articles:

1. Gurov S. Illiquidity Effects in the Russian Stock Market. HSE Economic Journal. – 2023; 27(1): 78-102 (In Russ). DOI: 10.17323/1813-8691-2023-27-1-78-102 (List C).

2. Teplova T. and Gurov S. New evidence on the impact of implicit trading costs on asset prices in the Russian stock market. Applied Economics. – 2022; 54(51): 5943-5955. DOI: 10.1080/00036846.2022.2055743 (List A).

3. Teplova T. and Gurov S. Nonlinear intraday trading invariance in the Russian stock market. Annual Operating Research: 5943–5955. DOI: 10.1007/s10479-022-04683-7 (List A).

4. Gurov S. and Teplova T. Media sentiment, news, and liquidity of Chinese property developer stocks amidst the shadow of a mortgage crisis in China. International Journal of Emerging Markets: 1–21. DOI: 10.1108/IJOEM-08-2022-1232 (List A).

The research results were presented at the following Russian and international conferences and seminars:

1. Report at the second scientific seminar of the Center for Financial Research and Data Analytics (Moscow, March 2021);

2. Report at the PhD Workshop “Current topics in financial research. How to prepare publications” (Moscow, February 2022);

3. Report at the international conference “First International Conference on Market Sentiment and Investment in Emerging Market” (Moscow, May 2022);

4. Report at the 7th international seminar “Financial Markets and Nonlinear Dynamics” (FMND) (Paris, June 2023);

5. Report at the World Finance Conference (Kristiansand, August 2023).

The research results were also discussed at seminars organized by the Doctoral School of Economics of the Higher School of Economics.

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