Why does the Interest Rate Decline Over the Day? Evidence from the Liquidity Crisis*

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Abstract

We provide a simple model, able to explain why the overnight (ON) rate follows a downward intraday pattern, implicitly creating a positive intraday interest rate. While this normally reflects only some frictions, a liquidity crisis introduces a new component: the chance of an upward jump of the ON rate, which must be compensated by an intraday decline of the ON rate. By analyzing real time data for the e-MID interbank market, we show that the intraday rate has increased from a negligible level to a significant one after the start of the liquidity crisis in August 2007, and even more so since September 2008. The intraday rate is affected by the likelihood of a dry-up of the ON market, proxied by the 3M Euribor - Eonia swap spread. This evidence supports our model and it shows that a liquidity crisis impairs the ability of central banks to curb the market price of intraday liquidity, even by providing free daylight overdrafts. Such results have implications for the efficiency of the money market and of payment systems, as well as for the operational framework of central banks.

Keywords: interbank market, intraday interest rate, financial crisis, liquidity risk

JEL Codes: E4, E5, G21

1 Introduction

The shortest maturity of the yield curve is the overnight (ON), since an explicit market for intraday loans does not exist. However, an intraday interest rate may implicitly be defined by the difference between the interest rates on two ON loans, delivered at different

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times within the same day (provided they are repaid at the same time next day). For example, the difference between the ON rates in the morning and in the afternoon may be interpreted as the interest earned on a "synthetic" intraday loan, made up by lending ON in the morning and borrowing the same amount in the afternoon. Therefore, a positive intraday rate emerges whenever the ON rate shows a declining pattern within the same business day.

There are good reasons to believe that a zero level for the intraday interest rate is optimal; in other words, efficiency calls for a flat intraday pattern of the ON rate. There are two streams of literature supporting this view. The first one is focussed on payment systems, and it shows that a positive intraday rate may induce individual banks to delay payments, putting a negative externality onto the banking system (see Angelini 1998, Bech and Garratt 2003, Mills and Nesmith 2008, Martin and McAndrews 2008). The issue of "delayed payments" have raised the concern of policymakers for its impact on the operational risk in the payment systems (see FED 2006, 2007). The second one focusses on the role of money as a medium of exchange. For example, Zhou (2000) distinguishes between "consumption/investment debt" and "settlement debt": since the latter does not affect the inter-temporal allocation of resources, the intraday rate is just a transaction cost which should be minimized. In Martin (2004) and Bhattacharya *et al.* (2007) a zero level of the intraday rate provides an insurance for consumers against liquidity shocks.

These arguments provide the rationale for the intervention of central banks, providing free daylight credit to the banking system. For example, the Eurosystem does not charge any fee on daylight overdrafts. The provision of free intraday credit by the central bank should prevent the (implicit) market price of intraday liquidity from reaching a significant level. This kind of intervention normally works pretty well: Baglioni - Monticini (2008) find an extremely low level of the intraday rate in euro area (an hourly rate of half basis point).

To the contrary, the ability of central banks to curb the market price of intraday liquidity seems to be impaired in a situation of liquidity crisis. Some preliminary evidence is provided in Baglioni - Monticini (2010), finding that the hourly rate jumped by ten times in August 2007. In this work we propose a theoretical rationale for such an outcome and we provide an extensive empirical evidence supporting our view.

We build up a simple model, where two components of the intraday rate are identified. The first one is due to some frictions, related to settlement procedures and to the cost of central bank intraday credit: this is the only component at work under normal circumstances, and it has been the focus of the literature so far (see the above references and VanHoose 1991). A liquidity crisis introduces a second component, which is related to the chance of an upward jump of the ON rate within the day, due to some news originating a hoarding of liquidity in the money market; under such conditions the central bank might be unable to reach its target level for the ON rate[1]. We show that an expected upward jump

[1] We are indebted to William Roberds for suggesting this approach to us.

of the ON rate must be compensated by an intraday decline of the ON rate, given that the jump does not actually occur. That's why we expect to observe an intraday interest rate of relevant size under a situation of liquidity stress.

These predictions are supported by the empirical evidence we provide for the euro area. By analyzing real time data for the e-MID interbank market (from January 2007 to April 2009), we show that the implicit intraday interest rate has increased from an extremely low level to a significant one after the start of the liquidity crisis in August 2007, and even more so since September 2008, when some dramatic events made the financial crisis worse. Moreover, the estimated intraday rate depends on the spread between the three month Euribor and the Eonia swap rates, that we use as a proxy for those factors − liquidity and counterparty risks − affecting the likelihood of a liquidity dry-up, where the central bank might loose control over the ON interest rate.

2 Identifying the components of the intraday interest rate

Let us consider an interbank market where overnight (ON) loans are traded. The business day is divided into two periods: $t = 1, 2$. We can think of $t = 1$ as the early operating hours (say the morning) and of $t = 2$ as the late operating hours (say the afternoon). The ON interest rate in each period is denoted by R_t. Of course, this is a stylized description: actually the interbank market is operational along the whole business day; however, the identification of a "morning session" and an "afternoon session" is quite useful here for expositional purposes. On empirical grounds, the morning ON interest rate will be computed as an average across all the trades taking place between 9 a.m. and 1 p.m., and the afternoon rate as an average across all the trades taking place between 2 p.m. and 6 p.m. (see section 3.1 below).

The ON interest rate in the morning (R_1) is linked to the expected afternoon rate ($E(R_2)$, where $E()$ is the expectation based on the information available at $t = 1$) by a simple argument. Assume that banks are risk neutral and that free intraday overdrafts are available from the central bank. On one side, if $R_1 > E(R_2)$, banks may profit by lending ON in the morning and borrowing ON in the afternoon: this is equivalent to lending money intraday, funding such loan by drawing on the intraday central bank facility; absent any cost, this enables a bank to earn an expected profit equal to $R_1 - E(R_2)$. On the other side, if $R_1 < E(R_2)$, a bank may profit by borrowing in the morning in the ON market, deposit the borrowed amount at the central bank, and lending it back in the ON market in the afternoon. Therefore, in equilibrium R_1 should not deviate from $E(R_2)$.

Actually there are some reasons why R_1 may be expected to be slightly above $E(R_2)$. First, the intraday credit from the central bank is not completely costless. In the euro area, the cost of an intraday loan from the Eurosystem comes from the collateral requirement. In the USA the Fed charges a small fee on intraday overdrafts[2]. Second, real time settlement

[2]See ECB (2008) and McAndrews - Rajan (2000) for institutional details on the euro area and the US

procedures for payments, securities and foreign exchange transactions introduce a positive time value of money within the business day: banks prefer to have liquidity available early in the day rather than later. Both these ”frictions” limit the convenience of engaging in the first kind of trade described above (intraday lending). Thus we may expect the following relationship to hold:

$$R_1 = E(R_2) + k \tag{1}$$

where k stands for the above mentioned frictions[3].

Now, let us define the intraday interest rate (i) as the difference between the ON rate in the morning and in the afternoon:

$$i \equiv R_1 - R_2 \tag{2}$$

which is the interest earned on a ”synthetic” intraday loan, made up by lending ON at $t = 1$ and borrowing at $t = 2$.

We label as d the difference between the expected value of the afternoon ON rate, based on the information available in the morning, and its realized level:

$$d \equiv E(R_2) - R_2 \tag{3}$$

Then, by substituting (1) into (2), the intraday interest rate turns out to be:

$$i = k + d \tag{4}$$

Of course, it is $E(d) = 0$ and $E(i) = k$: on average, the intraday rate should only reflect the cost of central bank intraday credit and some frictions related to settlement systems.

2.1 Normal times

The above framework is quite general. We can be more specific, by considering that the central bank targets the ON rate at some level r: this is the key rate signalling the monetary policy stance. In order to hit this target, the central bank supplies an amount of bank reserves able to meet the level demanded by the banking system for such level of the ON rate. The central bank has to forecast the liquidity shocks, affecting the supply of reserves, due to exogenous factors (e.g. payments to/from the public sector). In addition, an estimate of the daily demand for bank reserves has to be available. In presence of a reserve requirement with an averaging scheme (this is the case in the US, UK and the euro area), the demand for reserves is affected by the opportunity of engaging in inter-temporal arbitrage: this is a stabilizing device, which significantly contributes to meeting the target

respectively.

[3]Those frictions are discussed in more detail in Baglioni - Monticini (2008).

level for the ON rate, together with monetary policy operations.

Forecast errors related to liquidity shocks and possible shifts of the demand for bank reserves may cause the actual ON rate to deviate from the target level r. However, we may reasonably assume that the central bank is on average able to achieve its target[4]. This assumption implies that $E(R_2) = r$, and $d = r - R_2$. Of course, $E(i) = k$ still holds: the average level of the intraday rate depends only on the size of the friction parameter k, which we expect to be small in general.

2.2 Liquidity crisis

We can incorporate a liquidity crisis into our framework, by introducing a (small) probability that the ON rate jumps during the day to a level above the central bank target. The interbank market might "dry-up", due to a hoarding behavior by participants: banks prefer to accumulate excess liquid reserves rather than lend them out in the market, leading to an aggregate excess demand for liquidity. The banking literature has identified several reasons behind liquidity dry-ups in the money market: (i) coordination failures among market participants (Rochet - Vives 2004, Huang - Ratnovski 2008, Freixas *et al.* 2009, Acharya *et al.* 2009); (ii) contagion through the chain of interbank claims (Allen - Gale 2000 - 2007, Muller 2006, Goldsmith-Pinkham - Yorulmazer 2010); (iii) adverse selection due to counterparty risk together with hidden information (Flannery 1996, Heider *et al.*2009, Eisenschmidt - Tapking 2009, Baglioni 2012). Whatever its ultimate origin, in a liquidity crisis market participants face the risk that market conditions might suddenly worsen, due to a negative shock hitting the market, for example: the bankruptcy of a large financial institution, having obligations with many other market participants; the default of a country affected by large financial imbalances. Under such conditions the central bank might be unable to reach its target rate: either because there is no time to supply additional liquidity within the same day in which the negative news has been released, or because any injection of liquidity through open market operations is offset by the hoarding behavior of banks.

We assume two states of nature: $s \in \{0, 1\}$. With probability π, it is $s = 1$; this is the "jump state", such that $E(R_2 \,|s = 1) > r$: the expected afternoon ON rate, conditional on this state, is well above its target level. Otherwise, it is $E(R_2 \,|s = 0) = r$: outside the jump state, the central bank is still able to achieve its target on average[5]. Therefore, the

[4]Only on settlement days (i.e. at the end of the maintenance period of the reserve requirement) the ON rate may be expected to exhibit large deviations from the target level, due to the need of meeting the reserve requirement without the flexibility allowed by the averaging facility; this is the reason why those days will be excluded from the empirical analysis below.

[5]Note that this assumption is not necessary for our results. All we need is that $E(R_2 \,|s = 1) > E(R_2 \,|s = 0)$. The extension of the model to this more general case is straightforward. We stick to the more restrictive version, as we believe it to be more realistic (except when the ON rate deviates from the policy rate for a substantial time span).

morning expectation of the afternoon ON rate is:

$$E(R_2) = (1-\pi)r + \pi E(R_2\,|s=1) > r \tag{5}$$

Let us now focus on those days where no jump takes place. It is easy to see that:

$$E(d\,|s=0) \equiv E(R_2) - E(R_2\,|s=0) = \pi\,[E(R_2\,|s=1) - r] \tag{6}$$

which in turn implies that:

$$E(i\,|s=0) \equiv k + E(d\,|s=0) = k + \pi\,[E(R_2\,|s=1) - r] \tag{7}$$

Thus the chance of a jump of the ON rate during the day introduces another component into the intraday interest rate: the *expected jump*, adding to the friction parameter k. This should allow us to observe a significantly larger value of the intraday rate during the liquidity crisis, as long as no jump actually takes place.

The intuition behind this result is the following. On one side, a borrowing bank is ready to pay a higher rate on an interbank ON loan delivered in the morning rather than in the afternoon, to cover the risk that the ON rate jumps, due to some negative shock possibly occurring within the same day. On the other side, a lending bank asks a premium for trading early rather than later in the day: she must be compensated for loosing the chance of lending at a higher rate later. Therefore, the chance that the *ON rate might jump upward* during the day must be compensated by an *intraday decline* of the ON rate, given that the jump does not occur; in other words, a positive and significant intraday interest rate should emerge under such conditions. This is the hypothesis that we are going to test in the next section.

By the way, this argument parallels the one made by Lyons and Rose (1995) in a different context. They show that, in case of a currency crisis, the devaluation risk affecting a weak currency must be offset by a systematic intraday appreciation of that currency, given that no devaluation actually occurs. Absent this appreciation, an agent shorting the currency and closing his position within the same day would enjoy an expected profit at no cost, assuming a zero intraday interest rate (which is a good approximation of reality under normal conditions in the money market). Equivalently, an agent holding the currency suffers an expected intraday loss which is not compensated by an interest rate differential: hence he must be compensated by an intraday appreciation of the currency. A similar reasoning applies in our framework: absent an intraday decline of the ON rate, all banks short of liquidity would benefit from trading early in the day in the interbank market, while the opposite were true for those long of liquidity; then in equilibrium the ON rate should exhibit a declining intraday pattern[6].

[6]It is worth noting the substantial difference between our result and that obtained by Angelini (2000). In his approach, risk averse banks shift their interbank trades to the morning to offset a high intraday volatility of the ON interest rate; *both* lenders and borrowers share the same interest, namely to cover from

3 Empirical evidence

3.1 Data set

Our sample includes all ON trades taking place in the e-MID market in the time span going from January 17th 2007 to April 6th 2009. Our real time data set includes 100,148 observations. The e-MID platform is an electronic marketplace for interbank loans in the euro area. It is located in Italy, but it is quite representative of the money market of the whole euro area, since more than 200 counterparties from all over Europe have access to the system and they actively trade on it. The ON interest rate in the e-MID market is closely related to the Eonia rate, which is the euro ON index computed daily by the European Banking Federation[7].

We use our data to build up a daily time series of the intraday interest rate, following the definition introduced above (see equation 2). For each business day in our sample, we compute the average interest rate for the ON trades taking place between 9 a.m. and 1 p.m.: this is the morning rate (R_1). Similarly, we compute the average rate of the ON trades taking place between 2 p.m. and 6 p.m.: this is the afternoon rate (R_2). The difference (i) between R_1 and R_2 is the intraday interest rate.

As we pointed out in Section 2.2, our model predicts that we should be able to observe a larger intraday interest rate during the liquidity crisis, provided the afternoon ON rate does not show any abnormal behavior, or equivalently outside the "jump state". Actually we are not able to detect any day in our sample, where the ON rate jumped to an unusually high level, compared to the monetary policy target level. This can be due to the fact that no extreme event, such as the bankruptcy of a large financial institution, took place within the euro area during the time period under analysis. Of course, this *ex post* observation does not exclude that market participants did *ex ante* perceive the risk that such an event might possibly occur in the near future.

An extremely high volatility of the ON rate is usually observed in the last day of the maintenance period of the compulsory reserve, for the following reason. The reserve requirement is applied to the average end-of-day balances held in reserve accounts over the whole maintenance period, enabling banks to substitute the reserve of one day with that of some following day (within each period); of course, this stabilizing mechanism is not available in the last day of a maintenance period. As a consequence, in such days we can observe spikes and crashes of the ON interest rate; these are due to a purely technical reason which makes such days different from all the other days. Therefore we consider such days as non informative and we have excluded them from our sample. Ashcraft et al. (2011) find another source of volatility of the interbank interest rate, namely the limited

interest rate risk. This typically happens in settlement days. Bank risk aversion is not necessary in our approach.

[7]The correlation coefficient (computed with daily data) between the two interest rates has been 0.95 in our sample period.

participation constraints faced by small banks; this feature of the federal funds market in the U.S. is not shared by the European e-MID market, so this source of volatility is not present in our sample.

Finally, to make sure that our empirical analysis includes only days where the ON rate lies reasonably near to the target level set by the monetary policy ("no jump state" in our model), for each reserve maintenance period in our sample we have computed the 95% confidence band for the afternoon rate, and we have excluded all those days where the afternoon rate lies outside such a band. In the end, our daily time series of the intraday interest rate includes 520 observations.

3.2 Descriptive evidence

A preliminary look at the data is quite suggestive. The daily time series of the intraday interest rate is plotted in Figure 1. It is evident that the intraday rate is quite low and stable from the beginning of the sample through July 2007. Starting with the outset of the liquidity crisis (August 9th 2007: first vertical line), the intraday rate is significantly higher and more volatile. Following the Lehman Brothers collapse (September 15th 2008: second vertical line) and other well known crucial events, the intraday rate shows an even higher level and volatility, lasting until the end of our sample. The average intraday rate increased significantly across the three sub-periods, raising from 0.9 b.p. before the crisis to 3.8 b.p. in the second sub-period, and further to 13.2 b.p. in the time interval after the L.B. crash[8].

Our model implies that this sharp increase of the intraday interest rate is due to the likelihood that the ON rate might jump well above the central bank target during the afternoon session (see the expected jump component in equation (7) above); this prediction will be tested below. Another possible explanation is that the friction parameter (k) has increased substantially during the financial crisis, and the main candidate is the cost of the collateral needed to obtain intraday credit from the ECB. It is true that the cost of the collateral has presumably increased during the crisis: the ECB has remarkably enlarged the amount of liquidity provided to the banking sector (at different maturities), and this has made the eligible securities a scarce resource (since all ECB loans are collateralized). However, we believe that the magnitude of the observed rise of the intraday rate is so large that it can hardly be explained by a rise of the transaction costs alone.

3.3 Regression analysis

In order to test our model, we need a proxy for the risk that the ON rate might jump within the day well above the monetary policy target level. In other words, we need a

[8]We have tested the null hypothesis of equal mean between the first and second sub-samples, and between the second and third ones. In both cases, the null hypothesis is rejected by the parametric Welch two sample t-test and by the non-parametric Wilcoxon rank sum test at the 1% level.

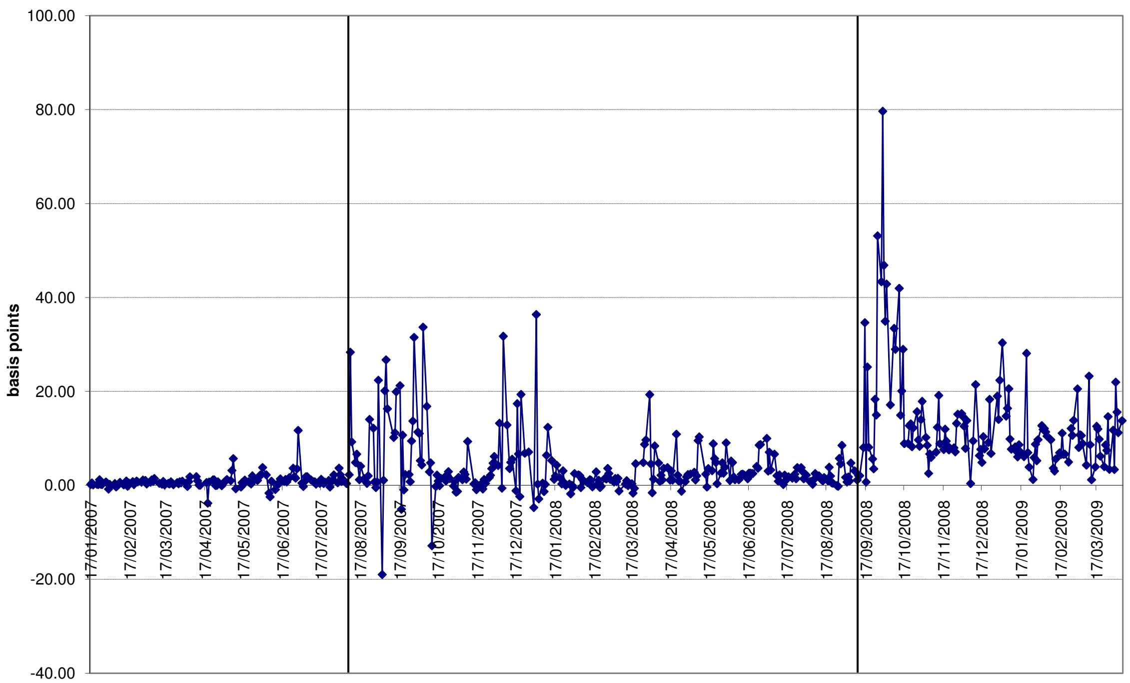

Figure 1: Intraday Interest Rate

proxy for the "expected jump" term appearing in the RHS of equation (7). An obvious candidate is the spread between the three month Euribor and the three month Eonia swap rate (hereafter "spread"). This is a well known indicator, often used in the analyses of the liquidity crisis. It reflects both the liquidity and the counterparty risks perceived by the participants in the money market; at the same time, it is not affected by expected changes of the level of interest rates within the three month horizon. Both the Euribor and the Eonia swap rate are calculated at 11 a.m., using the information provided by a panel of primary European banks[9]. Suppose this morning the spread is larger than yesterday: this may be taken as an indicator that the liquidity and counterparty risks perceived by market participants have gone up, presumably reflecting the release of some negative news. Then we take the daily change of the spread ("$\Delta spread$") as an indicator of news possibly able to alter the likelihood of a jump of the ON rate within the day.

The following regression (Model 1) has been run, where: i_t is the intraday interest rate in day t; $\Delta spread_t$ is the change of the spread in day t from the previous day; $D1_t$ is a dummy variable taking value 1 in the first period of the financial crisis (2007/08/09$\leq t \leq$2008/09/14) and zero otherwise; $D2_t$ is a dummy variable taking value 1 in the second crisis period (2008/09/15$\leq t \leq$2009/04/06) and zero otherwise; a linear $Trend_t$ is included; finally, $\varepsilon_t \sim i.i.d.\left(0, \sigma_t^2\right)$ with possibly $\sigma_t^2 \neq \sigma_s^2$ for $t \neq s$.

$$i_t = c + \beta_0 \Delta spread_t + \beta_1 D1_t + \beta_2 D2_t + \beta_3 Trend_t + \varepsilon_t \qquad \text{(Model 1)}$$

We expect all the coefficients β_0, β_1 and β_2 to be positive, reflecting the link between the likelihood of a jump of the ON rate and the intraday decline of the ON rate itself, as predicted by our model. In particular: β_0 should capture the effects of daily news hitting the money market and being reflected in the above defined spread; β_1 should capture the average increase of the intraday interest rate during the liquidity crisis, when the expected jump is supposed to be added to the frictions normally affecting the intraday rate (see equation 7); β_2 should capture the further increase of the average intraday rate after the Lehman Brothers collapse, when the danger of a liquidity dry-up, leading to a jump of the ON rate, grew substantially.

Regression results for Model 1 are shown in Table 1. All the coefficients have the expected sign and they are highly significant[10]. In particular, the estimate for β_0 shows that a change of the (3M Euribor - Eonia swap) spread leads to a considerable change $-$ in the same direction $-$ of the intraday rate. The dummy coefficients confirm that the intraday rate has shown a remarkable increase during the liquidity crisis: the estimated intercept for the first crisis period (starting on August 9th 2007) is larger by almost 7 b.p.

[9] They are provided by the European Banking Federation. See http://www.euribor.org/ for detailed information and for daily data.

[10] The standard errors have been obtained by heteroskedasticity and autocorrelation consistent (HAC) covariance matrix estimators with Bartlett kernel (see Andrews and Monahan 1992). We have also run a regression using the Cochrane-Orcutt approach and standard errors based on the wild bootstrap (see Davidson et al. 2007): the results, which are available upon request, are very similar.

than in the pre-crisis period, and it is larger by 20 b.p. in the second crisis period (starting with the L.B. crash). The extremely low estimated value of β_3 (although statistically significant) tells us that, within each of the two crisis sub-periods, the intraday rate, after showing a sharp increase, has followed a slightly declining trend.

The above analysis can be extended to consider specific factors and events affecting the likelihood of a liquidity dry-up in the money market. We take a step in this direction by including in our regression model the ECB policy rate, namely the minimum bid rate on its main refinancing operations (fixed rate since mid-October 2008), denoted by r_t. We want to check whether the announcement of an easier monetary policy stance has been able to lower the likelihood of a liquidity shortage, by signalling that the central bank is ready to increase the supply of bank reserves, thus providing more liquidity to the money market. If this is the case, a reduction of the policy rate should have been able to lower the intraday interest rate, during the period of financial turmoil. The following Model 2 has been estimated, where all the other variables have the same meaning as in Model 1.

$$i_t = c + \beta_0 \Delta spread_t + \beta_1 D1_t + \beta_2 D2_t + \beta_3 Trend_t + \beta_4 r_t + \varepsilon_t \qquad \text{(Model 2)}$$

The regression results (see Table 1) show that the impact of the ECB interventions has been significant but rather small: a change of the policy rate by 50 b.p. has an estimated impact of less than 2 b.p. on the intraday rate. However, this estimate measures the effectiveness of several monetary policy actions over the whole sample period, thus under quite different conditions.

Therefore, we undertake a more detailed analysis in Model 3 below, where − instead of the policy rate variable − each change of the policy rate is included as a dummy variable. We have 8 variables of this kind in our sample period, labelled as DP_{jt} with $j = 1, ..., 8$. For example: $j = 1$ stands for the change of March 2007, and DP_{1t} takes value 1 starting with the date of the announcement ($t \geq$2007/03/08) and zero otherwise.

$$i_t = c + \beta_0 \Delta spread_t + \beta_1 D1_t + \beta_2 D2_t + \beta_3 Trend_t + \sum_{j=1}^{8} \gamma_j DP_{jt} + \varepsilon_t \qquad \text{(Model 3)}$$

The regression results (see Table 1) show that only one monetary policy intervention had a significant effect, namely the 50 b.p. reduction of the policy rate announced on October 8th 2008 (effective October 15th). At the peak of the liquidity crisis, this action has been able to reduce the intraday rate by almost 10 b.p. (this estimate confirms the impression given by Figure 1). All the other changes of the policy rate did not have any significant impact on our dependent variable. So, with one important exception (October 2008), these results support the view taken in some theoretical models of the money market (referred to in Section 2.2), where the counterparty risk − together with asymmetric information

Table 1: Dependent variable: i_t (p.p.). Daily data: 2007/01/17 - 2009/04/06. Number of observations: 520.

independent variable	**Model 1**	**Model 2**	**Model 3**
c	0.022^{***} (0.005)	-0.112^{***} (0.065)	0.007^{***} (0.0024)
$\Delta spread$ (p.p.)	0.548^{***} (0.214)	0.444^{***} (0.154)	0.380^{***} (0.0129)
$D1$	0.069^{***} (0.017)	0.052^{***} (0.016)	0.0487^{***} (0.017)
$D2$	0.206^{***} (0.037)	0.227^{***} (0.042)	0.286^{***} (0.079)
$Trend$	-0.0002^{***} (0.000)	-0.0001^{***} (0.000)	-0.0001^{***} (0.000)
Policy Rate (r)		0.035^{***} (0.017)	
March 2007 (DP_1)			0.01 (0.007)
June 2007 (DP_2)			0.01 (0.007)
July 2008 (DP_3)			-0.0002 (0.010)
October 2008 (DP_4)			-0.098^{***} (0.03)
November 2008 (DP_5)			-0.004 (0.032)
December 2008 (DP_6)			0.022 (0.022)
January 2009 (DP_7)			-0.031 (0.020)
March 2009 (DP_8)			0.015 (0.014)
Adj R^2	0.367	0.402	0.424
D.W.	1.34	1.36	1.45

(***) denotes 1% significance level, based on HAC standard errors (in parenthesis)

− plays a key role in triggering a liquidity hoarding. This issue has little to do with the aggregate supply of liquidity; hence in this view an easing of the monetary policy stance is not likely to be an effective solution.

4 Concluding remarks

Our model predicts that in normal times the intraday interest rate (implicitly defined by the intraday pattern of the ON rate) should only reflect some frictions, including the cost of the central bank daylight credit. During a liquidity crisis, the chance that the ON rate might jump within the day well above the target level set by the central bank must be compensated by an intraday decline of the ON rate, given that the jump does not actually occur; this introduces an additional component into the intraday interest rate. Under these circumstances, the emergence of an intraday rate of relevant size does not imply the existence of unexploited arbitrage opportunities. It is true that a bank can profit by lending ON in the morning and borrowing back the money in the afternoon, relying in the meantime on the central bank daylight overdraft. However, the premium earned on the morning loan is actually the compensation for the risk of borrowing at a higher rate later, were the central bank unable to hit its target level for the ON market rate.

These predictions are supported by the empirical evidence we provide for the euro area. By analyzing real time data for the e-MID interbank market, we show that the implicit intraday interest rate has increased from 0.9 b.p. before the financial crisis to 3.8 b.p. after the start of the crisis in August 2007, and further up to 13.2 b.p. after the Lehman Brothers crash in September 2008. The estimated intraday rate is affected by changes of the spread between the three month Euribor and the Eonia swap rates, presumably reflecting some news altering the likelihood of a liquidity dry-up, where the central bank might loose control over the ON interest rate. The moves towards an easier monetary policy stance − signalled through reductions of the policy rates − were not able to lower the intraday rate, except at the peak of the financial crisis (October 2008).

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