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The Geography of Financial Markets

Geographic patterns of trading profitability in Xetra

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Abstract

Transaction data from the electronic trading system Xetra of the German Security Exchange is used to explore the relationship between trader location and trading profitability. The non-discriminatory nature of the electronic trading system and its wide international adoption allows interesting conclusions about the information geography of international equity trading. We use spectral analysis to examine trading profitability over intraday, intraweek, and intraquarter inventory cycles. Proprietary trader accounts reveal the underperformance of foreign traders at all three trading horizons. Our analysis confirms the hypothesis of financial market segmentation due to international information barriers. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

The last 20 years mark important progress towards liberalized financial markets.[1] Regulatory barriers to the free movement of capital have decreased

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[1] For an interesting survey of global financial market liberalization, see Williamson and Mahar (1998).

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throughout the world and promise the benefits of an integrated global capital market. At the same time electronic trading technologies allow direct low cost market participation for a geographically dispersed public. Is geography therefore becoming increasingly irrelevant for financial markets? We argue that such a view is flawed. While exogenous regulatory or technological barriers might largely disappear, information heterogeneity of investors is likely to represent an enduring feature of market microstructure with important macroeconomic consequences. Portes and Rey (1999) show that international capital flows are largely determined by geographic distance.[2] Our paper provides direct evidence that economically significant information asymmetries underlie this geographic pattern.[3]

Our research strategy is straightforward. We compare the trading performance of foreign-based and domestic traders in 11 German blue-chip stocks. The traders in our sample have equal non-discriminatory access to the electronic trading system Xetra. They represent sophisticated trading professionals located in different European financial centers. Systematic differences in the trading performance of foreign and domestic traders can therefore be attributed to international information asymmetry. The transaction data identifies trades as own account (proprietary) or client trades and allows for their separate analysis. Three main results can be highlighted. First, proprietary trading shows a statistically and economically significant underperformance for the foreign trader population. This result highlights the role of geography for the information structure of a financial market even among highly sophisticated investment professionals. Second, client investments are generally less profitable than the proprietary positions of the professional traders. Proprietary traders gain largely at the expense of client accounts with large inventory variations. Third, client transactions are disproportionately executed by domestic (German-based) traders. The limited number of client accounts with a foreign execution location nevertheless provide some (weak) evidence that foreign executed client trades underperform domestically executed client trades.

Our analysis here focuses only on the international aspect by grouping traders into foreign and domestic agents. Extending Hau (2000), we include client accounts in the analysis, but neglect the intra-country geography of the market. Evidence for a regional information geography is provided by Coval and Moskowitz (1999b), who show that local investments of mutual funds outperform their nationwide investment in the United States. But such internal

[2] A larger literature is concerned with the geographic pattern of equity holdings and documents a pronounced home equity bias. For a recent discussion, see Lewis (1999). Evidence for an intra-country allocation bias is provided by Coval and Moskowitz (1999a).

[3] The role of geography has also been emphazised by Gehrig (1993, 1998). For evidence on the role of geography in the locational choice of international banks see Choi et al. (1986, 1996).

information barriers are likely to be quantitatively less important than international ones as evidence by Hau (2001) suggests. Evidence for international information asymmetry was first provided by Shukla and van Inwegen (1995) in a performance comparison of British and American mutual fund managers for their investments in the U.S. market. Bacidore and Sofianos (2000) study international information barriers using inventory data for NYSE specialists. These specialists face a more important adverse selection risk in their market making for foreign stocks than domestic U.S. stocks. Choe et al. (2000) find evidence for information advantages of domestic over foreign individual investors in the Korean stock market. Conflicting evidence for foreign overperformance emerges from two other recent studies. Seasholes (2000) finds that capital inflows into Taiwan and Thailand show higher equity returns than the residual domestic holdings. But ultimate ownership of the capital inflows is not identified.[4] Grinblatt and Keloharju (1999, 2001) study daily returns on Finnish equity positions and find that foreign institutional investors outperform local investors. They suggest higher financial sophistication of the foreign institutions as an explanation.

We hope that this paper contributes to a clearer map of the information geography of financial markets. In Section 2, we describe our own data and the main institutional features of the German Security Exchange. Methodological issues of performance measurement are discussed in Section 3. Our analysis builds on the spectral profit decomposition previously used by Hasbrouck and Sofianos (1993). Section 4 discusses the summary statistics of the proprietary and client accounts. Section 5 documents the foreign underperformance and Section 6 concludes.

2. Xetra trading

Xetra is the name of the electronic trading platform of the German Security Exchange.[5] It allows decentralized and equal access to the German stock market. The Xetra trading system dominates the market for large stocks with a volume share of more than 90 percent. By October 1998, more than 1300 trading terminals were installed, of which approximately 10 percent were located in European countries outside Germany. The high costs of terminal installation limits the system to professional traders and asset managers in banks, investment and brokerage firms. Xetra supports continuous trading through an open limit order book, which posts the best bid and ask prices. The system operates on the base of strict price and time priority. Better prices always

[4] Off-shore capital reinvested domestically by local residents could be important for developing countries with extensive capital flight.

[5] For a detailed documentation on Xetra, see DB (1998).

dominate in the execution procedure, and in case of price equality early price input gets the execution preference. An initial auction opens the trading day and a closing auction establishes the closing price. Additional intraday auctions can be triggered by large price movements.

The data were obtained from the Trading Surveillance Unit and include all Xetra transactions in 11 German blue-chip stocks for the last 4 months in 1998. The stock selection is based on the German stocks represented in Europe's Stoxx 50 index.[6] Floor trades and off-exchange trades are not included in the data set. The data contain the complete electronic transaction record of each trade; namely price, quantity, transaction time and date, order placement time (for limit orders), trader identity (encrypted), the trader's institutional affiliation (encrypted), and the geographic location of the trader's institution. The order placement time allows us to reconstruct for each transaction the trade initiator (trade direction). Xetra also distinguishes client trades from proprietary (own account trades) of a trader. Traders have to label each order accordingly. The trader location is identified through institutional affiliation and the location of the institution. A proprietary account can therefore be associated with a distinct geographic location for the investment decision maker. By contrast, client trades do not directly reveal the location of the investment decision maker. The client identity and his geographic location is unknown. We can only aggregate all client trades executed through a particular trader into one consolidated client account. We highlight that the geographic association of foreign client trade execution with a foreign investor is problematic. A German investor may prefer a Swiss trader to execute a transaction if his capital is managed by a Swiss institution for tax reasons. Also, foreign investors can use domestic intermediaries. This should be expected if clients believe that domestic traders enjoy an information advantage which benefits their own investment decision.

3. Profit and performance measures

Profit and performance measures are calculated separately for each stock account of each trader. For any stock we denote ΔP_{s+1} the price change between transaction s and $s+1$, and Q_s inventory level of an account between these two transactions. An account can be either the trader's proprietary account or the consolidated account of all his client trades. The change in the market-to-market profit of the account is given by $\Delta \Pi_s = Q_s \Delta P_{s+1}$. We can calculate the total market-to-market profits over a sequence of $s = 1,2,\ldots,T$ market transaction as the sum of all profit increments and define the account

[6] The 11 stocks are Allianz, Bayer, Deutsche Bank, Daimler-Chrysler, Deutsche Telecom, Lufthansa, Mannesmann, Metro, RWE, Siemens, and Veba.

profit per market transaction as

$$\Pi = \frac{1}{T}\sum_{s=1}^{T} Q_s \Delta P_{s+1}. \tag{1}$$

The cross-product (1) shows that trading profit results from a positive covariance of the inventory level Q_s and the price change ΔP_{s+1}. A positive covariance can result from co-movements at high frequencies under frequent trading or low-frequency co-movements for long-run inventory changes. Similarly, information advantages of an investor may exist for either high- or the low-frequency price movements and their measurability based on account information is also frequency dependent. The low-frequency inventory movements are likely to generate very noisy profit statistics if the information advantage in any particular trade is weak. By contrast, high-frequency inventory changes use many observations and provide more statistical power for detecting any information asymmetry. This suggests a methodology based on a spectral decomposition of the profit contributions.[7] More precisely, we disaggregate the total profit into three components or spectral bands:

$$\Pi^f = \sum_{k\in f} \mathrm{Co}(\omega_k), \tag{2}$$

where the superscript $f = H, M, L$ denotes the high-, medium-, and low-frequency band, ω_k represents the set of Fourier frequencies in the respective band, and $\mathrm{Co}(\omega_k)$ the co-spectrum of a particular frequency. The co-spectrum states how much the inventory and the price change move together for a particular frequency. The high-frequency band comprises the profit contribution of intraday inventory movements, the medium-frequency band measures the intraweek profit contribution, and the low-frequency band captures the profit of inventory cycles longer than a week. Total profits are given as a summation over all frequencies. To make the frequency bands comparable across accounts we undertake the spectral decomposition uniformly based on the market transactions in a stock and not based on the transactions in any particular account.

An important shortcoming of the profit measure is its dependence on the size of a trader's inventory. A trader who manages an inventory cycle 5 times larger can also expect (ceteris paribus) 5 times the previous profit or loss. The size heterogeneity of the trader inventories is therefore a serious problem for any performance comparison across traders. A simple solution is not to measure

[7] Spectral band analysis was proposed by Engle (1974, 1978) and used for analysis of trading profits by Hasbrouck and Sofianos (1993). A useful reference on the co-spectrum is Hamilton (1994, p. 272).

profits by covariance, but rather measure performance by correlation in a particular frequency band. Formally, let $\mathrm{Var}(\Delta P)$ denote the variance of the price changes and $\mathrm{Var}(Q)$ the variance of the inventory level. A standardized performance measure is defined by

$$\mathrm{Corr}^f = \frac{\Pi^f}{\sqrt{\mathrm{Var}(\Delta P)^f \times \mathrm{Var}(Q)^f}}. \tag{3}$$

A cross-sectional analysis based on the correlation measure gives more weight to small accounts with a low standard deviation for the inventory value.

Finally, we note that transaction data only provide information on inventory changes and not on the inventory level of each account. Following Hansch et al. (1998), we calculate profits with respect to deviations from the 4 month inventory average. Our ignorance of the exact inventory level generates a measurement error for the low-frequency band. However, high-, and medium-frequency performance measures are independent of any mismeasurement of the absolute inventory level.

4. Summary statistics

A total of 1342 traders used Xetra in last 4 months of 1998. Double-counting any transaction as a buy and a sell trade, they collectively undertook 1,410,412 trades in the 11 selected German stocks. All client trades of a trader in each stock are aggregated in one consolidated client account. In order to limit the number of accounts with very noisy, non-informative profit statistics, we require a threshold of 10 transactions for any account to be considered. All transactions in proprietary or consolidated client accounts with less than 10 transactions are discarded; these represent only 1.2 percent of all transactions. A total of 4326 proprietary accounts (with a total of 861,713 trades) and 3523 consolidated client accounts (with a total of 531,739 trades) contain at least 10 transactions.[8]

Table 1 shows the summary statistics for these accounts. We report the mean and standard deviation of the profit in the high-, medium-, and low-frequency spectrum as well as the total account profits. The mean profit is positive for proprietary accounts and negative for client accounts in each frequency subsample. The difference is statistically significant at a 1 percent level for the low-frequency band as well as for total profits. The average net profit of a proprietary account is approximately DM 1.89 per market transaction. For

[8] It is difficult to evaluate if the self-declaration of trades as proprietary or client trades is always correct. We can exclude strategic motivations for an incorrect declaration as it is not displayed on the trading screen.

Table 1
Summary statistics[a]

Variable	Proprietary accounts		Consol. client accounts		Difference test	
	Mean	Std. dev.	Mean	Std. dev.	Δ Mean	*t*-value
Profit (H)	0.045	3.249	− 0.060	2.367	0.051	1.08
Profit (M)	0.123	7.222	− 0.177	7.265	0.300	1.39
Profit (L)	1.724	40.090	− 2.149	43.497	3.873***	3.10
Profit (T)	1.892	41.794	− 2.387	46.127	4.279***	3.22
Correlation (H)	0.0006	0.0041	0.0000	0.0028	0.0006***	4.84
Correlation (M)	0.0083	0.0857	0.0205	0.0831	− 0.0122***	− 4.63
Correlation (L)	0.0317	0.2816	0.0594	0.2777	− 0.0277***	− 3.40
Correlation (T)	0.0004	0.0028	0.0007	0.0026	− 0.0003***	− 2.82
FOREIGN	0.073	0.260	0.017	0.129	0.056***	4.60
INTENSITY	199	415	151	387	48**	2.21
INITIATION	0.485	0.198	0.488	0.182	− 0.003	− 0.30
VARIATION	13.94	1.56	13.95	1.43	− 0.01	− 0.20
Accounts	4326		3523			

[a]Reported are mean and standard deviation of the main account characteristics. Trading profits per market transaction are stated for high-frequency (H), medium-frequency (M), and low-frequency (L) band as well as for total profit in all frequency bands (T). Relative trading performance is measured by the correlation between stock inventory and consecutive price change over the same frequency bands. The dummy variable FOREIGN marks all traders outside Germany; INTENSITY gives the number of trades in an account; INITIATION indicates the percentage of initiated trades (market orders); and VARIATION denotes (in logs) the standard deviation of the inventory value. The robust *t*-values for the difference of the means allow for error correlation between different accounts managed by the same trader. We indicate significance on a 10 percent (*), 5 percent (**) and 1 percent (***) level.

a representative stock with approximately 50,000 quarterly transactions, we obtain an average quarterly profit of DM 94,500 per proprietary account. Most of this profit redistribution in favor of the proprietary accounts comes from long-run inventory cycles. The correlation measure calculates performance adjusted for the standard deviation of inventory value. Proprietary accounts do significantly better in intraday trading. This indicates an advantage of the Xetra traders in high-frequency trading. On a per account base, the average client investors accounts outperforms the proprietary account. But their positive performance is concentrated in many small accounts, while large consolidated client accounts with high inventory variation show high relative losses. This explains why the difference of the population means is positive for the profits and negative for the correlation measure in the low-frequency band.

The dummy variable FOREIGN takes on the value of 1 for accounts held by traders outside Germany and 0 otherwise.[9] Foreign traders manage 315 proprietary accounts (7.3 percent) and 60 consolidated client accounts (1.7 percent). Client trades are disproportionately executed by domestic (German-based) traders. This might itself reflect an endogenous client response to differences in the execution quality or investment advice. We use three different account characteristics to control for account heterogeneity. Accounts differ in the number of transactions undertaken. The variable INTENSITY measures the number of trades; it ranges from the lower cut-off value of 10 trades to 9129 trades for the most active account. On average proprietary accounts register 199 trades and consolidated client accounts 151 trades. We also measure the percentage of trades in an account initiated through a market order (INITIATION). A high percentage indicates an active account management as opposed to passive liquidity supply though limit order submission. Trade initiation typically implies a short-run loss due to the bid–ask spread, but might procure long-run profit if it is based on an information advantage. The variable VARIATION denotes (in logs) the standard deviation of the inventory value. Limited market liquidity renders large inventory changes expensive with a negative impact on account performance.

5. Evidence on foreign underperformance

To explore the relative performance of foreign and domestically managed accounts, we use both the profit and the correlation statistics as dependent variables in a simple OLS regressions. Separate regressions are undertaken for each of the three frequency bands as well as for the entire band of all frequencies. The baseline specification includes only a constant term and the dummy variable for the foreign trader accounts (FOREIGN). We calculate robust standard errors which allow for correlation of the error term across different accounts managed by the same trader.

Since proprietary accounts show a significantly higher percentage of foreign account management, we concentrate our discussion on these accounts. Moreover, proprietary account performance is easier to interpret because the investment decision location coincides with the trader location. By contrast, we do not have any information on the residence of the clients for the client accounts. Table 2 shows the results for the profit regression. Foreign traders have lower profits in high-frequency trading. Controlling for the number of trades in an account (INTENSITY), the average trade direction (INITIATION) and the

[9] The foreign trader locations are Amsterdam, Copenhagen, Lausanne, Linz, London, Paris, Vasa (Finland), Vienna, Zug, and Zurich.

standard deviation of the account value (VARIATION), we find a statistically significant foreign underperformance of DM 0.95 per market transaction (column (2)). This point estimate implies a quarterly relative loss of approximately DM 47,500 for intraday trading only. Intraweek profits show an additional foreign profit shortfall of approximately DM 1.86 per market transaction (column (4)). Low-frequency trading at inventory cycles longer than a week generates further relative losses for the foreign traders, but here the regression coefficient for the dummy FOREIGN is not statistically significant. We report a total relative foreign underperformance of approximately DM 3.00 per market transaction over all frequency bands (column (7)). This amounts to a quarterly average foreign profit shortfall of DM 150,000 for each proprietary account. We find this a surprisingly high price for the locational disadvantage of trading from a distant location.

The point estimates for the control variables provide additional insights. An active account management with a high percentage of market orders (INITIATION) exercises a negative impact on intraday and intraweek profits. This is not surprising since trade initiation implies the short-term loss of the bid–ask spread. Large variations in the account value also diminish short-term profitability. This can be explain by limited market liquidity with a short-run price impact for large trades.

As noted above, the profit measure (2) is linear in the magnitude of the inventory cycle. This obscures the cross-sectional comparability of trading outcomes if traders operate at very different inventory scales. The correlation statistics (3) provides an alternative performance measure which normalizes for inventory scale by the standard deviation of the inventory. Accounts with only small inventory variations receive therefore a larger weight in the cross-sectional analysis compared to the previous profit statistics. Table 3 presents the regression results for the correlation measure as the dependent variable. The FOREIGN dummy is again negative at the 5 percent significance level for high-frequency performance in the augmented specification (column (2)). The adjusted $\bar{R}^2$ increases to 0.15 compared to 0.03 in the previous profit regression. The correlation-based performance measure provides stronger evidence for foreign underperformance at the medium and long horizon. Intraweek (medium-frequency) performance is lower for the foreign-based trader at a statistical significance level of 1 percent with or without inclusion of the control variables. A similar result is obtained for the low-frequency correlation measure and for the total correlation over the entire frequency band. The control variables have the expected signs. The variable INITIATION shows again a negative effect for intraday and intraweek profits. However, more actively managed proprietary accounts reveal superior performance in the low-frequency band (column (6)). This reflects an information advantage of the active market order trader, who loses the spread in the short-run, but recovers his loss in the long-run.

Table 2
Profit determinants for proprietary accounts[a]

	High-freq. profit		Medium-freq. profit		Low-freq. profit		Total profit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.101	0.114	0.247	0.259	1.763**	1.839**	2.111**	2.212**
	(1.22)	(1.39)	(1.52)	(1.51)	(2.06)	(2.05)	(2.37)	(2.35)
FOREIGN	− 0.766*	− 0.949**	− 1.698*	− 1.861**	− 0.536	− 1.572	− 3.000	− 4.383
	(− 1.87)	(− 2.38)	(− 1.86)	(− 2.05)	(− 0.16)	(− 0.45)	(− 0.75)	(− 1.07)
INTENSITY		0.203*		0.131		1.390*		1.724*
		(1.81)		(0.49)		(1.67)		(1.76)
INITIATION		− 2.690***		− 2.426***		2.650		− 2.467
		(− 4.46)		(− 3.71)		(0.57)		(− 0.55)
VARIATION		− 0.189***		− 0.012		1.183		0.983
		(− 2.75)		(− 0.08)		(1.13)		(0.929)
Obs.	4326	4326	4326	4326	4326	4326	4326	4326
Traders	756	756	756	756	756	756	756	756
$\bar{R}^2$	0.0038	0.0344	0.0037	0.0084	0.0000	0.0074	0.0003	0.0074

[a]The proprietary trading profits of 756 traders in 11 German stocks in the Stoxx 50 index are pooled to obtain 4326 individual profit accounts with at least 10 transactions each. A spectral decomposition is used to separate total profit of each account to intraday (high-frequency) profit, intraweek (medium-frequency) profit, and intraquarter (low-frequency) profit. Trading profits are regressed on a dummy variable (FOREIGN) for the traders located outside Germany. The control variables are the number of trades in an account (INTENSITY), the percentage of market orders for each account (INITIATION), and the standard deviation of the account inventory value (VARIATION). The control variables are in logs and de-meaned. We report OLS regression coefficient and the robust t-values in parentheses adjusted for the cluster structure. Significance on a 10 percent (*), 5 percent (**) or 1 percent level (***) is indicated.

Table 3
Relative performance determinants for proprietary accounts[a]

	High-freq. correl.		Medium-freq. correl.		Low-freq. correl.		Total correl.	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.0007***	0.0007***	0.0098***	0.0099***	0.0363***	0.0361***	0.0005***	0.0005***
	(6.03)	(7.25)	(5.43)	(5.47)	(6.17)	(6.13)	(8.25)	(8.51)
FOREIGN	− 0.0006	− 0.0013**	− 0.0217***	− 0.0229***	− 0.0638**	− 0.0601**	− 0.0008***	− 0.0009***
	(− 0.99)	(− 2.37)	(− 2.66)	(− 2.90)	(− 2.59)	(− 2.41)	(− 2.74)	(− 3.13)
INTENSITY		0.0011***		0.0013		− 0.0037		0.0002***
		(7.41)		(0.62)		(− 0.65)		(3.17)
INITIATION		− 0.0059***		− 0.0254***		0.0687***		− 0.0005
		(− 12.75)		(− 2.83)		(2.58)		(− 1.50)
VARIATION		− 0.0007***		− 0.0027*		0.0052		− 0.0002***
		(− 10.14)		(− 1.78)		(1.17)		(− 3.87)
Obs.	4326	4326	4326	4326	4326	4326	4326	4326
Traders	756	756	756	756	756	756	756	756
$\bar{R}^2$	0.0015	0.1507	0.0043	0.0092	0.0035	0.0062	0.0057	0.0165

[a] Relative performance measures for 756 traders and 11 German stocks in the Stoxx 50 index are pooled to obtain 4326 individual performance measures for all proprietary accounts with at least 10 transactions. The relative performance consists of the correlation of the inventory level with consecutive price changes. A spectral decomposition is used to separate total correlation for each account into intraday (high-frequency) correlation, intraweek (medium-frequency) correlation, and intraquarter (low-frequency) correlation. These performance measures are regressed on a dummy variable (FOREIGN) for the traders located outside Germany. The control variables are the number of trades in an account (INTENSITY), the percentage of market orders for each account (INITIATION), and a measure of the standard deviation of the account inventory value (VARIATION). The control variable are in logs and de-meaned. We report OLS regression coefficient and the robust t-values in parentheses adjusted for the cluster structure. Significance on a 10 percent (*), 5 percent (**) or 1 percent level (***) is indicated.

We repeat these regressions for the client accounts. Only 60 client accounts (1.7 percent) with more than 10 transactions have trade execution by foreign-based traders. This suggests relatively low power for any test of foreign underperformance. The analogous regression results for the client accounts (not reported) provide only weak evidence for a relative underperformance of the foreign-executed client trades. The FOREIGN dummy is negative for the correlation measure at all three frequencies, but reaches only a modest 10 percent significance level for the medium-frequency band. The small number of observations can explain this weak evidence. Moreover, the geographic linkage between the client location and the trader location is plausible, but cannot be documented in our data.

6. Conclusions

This paper examines the degree of financial market segmentation due to geographic information asymmetry. Evidence on international capital flows suggests that geography is an important determinant for their magnitude. Corresponding underlying information asymmetries represent a leading explanation for this geographic pattern. We use microdata from the trading system Xetra of the German Security Exchange on 11 large German blue-chip stocks to explore the evidence on international information barriers. The non-discriminatory nature of the trading system allows us to interpret systematic performance differences in the investment positions as direct evidence of information asymmetry. Proprietary accounts of foreign traders show indeed a systematic underperformance both in terms of absolute profitability as well as for performance measures standardized for account size. We also highlight that the foreign underperformance is of an economically significant magnitude and occurs among professional traders of high financial sophistication with access to a wide range of information sources. Similar inference on client accounts is difficult as relatively few client trades are executed by foreign-based traders. This relative underrepresentation of client trading in the foreign trading activity may itself be indicative of the importance of information barriers.

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