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THE END OF MONTH RULE AND LIQUIDITY RISK: WHAT THE MONEY MARKET SAYS

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The end of month rule and liquidity risk: what the money market says(*)

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Sumário: O efeito da regra de reservas contemporâneas no último dia de cada mês nos mercados monetários é estudado neste trabalho, recorrendo-se a dois conjuntos de informação estatística. O prémio de liquidez, medido pelo coeficiente de variação, é substancial em certos períodos e para ambos os conjuntos de informação.

(*) All data were kindly provided by Mrs. A. Conceição. All errors are mine.

Some evidence on the liquidity effect of the end of month rule

1. Most of deposit taking institutions are required by law to hold reserves against their monetary liabilities, i.e. mainly sight and time deposits, in vault cash or deposits in the Banco de Portugal. From 1979 reserves were hold on a "weekly" basis [1]. In each week, the daily average of an institution's eligible liabilities is computed and it must hold, on average, in the following week, the required reserves. These are, normally, known around the middle of the following working week or before and the bank[2] has a day or two to adjust its reserves within those required by the law.

On top of the lagged reserves regime, there is a rule whereby banks' reserves at the last day of the month must be a fraction of its eligible liabilities of that day. This end of the month[3] contemporaneous reserve requirement introduces uncertainty in banks' reserve management insofar as liabilities are difficult to be predicted on a daily basis. What ever the

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(1) Weeks are defined as periods ending at the 8th, 15th, 22nd and the last day of the month.

(2) Henceforth, banks stands for deposit taking institutions.

(3) This rule was abolished from May 1990.

merits the end of month rule has, it does involve a cost borne by banks (ultimately by borrowers or depositors) in the form of excess reserves. This additional cost can be calculated using a series of excess reserves. But banks' deposits in the central bank are also used for clearing as well as interbank trading in (short-term) funds purposes; thus excess reserves can be due to, for example, a bank holding excess deposits in expectation of a shortage of funds in other banks which did not materialize. Nevertheless, this work aims at measuring the effect on the impact of such contemporaneous rule on liquidity risk and not on the overall effect on the cost of capital. The underlying reason why the former is of interest is that, in the absence of central bank intervention, an increase in liquidity risk redistributes income from illiquid banks to banks with excess liquidity without an impact on the cost of capital.

2. To enhance reserves on a very short term basis, banks can buy funds in the interbank money market or to ask for discount facility at the central bank. The latter has supplied funds, whenever a shortage of funds occurs, through the interbank money market or a repurchase of treasure bills on a short term basis. Thus, to the extent the end of month rule induces a higher demand for monetary base, interbank money market data should reflect such effect around the last trading day of each month.

Simple statistical test used below do not allow, unfortunately, for a variable variance of the underlying data generating process of each day though a test on the equality of the variance of the last trading day and its adjacent days has been carried out. This work utilizes two set of data;

the first, from January 1985 to the beginning of December of 1989, has a total of 60 observations for the maturity and trade weighted money market rate (overnight up to five days) of the day before last, the last trading day and the first trading day of a month.

Ignoring learning problems and less than perfect competition on short term funds markets, and assuming that the liquidity effect occurs throughout the choosen sample period (i.e. the end of month rule is always binding), a statistically significant difference between the level of the money market rate at the last trading day and its adjacent lays is consistent with the existence of a liquidity effect.

For the whole period a liquidity premium, measured by the coefficient of variation, obtains. Spliting the data into two subsets, a substantial premium has been observed in the second subperiod. The coefficient of correlation of changes in the interest rate (the correlation of the difference between the day before last and the last trading day, and the difference of the latter and the first trading day) is statiscally significant and it is negative for the whole period as well as for subsamples of the data set.

One of the many objections on the procedure summarized above is that the end of month rule needs not be binding all the time. Namely, high lending rates or credit control could have created excess liquidity in some periods. Moreover, if the money market were thin, periods with overall excess liquidity should behave much less volatile than in periods with lack of funds.

TABLE 1

Average of the square of variation between the last trading day of the month and adjacent days

	1985	1986	1987	1988	1989
Jan	-	4.01	7.04	0.07	0.01
Feb	-	31.83	3.23	0.04	0.01
March	-	29.03	4.06	0.11	0.0004
April	-	56.7	0.08	0.002	0.07
May	-	0.26	17.14	0.02	37.25
June	-	15.08	21.17	0.02	0.002
July	-	72.48	2.43	0.07	0.2
August	3.04	12.0	0.2	0.04	0.004
Sept	194.04	23.22	0.3	0.001	0.01
Oct	-	5.68	0.28	0.003	0.01
Nov	15.06	20.18	0.14	0.17	0.04
Dec	110.95	8.97	1.87	0.07	-

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A second set of data on individual trades in the money market at the last trading day has been constructed. Unlike the first set, the data does not aggregate all the individuals trades owned at the last trading day of a month; it covers only the deals that enhance banks' liquidity on a very short term basis for meeting the requirements of the end of month rule. In a month ending at 31st and the last trading day being the 30th only the overnight deals were included in the new data set, or, if no 24 hours trade occured, two days contracts are recorded, and etc..

The selection criteria used for the second set is the average of the square of variation of the short term money market rate (of the first data set) between the last day of a month and its adjacent days. From August 1985 to November 1989 this average registered a maximum of 194 and a minimum of 0.004. Large values in 1985 and 86 can be due to interest rates been higher, to learning or some other specific factor. Thus the variation observed in May 1989 were due to large sales of public debt to banks causing an accute overall lack of liquidity. Excluding the months of very large variation (until August of 1987 but including April of that year) two groups were formed as follows:

TABLE 2

I	II
April 1987	August 1987
Jan 1988	Sept 1987
Feb 1988	Oct 1987
April 1988	Nov 1987
May 1988	Dec 1987
June 1988	March 1988
July 1988	Nov 1988
Aug 1988	July 1989
Oct 1988	
Dec 1988	
Jan 1989	
Feb 1989	
March 1989	
April 1989	
June 1989	
Aug 1989	
Sept 1989	
Oct 1989	
Nov 1989	

From the individual transaction on the last trading day with maturity at the last day of the month or, in its absence, at the first or second day of the next month, we recorded the average, standard deviation and the spread of the observed transaction. No attempt at weighting the interest rates by the value of each deal (see Appendix) were done.

3. The recent turbulence in the short term money market highlights the import of the reserve requirements regime as a channel of transmission of monetary policy. The demand for deposits in the central bank (monetary base in general) due to the reserve regime can be used to enhance other monetary instruments. Using data from the money markets, this note studies the effect of the contemporaneous reserves clause for the last day of every month.

In order to carry out simple statistical tests, a simplifying assumption has been adopted throughout. It is assumed that the data generating process can be described by its first two moments: moreover, it is a time additive process and its first moment, possibly, has a (constant) time trend. Thus, as an illustration, if the interest rate, i_t, is generated by

$$i_t \sim N(\mu_t, \sigma)$$
$$\mu_t = \mu + at$$

with μ and σ constants, then the observed average interest rate, i, in a given period, should follow

$$i = \frac{\sum_{t}^{n} i_t}{n} \sim N\left(\mu + a\,\frac{\Sigma t}{n},\ \sigma\right)$$

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The liquidity effect around the end of month will be measured by the coefficient of variation. This coefficient is useful to study the variability of the data corrected by (the shift in the) mean; thus, a higher mean in the last trading day compared to its adjacent trading days, but with a commenmate higher variance should be interpreted as a case of no increased risk. For the second data set, months with binding and non-binding contemporaneous reserve constraint are identified, a statistical test on the equality of the variance of the two groups is carried out and, again, the coefficient of variation is used to identify the liquidity effect.

4. Let x denote the short term interest rate of the day before the last trading day, y the last trading day rate and z the first trading day rate. Changes in these rates, $t = y - x$, and, $v = z - y$, are computed and the correlation between r and t for the whole period and subperiods is shown in table 3.

TABLE 3

	ρ
1985 - 1989 (n = 60)	- .559
1985 - 05/1987 (n = 29)	- .691
06/1987 - 1989 (n = 31)	- .806

The hypothesis that $\rho = 0$ can be tested using the fact that (n being the size of the sample)

$$\text{rho} = \sqrt{n-2}\ \frac{r}{\sqrt{1-r^2}} \sim t(n-2)$$

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Table 4 records the values of rho for the periods used in table 3.

TABLE 4

1985 - 1989 (n = 60)	- 5.55
1985 - 05/1987 (n= 29)	- 4.97
05/1987 - 1989 (n = 31)	- 7.34

Clearly the hypothesis of no correlation can be rejected, and the case for a negative correlation is strong. Thus, the last trading day of a month seems to show a systematic, positive effect on the level of interest rates. Through an F-test, the hypothesis of the variance of x being equal to the y can be rejected except for the period 1985 to May 1987, and that the variance of the last trading day is significantly different from the variance of its adjacent trading days only for the period of May 1987 to the end of the data set. The test on the equality of the mean of x, y and z shows that one can reject the equality between x and y but not between y and z for all periods considered in this note.

The last result, in the light of the negative correlation of the changes in the interest rate around the end of the month, shows that there is a persistence effect of the end of month rule; an increase in interest rates, on average, at the last trading day is not followed by a decrease in the

subsequent trading day. Such persistence suggests that there is, possibly, some imperfection in the money market, though further analysis is required in order to identify such effect. The following Tables 5 and 6 summarize the results obtained for the first set of data.

TABLE 5

		μ	σ^2
x			
	n = 60	13.166	12.046
	n = 29 (up to 5/87)	13.748	23.429
	n = 31 (6/87 - 12/87)	12.576	0.675
y			
	n = 60	16.102	19.577
	n = 29 (up to 5/87)	19.079	19.487
	n = 31 (6/87 - 12/87)	13.318	3.616
z			
	n = 60	15.89	16.676
	n = 29 (up to 5/87)	19.125	13.133
	n = 31 (6/87 - 12/87)	12.863	1.037

TABLE 6

(coefficient of variation)

	n = 60	n = 29	n = 31
x	0.264	0.351	0.065
y	0.275	0.231	0.143
z	0.257	0.189	0.079

The test on the equality of variance is the F-test

$$F_{y,x}(n,n) = \frac{\sigma_y^2 \; n/n-1}{\sigma_x^2 \; n/n-1} \sim X(n)$$

with n = 60, $F_{y,x} = 1.625$ and $F_{y,z} = 1.174$, so that the hypothesis $\sigma_y = \sigma_z$ is accepted but not $\sigma_y = \sigma_x$ The test on the equality of the mean between x and y (with different variance) is given by

$$t = \frac{\bar{y} - \bar{x} - (\mu_y - \mu_x)}{\left(\frac{s'^2_y}{n_y} + \frac{s'^2_x}{n_x} \right)^{1/2}} \sim t\left(\frac{\frac{s'^2_y}{n_y} + \frac{s'^2_x}{n_x}}{\frac{(s'^2_y/n_y)^2}{n_y - 1} + \frac{(s'^2_y/n_x)^2}{n_x - 1}} \right)$$

where $\bar{y}$ is the mean of y, $s'^2_y = s^2_y \frac{n}{n-1}$ the unbiased variance and t is the t-student distribution: We have

$$t = 4.011$$

and hence the hypothesis that $\mu_y = \mu_x$ can be rejected. The test of $\mu_y = \mu_z$ is done through

$$h = \frac{\bar{y} - \bar{z} - (\mu_y - \mu_z)}{\left[\frac{(n_y - 1)s'^2_y + (n_z - 1)s'^2_z}{n_y + n_z - 2} \left(\frac{1}{n_y} + \frac{1}{n_z} \right) \right]^{1/2}} \sim t(n_y + n_z - 2)$$

with h = 0.271 the hypothesis $\mu_y = \mu_z$ is accepted. For the subperiods the results are recorded in the following

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TABLE 7

1985 - 05/1987

$F_{y,x}$ (29, 29) = 1.202
$F_{y,z}$ (29,29) = 1.484
$h_{y,x}$ = 6.19
$h_{y,z}$ = -0.06

TABLE 8

05/1987 - 1989

$F_{y,x}$ (31, 31) = 5.357
$F_{y,z}$ (31,31) = 3.487
$t_{y,x}$ = 1.9616
$t_{y,z}$ = 1.1545

5. The second data set consisting of individual trades at the last trading day of a month can provide complementary evidence on the liquidity effect of the end of month rule. As discussed above, two sets of months had been identified using the square of variation in the weighted interest rate of the first data set. In this way the arbitrariness is lessened though there can be other way to classify the data.

The first group (I) with low variation values has 533 number of observations and the group (II) with high variation has 159. The latter group is interpreted as the case where the end of month rule is binding and,

hence, it should have a higher variance. Both groups include the month of December which has some specific characteristics. To avoid this effect the test used below are done with and without the month of December.

The F-test on the equality of the variance rejects the hypothesis of equality (with December)

$$F(159, 533) = 10.678$$

and without the month of December

$$F(135, 504) = 7.045$$

thus the variance of the group of months with high variability around the end of month is substantially larger than the other group of observations. The coefficient of variations for both groups with and without December is:

TABLE 9

(coefficent of variation)

	I	II
with December	0.009511	0.028038
without December	0.008909	0.023144

The high variance group has also larger variability around its mean, and the liquidity risk induced by the end of month rule seems to be substantial. Comparing with the coefficient of variation of the first data

set in the second subperiod, the magnitude of the liquidity risk is not much larger ($2.6 = \frac{.023}{.0089}$ against 2.2 and 1.8). As the second data set is not trade weighted, one expects a bias for higher volatility.

6. The identification of the liquidity effect of the end of month rule suggests that it envolves a substantial increase in volatility in the short-term money market rates at the last trading day of a month. If smoothing interest rates were a guide to monetary policy then the regime of contemporaneous reserve should not be utilized. The liquidity effect uncovered above suggests also that the central bank can control the short term rates through interventions in the money markets or manipulating the legal reserve ratio.

A caveat should be stressed, however. If the first set of data were collected under the bizarre hypothesis that the end of month rule were always binding, and, moreover, the fact that there is a persistence affect in increases of interest rates were not satisfactory, a glance on table 2 tells us that, in 1989, the end of month rule were binding only in July (May being explained in the text above). The selection criteria, then, can be misleading or perhaps, in fact, the end of month rule were becoming not much more than an expensive nuisance.

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1985

	n	μ	s	s/u	sp	V
Jan	-	-	-	-	-	
Feb	-	-	-	-	-	
Mar	-	-	-	-	-	
Apr	-	-	-	-	-	
May	-	-	-	-	-	
Jun	-	-	-	-	-	
Jul	-	-	-	-	-	
Aug	18	21.03	3.157	0.085	17.5-25.	3.04
Set	23	25.34	2.535	0.063	22.6-28.	194.04
Oct	15	24.02	3.137	0.074	22.-30.	33.07
Nov	32	22.58	0.705	0.037	20.5-24.	15.06
Dec	32	23.08	23.779	0.211	18.-33.	110.95

n -number of observations;
sp - spread between the highest and the lowest rate;
V - average of the square of variation between the last day of the month and adjacent days.

1986

	n	μ	s	s/u	sp	V
Jan	23	15.64	5.271	0.147	10.-19.	4.01
Feb	33	19.38	0.227	0.025	18.6-20.9	31.83
Mar	42	22.71	11.593	0.150	19.-35.	29.03
Apr	33	19.27	1.386	0.061	15.-21.	56.7
May	32	17.45	0.476	0.040	16.-19.	0.26
Jun	30	16.41	3.987	0.122	10.-19.	15.08
Jul	39	17.94	1.371	0.065	15.-22.	72.48
Aug	13	11.20	6.489	0.227	5.5-15.6	12
Set	21	15.92	0.536	0.046	13.5-17.	23.32
Oct	32	16.73	0.193	0.026	15.5-18.	5.68
Nov	33	18.36	1.773	0.073	15.2-18.3	20.18
Dec	31	15.36	1.679	0.084	10.-16.5	8.97

n -number of observations;
sp - spread between the highest and the lowest rate;
V - average of the square of variation between the last day of the month and adjacent days.

1987

	n	μ	s	s/u	sp	V
Jan	26	12.21	0.835	0.075	10.-14.	7.04
Feb	45	14.93	0.195	0.030	13.-15.5	3.23
Mar	55	15.63	0.186	0.028	14.8-16.1	4.06
Apr	42	14.85	0.053	0.016	14.-15.3	0.08
May	31	18.89	4.290	0.110	15.-22.	14.14
Jun	36	15.84	1.079	0.066	14.-17.5	21.17
Jul	29	15.75	0.095	0.020	15.3-16.5	2.43
Aug	14	13.92	0.113	0.024	13.5-14.5	0.2
Set	18	13.52	0.106	0.024	13.-14.1	0.3
Oct	26	13.09	0.151	0.030	12.5-14.	0.28
Nov	20	13.10	0.369	0.046	12.2-13.9	0.14
Dec	24	13.65	0.723	0.062	12.6-15.	1.87

n -number of observations;
sp - spread between the highest and the lowest rate;
V - average of the square of variation between the last day of the month and adjacent days.

1988

	n	μ	s	s/u	sp	V
Jan	18	12.14	0.134	0.030	11.3-12.5	0.07
Feb	18	12.12	0.015	0.010	11.9-12.3	0.04
Mar	13	12.47	0.026	0.013	12.1-12.8	0.11
Apr	23	12.18	0.011	0.009	12.-12.5	0.002
May	22	12.13	0.005	0.006	12.-12.2	0.02
Jun	26	12.27	0.012	0.009	12.12.5	0.02
Jul	29	12.32	0.004	0.005	12.1-12.5	0.07
Aug	12	12.17	0.017	0.011	11.8-12.3	0.04
Set	22	12.29	0.003	0.004	12.3-12.4	0.001
Oct	27	12.31	0.005	0.006	12.1-12.5	0.003
Nov	30	12.29	0.005	0.006	12.-12.4	0.17
Dec	29	12.44	0.068	0.021	12.-13.4	0.07

n -number of observations;
sp - spread between the highest and th lowest rate;
V - average of the square of variation between the last day of the month and adjacent days.

1989

	n	μ	s	s/u	sp	V
Jan	27	12.18	0.001	0.003	12.1-12.3	0.01
Feb	25	12.26	0.010	0.008	12.1-12.5	0.01
Mar	21	12.39	0.003	0.005	12.3-12.4	0.004
Apr	31	12.51	0.022	0.012	12.3-12.8	0.07
May	53	19.20	3.382	0.096	13.3-21.3	37.25
Jun	32	12.40	0.014	0.009	12.-12.8	0.002
Jul	14	12.85	0.060	0.019	12.4-13.3	0.2
Aug	24	12.18	0.005	0.006	12.-12.3	0.004
Set	33	12.49	0.009	0.008	12.3-12.8	0.01
Oct	24	12.40	0.008	0.007	12.3-12.5	0.01
Nov	48	12.62	0.007	0.007	12.4-12.8	0.04
Dec	58	19.80	1.877	0.069	14.-22.	

n -number of observations;
sp - spread between the highest and the lowest rate;
V - average of the square of variation between the last day of the month and adjacent days.