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The Impact of the 2004 Reform of the Operational Framework of the ECB: Structural GARCH Evidence

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Abstract

We investigate the money-market impact of the reform of the operational framework of the European Central Bank that took place in March 2004. We estimate a structural bivariate GARCH model with the overnight rate and 1-year swap rate, where identifying restrictions are imposed on the conditional variances. Differently from previous studies, we use a measure of structural correlation to study the linkages between the short end and the longer end of the term structure of money market swaps. Our results indicate that the 1-year swap segment has decoupled from the overnight rate as the two rates do not co-vary any longer.

JEL classification numbers: C22, E58
Keywords: money market, multivariate GARCH, structural identification

1 Introduction

In March 2004, the European Central Bank adopted a reform to its operational framework for monetary policy. The reform was introduced for two reasons. First, there was the need to limit the volatility for the short maturities of

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the money market term structure at the end of the maintenance period. The reason is that this could have blurred the transmission of monetary policy impulses along the yield curve. Second, to comply with the principle of neutrality of liquidity policy, there was a case for limiting the volatility spillovers from the shorter to the long end of the money market curve (see ECB, 2005b).[3] In order to prevent excessive bidding from taking place during the main refinancing operations, the Governing Council decided to change the timing of the reserve maintenance period, and to shorten the maturity of the main refinancing operations to one week.

A number of contributions have investigated the impact of the 2004 reform. The ECB (2005a, 2006) argues that the reform has contributed to reducing the average volatility of the overnight interest rate. Durré and Nardelli (2008) focus on the role of volatility spillovers. They use estimates of realized variance to show that exogenous shocks to the volatility of the Euro Overnight Index Average (EONIA) rate have no impact on the volatility of the money market rates at longer maturities after March 2004. This suggests that the liquidity management does not affect the transmission mechanism along the money-market yield curve.

In this paper, we measure money market segmentation by studying the correlation of the rates at the two extremes of the maturity profile. In other words, we investigate whether the reform has induced any changes in the correlation between the EONIA rate and the 1-year Euro money market swap rate. This metrics complements the information obtained from looking at the interactions in volatility along the term structure, and focuses on the joint movements of the rates after a shock. We consider the possibility that shocks to the 1-year swap rate can have an impact on the overnight rate, and vice versa.[4] This view is relevant under the assumption that banks operate systematically and contemporaneously in different segments of the money market. For instance, banks could use money-market instruments at different maturities to hedge over liquidity needs, or to minimize the costs of raising funds over a given horizon. As a result, the perspective considered in this paper differs considerably from the standard view of

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[3] Before the implementation of the changes, the reserve maintenance period for private banks started on the 24th of each month and ended on the 23rd of the following month. The duration of the maintenance period was set independently from the dates of the Governing Council meeting. Also, the maturity of the weekly main refinancing operation was two weeks. Given that the tenders were conducted at fixed rates, when the market expected an increase in the key policy rates, banks submitted high bids (overbidding). In other words, banks tended to absorb liquidity before the expected increase in cost would materialise. When there were expectations of interest-rate reductions instead, the bids submitted fell short of the amounts needed to satisfy the reserve requirements (underbidding).

[4] Differently from Zagaglia (2010), however, in this paper we focus on the level of the rates, and not on their volatility.

the money market, which tends to overlook at the linkages between the very short and the long-term parts of the market.

Standard measures of time-varying correlation suffer from an endogeneity problem as they do not allow to distinguish the mechanisms of shock transmission from their exogenous source. To deal with this issue, we estimate a bivariate GARCH model for the EONIA and the 1-year swap with identifying restrictions imposed on the covariance matrix. The structural moments disentangle the effects of exogenous shocks from the endogenous response. The reduced-form moments, instead, embed all the market linkages and do not address the identification problem. Identification through heteroskedasticity has been applied successfully by Rigobon and Sachs (2003b, 2004) to study the relation between monetary policy, macroeconomic events and asset prices.

The results presented in this note for the ‘very short’ and ‘very long’ maturity segments of the Euro area money markets point out an aspect of the 2004 reform of the operational framework that has received little attention. The structural estimates are far lower than the reduced-form estimates of correlation over the entire sample. However the structural correlations drop to nearly zero over the subsample after March 2004. These results suggest that the idiosyncratic factors that drive each part of the market have enhanced the segmentation as the rates do not co-vary any longer.

This paper is organized as follows. The modelling framework is presented in the following section. Section 3 discusses the results. In Section 4, we present some concluding remarks.

2 The Structural Multivariate GARCH Model

Let us assume that the evolution of the variables can be summarized by a structural VAR model

$$Ax_t = \psi + \Phi(L)x_t + \eta_t$$

where η_t is the vector of structural shocks, and A is the structural parameter matrix

$$A = \begin{bmatrix} 1 & a_{12} \\ a_{21} & 1 \end{bmatrix}.$$

Direct estimation of the matrix A through OLS leads to asymptotically-biased estimates, owing to the endogeneity of the variables. For the purpose of identification, we assume that the structural shocks have a zero mean, are independent, and that their variances follow the GARCH process

$$\begin{bmatrix} \eta_1 \\ \eta_2 \end{bmatrix}_t = \begin{bmatrix} \sqrt{h_1} & 0 \\ 0 & \sqrt{h_2} \end{bmatrix}_t \begin{bmatrix} \xi_1 \\ \xi_2 \end{bmatrix}_t ,$$

$$\begin{bmatrix} \xi_1 \\ \xi_2 \end{bmatrix}_t \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \right)$$

with $h_t = \sqrt{h_t}\sqrt{h_t} = V(\eta_t)$ defined as

$$\underline{h}_t = \underline{c} + \Gamma \underline{h}_{t-1} + \Lambda \underline{\eta}^2_{t-1}$$

$$\underline{h}_t = \begin{bmatrix} h_{11} \\ h_{22} \end{bmatrix}_t \qquad \underline{\mathrm{c}} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} \qquad \underline{\eta}^2_{t-1} = \begin{bmatrix} \eta_1^2 \\ \eta_2^2 \end{bmatrix}_{t-1}$$

The matrices Γ and Λ are square with dimension 3. Their elements are restricted to be positive. Since the shocks of the reduced form are a linear combination of the structural shocks, they also have a conditional variance that follows a GARCH process. In particular,

$$\begin{bmatrix} H_{11} \\ H_{12} \\ H_{22} \end{bmatrix}_t = B_l \underline{c} + B_l \Gamma \left(B^2\right)^{-1} \begin{bmatrix} H_{11} \\ H_{22} \end{bmatrix}_{t-1} + B_l \Lambda \left(B^2\right)^{-1} \begin{bmatrix} v_1^2 \\ v_2^2 \end{bmatrix}_{t-1}$$

$$B_l = \begin{bmatrix} b_{11}^2 & b_{12}^2 \\ b_{11}b_{21} & b_{12}b_{22} \\ b_{21}^2 & b_{22}^2 \end{bmatrix} .$$

In this model, the restrictions that yield identification are imposed on the covariance matrix of the reduced form. This, in turn, depends on the heteroskedasticity of the structural shocks.

We should stress that the formulation of Rigobon and Sachs (2003a) does not guarantee that variance-covariance matrices are positive-definite, which is a problem typical of every vector – vech model – GARCH. To deal with this issue, we rely on the BEKK-GARCH model of Engle and Kroner (1995). We assume that the structural form innovations η_t are distributed according to $\eta_t \sim N\left(0, h_t\right)$,

$$h_t = CC' + G h_{t-1} G' + T \eta_{t-1} \eta'_{t-1} T' ,$$

where C is a triangular matrix whose elements are all positive, and G and T are two parameter matrices such that G_{11} and T_{11} are constrained to be positive.

Identification of the structural parameters is achieved through restrictions on the conditional variance-covariance matrix of the reduced form innovations. We begin with the OLS estimates of the reduced-form VAR

$$x_t = c + F(L) x_t + v_t$$

with $c = A^{-1}\psi$, $F(L) = A^{-1}\Phi(L)$. The term $v_t = A^{-1}\eta_t$ indicates the reduced form innovations, whose variance-covariance matrix is a combination of the variance-covariance matrix of the structural form innovations $H_t = A^{-1}h_t A^{-1}$, with

$$H_t = BCC'B' + BGh_{t-1}G'B' + BT\eta_{t-1}\eta_{t-1}'T'B' .$$

In this formulation the variance-covariance matrix of the reduced form innovations is a function of the structural innovations, which we the econometrician does not observe. However, we can use the equality to represent H_t in terms of the reduced form innovations

$$H_t = BCC'B' + BGAH_{t-1}A'G'B' + BTAv_{t-1}v_{t-1}'A'T'B' .$$

Given the positive-definiteness of H_t by construction, we can estimate the model using standard maximum likelihood methods.

Summing up, the advantage of the model discussed here is that the structural innovations are correlated. This introduces a point of novelty that has not been considered in previous studies of the Euro-area money market. Since we estimate the model on the returns on money-market rates at two different maturities, the correlation assumption allows us to provide evidence on the existence of common factors that link the structural form innovations of the two series. Furthermore, comparing the time-variation pattern of the structural and the reduced-form correlations can provide a flavour of the role of money-market linkages.

3 Main Results

The dataset consists of weekly averages of the EONIA and 1-year swap rates, which are plotted in Figure 1. Following the principles of the monetary transmission mechanism, the rates follow the same average path. However, they diverge over the whole sample. During periods of decline, the swap rate drops below the overnight rate. In periods of hike instead, their relative position reverses.

We estimate the model on the returns computed as the first difference of the logarithm. Table 1 reports some sample statistics. The data display the standard features of financial data. The large kurtosis coefficient is indicative of non-normality. The empirical distribution appears also skewed. We also investigate the persistence of the returns. Since Perron and Ng (1996), it is well known that the standard tests for unit roots of Dickey and Fuller (1979) and of Phillips and Perron (1988) suffer from severe size distortions in small samples with outliers and with an undetected fractional order of integration. Hence, to deal properly with these issues, we compute four modified test statistics for unit roots proposed by Perron and Ng (2001). The auxiliary regressions include only a constant. Table 2 reports the test statistics. All the tests reject the null of a unit root at the 5% confidence level. The VAR and BEKK estimates are listed, respectively, in Table 3 and 4.

Two results from the plots of structural variances and the structural correlation are worth stressing. Figures 2 and 3 show that the estimates of the structural variances are higher than the reduced-form variances. In other words, disregarding the linkages between segments uncovers higher variability of the rates. Standard GARCH measures underestimate volatility due to the fact that the linkages between segments dampen the volatility of the shocks to the interest rates. From Figures 2 and 3, one can also notice that the peaks in the structural variances take occur on the same days of the peaks in the structural conditional variances. This means that when volatility is low the shocks in the two markets are negatively correlated, while they are positively correlated in periods of high volatility. This evidence can be due to the fact that the financial contracts underlying the two interest rates are substitutes, so that a shock to one rate implies an opposite shock to other rate.

Figure 4 compares the reduced-form and the structural conditional correlation. The reduced-form correlation swings between positive and negative values all throughout the sample. Before the 2004 reform of the operational framework, the average reduced-form correlation is negative, whereas it turns close to zero right after the reform. This suggests that shocks on one the yields induces a systematic response of the other yield. As argued earlier, reduced-form correlations provide no information on the joint movements of the rates after exogenous shocks to either yield. In this sense, one should focus on the structural correlation. Structural correlations are far smaller than reduced-form correlations. In orther words, being unable to disentangle the role of exogenous shocks generates an overestimation of the linkages between rates. Figure 5 provides an enlarged picture of the structural correlation. Before March 2004, there are frequent peaks. The structural correlation also varies on a scale larger than in the subsequent period. The subsample after March 10 2004 has a mean of less than one tenth the mean of the rest of the sample. A *t*-test of equality between the means of the two subsamples yields a *p*-value equal to 2e-9, which suggests that a statistically-significant fall in the mean has taken place. In other words, the reform of the ECB operational framework has insulated the EONIA segment from that of the 1-year swap rate also in terms of correlation between the rates.

4 Conclusion

This paper studies the impact of the reform of the ECB operational framework introduced in 2004. We focus on the segmentation of the money market by considering the relation between the very-short end and the longer end of the money market. In particular, we estimate a measure of correlation between the EONIA rate and the 1-year swap rate that is structural, in the sense that it does not suffer from endogeneity. For this purpose, we estimate a bivariate GARCH model by imposing structural restrictions on the covariance matrix. The empirical results uncover an interesting pattern. Considering only the spillovers in volatility along the term structure of the money market. Following the reform, there is a sudden drop in correlations. In other words, the EONIA and the 1-year swap rate stop moving in tandem. This suggests that the 2004 reform of the operational framework has increased the segmentation of the money market, regardless of the transmission of volatility shocks.

The analysis presented in this paper can be extended in several relevant ways. First of all, a multivariate model of the entire maturity structure of swap rates could provide the ground for a robustness analysis of our results. This would require us to consider a more parsimonious model of GARCH dynamics, such as the standard Dynamic Conditional Correlation model. Our findings raise the question of why the correlation between the short and the long-end of the swap curve drops in 2004. In particular, it would be important to investigate how the demand for liquidity changes along the term structure. This would obviously related to the determination of asset-liability management strategies of banks, and how these schedule their demand for loans in the money market over alternative planning horizons.

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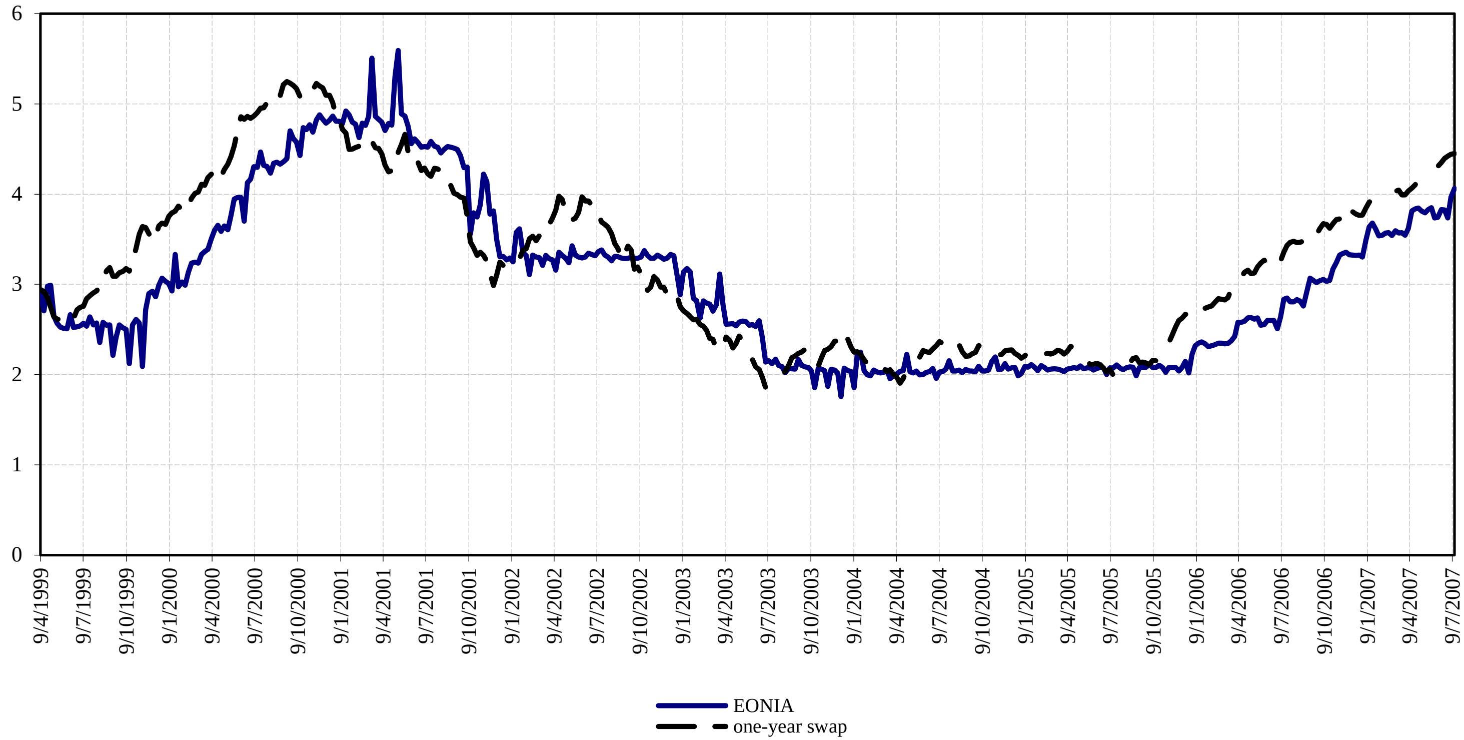

Figure 1: EONIA and 1-year swap rate

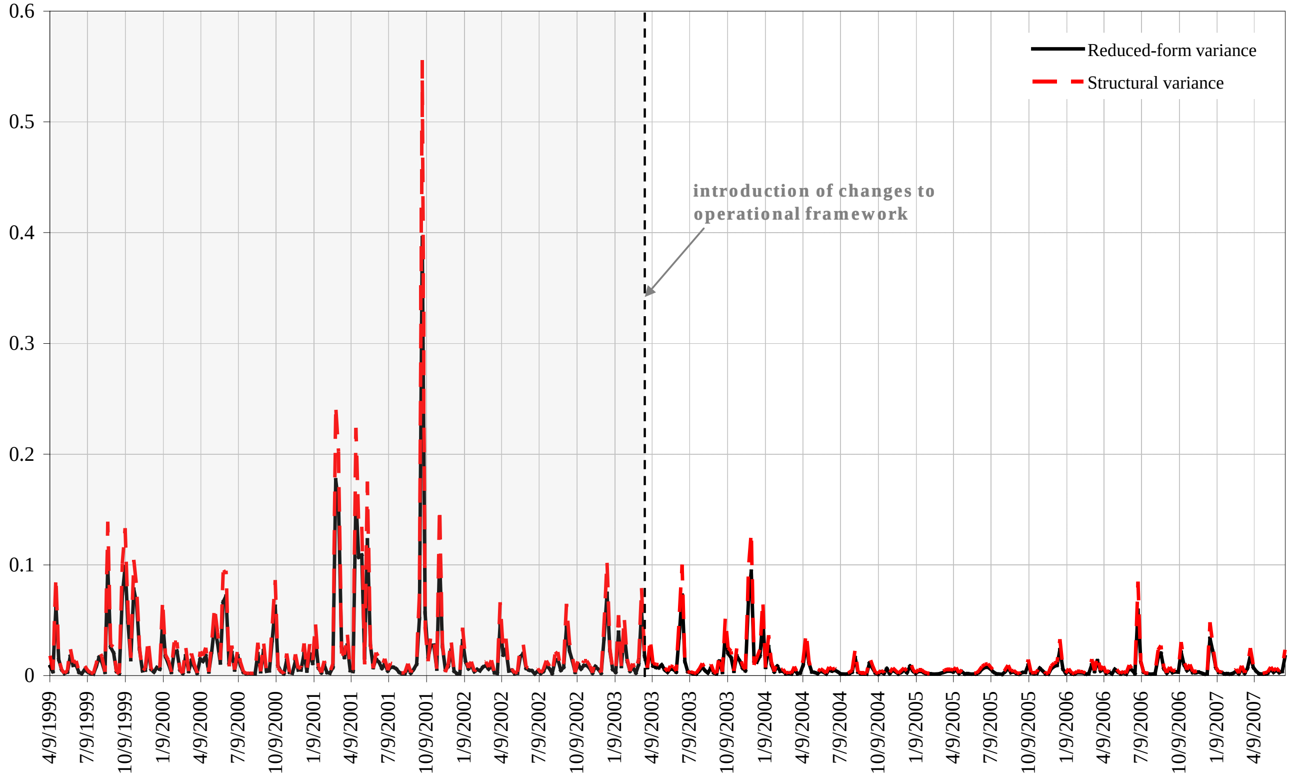

Figure 2: Reduced and structural-form variance of EONIA rate

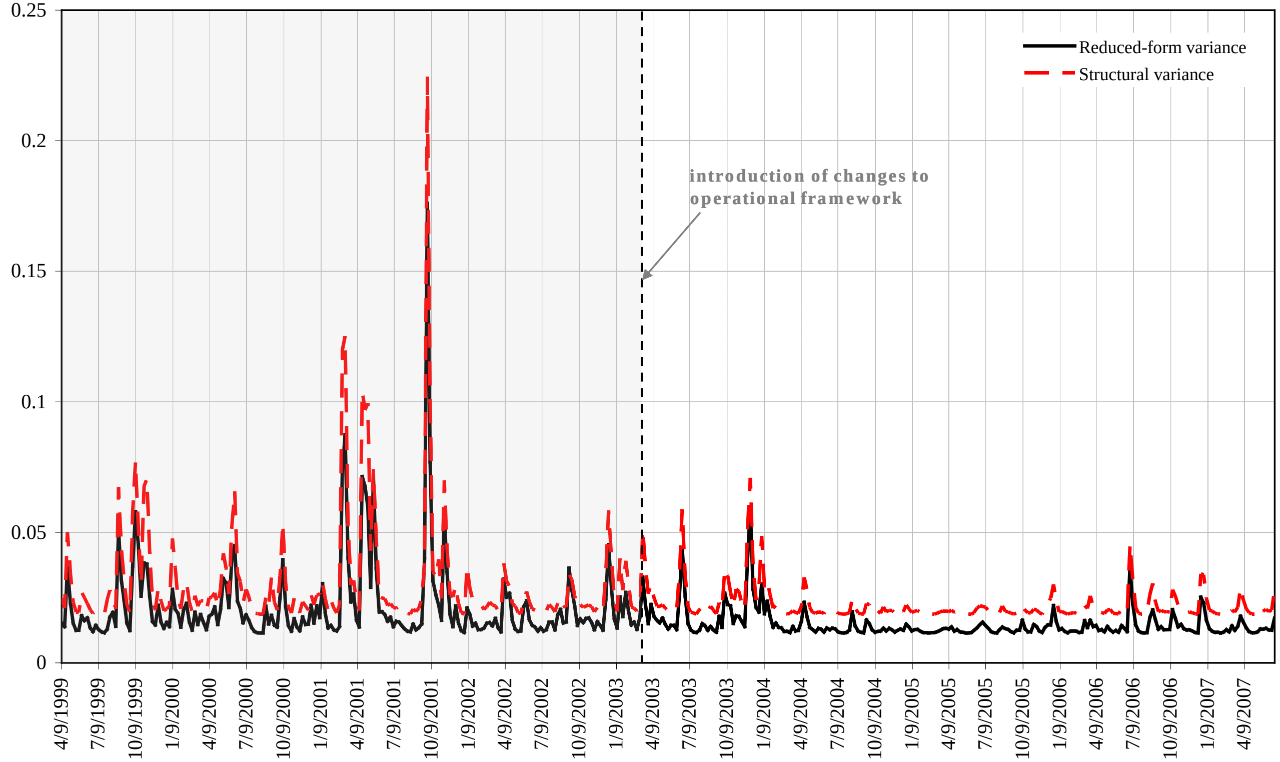

Figure 3: Reduced and structural-form variance of 1-year swap rates

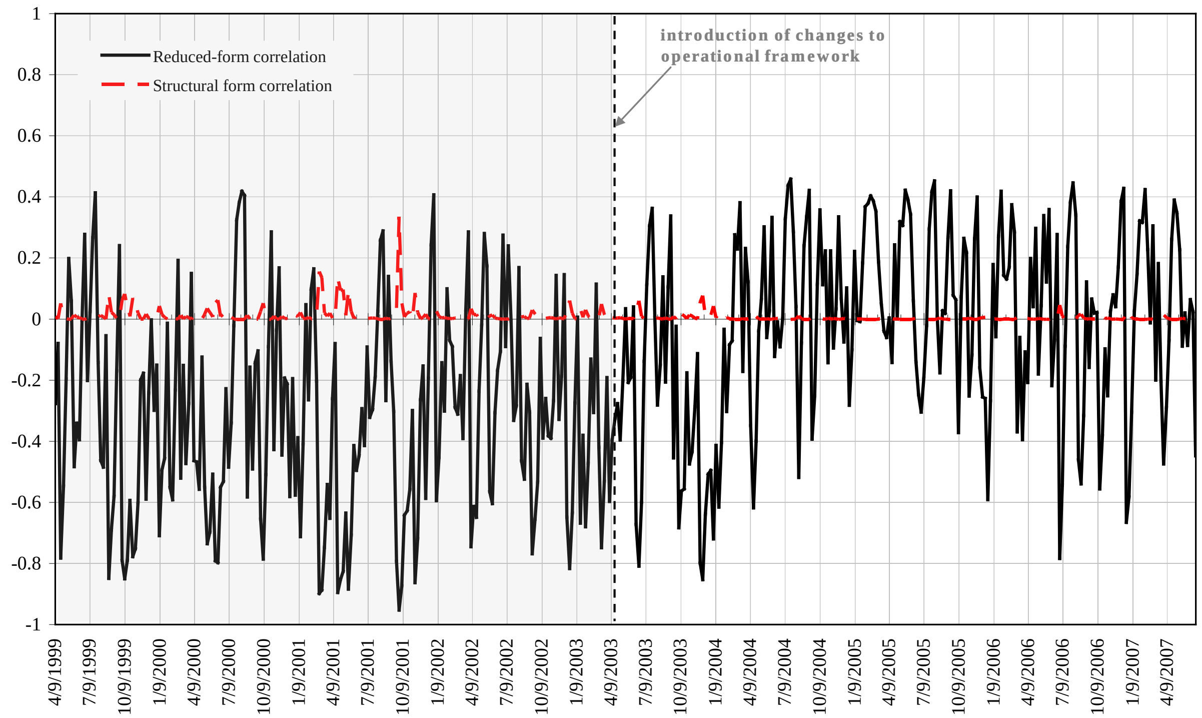

Figure 4: Reduced and structural-form correlation between EONIA and 1-year swap rates

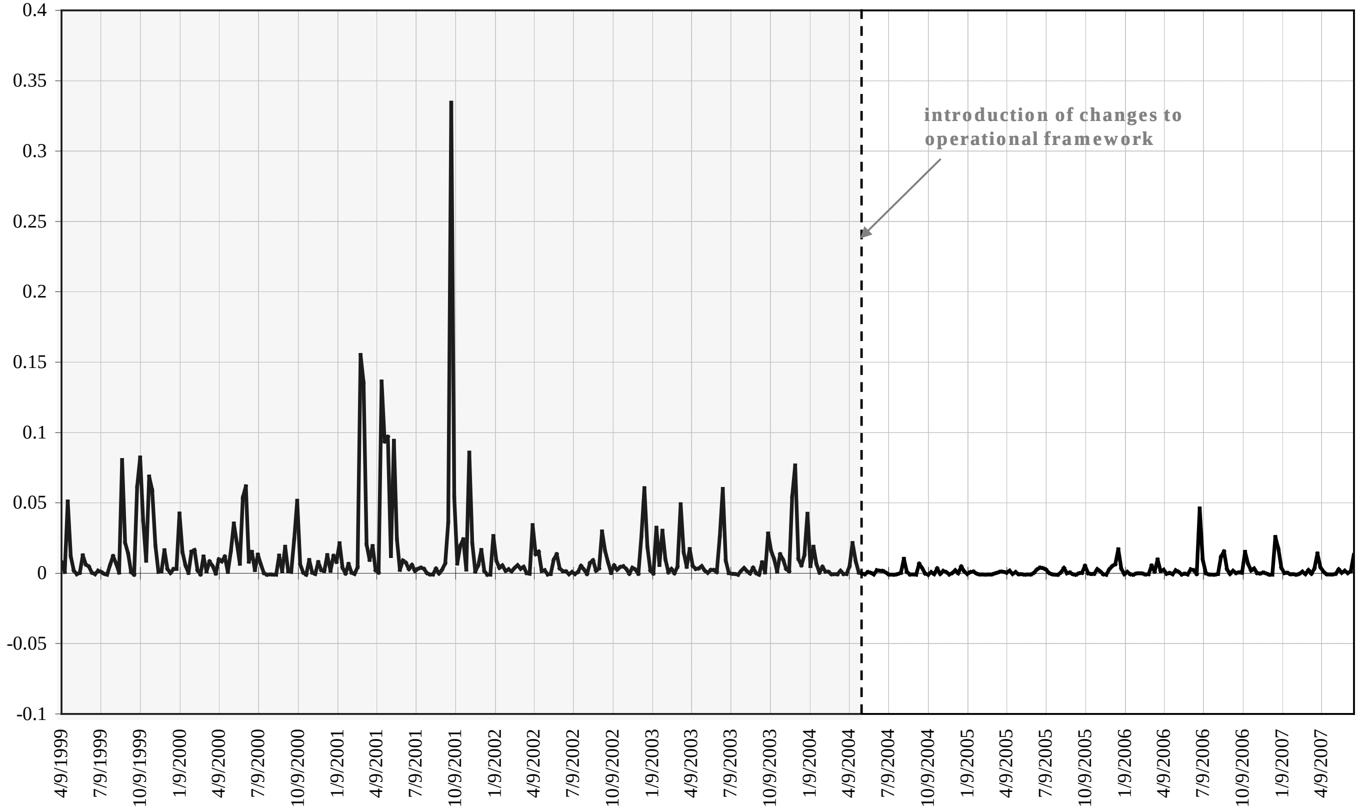

Figure 5: Structural-form correlation between EONIA and 1-year swap rates

Table 1: Sample statistics of returns on EONIA and 1-year swap rates

Statistics	EONIA rate	1-year rate
Mean	0.0028	0.0035
Minimum	-0.7400	-0.2880
Maximum	0.6460	0.1720
Standard deviation	0.1364	0.0613
Skewness	-0.2991	-0.4565
Kurtosis	10.7151	4.5456

Table 2: Unit-root tests on the differenced series

	EONIA	1-year swap
MZ_α	-20.5020*	-18.5497*
MZ_t	-2.9995*	-3.0665*
ADF	-3.6297*	-3.1175*

Legend: The autoregressive models include both a constant and a linear trend. Their order is chosen by minimizing the AIC. (*) rejection at the 5% level.

Table 3: Parameter estimates of the VAR(2) model

Parameter	Estimate	t statistics
EONIA rate		
ψ_1	0.003	0.455
$\Phi_1(1)$	-0.246	-5.029
$\Phi_1(2)$	-0.445	-2.968
$\Phi_2(1)$	0.184	3.244
$\Phi_2(2)$	0.935	2.308
1-year swap rate		
ψ_2	0.002	0.880
$\Phi_1(1)$	-0.215	-2.727
$\Phi_1(2)$	0.350	2.423
$\Phi_2(1)$	0.415	8.463
$\Phi_2(2)$	-0.258	-4.192

Legend: The variables are ordered as EONIA rate and 1-year swap rate.
Figures in parenthesis indicate the lag. Figures in subscript indicate the EONIA – 1 – and the swap rate – 2.

Table 4: Parameter estimates of the BEKK-GARCH model

Parameter	Estimate	t statistics
c_{11}	0.343	3.678
c_{21}	1.031	12.831
c_{22}	1.939	26.955
a_{12}	-4.057	-3.841
a_{21}	2.876	6.635
g_{11}	0.743	8.679
g_{12}	-0.979	-3.179
g_{21}	-0.729	-3.040
g_{22}	0.864	3.624
t_{11}	0.475	4.964
t_{12}	0.873	8.478
t_{21}	0.314	9.059
t_{22}	0.683	7.558