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Massimiliano Marzo
University of Bologna
The Rimini Centre for Economic Analysis (RCEA)

Paolo Zagaglia
University of Bologna
The Rimini Centre for Economic Analysis (RCEA)

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The Rimini Centre for Economic Analysis
Legal address: Via Angherà, 22 – Head office: Via Patara, 3 - 47900 Rimini (RN) – Italy
www.rcfea.org - secretary@rcfea.org

Trading directions and the pricing of Euro interbank deposits in the long run

Massimiliano Marzo and Paolo Zagaglia*

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Abstract

We investigate the relation between aggregate trading imbalances and interest rates in the Euro money market. We use data for OTC contracts as well as information from the major electronic trading platform in Europe to study the presence of cointegration between trading pressures and money market rates. We report strong evidence of a long-term linear relation between trading imbalances and liquidity prices for Euro interbank deposits.

Keywords: Euro money market, order flow, interest rates.
JEL classification: G14, E52.

*Both authors: Department of Economics, Università di Bologna. Marzo: massimiliano.marzo@unibo.it. Zagaglia: paolo.zagaglia@gmail.com. We thank Stefano Nardelli for suggesting the topic of this paper. Zagaglia acknowledges the kind hospitality of the Research Unit of the Bank of Finland in March 2009, when this work was undertaken. The authors are very grateful to H. Bierens for sharing a utility that we have used to compute boostrapped significance levels for nonlinear cointegration tests.

1 Introduction

The recent turmoil in financial markets has prompted a large interest in the functioning of money markets worldwide. For the Euro area, a small number of recent contributions has investigated the issue of price formation in the interbank market. Most of the available results are related to the overnight segment.[1] However, an increasing number of contributions has devoted their attention to the determination of interest rates on term lending.[2]

Studying price formation requires understanding the patterns of bilateral trades in the interbank market. Recently Durré and Nardelli (2008) have argued that information asymmetry is a key driver of the overnight market for unsecured lending. They consider a microstructure model where heterogeneity among market participants in the access to liquidity is a source for information asymmetries. In the Euro money market, only a part of the banking system has access to the liquidity actions of the European Central Bank. This implies that the distribution of liquidity to the rest of the banking sector takes place through trading activity in the available segments of the money market. This institutional feature allows Durré and Nardelli (2008) to modify the framework of Easley and O'Hara (1992) originally proposed for the stock market. In fact, they assume that a part of the banking sector finds it harder to fulfill its liquidity needs. The remaining part of the banking system, instead, faces a more viable access to the supply of liquidity. Through enhanced trading opportunities, this latter set of banks can acquire information on the expected aggregate demand for liquidity, thus enjoying an information advantage.

Durré and Nardelli (2008) compute a standard index of information heterogeneity for the overnight market in populations of traders, the so-called probability of informed trading (PIN). This probability measure is computed from a proxy for aggregate order imbalances for funds. In other words, the model suggests that the pattern of buy and sell orders reflects the heterogeneity of information in the market. It should be stressed that this interpretation emphasizes the role of institutional arrangements and market organization for the dissemination of knowledge. Ultimately, these factors are argued to drive the determination of prices. Zagaglia (2010) computes the PIN for lending contracts with a maturity beyond the overnight, in particular until one year. Moreover, Zagaglia (2010) incorporates the PIN in empirical models of pricing of interbank deposits, and finds that this measure of information asymmetry is factored into money market rates. The emergence of this result is not uncommon for other markets, like those for stocks (see Easley, Hvidkjaer and O'Hara, 2000) and bonds (see Li, Wang, Chunchi and He, 2009). However, it provides

[1] The reason is that the pricing of funds in the overnight market is largely determined by the interplay between demand and supply of liquidity, with the supply by the European Central Bank playing a key role. In the jargon used in the official statements of the ECB, the liquidity supply should be 'neutral' (e.g., see ECB, 2005b). This means that the the monetary-policy stance should affected only by the decision on the key interest rates. The management of the daily liquidity conditions should not impair the signals conveyed by the ECB about the policy stance.

[2] A non-exhaustive list includes Angelini, Nobili and Picillo (2009), Baglioni and Monticini (2008), Beaupain and Durré (2008), Durré and Pilegaard (2003) and Heider and Hoerova (2009).

the ground for further relevant investigations.

The aggregate 'order flow' or imbalance is measured as the difference between the number of trades that are sell-initiated, and the number of trades that are buy-initiated. In alternative markets, such as the foreign exchange market, the order flow provides a direct measure of the net buying or selling pressure of an asset.[3] This is based on the presence of a market-maker or dealer that post quotes, thus allowing the buy and the sell side of the market to meet. In turn, the quoting behavior of dealers is guided by inventory management of demand and supply flows (see Westerhoff, 2003). Hence, the order flow to the market-maker imposes a bottleneck on the market.

In the Euro market for unsecured bank lending, banks trade without the intermediation of a market-maker. In general terms, the aggregate imbalance between demand and supply of funds captures the information that allows to identify the direction of trading prevailing in the market.[4] In the interpretation of Durré and Nardelli (2008), the fraction of banks that can observe and interpret the trading direction enjoys an information advantage with respect to the rest of the banking system.

In this paper we study whether buy- or sell-side pressure affects the pricing of interbank deposits in the long run. We approach this question by shedding light on the role of trading directions for the determination of money market rates. In particular, we focus on the existence of cointegration between trade directions and money market rates across the maturity structure of interbank contracts.

Our results are indicative of the presence of a long-term relationship. This finding suggests that there are common factors characterizing the relation between aggregate demand imbalance and liquidity pricing. In other words, an excess demand for liquidity create pricing tensions in the long run. This is an empirical fact that is well established for other markets, such as the short market (e.g., see Boyer and Van Norden, 2006). Interestingly, it sheds additional light on a channel of long-term market power that informed banks can exploit. As argued by Zagaglia (2010), the extraction of maturity-specific information requires knowledge of the aggregate trading patterns that characterize the interplay between demand and supply of liquidity. The evidence presented here can also be interpreted as the outcome of existing trading patterns. In this sense, it supports the idea that bottlenecks in the aggregate liquidity supply can have an impact on prices in the long run.

This paper is organized as follows. Section 2 reviews the key features of the organization of the Euro money market, and suggests why the heterogenous access to the supply of liquidity provides the scope for information to matter. Section 3 describes the dataset. Section 4 outlines the results of the paper. Section 5 concludes.

[3] Evans and Lyons (2001) suggest that, in the foreign exchange market, order flows explain a substantial fractions of exchange rate fluctuations.

[4] Bjonnes and Rime (2005) measure order flow as the "*cumulative flow of directions*".

2 Features of the Euro area money market

The framework employed in this paper departs from the observation that banks have asset-liability management strategies over different time spans. The need to put in place the asset-liability plans generates a demand for 'liquidity' or 'cash' with different maturities. For instance, banks may issue loans that produce inflows of cash at future points in time. At the time of issuance, however, the banks need to raise liquidity that is transferred to the loan beneficiaries. These cash flows can arise from activities that follow systematic (planned) or non-systematic (unforeseen) patterns. Banks can have investment plans or commitments. One of the systematic sources of the demand for liquidity is related to the institutional constraints present in the money market. In particular, banks are required to hold average reserves at the ECB over a maintenance period.

There are two types of liquidity supply. The structure of the Euro area money market contemplates a primary supply by the ECB to the banking sector through open market operations. There are three types of money market operations. Main refinancing operations (MROs) are weekly repurchase operations with a maturity of normally one week. They are executed as variable rate tenders with a minimum bid rate given by the policy rate. Longer-term refinancing operations (LTROs) are repurchase agreements with a monthly frequency and a maturity of normally three months where the ECB is a rate-taker. Fine-tuning operations (FTOs) are executed on ad hoc basis through quick tenders or bilateral procedures. They take place generally at the end of reserve maintenance periods to resolve liquidity imbalances and to avoid further significant departures of the overnight rate from the minimum bid rate or an excessive level of volatility. Unlike the other two, FTOs can either supply or withdraw liquidity to the market depending on the sign of the imbalance.

The liquidity provided by the ECB is distributed in the banking system across the interbank market. In this market, banks trade lending and borrowing contracts. These transactions can involve trades through bilateral direct deals, voice brokers and electronic trading platforms.[5] The market consists of four segments, including a secured and an unsecured segment, swap derivatives and short-term securities.[6]

2.1 Why heterogeneity and information matter

The microstructure model considered in this paper postulates that heterogeneity among market participants in the access to liquidity is a source of asymmetric information. In particular, the framework assumes that a fraction of banks find it harder to fulfill their liquidity needs. The remaining part of the banking system, instead, faces a more viable access

[5]The 2009 Euro Money Market Study suggests that around 35% of the overall trading activity takes place through bilateral deals, 20% through voice brokers, and 45% through electronic platforms.

[6]The unsecured market involves trading uncollateralized lending and borrowing contracts. The secured segment, instead, consists of trades where collateral is posted against interbank lending. The 2009 Euro Money Market Survey reports that around 60% of trades in both the unsecured and the secured segments have a maturity longer than one month.

to the supply of liquidity. Through enhanced trading opportunities, this latter set of banks can acquire information on the expected demand for liquidity, thus enjoying an information advantage.

This framework is well suited for studying the functioning of the Euro area money market. In fact, there are several features of this market that affect the the possibility for banks to satisfy their liquidity needs through the available channels. These factors are related to the institutional rules of the ECB supply of liquidity, and to the importance attached to counterparties creditworthiness in the money market.

The rules of the ECB for the conduct of open market operations establish a number of requirements for the participating institutions. First, banks have to post appropriate assets as a collateral. These assets are subject to two types of valuation criteria. They have to carry the required credit rating, and they must have an appropriate value. The ECB applies 'haircuts' to the value of nominal value of the assets used as collateral. The amount of liquidity received by the participating banks is equal to the nominal asset value minus the haircut. The total value of collateral required to participate in the open market operations is equal to the amount borrowed, plus the haircut and the interest paid to the ECB. The private banks that can take part to the liquidity tenders are listed by the ECB.[7] The number of banks eligible to participate in the fine-tuning operations is more restricted, and is typically limited from ten to fifteen large banks. In this sense, the operational rules of the ECB generate a discrimination between banks in the access to the primary supply of liquidity. In addition to this factor, banks face also administrative costs for participating to the ECB tenders. These transaction costs may represent a disincentive especially for the banks of smaller dimensions.

Idier and Nardelli (2008) suggest that the possibility for banks to lend or borrow in the unsecured money markets is largely affected by their reputation. As noticed earlier, trading in the unsecured markets operates over the counter. Therefore trust between counterparts is a relevant factor that determines the matching process between banks, and the reputation of banks plays an important role. Market reputation depends on different factors, such as the size of banks. Larger banks are more likely to have both the organizational structure and the knowledge needed to put in place comprehensive asset-liability management plans. In this sense, they can obtain a larger advantage from being active traders in the money market.

There is also a geographical factor that generates heterogeneity in the possibility for banks to satisfy their liquidity needs. Despite the introduction of the Euro, there is evidence suggesting that a national bias is still present in the money market. The 2009 Euro Money Market study indicates that 35% of the transactions on average involve national counterparts both in the unsecured and the secured segments. Around 45% of trades take place between non-national counterparties from the Euro area. This suggests that the banks that do not take part to the open market operations of the ECB can still face some form of rationing in

[7]Idier and Nardelli (2008) report that approximately 2000 financial institutions are eligible for the main refinancing operations, out the 6500 located in the Euro area. However, only between 340 and 400 institutions take part, while only 148 participate on average to the longer-term refinancing operations.

cross-country lending or borrowing.

2.2 The value of information from trading directions

The ability of banks to gather and interpret information concerns the valuation of the asset. Denote by cf_t the future cash flows generated by the interbank deposits, and by r_t the market discount rate. The expected value can be written as

$$V_t = \sum_{t=1}^{d} E_t \left[\frac{cf_t}{1 + r_t} \right] \tag{1}$$

The market discount rate is determined by the imbalance between demand and supply of liquidity in the long run. The asset valuation approach stresses two aspects that are related to the interpretations of these imbalances. First, the value of information stems from the capacity of banks to anticipate the evolution of the interest rate level. Second, money market participants can gain insight from understanding the shocks that affect the long-term demand and supply of liquidity.

3 The dataset

In this paper we focus on trading behaviour through bilateral deals in the unsecured segments for interbank deposits with different contract maturities. To provide a full picture of the market, we use two types of data. The first one provides an account of over-the-counter trading activity. The second one is instead based on bilateral trades that take place over the main electronic platform in Europe, the European markets for interbank deposits (e-Mid). It should be stressed that, owing to data limitations, the two types of data cover different time frames. The dataset on OTC activity spans from November 29 2000 to June 18 2007, and it contains 1709 daily observations. The dataset on e-Mid transactions runs from January 2 2006 to December 31 2009, and includes 1022 observations.

The main reason for using a series of data on OTC trading is related to the role of reputation in the unsecured segment. As argued earlier, the presence of banks with different market reputation is a motive for market power and heterogenous access to the private liquidity supply. In this sense, using a dataset on on OTC trading provides a better picture on the role of reputation. However, in this case, data on effective prices and volumes are unavailable to the general public. The dataset on OTC trading activity consists of Reuters quotes on unsecured lending with maturity of 1, 3, 6 months and 1 year. It contains best bid and ask prices, and the time stamp sampled at a 5-minute frequency from Reuters terminal screens. In order to restrict the sampling to the trading hours when most of the trading takes place, intraday quotes are available from 8am to 7pm CET. This provides 120 intraday data points on average.

A number of studies has used high-frequency data from e-Mid.[8] The rules for access to e-Mid require banks to have net assets worth more than 10 million U.S. dollars. This prevents smaller banks from operating in e-Mid. Since trades with a maturity above the overnight represent only a small fraction in e-Mid, we report the results on overnight contracts in this paper.

We should stress that there is a substantial difference in the information available for OTC contracts and for the electronic platform. In particular, e-Mid provides prices, volumes and and trade origination for realized transactions. This means that we can compute measures of trading directions from actual figures for buy-initiated and sell-initiated trades. Since these figures are not available for OTC transactions, we need to use bid and ask quotes to extract an approximation of implicit trading activity. This aspect is discussed in the following section.

3.1 The classification of trades from Reuters quotes

For e-Mid data, we use the method for trade classification proposed by Lee and Ready (1991). For this purpose, we assume that quoted bid and ask prices are driven mainly by inventory constraints. This assumption can be justified with the need for banks to comply with future asset-liability management plans and reserve requirements. Furthermore, it implies that banks hold liquidity at a level close to the optimal size. Hence, information on trade initiation can be obtained from relative changes in bid and prices. Idier and Nardelli (2008) suggest that five cases are possible. An increase in both ask and bid prices indicates that dealers are willing to sell the contract at a price higher than in the previous transaction. This is a buy order, or a borrowing contract. A fall in both ask and bid prices, instead, suggest that a sell order takes place, or a lending contract. An increase in the ask and a decrease in the bid is classified according to the relative size of the change. If the positive increase in the ask is larger (lower) than the decrease of the bid in absolute value, then the trade is classified as buy (sell) initiated. If the positive increase in the bid is larger (lower) than the fall in the ask price, then the trade is classified as buy (sell) initiated. On the other hand, if the positive increase in the bid is larger (lower) than the fall in the ask price, then the trade is classified as buy (sell) initiated. Finally, symmetric changes or no changes at all in bid and ask prices indicate no trades.

4 Results

We construct indicators of trading directions as the cumulative difference between that number of trades that sell-initiated and buy-initiated each day. Figure 1 reports the trading imbalance and the rates for OTC transactions. The interest rate data are measured at the end of the day, and are obtained from the Reuters quotes. Figure 2 plots the trading directions and the end-of-day rates in e-Mid. For the Reuters quotes, there is a negative correlation between

[8] See Baglioni and Monticini (2008), Beaupain and Durré (2008) and Angelini, Nobili and Picillo (2009).

trading directions and rates for the entire maturity spectrum until 2006. After 2006, a net selling pressure corresponds with rising rates. This can also be seen in the e-Mid data. Two factors can explain this pattern. The first one has to do with the tightening cycle of the ECB monetary policy between 2006 and 2007. The second factor is related to the abundant liquidity supply of the ECB through open market operations that took place between October 2005 and the beginning of 2007. The pattern discussed here can be interpreted as suggesting that the banking sector tried to pass the excess public supply on to other private counterparties at rising rates.

Figure 2 shows that the e-Mid has been characterized by a steep drop of funding costs from June 2008. The apparent loosening of lending conditions at the height of the turmoil can reflect a sample selection bias. In particular, the number of participating institutions in e-Mid has fallen substantially since the beginning of the turmoil. This is due, among other factors, by the unwillingness of banks to put their liquidity needs on public display. Hence, the market may have been characterized by a shortage of buy-side institutions

The ADF tests indicate that the PINs can be appropriately described by a unit root process. In this section we study whether a long-run relation is present in the form of cointegration. We compute the standard test of Johansen (1988) between pairs of maturities. The auxiliary models include an unrestricted constant and trend.[9] The test statistics are reported in Table 4. The null of a unit root is rejected in all the cases, which suggests that there are no long-run linkages between measures of PIN.

Table 1 reports some descriptive statistics about trading directions. The first panel shows that there is excess buying pressure only for the one-year maturity of OTC contracts. For the other maturities, there is an excess selling pressure on average. Some of the distributions are skewed and asymmetric, which suggests the large liquidity imbalances do occur in the various segments. The second panel of table 1 reports the contemporaneous correlation between trading directions from Reuters quotes. Longer maturities are negatively correlated with shorter maturities. This indicates that there is substitutability in the imbalances between demand and supply. In other words, excess demand pressure in, say, the overnight segment is associated with excess supply pressure in the 1-year segment.

Table 2 compares average rates and average trading directions. Increasing rates as a function of maturity are associated with falling trading directions on average. As a preliminary step, we use two criteria for the choice of lag selection for vector autoregressive (VAR) models. The criteria lead to the choice of fairly different models. Therefore, our results will reflect these patterns.

[9]The tests with models with unrestricted constants only produce the same results and are not reported here for brevity.

4.1 Linear cointegration

As a starting point, we consider the standard test for linear cointegration of Johansen (1988) The asymptotic p-values for the max eigenvalue and trace tests are reported in Table 4. The results indicate a strong rejection of the null of one linear cointegrating relation for all the contract maturities. This result is robust to different lag lengths for the VARs.

The cointegration test of Johansen (1988) suffers from a small-sample problem as it tends to produce evidence for spurious cointegration. To address this issue we compute p-values from bootstrap distributions. These distributions are computed as follows:

a. we estimate VAR models on stationary series that are in first differences;

b. we simulate 50000 series of exchange rates and order flows. The simulated data length is the same as the empirical data length. Level series are then constructed;

c. the cointegration tests estimated and the p-values are collected into empirical distributions under the null of no cointegration.

The bootstrap distributions are reported in Figure 3-6. For each cointegration test, we report the results arising from the two lag-selection criteria. For each contract maturity and market, the simulated distributions are similar across tests and models selection criteria. However, there are major differences in the size of the left tails of the distributions, which denote the rejection regions. Furthermore, some of the distributions have peaks. These consideration suggest that there are benefits from using bootstrapped p-values as opposed to asymptotic p-values.

4.2 Nonlinear cointegration

Neglected nonlinearity can affect the outcome of the cointegration tests. For this reason, we compute also the tests for nonlinear cointegration of Bierens (1997). The test statistics involved in both approaches are obtained from the solutions of a generalized eigenvalue problem and the hypotheses tested are the same. The main difference is that the approach of Bierens (1997) is nonparametric, and the generalized eigenvalue problem is formulated on the basis of two random matrices which are constructed independently of the DGP.[10] Two alternative statistics for empirically determining the cointegration rank r are provided. Given the ordered eigenvalues $\hat{\lambda}_{1,m} \geq \hat{\lambda}_{n,m}$ with the parameter m and the dimension of the system n, Bierens (1997) proposes the lambda-min statistics $\hat{\lambda}_{n-r_0,m}$ for testing the hypothesis

$$H_0(r_0): \ r = r_0, \quad H_1(r_0): \ r = r_0 + 1 \tag{2}$$

[10]These matrices consist of weighted means of the system variables in levels and first differences and are constructed such that their generalized eigenvalues share similar properties to those in the Johansen (1988) approach.

The asymptotic null distribution of this test is nonstandard and critical values can be found in Bierens (1997). Second, he proposes the $g_m(r_0)$ statistic to estimate r consistently. In this paper, we apply the rule of thumb proposed by Bierens (1997) and choose $m = 2n$.

Table 6 reports the bootstrapped p-values computed for the test statistics of nonlinear cointegration. The methods for computation these statistics follows the principles outlined in Bierens (1982). The null hypothesis of zero cointegrating relations against one nonlinear cointegrating relation is strongly accepted. At the same time, the null of one cointegrating relation is also accepted against the alternative of two cointegrating relations. Hence, this provides evidence suggesting that there is a long-term linear relation between order flows and interest rates in the Euro money market.

5 Conclusion

This paper is the first empirical investigation on the relation between aggregate trading imbalances and interest rates in the Euro money market. We use data for both OTC contracts and information from the major electronic trading platform to study the presence of cointegration between measures of trading pressures and the pricing of liquidity for different contract maturities. Similarly with other financial markets, we report strong evidence of a long-term linear relation between trading imbalances and market rates.

The implications of the results presented in this contribution are far fetching for policy formation. In this sense, the results should be strengthened and complemented along several directions. First, we are planning to use a more complete dataset on bilateral transactions in e-Mid to study how the presence of cointegration may be affected by the ongoing turmoil in financial markets. Second, we intend to investigate how the short-term pricing impact of changes in volumes demand and supplied in e-Mid affects the stability of the long-term relation between quantities and prices.

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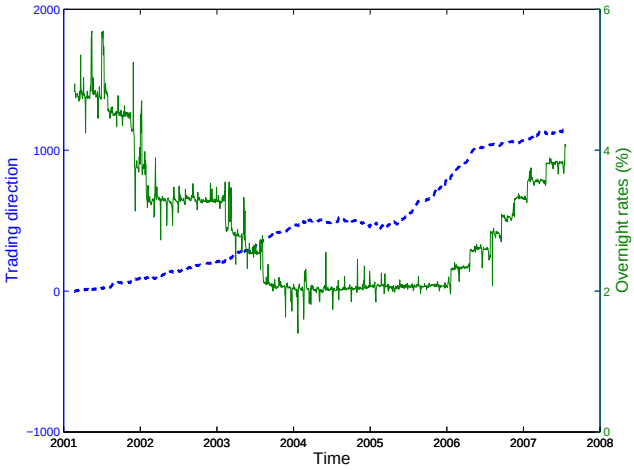
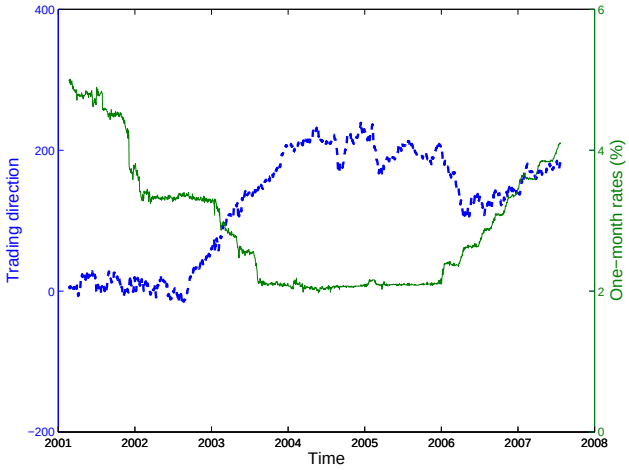
Figure 1: Trading direction and money market yields from Reuters quotes

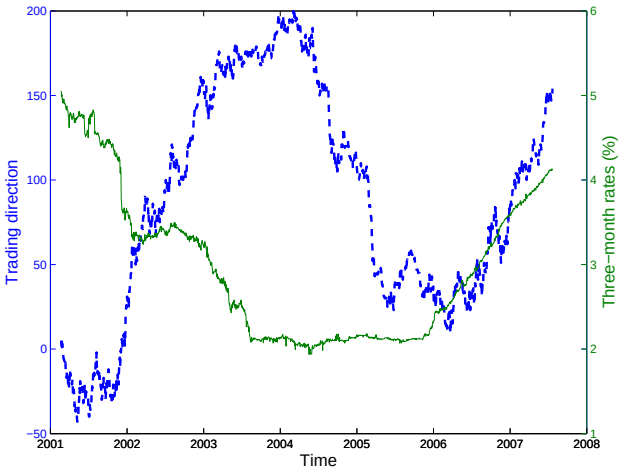
(a) OTC overnight maturity



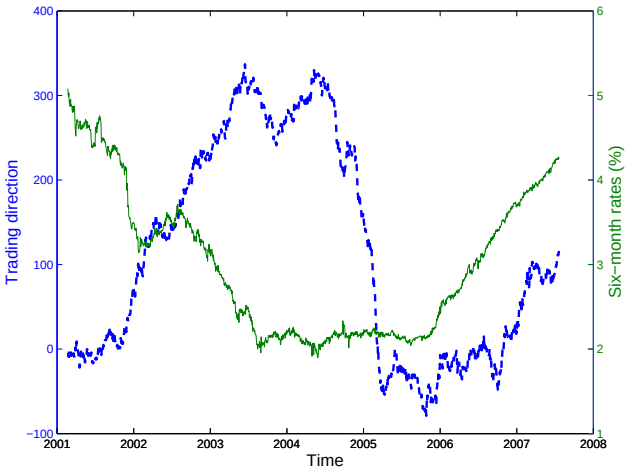
(b) One-month maturity



(c) Three-month maturity



(d) Six-month maturity



(e) One-year maturity

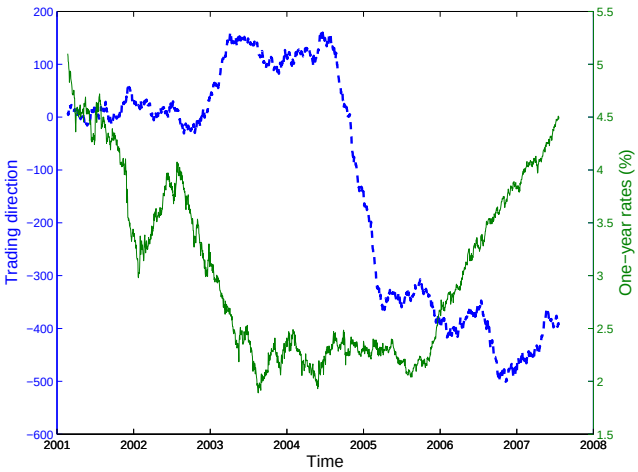


Figure 2: Trading direction and money market yields from e-Mid

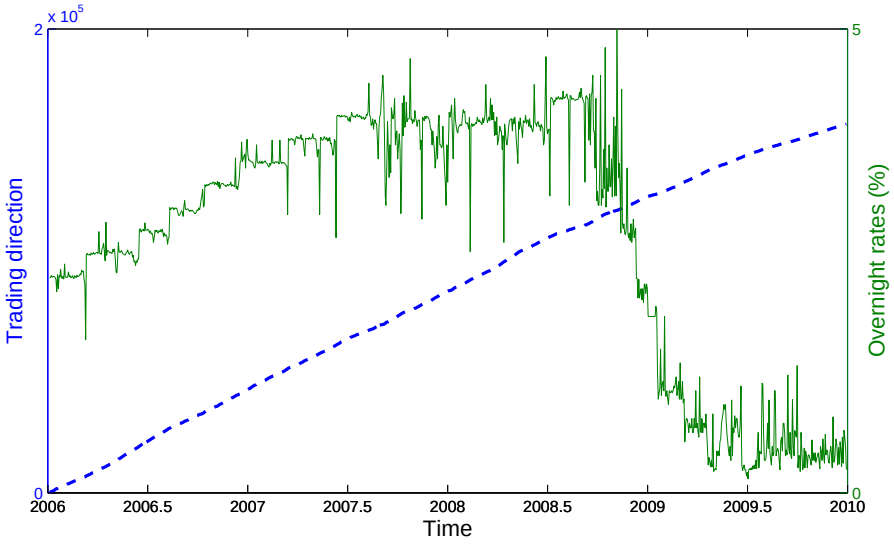


Figure 3: Kernel estimates of bootstrapped likelihood-ratio test statistics, AIC

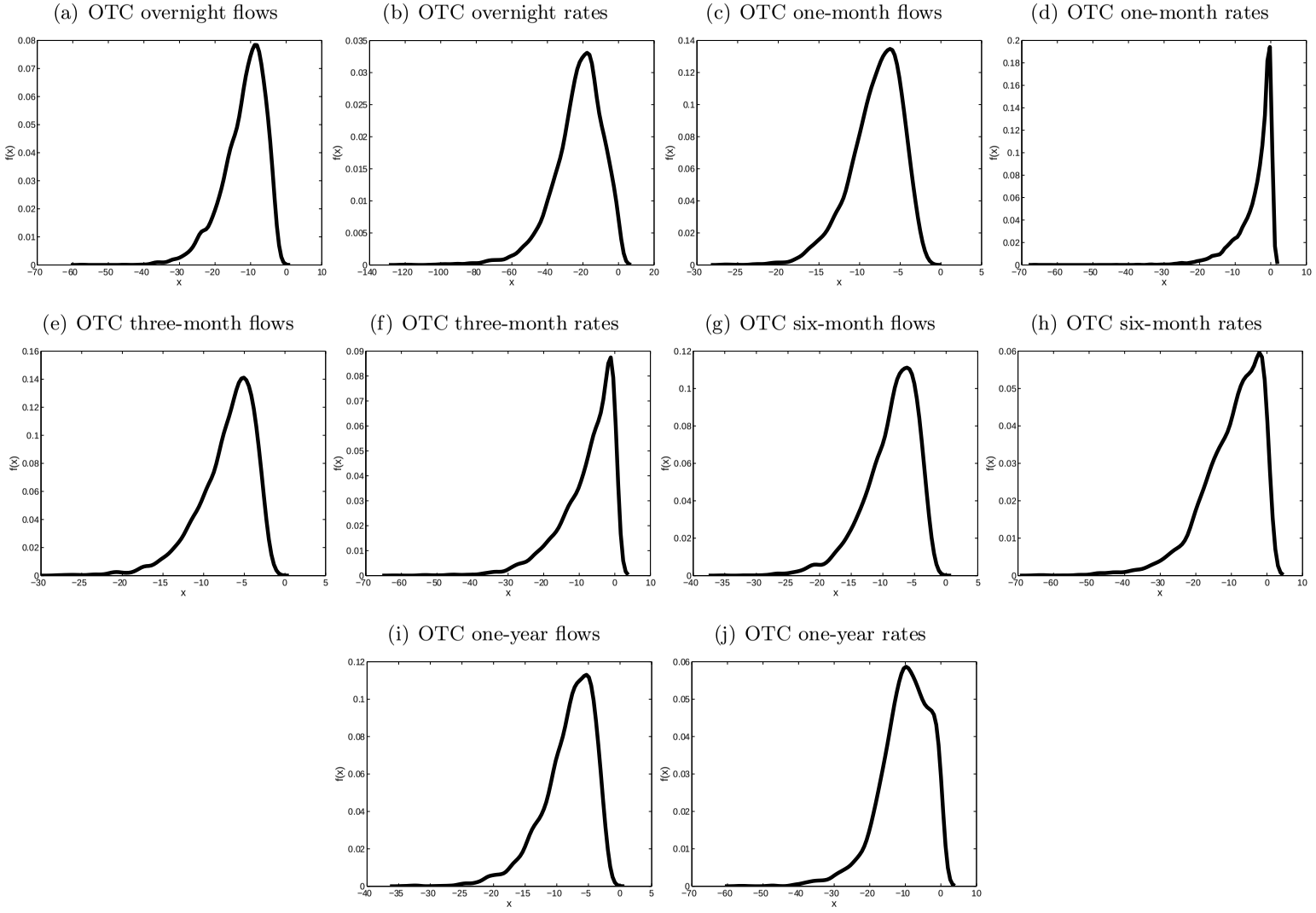


Figure 4: Kernel estimates of bootstrapped likelihood-ratio test statistics, BIC

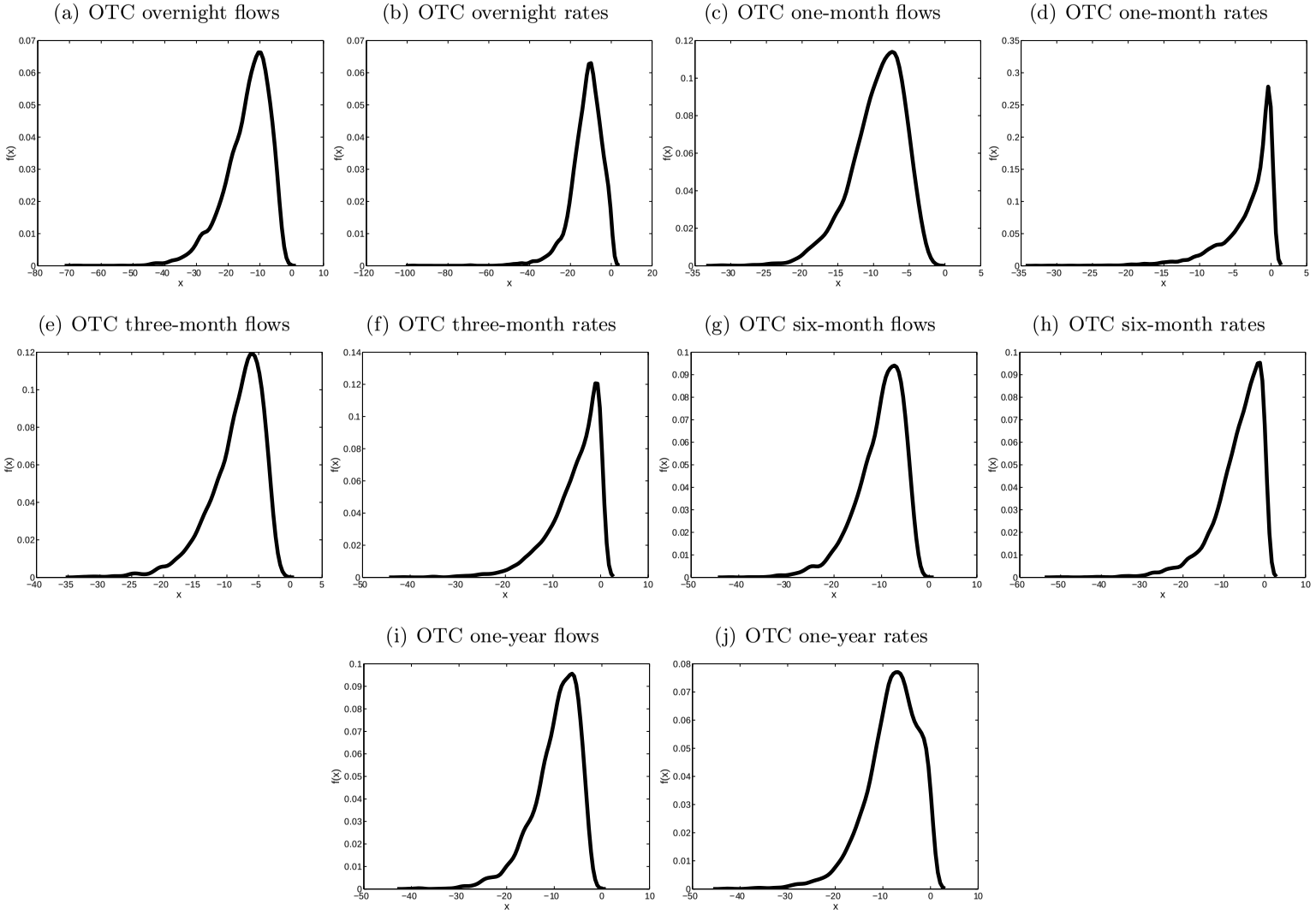


Figure 5: Kernel estimates of bootstrapped maximum-eigenvalue test statistics, AIC

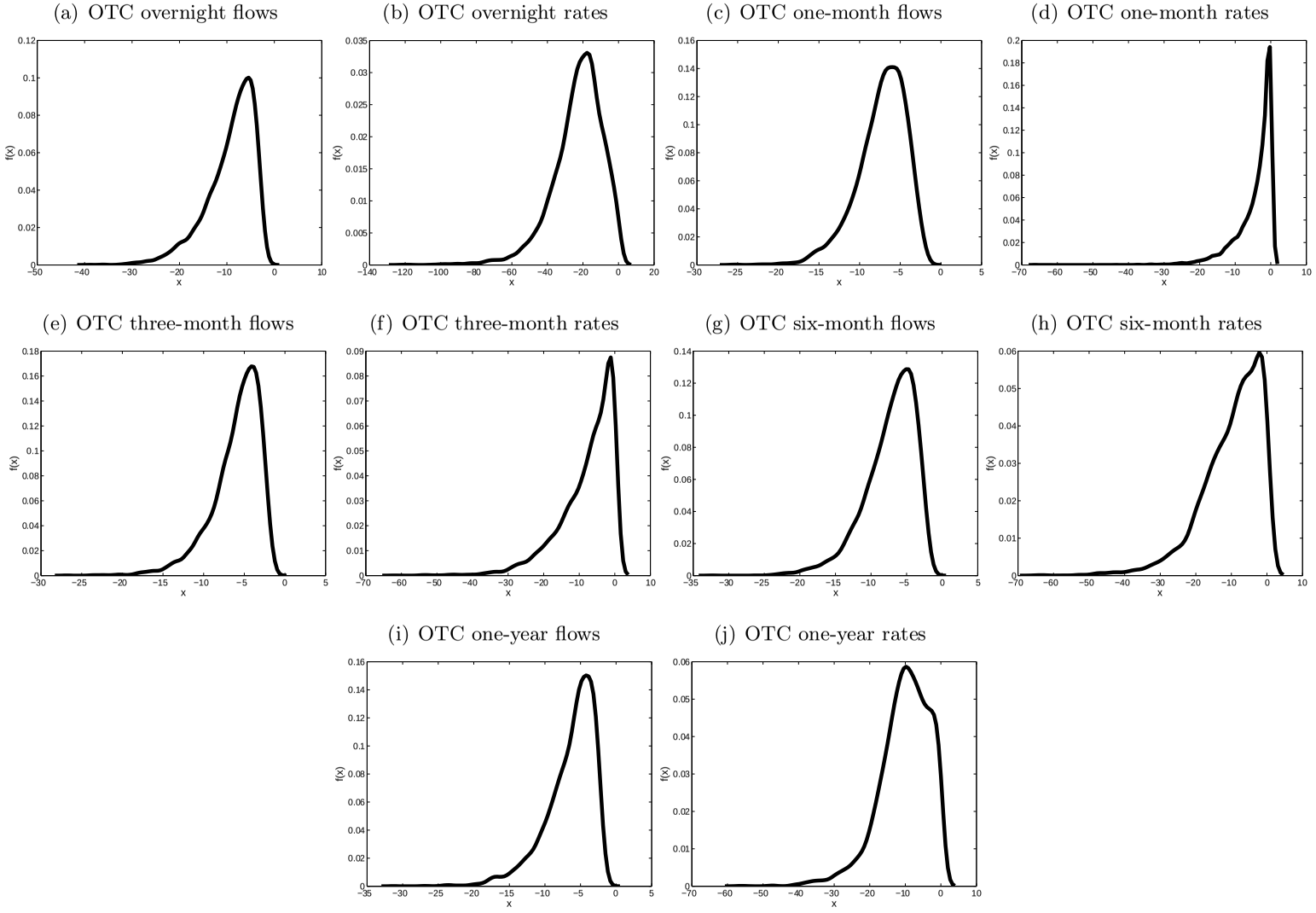


Figure 6: Kernel estimates of bootstrapped maximum-eigenvalue test statistics, BIC

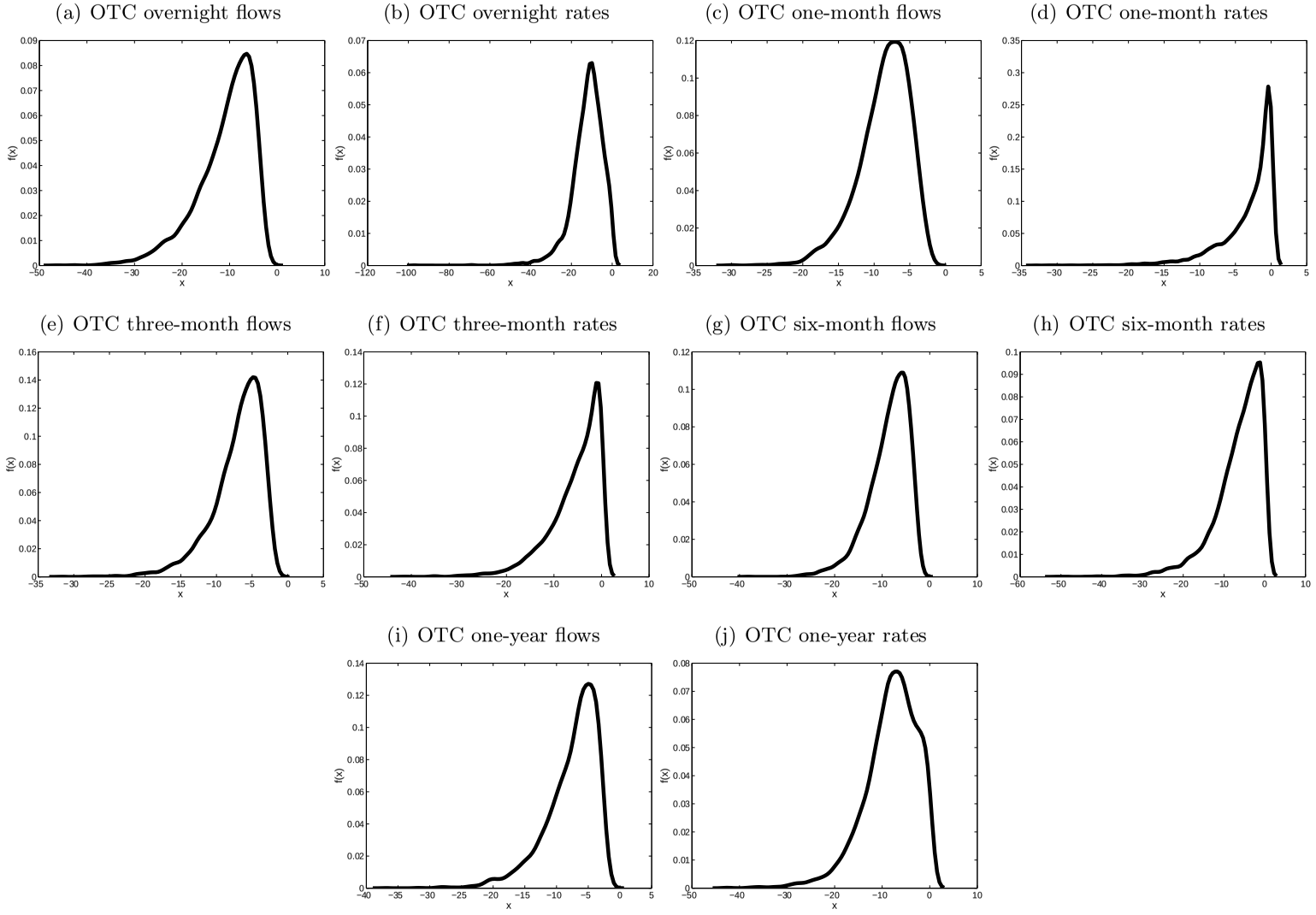


Table 1: Descriptive statistics of trading directions

	Reuters					e-Mid
	Overnight	1-month	3-month	6-month	1-year	Overnight
Mean	493.29	124.06	87.91	115.09	-120.18	202.56
Std. dev.	356.88	79.348	66.35	127.89	222.03	109.30
Skewness	0.4439	-0.4593	-0.0832	0.2525	-0.3604	-0.4094
Kurtosis	-1.0093	-1.3030	-1.0957	-1.4735	-1.5532	-1.0090

	Contemporaneous correlations for Reuters data				
Overnight	1				
1-month	0.6129	1			
3-month	0.0852	0.4343	1		
6-month	-0.2831	0.1527	0.8825	1	
1-year	-0.7953	-0.3002	0.4171	0.7481	1

Table 2: Average money market rates and trade directions from Reuters quotes

Maturity	Average rates (%)	Average trading directions
Reuters		
Overnight	2.9104	493.2861
1-month	2.9356	124.0638
3-month	2.9638	87.9146
6-month	2.9941	115.0878
1-year	3.0840	-120.18371
e-Mid		
Overnight	2.9104	493.2861

Table 3: Lag selection of VAR models

	AIC	BIC
Reuters		
Overnight	8	4
1-month	2	2
3-month	7	2
6-month	4	2
1-year	4	2
e-Mid		
Overnight	6	6

Table 4: Johansen cointegration tests for bivariate VAR models of rates and trading directions: asymptotic p-values

	λ-max test	Trace test
	Lag-length choice: AIC	
Reuters		
Overnight	0.116	0.724
1-month	0.239	0.254
3-month	0.628	0.282
6-month	0.558	0.350
1-year	0.142	0.386
e-Mid		
Overnight	0.386	0.350
	Lag-length choice: BIC	
Reuters		
Overnight	0.290	0.252
1-month	0.296	0.260
3-month	0.135	0.983
6-month	0.228	0.179
1-year	0.558	0.603
e-Mid		
Overnight	0.239	0.116

Legend: The models include an unconstrained constant and time trend.

Table 5: Johansen cointegration tests for bivariate VAR models of rates and trading directions: bootstrapped p-values

	λ-max test	Trace test
	Lag-length choice: AIC	
Reuters		
Overnight	0.174	0.510
1-month	0.606	0.213
3-month	0.446	0.490
6-month	0.450	0.394
1-year	0.340	0.506
e-Mid		
Overnight		
	Lag-length choice: BIC	
Reuters		
Overnight	0.683	0.648
1-month	0.184	0.153
3-month	0.125	0.498
6-month	0.553	0.284
1-year	0.261	0.290
e-Mid		
Overnight	0.790	0.320

Legend: The models include an unconstrained constant and time trend.

Table 6: Bootstrapped p-values for Bierens nonparametric cointegration tests

	$r = 0/r = 1$	$r = 1/r = 2$
Reuters		
Overnight	0.087	0.1240
1-month	0.088	0.1991
3-month	0.067	0.1851
6-month	0.071	0.1990
1-year	0.088	0.1731
e-Mid		
Overnight	0.9887	0.9974

Legend: This table reports the bootstrapped p-values for the nonparametric cointegration tests of Bierens. The results reported in this table were obtained using a simulation utility kindly provided by H. Bierens.