

On the Persistence of the Eonia Spread

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Abstract

The European overnight rate (Eonia) signals the monetary policy stance of the European Central Bank. Controllability of the Eonia requires that the *persistence* of the Eonia spread, i.e. the spread between the Eonia and the key policy rate, remains sufficiently low. Motivated by a recently observed upward trend in the Eonia spread, this letter applies fractional integration techniques to examine its (changing) persistence.

Keywords: Long memory and fractional integration, controllability and persistence of interest rates, new operational framework of the ECB;

JEL classification: C22, E52

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1 Introduction

Like many other central banks in industrial countries, the European Central Bank implements monetary policy by steering the very short-term interest rates in the interbank money market. In particular, the overnight rate Eonia¹ plays a central role in signalling the stance of monetary policy. Typically, the Eonia closely follows the ECB's key policy rate and its volatility remains well contained. However, controllability of the Eonia also requires that the *persistence* of the Eonia spread, i.e. the spread between the Eonia and the key policy rate, remains sufficiently low. If the persistence of the Eonia spread is too high, the lasting impact of shocks would impede the signalling role of the Eonia and the central bank's control over interest rates. This letter applies recent tests for long memory to investigate the (changing) persistence and, thus, the controllability of the Eonia spread.

Our analysis is stirred by a recently observed upward trend in the Eonia spread. According to the ECB, the increased spread was not intended and it seems that it is neither clear why it happened nor whether this upward trend will continue. Possible explanations for a changing behavior of the Eonia spread center around the introduction of the ECB's new operational framework in March 2004. Therefore, we analyze the persistence of the Eonia spread for the period before and after the reform separately.

Recent work on the dynamics and the volatility of the Eonia assumes that the Eonia spread is stationary and, more precisely, integrated of order zero ($I(0)$), see e.g. Pérez Quirós and Rodríguez Mendizábal (2006) or Nautz and Offermanns (2007). This result is typically established by means of standard unit-root tests where the null hypothesis "the spread is $I(1)$ " is rejected against the alternative that it is $I(0)$. However, modeling persistence in the $I(1)/I(0)$ dichotomy might be too restrictive. The order of *fractional* integration d is a more general measure for the persistence of a time series. In our application, the order of fractional integration of the Eonia spread may be interpreted as a measure of the central bank's ability to control the overnight rate. If the ECB wants to steer the Eonia by its key policy rate, the order of integration of the Eonia spread should be less than 0.5.

¹The Eonia (**E**uropean **O**ver**N**ight **I**ndex **A**verage) is a weighted average of all overnight lending transactions between the most active credit institutions in the Euro area's money market.

In the following, we present the data and briefly review the operational framework of the ECB. Section 3 tests for long memory, Section 4 estimates the Eonia spread's order of integration, and Section 5 concludes.

2 The Eonia spread and the ECB's operational framework

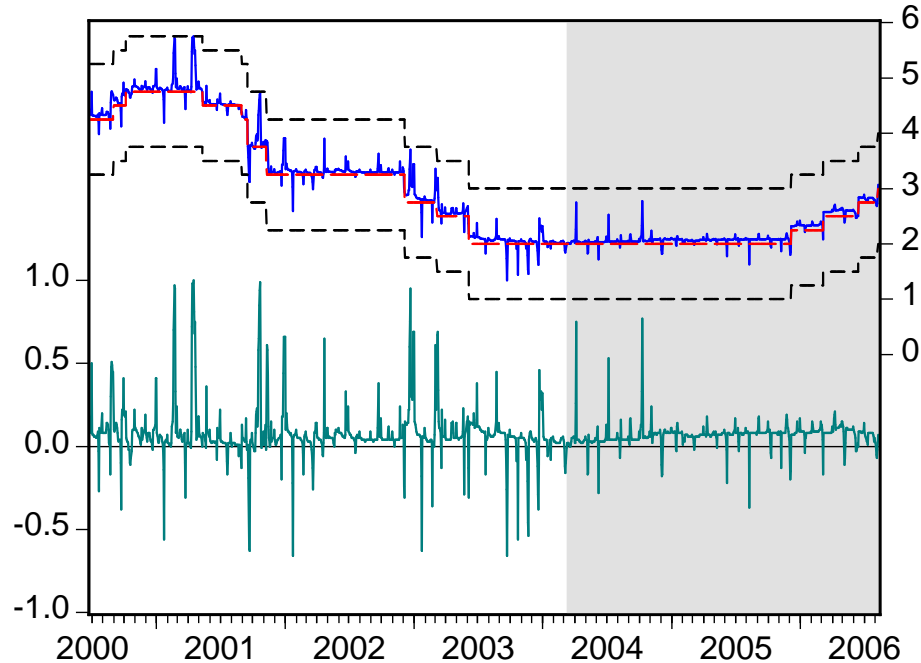
The ECB's interest rate corridor The ECB's key interest rate has been always implemented via its weekly main refinancing operations (MROs) that determine the liquidity of the European banking sector. Since June 2000, MROs are conducted as variable rate tenders, a standard multi-unit auction augmented by a minimum bid rate which has been the ECB's key policy rate since then. Our empirical analysis of the persistence of the Eonia spread uses daily data for the representative Euro overnight rate Eonia and the MRO minimum bid rate. Since overnight rate dynamics may be affected by the applied auction rule, we concentrate on the recent variable rate tender period running from June 27, 2000 to September 30, 2006.

Interest rates of two standing facilities, the marginal lending and the deposit facility, where banks can lend and deposit overnight liquidity at short notice, define an interest rate corridor that bounds the volatility of the Eonia. Figure 1 depicts the time series of the Eonia (i), the ECB's policy rate (i^*), the marginal lending and deposit rate and the Eonia spread defined as $i - i^*$. Note that the ECB's key policy rate has always been the midpoint of the corridor. Apparently, the ECB has been very successful in steering the Eonia. The Eonia never left the interest rate corridor and apart from a few outliers, the Eonia follows the policy rate of the ECB closely.

Minimum reserves and seasonal Eonia volatility Minimum reserves are an integral part of the ECB's operational framework. In particular, they create a liquidity buffer for banks since reserve holdings can be averaged over the maintenance period. The ECB's minimum reserve system is therefore a particular powerful tool to smooth the Eonia *within* the reserve maintenance period. At the end of the maintenance period, however, liquidity shortages or excess reserves can lead to sharp interest rate peaks and troughs. The following analysis of the persistence of the Eonia spread shall take into account that those

dramatic increases of Eonia volatility are temporary, well understood by the market and, therefore, less problematic for the communication of monetary policy.

Figure 1: The ECB's interest rate corridor and the Eonia spread



Right scale: Eonia (solid line) and ECB key rates (dashed line: minimum bid rate, dotted lines: deposit and marginal lending facilities). Left scale: Difference between Eonia and the minimum bid rate (*Eonia spread*). The shaded area refers to the period after the reform in the ECB's operational framework in March 2004.

To ensure that our results will not depend on end-of-period observations, we filtered the Eonia spread as follows. First, we regressed the series on a small set of calendar dummies typically found to be significant in earlier work.² In a second step, we excluded the end-of-period days (defined as the days after the last MRO in a reserve period) from the sample.³ The resulting sample contains 922 and 638 observations before and after the introduction of the ECB's new operational framework, respectively.

²We included dummies for end-of-month, end-of-quarter, end-of-season, and end-of-year observations.

³Note that the complex dynamics of the Eonia spread at end-of-period days cannot not be captured by a few end-of-period dummies. In fact, the whole data generating process of the Eonia spread becomes different during end-of-period days. For example, the ECB conducts interest smoothing fine tuning operations only at end-of-period days.

The puzzling increase of the Eonia spread A slightly positive Eonia spread ($i - i^*$) is often called 'natural' because the collateral cost for refinancing via the interbank money market and the ECB's refinancing operations differ, see e.g. Würtz (2003). Furthermore, it seems plausible that a policy rate implemented as a minimum bid rate tends to be somewhat lower than related market interest rates. Interestingly, however, the median of the Eonia spread has increased over time from 5 to 8 basis points before and after March 2004, respectively. So far, it is unclear whether the new framework actually contributed to this phenomenon.⁴

In any case, the increase in the Eonia spread was not intended by the central bank. Since October 2005, the ECB has "communicated to market participants its uneasiness about the upward trend in the spread between the Eonia and the minimum bid rate", see European Central Bank (2006, p. 33). In fact, the ECB has repeatedly allotted up to 2 billion Euros excess liquidity but even these strong measures could not bring the Eonia spread back to its former level. Given former estimates of the liquidity effect in the Euro area, the non-response of the Eonia to the excess liquidity provided by the ECB is surprising. In the following, we will examine whether the weak response of the Eonia to the ECB's liquidity injections can be explained with an increase in the persistence of the Eonia spread measured by the order of (fractional) integration.

3 Long memory and the order of integration

Fractional integration and the autocorrelogram The fractionally integrated process y_t is defined as

$$(1 - L)^d y_t = x_t, \quad t = 1, \dots, T. \quad (1)$$

where y_t is a purely stochastic process without deterministic components, L is the lag operator and the fractional differences $(1 - L)^d$ are given by binomial expansion. If x_t is a stationary and invertible autoregressive moving-average [ARMA] process, then y_t is called an ARFIMA process, fractionally integrated of order d . The process is stationary as long

⁴With the introduction of the new operational framework, the ECB shortened the maturity of its main refinancing operations from two to one week. As a consequence, there is no overlap of subsequent MROs anymore which could have made banks' refinancing more difficult, more risky and, thus, more expensive. Note that if a bank does not achieve the necessary amount of refinancing in the last MRO of a reserve period, a far greater proportion of the total refinancing volume is affected than under the old framework with overlapping maturities.

as $d < 0.5$, but it displays long memory for $d > 0$. Long memory implies a form of serial dependence and persistence that cannot be captured by traditional ARMA processes. The autocorrelation function $\rho_y(h)$ of a fractionally integrated process behaves as follows with lag h being large:

$$\rho_y(h) \sim \rho h^{2d-1}.$$

We observe that $\rho_y(h) \rightarrow 0$ as long as $d < 0.5$, but for $d > 0$ the rate of convergence is so slow that serial correlation coefficients are not summable. This long memory property translates into persistence with respect to shocks the following way. Upon inverting $(1-L)^d$ and expanding the ARMA polynomials we obtain the Wold representation in terms of white noise ε_t (with impulse response function c_j):

$$y_t = (1-L)^{-d}x_t = \sum_{j=0}^{\infty} c_j \varepsilon_{t-j}, \quad \text{with } c_j \sim c j^{d-1}.$$

The effect of past shocks dies out as long as $d < 1$ (mean reversion): $c_j \rightarrow 0$. But again, the rate is so slow that the impulse response function is not summable for $d > 0$ (long memory). For further aspects of fractional integration we recommend the survey article by Baillie (1996).

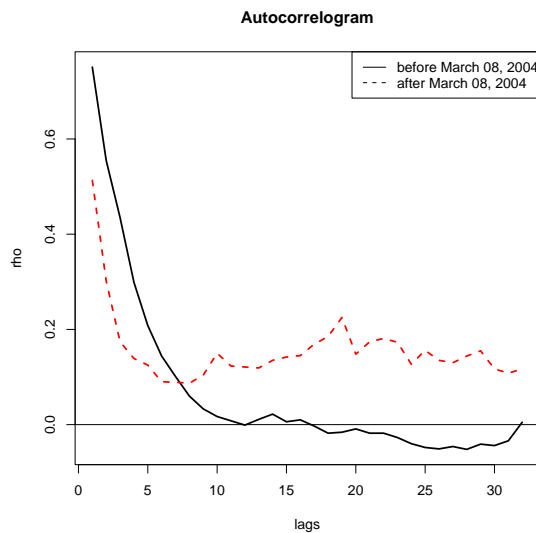


Figure 2: Autocorrelograms of Eonia spread before and after March 2004

Figure 2 shows the estimated autocorrelation functions of the Eonia spread before (bold line) and after (dashed line) the introduction of the ECB's new operational framework in

March 2004. While the autocorrelations before March 2004 converge rapidly to zero, there is no obvious decline of autocorrelations after March 2004 suggesting an increase in the Eonia spread's order of integration. Next, we investigate the statistical significance of this preliminary evidence on the changing persistence in the Eonia spread.

Long memory testing The following procedure allows to test for any specified value d of fractional integration. Due to our application we focus on the special null hypothesis H_0 that $d = 0$ in (1). Breitung and Hassler (2002) propose a regression-based Lagrange Multiplier [LM] test. Recently, Demetrescu et al. (2007) simplified and improved this procedure. They call it augmented LM test [ALM] because it relies on a regression augmented by lags. The test regression estimated by ordinary least squares [OLS] becomes

$$x_t = \hat{\phi} x_{t-1}^* + \hat{a}_1 x_{t-1} + \hat{a}_2 x_{t-2} + \dots + \hat{a}_p x_{t-p} + \hat{\varepsilon}_t, \quad x_{t-1}^* = \sum_{j=1}^{t-1} \frac{x_{t-j}}{j}, \quad (2)$$

with $x_t = (1 - L)^0 y_t = y_t$ being the (fractional) differences under H_0 ($d = 0$). Demetrescu et al. (2007) propose to work with White's standard errors to account for heteroskedasticity, and to choose the lag length p in (2) according to the sample size: $p_T = [4(T/100)^{1/4}]$. The test statistic is the t statistic \tilde{t}_ϕ testing for $\phi = 0$. Under the null hypothesis, they prove asymptotically that \tilde{t}_ϕ follows a standard normal distribution. Testing against positive alternatives, $d > 0$ in (1), we reject if \tilde{t}_ϕ is too large.

Applying the ALM test for the demeaned Eonia spread, we obtain the following results \tilde{t}_ϕ for the two operational regimes:

$$\text{before March 2004: } \tilde{t}_\phi = -0.341 \text{ (0.6334),}$$

$$\text{after March 2004: } \tilde{t}_\phi = 3.105 \text{ (0.00095).}$$

The p-values in brackets are for one-sided tests against the alternative $d > 0$ (long memory). The results indicate that the order of integration and, thus, the persistence of the Eonia spread has changed over time: While the null hypothesis of short memory cannot be rejected before the introduction of the new framework, the test statistic is highly indicative in favor of long memory in the Eonia spread after March 2004.

4 The long memory parameter of the Eonia spread

Semiparametric estimation of d Having established that the Eonia spread has long memory ($d > 0$) after March 2004, it is naturally of interest to estimate d in a second step of our analysis. To that aim, we apply techniques that are semiparametric in the sense that d is estimated without further specification or estimation of ARMA components in x_t . Typically, such procedures are settled in the frequency domain, relying on the periodogram $I(\lambda)$ as spectral estimator evaluated at frequency λ . Close to $\lambda = 0$, the periodogram is dominated by the order of integration d . Therefore, one evaluates $I(\lambda_j)$ at the so-called harmonic frequencies,

$$\lambda_j = \frac{2\pi j}{T}, \quad j = 1, 2, \dots, m, \quad \frac{m}{T} \rightarrow 0,$$

where m increases much more slowly than the sample size T . One proposal due to Geweke and Porter-Hudak (1983) is the so-called log-periodogram regression [PR].⁵ Robinson (1995) discusses a competing although related procedure, often called “local Whittle estimator” [LW], because it minimizes an objective function due to Whittle in the frequency domain. In order to become semiparametric, only m harmonic frequencies around zero are evaluated. The resulting estimator \hat{d}_{LW} is robust to a certain degree of conditional heteroskedasticity. In fact, it is an approximation to the maximum likelihood estimator of d and more efficient than \hat{d}_{PR} . For both estimators it holds approximately (m large)

$$t_d^{PR} = \frac{\sqrt{24m}}{\pi} (\hat{d}_{PR} - d) \sim \mathcal{N}(0, 1) \quad \text{and} \quad t_d^{LW} = \sqrt{2m} (\hat{d}_{LW} - d) \sim \mathcal{N}(0, 1). \quad (3)$$

The optimal choice of m is of order $T^{4/5}$. Following Henry (2001) we obtain⁶

$$m_{PR} = \left(\frac{27}{512\pi^2} \right)^{1/5} \frac{1}{2^{2/5}} T^{4/5} \quad \text{and} \quad m_{LW} = \left(\frac{3}{4\pi} \right)^{4/5} \left(\frac{1}{2 + d/12} \right)^{2/5} T^{4/5},$$

where we will choose $d = 0$ for m_{LW} , this parameter not being known a priori.

Empirical results For the period after March 08, 2004, we first determine the optimal choice of m_{LR} in order to estimate the long memory parameter d with the log-periodogram regression. The optimal choice is $m = 47$. As a robustness check, we also increase m to

⁵For a rigorous proof of the asymptotic properties see Hurvich et al. (1998).

⁶For x_t in (1) being AR(1), $(1 - aL)x_t = \varepsilon_t$, the optimal m depends on the autoregressive parameter a . The autocorrelogram in Figure 2 suggests $a = 0.5$. That is the assumption that we work with.

see whether the estimation outcome remains stable, see Table 1. With the exception of $m = 57$, the estimates are fairly robust around $\hat{d} = 0.19$. With $z_{0.975} = 1.96$ being the 97.5% percentile of the standard normal distribution, we observe significance at least at the 2.5% level when computing a one-sided test for $d = 0$ (short memory) against $d > 0$ (long memory). At the same time, when testing for $d = 0.5$ (nonstationarity), we clearly reject in favour of $d < 0.5$.

Table 1: Long memory parameter of the Eonia spread: Log-periodogram regression [PR]

m	47	57	67	77	87	97
\hat{d}_{PR}	0.187	0.260	0.196	0.176	0.193	0.188
t_0^{PR}	2.0000	3.0624	2.5032	2.4077	2.8093	2.8879
$t_{0.5}^{PR}$	-3.3476	-2.8268	-3.8825	-4.4323	-4.4687	-4.7926

Note: Estimates for the Eonia spread under the ECB's new operational framework from the log-periodogram regression, and test statistics for $d = 0$ and $d = 0.5$ from (3).

Similar findings are obtained from the local Whittle estimation. With optimal $m_{LW} = 42$ we use this value as starting point, see Table 2. Now, the estimates vary with growing m between 0.20 and 0.25. Their difference from 0 and 0.5 is even more significant.

Table 2: Long memory parameter of the Eonia spread: Local Whittle estimation [LW]

m	42	52	62	72	82	92
\hat{d}_{LW}	0.252	0.249	0.220	0.208	0.219	0.226
t_0^{LW}	3.2685	3.5931	3.4646	3.5314	3.9674	4.3378
$t_{0.5}^{LW}$	-3.2166	-3.6219	-4.4094	-4.9575	-5.0906	-5.2591

Note: Estimates for the Eonia spread under the ECB's new operational framework from Local Whittle estimation and test statistics for $d = 0$ and $d = 0.5$ from (3).

5 Conclusions

For most central banks, overnight rates play a crucial role for signalling and implementing the stance of monetary policy. This paper argued that the controllability of the overnight rate is reflected in the persistence of its deviations from the target level. Motivated by the recent increase in the European Eonia spread, this paper applied recent tests for

long memory to investigate whether the persistence of the spread has changed since the introduction of the ECB's new operational framework in March 2004.

We found that the Eonia spread is $I(0)$ before but fractionally integrated with long memory after March 2004 when the order of fractional integration d has increased to about 0.2. Since $d < 0.5$, the Eonia is still under the ECB's control. However, the increased persistence of the Eonia spread suggests that the degree of controllability of the Eonia spread may have declined.

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