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Volume, Volatility, Spreads and Periodic Closure in the French Market

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ABSTRACT

This paper studies the effects of opening and closing on transactions demand, volume, volatility and the bid-ask spreads of options prices and their underlying assets. This question is studied in Brock and Kleidon (1992), Smith and Webb (1994), Hsieh and Kleidon (1996), Hong and Wang (2000), among others. An extension of the models in Merton (1971), Garman (1976) and Bellalah and Zhen (2002) is used and the empirical implications of our model are studied. We show that transactions demand at open and close in options markets and the underlying assets markets are greater than at other times of the day. The study reveals that periodic market closure leads to periodic changes in the demand for transaction services and reveals the presence of an increased demand and less elastic transactions around closure. The predictions of periodic demand with high volume and narrow spreads in options markets are not always consistent with empirical evidence on the Paris Bourse. In fact, the results depend on the length of the time interval chosen at the open and the close and the degree of synchronization of options prices and the underlying assets prices.

JEL: *G1, G12, G13, G14, G15, F3*

Keywords : *Volume; Volatility; Periodic market closure*

I. INTRODUCTION

Stocks on the Paris-Bourse are traded in a market where settlements take place periodically on a given date as in the U.K.[1] MONEP traded options are quoted on a continuous basis on a screen trading system.[2] Before 1999, there was a dual quotation for stock options and index options.[3] The quote information disseminated to the public during the open period concerns the bid and offer prices. This information is no longer disseminated in the close period and there is an abrupt change from a regime of continuous trading to a regime of no trading. The question of how the trading behavior at open and close is affected in financial markets is analyzed in Admatti and Pfeiderer (1988), Brock and Kleidon (1992), Smith and Webb (1994), Hsieh and Kleidon (1996), Hong and Wang (2000), Bellalah and Zhen (2002) among others.[4]

This paper gives an answer to a similar question in options markets and their underlying assets markets in a slightly different context. There are several reasons explaining periodic trading demand shifts at the open and the close of the trading, most of which are based on the effect of the periodic inability to trade. We analyze some of these reasons and show that there is a greater demand to trade at open and close than the other times of the trading day. The inability to trade modifies the optimal portfolio of investors.

Following "standard" theory, we examine the reaction of a specialist market maker. Therefore, a model of periodic market closure is presented, which is an extension of the models in Garman (1976), Brock and Kleidon (1992) and Bellalah and Zhen (2002). The model accounts for periodic changes in transactions demand in options markets and provide conditions under which higher transactions imply narrower bid and ask spreads. This is because an increase in the trading activity reduces the spread and converges market prices toward fair options prices. However, lower spreads does not mean necessarily fair option prices since it refers mainly to a low cost of trading. Even if the general question of whether increased trading volume (around closure) is associated with narrowing or widening the bid-ask spread in options is of some interest, it is fundamental to the understanding of how markets work at special points in time. The empirical evidence gives some support to the implications of the model. We find that volume traded in the MONEP is concentrated at open and close. Also, that narrower bid-ask spreads are in general associated to times of high volume on the options market.

The principal empirical results of this paper are that:

(1) There may not be greater demand just at the open of trading in the option market relative to the middle of the day; and (2) High transactions demand at the close of trading in the option market need not coincide with narrower bid/ask spreads.

Our analysis concerns the simultaneous examination of the option market and the underlying asset markets. Several descriptive statistics regarding volume, volatility and spreads in the Paris bourse are provided. Even if these results are known for other markets, they are presented for the first time for the case of the Paris Bourse. This allows studying the implications of our model.

This paper studies some of these issues around market closure. Its structure is as follows:

Section 1 extends the basic concepts used in Garman (1976), Brock and Kleidon (1992) and Bellalah and Zhen (2002) to show that periodic market closure results in periodic changes in the demand for transaction services in options markets. Under some conditions, the options dealer sets a higher ask in periods of high demand to buy options and lower bids when the demand to sell is high. He adjusts his bid and ask prices in a way such that the spread applied with high volume is less than the spread quoted in periods of less volume. Increased transactions at the open and the close imply in general a narrowing of the spread.

Section 2 presents our main findings of periodic market demand changes at open and close and the results in relation to some empirical tests regarding volume, volatility and trades in the Paris-Bourse. The implications of our model are also studied. The empirical work is done along the lines of Brock and Kleidon (1992), Fedenia and Grammatikos (1992), Berkman (1992) and Ronn and Sheik (1994), using a new dataset for the period 1992-1998 in which transactions, volumes and spreads are given. Our empirical findings provide similar results to those reported in other markets for half an hour time intervals. However, they are slightly different for the open for small time intervals (quarter of an hour).

II. MODEL FOR PERIODIC DEMAND SHIFTS, VOLUME AND OPTIONS SPREADS

This section presents some reasons for periodic demand shifts. Then, it studies the reaction of a market maker in the option market. It extends the analysis for the underlying assets conducted in Garman (1976) and Brock and Kleidon (1992). Since several options are traded with a specialist market maker, it is possible to approximate the trading in these options by the actions of a monopolistic option market maker. The simple model provides some foundations for the explanations of volume, volatility and spreads in the Paris-Bourse.[5]

A. Some Reasons for Periodic Trading Demand Shifts

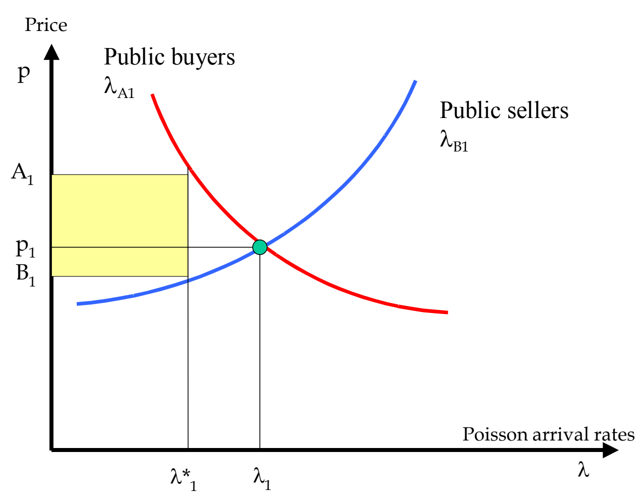
Brock and Kleidon (1992) propose different explanations for the increased transactions demand at the open and the close of the stock exchange. Their first argument explaining the greater demand to trade at open and close concerns the effect of the periodic inability to trade. Their second argument refers to the ability to trade on an alternate market if the primary market is closed.[6]

To explain the periodic market closure, Brock and Kleidon (1992) extend Merton (1971), Garman (1976) and Bellalah and Zhen (2002) models by accounting for an alternate regime. The main result regarding periodic market closure is that the demand to trade at open and close will be stronger and relatively inelastic at these special points in time. The first reason concerns the optimal portfolio weights allocated to different securities at the end of the trading day. The second reason concerns the optimal weights for the overnight period.

B. The Model for Periodic Demand Shifts, Volume and Spreads

Consider a monopolistic options market maker who is assumed to maximize expected profits per unit time and who seeks to equate arrival buy and sell orders. Transactions evolve as a stationary continuous time stochastic jump process as in Garman (1976), Brock and Kleidon (1992) and Bellalah and Zhen (2002).

Figure 1
Optimal expected bid-ask and arrival rate

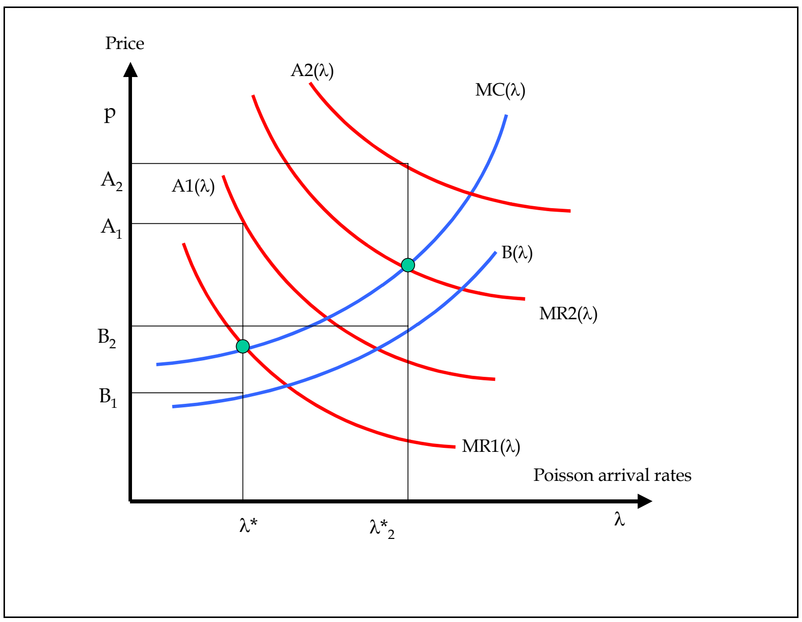


We present a simple model. Let $\lambda_B(c,t,z)$ to be the arrival rates of sell orders as a function of the options price c, time t and a vector of variables z other than the options with $\frac{\partial \lambda_B}{\partial c}(c,t,z) > 0$. The subscript B refers to the market maker's bid at which public sell orders will be transacted. Let $\lambda_A(c,t,z)$ to be the arrival rates of buy orders as a function of c, t and z with $\frac{\partial \lambda_A}{\partial c}(c,t,z) < 0$. The subscript A stands for the dealer's ask at which public buy orders will be transacted. The arrival rates define supply and demand functions at each instant t during the trading interval [0,T] beginning at time 0 and ending at time T.

Let B_t and A_t to be the equilibrium bid and ask prices associated with these supply and demand functions at each instant t and let $\lambda_A(c,t,z)= \lambda_{Ai}$, $\lambda_B(c,t,z)= \lambda_{Bi}$, and the asks and bids, $A_t = A_i$, $B_t = B_i$ for all $t \in t_i$. Then as in figure (1) in Brock and Kleidon (1992) and figure (2) in Garman (1976), for a trading interval t_1, the optimal arrival rates are given by $\lambda^*_{A1} = \lambda^*_{B1} = \lambda^*_1$ where the bid (ask) is equal to B_1, (A_1) at all times in the interval t_1.

If during the day trading occurs over several intervals t_i, then the resulting A_i, B_i and the spread, $(A_i - B_i)$ are determined in the same way.

Figure 2
Increased bid-ask spread after increased demand and non changing supply



Now, consider the assumption of zero production costs so that the options dealer equates the marginal cost MC(λ) of buying options with the marginal revenue MR(λ) from reselling them.

We denote respectively by B(λ), the fixed supply function given by the inverse function of $\lambda_B(c,t,z)$, by A1(λ), the original demand, by MR1(λ), the original marginal revenue, by A2(λ), the increased demand and by MR2(λ), the increased marginal revenue. If we assume that the increase in demand for the options from A1(λ) to A2(λ), for a fixed supply B(λ), is such that the following three assumptions are satisfied then it is possible to give the necessary and sufficient conditions under which increased transactions demand yield increased volume and narrower bid ask spreads.[8]

Assumption 1: MR2(λ*) > MR1(λ*)

This assumption indicates that the value of MR2(λ*) exceeds that of MR1(λ*) at λ*. It guarantees that the new optimal quantity is greater than the old optimum quantity λ*. Hence, the increase in demand yields a higher optimal quantity.

Assumption 2: $\forall$ λ, $\frac{\partial A2}{\partial A}(\lambda) \geq \frac{\partial A1}{\partial \lambda}$

This assumption indicates that the slope of the new demand is less than or equal to the original demand which implies parallel shifts in demand.

Assumption 3: $\forall$ λ, $\frac{\partial A2}{\partial \lambda}(\lambda) + \lambda \frac{\partial^2 A2}{\partial \lambda^2}(\lambda) < \frac{\partial B}{\partial \lambda}(\lambda) + \lambda \frac{\partial^2 B}{\partial \lambda^2}(\lambda)$

This assumption is the same as that in Brock and Kleidon (1992). It requires that the sum of the (absolute) slopes of the functions of marginal cost and marginal revenue to be greater than that of demand and supply functions. It implies that the sum of slopes of MR2(λ) and MC(λ) is less than the sum of absolute slopes of A2(λ) and B(λ) as follows.

MC(λ) = $\frac{\partial (B\lambda)}{\partial \lambda}(\lambda) = B + \lambda \frac{\partial B}{\partial \lambda}$ and $\frac{\partial MC}{\partial \lambda} = 2\frac{\partial B}{\partial \lambda} + \frac{\partial^2 B}{\partial \lambda^2}$

Also, since: $\frac{\partial MC^2}{\partial \lambda} = 2\frac{\partial A2}{\partial \lambda} + \frac{\partial^2 A2}{\partial \lambda^2}$, assumption (3) implies that:

$$\frac{\partial B}{\partial \lambda} - 2\frac{\partial A2}{\partial \lambda} < (2\frac{\partial B}{\partial \lambda} + \lambda \frac{\partial^2 B}{\partial \lambda^2}) - (2\frac{\partial A2}{\partial \lambda} + \lambda \frac{\partial^2 A2}{\partial \lambda^2}) \text{ or } \frac{\partial B}{\partial \lambda} - \frac{\partial A2}{\partial \lambda} < \frac{\partial MC}{\partial \lambda} - \frac{\partial MR2}{\partial \lambda}$$

Also we have $\frac{\partial MC}{\partial \lambda} = 2\frac{\partial B}{\partial \lambda}$ and $\frac{\partial MR2}{\partial \lambda} = 2\frac{\partial A2}{\partial \lambda}$.

These assumptions are not totally arbitrary since similar arguments were used in Brock and Kleidon (1992), Garman (1976) and Bellalah and Zhen (2002) for the study of stock markets.[7]

Using the assumptions (1) and (2), we obtain the following lemma.

Lemma: At the original optimal quantity λ*, the increase in demand implies a lower increase in the ask price than the corresponding increase in the marginal revenue, i.e; A2(λ*) - A1(λ*) $\leq$ MR2(λ*) - MR1(λ*)[9]

Using the assumptions (1) to (3), the two following propositions are obtained. The proof is provided in the appendix.

Proposition 1: The spread narrows when the demand increases with non changing supply and: (A2- B2) < (A1-B1).
Proposition 2: The ask falls when demand increases with fixed supply, or:
$A2(\lambda^*_2) < A1(\lambda^*)$.

The above propositions show a lower bid-ask spread and a lower ask for a fixed supply and increased demand.[10]

III. EMPIRICAL EVIDENCE ON VOLUME, VOLATILITY AND SPREADS

This section defines the specific features of the dataset, then it presents empirical evidence regarding the volume, the trading activity, the volatility and the spreads in the options markets. The main empirical results are provided and the implications of our model are studied.

A. Specific Features of the Data-base

MONEP trades two option contracts on the CAC 40 index: the CAC 40 American short term option (PX1) and the CAC 40 European long term option (PXL). PXL options may be traded at any time until the expiration date, which is the last business day of the month of maturity. Trading months are March and September, up to two years. Strike prices are set at standard intervals of 150 index points each. When a maturity opens, call and put series are created for the three following strike prices: one "at the money", two "out of the money".[11]

The data base comprises daily data and intraday data. The daily data regarding short term index options (PX1) and long term index options (PXL) are taken from the MONEP data base for the period from January 1992 to June 1998. For each day, the data regarding calls and puts show the number of transactions, the number of traded contracts and the amounts of capital exchanged. The data covers 1632 trading days. The intraday data set is available on a CDROM since the year 1995. The intraday data concerns calls, puts, the time of quotation, the degree of parity and the time to maturity. The data covers 653 225 trade and 215 045 options series. The data regarding the underlying index and the futures index contracts are also available for the same period.[14]

B. Implications of the Model for Open and Close on the Paris Bourse

Our analysis of bid and ask prices needs some information on demand at the initial trades after opening and before the close. If a trader or a dealer is informed about the underlying asset, he conditions on the opening spread on the options market and trades in the first couple of trades. For the closing procedure, an increase in the demand to trade at the end of the day leads to an increase in the ask, a decrease in the bid and a lower spread in the options market. Hence, assuming an increased periodic demand at the open and close on the buy and sell side, implies a narrower spread by the model of the preceding section. Even if our analysis assumes a monopolist dealer, this may be "true" for some markets since the options specialist has a priority to trade on both sides of the spread and to accomplish most of the transactions before the others. Since the options specialist has a priority, he can manage an important position by implementing spreads, straddles, strangles and other risk reducing strategies.[12]

C. Evidence on Volume, Volatility and Options Spreads

We used three measures for the volume of transactions: the number of trades Nt, the number of traded contracts Nc and the amounts of capital exchanged ca. For intraday data, these measures are standardized by the total value each day. For the degree of parity of options, we calculate each day for each transaction, the difference between the index level at that time and the strike price. This difference approximates for the degree of parity. We define five levels of parity for short term and long term options. The difference between two successive strike prices for short term options is 25 points. The difference for long term options is 150 points of the index.

Table 1 defines the degree of parity for PXL options as the difference $X = K - S$ where K stands for the option strike price and S for the implicit index level.

Table 1
Degree of parity for CAC 40 PXL options

Parity	PXL
-2	$-450 \leq X$
-1	$-450 \leq X \leq -150$
0	$-150 \leq X \leq +150$
+1	$+150 \leq X \leq +450$
+2	$+450 \leq X$

In the same context, we define three levels for the maturity dates as a function of the number of remaining days to the maturity date T. Table 2 contains the levels of maturity for the corresponding options.

Table 2
Levels of maturity in months for CAC 40 PXL options

Maturity	PXL
1	$T \leq 6$
2	$6 \leq T \leq 12$
3	$12 \leq T$

Since index options are traded each day from 10 H to 17 H Paris time, we divide the trading day into 28 time intervals of length 15 minutes. Figure 3 represents for CAC 40 PXL options the number of traded contracts and the capital exchanged each year for the period 1992-1998. The capital exchanged gives an idea of market liquidity. These measures reflect the trading activity in the Paris Bourse. The number of traded contracts seems to be the lowest in 1992.[13]

Figure 4 shows the dynamics of the capital exchanges for PXL options each day, as well as the put/call ratios, as a function of the number of contracts for the period 1992-1998. In order to appreciate the mean measures for the number of transactions and the number of traded contracts, Figure 5 reports the number of transactions as a function of the degree of parity and the maturity date for PXL options. It shows also the number of traded contracts as a function of the degree of parity and the maturity date. It is important to note that the highest values for the number of transactions and the number of traded contracts are observed for at the money options. Note that the number of transactions and the number of traded contracts seem to be half-U-shaped for PXL options. This result is nearly similar to those reported in other markets.

We have also tried to detect systematic patters in the number of traded contracts and the amounts of capital exchanged for the last 10 days preceding the option's maturity dates, according to the days of the week and the months of the year. The list of major anomalies in stock returns corresponds to the size/January effect, the monthly effect, the weekend effect, etc. The weekend effect describes the tendency for Monday stock returns to be negative. It was documented by French (1980) and Gibbons and Hess (1981) and studied by several authors.

Figure 3

The number of traded contracts Nt and capital exchanged ca, each year, for the CAC 40 PXL options for the period (1992-1998)

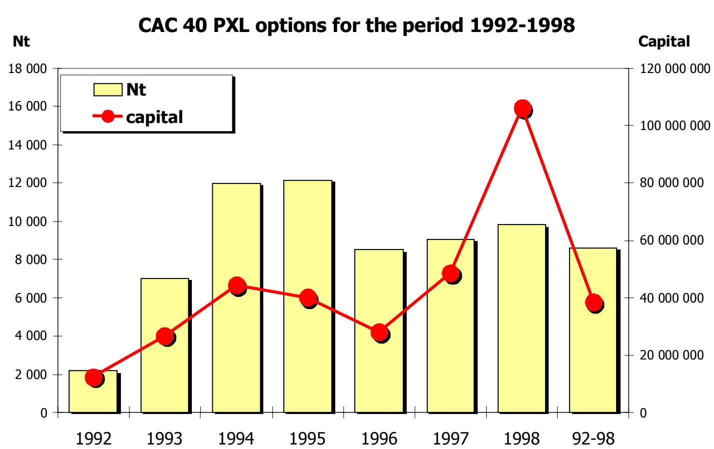


Figure 4
Daily variations in capital exchanged for CAC 40 PXL options for the period 92-98 and put call ratios as a function of the capital exchanged

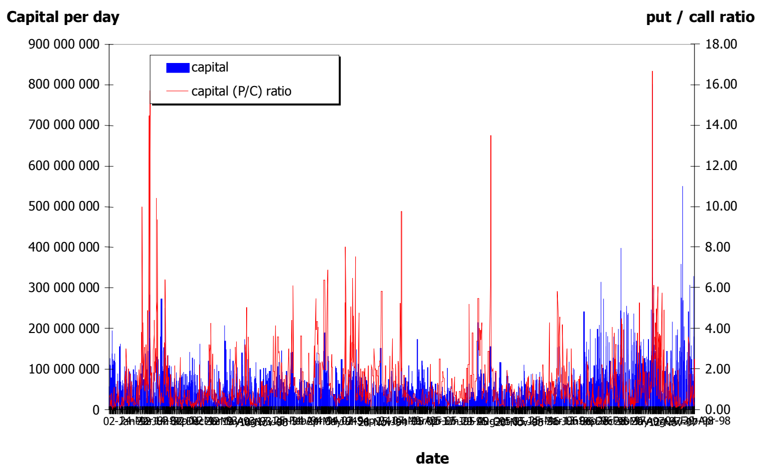


Figure 5
The number of transactions Nt and the number of contracts Nc as a function of the degree of parity and maturity for PXL options

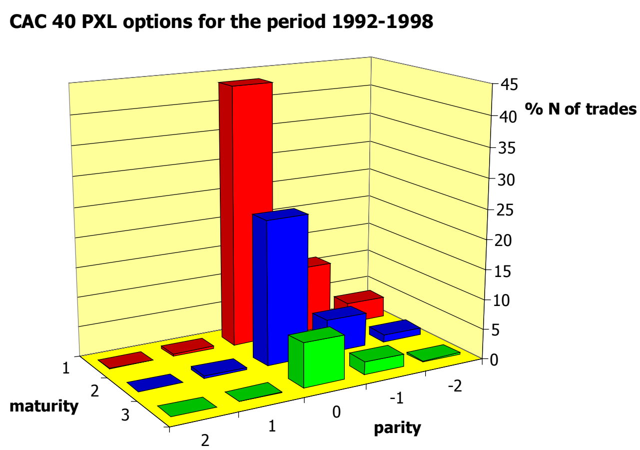


Figure 5 (continued)

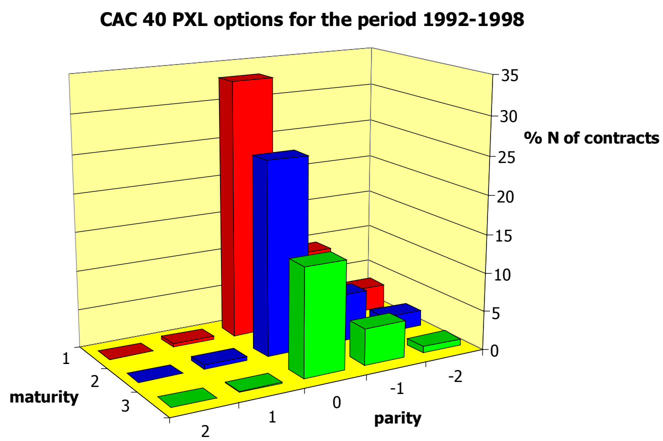


Figure 6

The effect of maturity date on volume volume (number of traded contracts Nt and exchanged capital ca) for PXL options

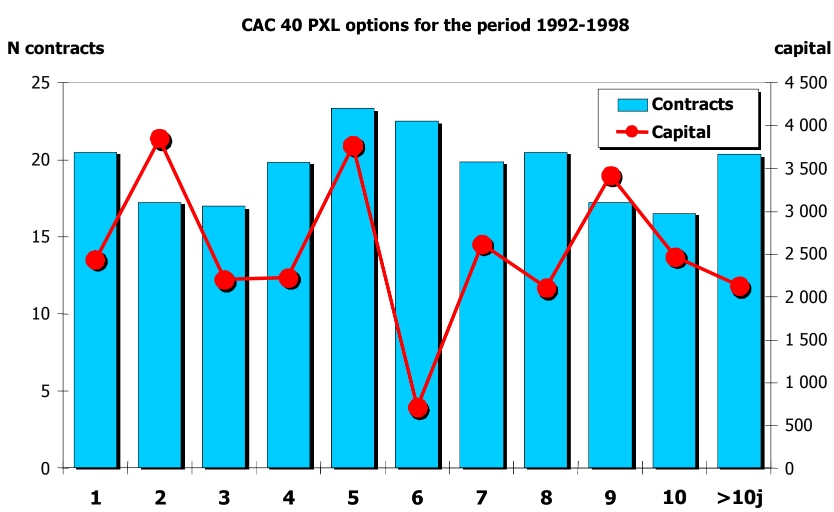


Figure 6 reports the effect of the maturity date on the statistics of volume for the period 1992-1998. The pattern in these two variables seems to follow an inverted U-shaped curve. However, there does not seem to be a systematic pattern in the traded volume and the exchanged capital for these options. We have also tried to detect systematic patters in the number of traded contracts and the amounts of capital exchanged according to the days of the week.

Connolly (1991) reports a posterior odds evaluation of the day-of-the week and weekend effect that reverses earlier findings. Connolly's (1991) paper presents several contributions to the literature on the weekend effect. He shows that the tests of the weekend effect are sensitive to the assumed error distribution. He does not find systematic evidence that returns vary by day of the week. The results in Connolly (1991) confirm the findings in Connolly (1989) where it is shown that robust tests for day-of-the-week and weekend effects do not support these apparent anomalies. The author finds only weak evidence of a weekend effect.

Figure 7 reports the effect of the days of the week on the mean volume for the period 1992-1998.

However, there does not seem to be a systematic pattern in the traded volume and the exchanged capital for these options according to the days of the week. The volume statistics seem to be lowest on both Mondays and Fridays.

Figure 8 reports the effect of the months of the year on volume statistics in the period 1992-1998 for PXL options. The figure shows that the volume is lowest (number of traded contracts and the amount of exchanged capital) in December for the whole period 1992-1998 in the PXL option market. The pattern in these two variables seems to be systematic for the whole period.

Figure 7
The effect of the days of the week on the mean volume volume (number of traded contracts and exchanged capital) for PXL options

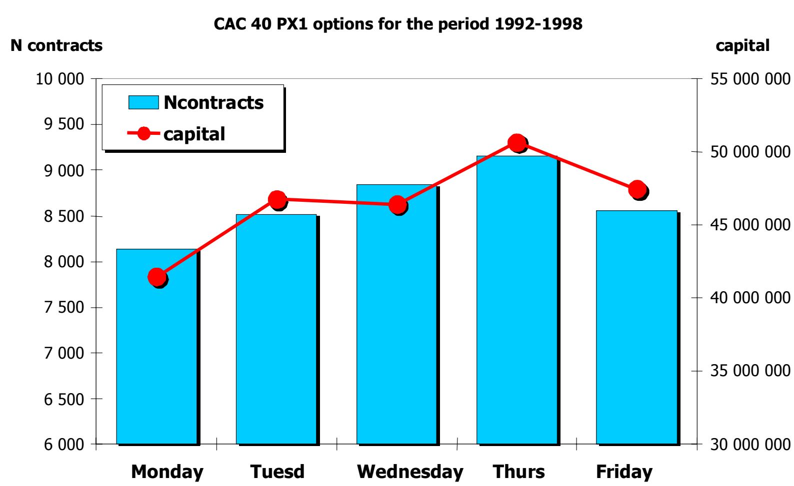


Figure 8
The effect of the month of the year on the mean volume volume (number of traded contracts Nt and exchanged capital ca) for PXL options

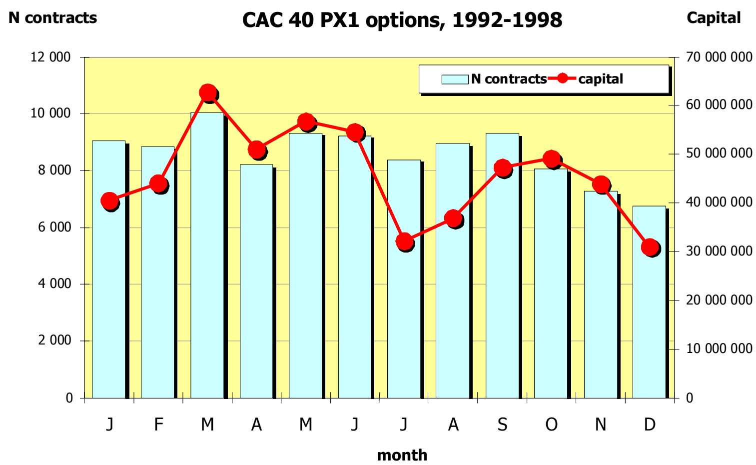


Table 3
Effect of the day of the week on the volume of trades for CAC 40 PXL options.

Panel A shows the effect of the day of the week on the number of transactions.

	Coefficient	Std	$T_{statistic}$
Constant	197.35	7.88	25.05
Monday	-17.98	11.21	-1.60
Tuesday	-18.86	10.99	-1.72
Wednesday	-16.88	11.03	-1.53
Thursday	-13.91	11.08	-1.26

F(4,2008)=0.98, DW = 0.45

Panel B: The effect of the day of the week on the number of traded contracts.

	Coefficient	Std	$T_{statistic}$
Constant	8 561.17	352.84	24.26
Monday	- 421.59	501.90	-0.84
Tuesday	-45.10	492.37	-0.09
Wednesday	285.55	494.11	0.58
Thursday	593.57	496.21	1.20

F(4,2008)=1.17, DW = 1.07

Table 4
Effect of the month of the year on the volume of trades for CAC 40 PXL options.

Panel A shows the effect of the day of the week on the number of trades.

	Coefficient	Std	$T_{statistic}$
Constant	159.14	11.83	13.45
January	39.52	16.34	2.42
February	41.19	16.55	2.49
March	60.97	16.20	3.76
April	9.68	16.66	0.58
May	13.96	16.81	0.83
June	18.48	16.34	1.13
July	-4.16	18.23	-0.23
August	17.70	17.91	0.99
September	42.69	17.30	2.47
October	42.01	16.94	2.48
November	-2.66	17.24	-0.15

F(11,2001)=3.17, DW = 46

Panel B: The effect of the day of the week on the number of traded contracts.

	Coefficient	Std	$T_{statistic}$
Constant	6 742.84	530.20	12.72
January	2 310.73	731.94	3.16
February	2 099.81	741.49	2.83
March	3298.38	725.76	4.54
April	1461.44	744.53	1.96
May	2575.11	753.12	3.42
June	2485.76	731.94	3.40
July	1649.64	816.75	2.02
August	2208.16	802.52	2.75
September	2555.73	775.28	3.30
October	1350.97	758.85	1.72
November	526.19	772.60	0.68

F(11,2001)=3.19, DW = 1.08

We run some regressions using the standard OLS method to appreciate whether the results for the effects of the days of the week and the months of the year on volumes for PXL options are significant. Table 3 reports the main results. The results confirm the shape observed in Figure 7.

Table 4 reports the effect of the year on the volume of trades for CAC 40 PXL options. The results confirm the patterns observed in Figure 8.

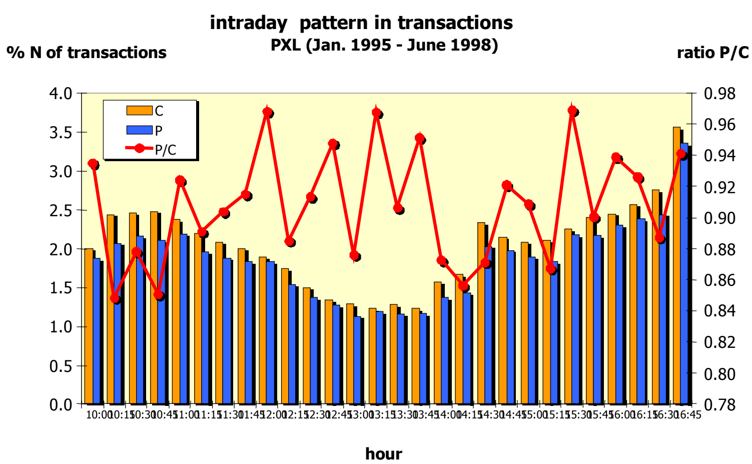
The Tables report a regression model investigation results into whether returns differ on Monday using a different methodology from that in Connolly (1991). However, the results show the presence of a weekend effect with no systematic pattern. This confirms the main findings in Connolly (1991) and a further analysis can reveal the presence of Lindley Paradox. This is beyond the scope of this paper. Shanken

(1987) and Connolly (1989) point out that the Lindley Paradox can affect the results from the classical tests of coefficient restrictions using fixed significance levels. The Lindley Paradox reveals that while the p-value suggests rejection of the null hypothesis, the posterior probability of the null is very high. This is discussed at length in Lindley (1957) and Connolly (1989, 1991) among others.

D. The Intraday Pattern in Volume, Volatility and Spreads

The study by Admati and Pfeiderer (1988) started the controversy where it is shown that spreads will narrow with high volume. Brock and Kleidon find that the underlying assets spreads narrow with low volume and vice-versa. By studying the intraday volume on similar time intervals on the period 1995-1998, we find that average trading volume is highest during the first half hour each day. It declines then between the third and fourth hour and increases again between the fifth and the seventh hours. The frequency of trading is highest at the open and the close and is lowest around the lunch hour. This increased volume around closure is consistent with our model of periodic transactions demand at open and close.

Figure 9
Intraday pattern in the volume of transactions Nt and the put/call ratio P/C for PXL options



If we divide the half hours into two 15 minutes intervals, it is clear that just at the open, the transactions are low when compared to the middle of the day. This is normal because transactions in the option market in the first seconds are linked to the trades in the futures contracts and the underlying indexes. Trading in option contracts can not begin before trading in the underlying asset market. Therefore, during the first few seconds of the day, volume is low. This result is especially verified for less liquid options or options on less liquid stocks. The result seems to be different from those reported in other markets because of the length of the time interval separating trading in the option market and the underlying asset market.

Figures 9 and 10 report the intraday pattern in volume for the number of transactions and the number of traded contracts for the case of PXL options during the period 1995-1998. In each of the three cases, the transactions and the number of traded contracts seem to be U-shaped for PXL calls and puts during the same period.

We have also used several intervals to define the degree of parity of options. The parity is defined with respect to zero, then in the money options are defined for the intervals from -1 to -5. Out of the money options are defined in the intervals + 1 to + 5. The choice of a higher number of intervals allows the observation of a similar pattern for the dynamics of the volume of trades. Figures 11 and 12 reveal the volume of traded contracts respectively for PXL calls and PXL puts as a function of the degree of parity. Both figures show that the highest volume is concentrated for at the money and in the money options as for short term options.

Figure 10

Intraday pattern in the number of traded contracts and the put/call ratio for PXL options

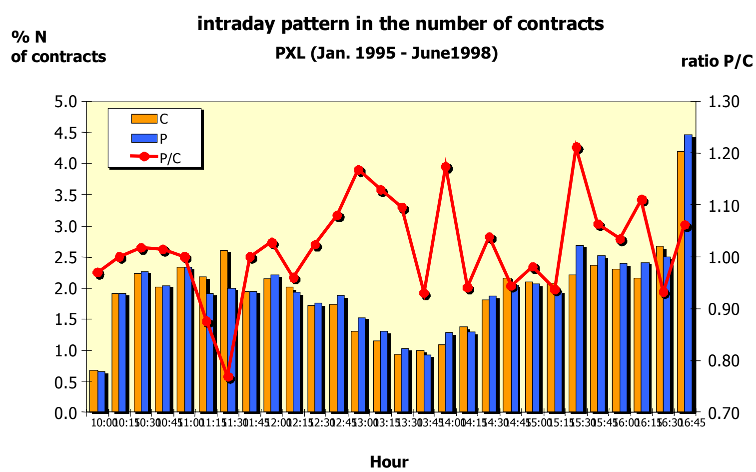


Figure 11
The volume of trades V for PXL calls for the period 95-98

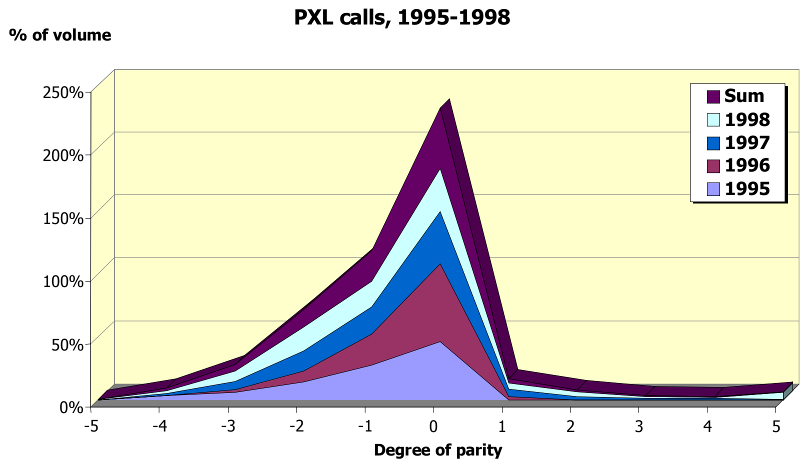
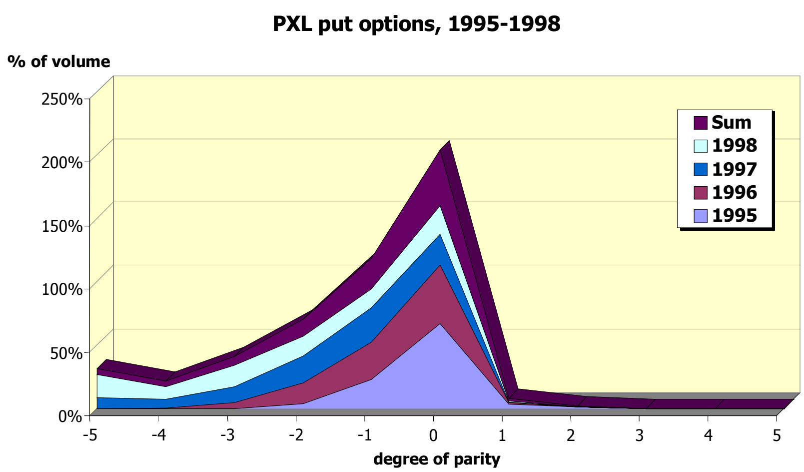


Figure 12
The volume of trades for PXL puts for the period 95-98



Many authors report evidence of significantly greater volatility in NYSE stock returns at the open and close of trading. The reader can refer to Stoll and Whaley (1990), Amihud and Mendelson (1987), Webb and Smith (1994) and the references therein. Several studies report greater volatility of stock returns at the open and close of trading than at other times of the trading day. Webb and Smith (1994) examine whether the observed patterns in volatility are also characteristic of other financial markets. Using Eurodollar futures prices, they find greater volatility during the opening of trading than during all other intervals. They find also a significant market closing for the CME.

To proxy for the CAC 40 volatility rate, volatility estimates are implied from each transaction, each day, using a modified lattice approach as in Bellalah (2000). The binomial model is appropriate for the pricing of CAC 40 options. Each day, implied volatilities are aggregated with respect to the degree of parity. Hence, we obtain each day 11 average implied volatilities corresponding to different degrees of parity. To get an idea about the index volatility estimates, we calculate an implied ratio of volatility. This ratio is defined as follows:

$$Rv_{K,t} = \frac{\sigma_{k,t}}{\sigma_{0,t}} \quad \text{for } k= -5,...5.$$

By construction, this ratio is equal to one for at the money options. Figure 13 reports the put/call ratios according to the degree of parity for PX1 and PXL calls and puts for the period 1995-1998.

Figure 13

Put/Call ratios P/C for CAC 40 options, 1995-1998

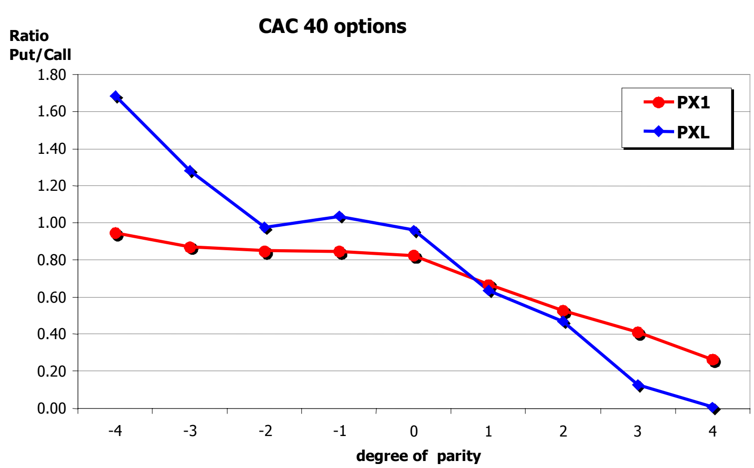


Figure 14
Mean ratios of implied volatilities Rv for PXL calls and puts in the period 1994-1998

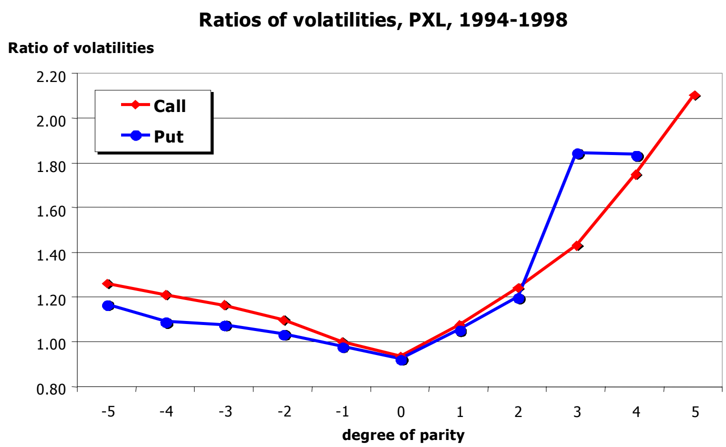


Figure 14 shows the mean ratios of implied volatility according to the degree of parity for PXL calls and puts for the period 1994-1998. The figure reveals clearly the presence of a smile effect for call and put options. The shape of the volatility smile reveals higher volatilities for out of the money options. It is nearly U-shaped for calls and puts traded in the Paris Bourse.

The analysis of the spreads is restricted to the days 5, 15, 25, 35, 45, 55, 65 until 125 by a step of ten days in order to reduce the number of observations for the year 1998. Also, the day is divided into two-half our intervals from 10.00-10.30 and 16.30-17.00 and six-hour intervals from 10.30 to 16.30. Since the effect of the spreads during this high volume period is a central focus of the spreads on the option markets, a distinction is made: first, we take the whole interval, second, the interval is divided into two intervals.

We do not omit the first few minutes but rather the first interval is divided into two intervals because it is interesting to see the volume, the volatility and the spreads for shorter time intervals.[15] At the open, options trading can not begin before trading on the underlying asset market has started. It takes at least few minutes to observe the transactions on the underlying asset market and to adjust the spreads in the options market. Also, around the close, in the last few minutes of the trading day, there is often a non-synchronization between the quoted underlying index futures (index contracts) spreads and options spreads. In fact, it is often observed that the quoted options prices do not correspond to the closing spreads in the underlying asset markets. The non synchronization may have different causes. It results from the fact that around the close of the exchange, several traders place different orders in both markets: the option market and the underlying asset market. Since the market becomes very erratic, some orders are executed for small quantities and others are not fully executed, this leads to transaction prices in the underlying asset markets which do not correspond to the option spread. The quoted option spread does not correspond to any transaction in the market place. Sometimes, non synchronization appears because of errors in recording the transactions or in reporting at the nearest second the quoted prices in both markets. This non synchronization of the underlying assets spreads and options spreads would be interesting to study since it can lead to "abnormal" results. Therefore, we do not eliminate systematically the first and last minutes of the day. The intraday pattern of the observed bid-ask spread for the options in the sample is analyzed and the findings are compared with the model predictions and other studies.[16]

The average spread which actually occurred in a time interval is used. Let us define the reservation fee as the minimum fee such that a dealer is indifferent between doing nothing, selling at $A_i = c_i(1+a_i)$ or buying at $B_i = c_i(1-b_i)$ where c_i is the true options price according to the dealer and a_i and b_i are measured as a proportion of c_i. The proportional bid-ask spread for each quotation is calculated as:

$$\text{Spread}_{d,t,i} = \frac{A_{d,t,i} - B_{d,t,i}}{\frac{(A_{d,t,i} + B_{d,t,i})}{2}}$$

where the subscripts d, t and i stand for the day d, the time t and the options series i for which a quotation is given.[17] Each day, these time intervals and options series are used to calculate the average proportional bid-ask spread. The average proportional bid-ask spreads (by half an hour, an hour, series and day) are used to calculate an average across options series and trading days. This gives us the average proportional market spread by interval.

Table 5 gives some statistics of the total market spread during the trading day. After the opening, the spread declines, remains stable during the rest of the day and declines again around the close.[18]

Table 5

Statistics on the proportional spread by time period during the trading day in the year 1998.[19]

Interval	N	Mean	Std	Max	Min	Q1	Median	Q3
10.00-10.30	594	0.25	0.111	0.975	0.058	0.093	0.20	0.280
10.30-11.30	650	0.28	0.132	0.888	0.043	0.094	0.25	0.312
11.30-12.30	700	0.25	0.101	0.735	0.031	0.091	0.20	0.301
12.30-13.30	602	0.24	0.131	0.887	0.036	0.078	0.19	0.292
13.30-14.30	558	0.24	0.113	0.665	0.033	0.072	0.18	0.286
14.30-15.30	670	0.24	0.108	0.698	0.041	0.075	0.18	0.284
15.30-16.30	660	0.25	0.101	0.732	0.042	0.078	0.19	0.272
16.30-17.00	680	0.25	0.100	0.678	0.051	0.082	0.19	0.260

We report a reduction in the spread in the last half hour. This finding is not reported in the other studies mainly because during the last few minutes before the close of the exchange, bid ask spreads do not reflect market conditions.

It is true that the spread is largest at the first and the last minutes of the day (as it is the case for volume in Figures 10-11-12), but this is because of non synchronization problems between the options market and the underlying asset market.

We make also another test using a record of fifteen by fifteen minute which is created for the expiration cycles of December and June, 1998. The first quote is recorded in the first five minute in which it appears. The average across all options and days of bids, asks and spreads by fifteen minutes from 10 a.m to 5 p.m is calculated separately for at the money options, in the money options and out of the money options. We find that proportional spreads in the options markets are "widest" when the volume of trading is low. They narrow after the opening and around the close and widens around midday. Several explanations can be advanced. There seems to be a correlation between the volume in the options market and the volume in the underlying asset market. When the volume is high in the underlying asset market, this produces trading in the options market. Also, when volume is important in the options market, and particularly for in the money options, this produces volume in the underlying asset market since options dealers use the underlying asset to implement their hedging strategies.

In reality, for liquid underlying assets, a high volume around closure leads in general to lower spreads in the options markets while the opposite result appears for less liquid assets. This remark might explain the conflicting results in the literature about the options spreads in connection with the underlying asset spreads.

VI. CONCLUSION

This paper studies volumes, volatilities and spreads in the Paris Bourse and whether the open and close of trading represent special moments in financial markets. This question is examined simultaneously for options markets and their underlying asset markets. Periodic market closure leads to periodic changes in the demand for transaction services showing an increased demand and less elastic transactions around closure. We present an extension of the model in Garman (1976) and Bellalah and Zhen (2002) from stock markets to options markets. We show that transactions demand at open and close in options markets are greater than at other times of the day. This allows studying the relationships between market closure, volume, volatility, and bidding ask spreads.

The empirical evidence is, in general, consistent with our predictions of high volume supporting the periodic demand model for options and the underlying assets. A similar study in the underlying asset market is done in order to investigate the effects of opening and closing. The simultaneous study of both markets provides some insights about the correlation in volume and the trading activity in both markets. In line with previous research, our study confirms some of the main findings using the recent options and assets prices data on the Paris-Bourse. The effect of periodic market closure on transactions demand and the bid-ask of options prices is studied.

When we consider 15 minutes intervals, it is clear that just at the open, the transactions are low when compared to the middle of the day. This result seems to be different from those reported in other markets. This may be due to the institutional features of the Paris-Bourse. In general, empirical tests reveal that high volume in options markets is accompanied by narrower bid and ask spreads and vice-versa (except for small time intervals at the open).

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NOTES

1. The traded options market is located in the Palais de la Bourse (Euronext) and options are traded on the Marche des Options Negociables de la Bourse de Paris, (MONEP). The marche a reglement mensuel de la Bourse de Paris, RM, is a forward market. (See for example Solnik (1990), Biais, Hillion and Spatt (1995), Briys-Bellalah et al. (1998), Bellalah (2001), etc.)
2. The RM market is replaced by the "Service de Reglement Differe, SRD" from September 2000. (See La Tribune, 17 May, 2000 or Bellalah (2000)
3. For index options, there are no bid-ask spreads on the underlying index. Instead, the spread on the futures index contract can be used.
4. As it appears in Hong and Wang (2000), the literature on the empirical patterns of stock returns and trading activities in relation to market closures reveals that:
   - The intraday mean return and volatility are U-shaped,
   - The intraday trading volume is also U-shaped,
   - Open-to-open returns are more volatile than close-to-close returns,
   - Returns are more volatile over trading periods with comparison to non-trading periods.
5. The trading hours on MONEP for equity options and index options are from 10 a.m to 5 p.m Paris time, Monday to Friday. Central European time is six hours ahead of Eastern standard time: that is 9:00 a.m. Eastern standard time in New York is 3:00 p.m. Central European time in Paris.
6. In some countries, like in France, the high demand to trade in index options, index futures and the underlying contracts leads the market authority to extend the hours of trading (in the exercise of options) with a specific period, 5:00 p.m. to 5:45 p.m. However, this does not prevent market participants to trade heavily at the close. For index options, this additional time of 45 minutes gives rise to a wildcard option. This option is analyzed and valued in Bellalah (2001)
7. The same arguments apply for an increase in supply.
8. However, we recognize that we simplify the reality, because the use of actual supply and demand functions (non-linear) complicates considerably the analysis without giving any analytic results.
9. The proof of this lemma is immediate.

In fact, since MR= A + $\lambda \frac{\partial A}{\partial \lambda}$, then from assumption (2), we have:

MR2(λ*)-MR2(λ*)= A2(λ*)- A1(λ*) + (λ*) $(\frac{\partial A2}{\partial \lambda} - \frac{\partial A1}{\partial \lambda})$.

10. For an increase in supply, equivalent results can be obtained using similar arguments.
11. PXL calls and puts have different strike prices: i.e. if the index price is 2052, the following strike prices are opened: 2050, 2200, 2350 for calls and 1900, 1750 for puts.
    [1] However, we have only the spreads for the year 1998 since the MONEP database is actually in construction.
12. PXL calls and puts have different strike prices: i.e. if the index price is 2052, the following strike prices are opened: 2050, 2200, 2350 for calls and 1900, 1750 for puts.
    [1] However, we have only the spreads for the year 1998 since the MONEP database is actually in construction.
13. PXL calls and puts have different strike prices: i.e. if the index price is 2052, the following strike prices are opened: 2050, 2200, 2350 for calls and 1900, 1750 for puts.
14. However, we have only the spreads for the year 1998 since the MONEP database is actually in construction.
15. However, the specialist exists only for stock options and not for index options.
16. Hong and Wang (2000) study how market closures affect investors' trading policies and the corresponding return-generating process. They show that closures generate U-shaped patterns in the mean and volatility of returns over trading periods and that there is a higher trading activity around the close and open. They find also that closures can make prices more informative about future payoffs.
17. The spreads quoted during the first and the last few seconds are not accounted for since they do not reflect the real market conditions.
18. Spreads in index options are often narrower than spreads in stock options because of the high volume of trading which allows dealers to manage their inventories and roll-over their positions by resorting to the index futures contracts. Stock dealers do not benefit from these specific risk management tools. Hence, high volume on the options market tends to reflect in some way the market liquidity. This liquidity allows the implementation of market making risk-reducing strategies that lower the risks and the bid and ask spreads. Similar arguments do not necessarily apply to the underlying assets dealers since they have fewer opportunities to diversify their risks when compared to options market makers.
19. This definition eliminates the bias toward more frequently quoted securities. In fact, in the study of Brock and Kleindon (1992) for listed stocks, the pattern of the bid-ask spread was divided by the stock's price. The average spread in a particular minute corresponds to the average spread using the quotations that actually occurred during that time.

This method presents a bias toward more frequently quoted stocks. This bias is corrected by Berkman (1992) who admits that a quote remains until a new quote is given.

20. The first and last few seconds of each trading day are eliminated. The reduction in the spread in the first half hour in our sample is a result reported also in the studies of Berkman (1992) and MacInish and Wood (1992).
21. F-tests are used for the significance of differences in total spreads during the day. The mean spread differs from one time interval to another and is equal to F_{hour}=16.38.
    It is significantly lower in the first and last interval F_1=40.32, F_8=37.12.
    The mean spread is significantly higher in interval 2, F_2=8.41 than the mean spread in intervals 3 to 8.

REFERENCES

Amihud, Y. and Mendelson H., 1986, "Asset Pricing and the Bid-ask Spread," *Journal of Financial Economics* 17, 223-249

Amihud, Y. and Mendelson, H., 1987, "Trading Mechanisms and Stock Returns: An Empirical Investigation," *Journal of Finance*, 3, 533-555

Amihud, Y. and Mendelson, H., 1988, "Liquidity and Asset Pricing: Financial Management Implications," *Financial Management*, spring, 5-15

Bellalah, M., 2001, "The Valuation of CAC 40 Options and Wildcard Options in the Paris Bourse," *International Review of Economics and Finance*, 10, 75-94.

Bellalah, M., 2000, "A Risk Management Approach to Options Trading on the Paris Bourse," *Derivatives Strategy*, Vol 5, N 6, June, 31-33

Bellalah and Zhen, 2002, "A Model for Market Closure and International Portfolio Management within Incomplete Information," *International Journal of Theoretical and Applied Finance*.

Berkman, H., 1992, "The Market Spread, Limit Orders and Options." *Journal of Financial Services Research*, 399-415.

Briys, E., Bellalah, M. et al., 1998, *Options, Futures and Exotic Derivatives*, John Wiley & Sons, 1998.

Biais, B., Hillion, P. and C. Spatt, 1995, "An Empirical Analysis of the Limit Order Book and the Order Flow in the Paris Bourse," *Journal of Finance*, Vol L, No 5, December, pp 1655-1689

Brock, W. A and Kleidon, A.W, "Periodic Market Closure and Trading Volume," *Journal of Economic Dynamics and Control* 16, (1992) p 451-489.

Connolly, R.A., 1989, "An Examination of the Robustness of the Weekend Effect," *Journal of Financial and Quantitative Analysis*, 24, pp 133-171

Connolly, R.A., 1991, "A Posterior Odds Analysis of the Weekend Effect," *Journal of Econometrics* 49, pp 51-104

Fedenia and Grammatikos, 1992, "Options Trading and the Bid-Ask Spread of the Underlying Stocks," *Journal of Business*, N 3, 335-51.

French, K.R, 1980, "Stock Returns and the Weekend Effect," *Journal of Financial Economics* 8, pp 55-69

Garman, Mark, 1976, "Market Microstructure," *Journal of Financial Economics*, N 3, 257-75.

Gibbons, M.R. and P. Hess, 1981, "Day of the Week Effects and Asset Returns," *Journal of Business* 54, pp 579-596

McInish, TH and Wood, R.A, 1992, "An Analysis of Intraday Patterns in Bid-Ask Spreads for NYSE Stocks," *Journal of Finance*, 47, 753-764.

Hong, H. and Wang, J., 2000, "Trading and Returns under Periodic Market Closures," *Journal of Finance*, Vol LV, No 1, February, 297-354

Hsieh, D. and A. Kleidon, 1996, "Bid-Ask Spreads in Foreign Exchange Markets: Implications for Models of Asymmetric Information," in J. Frankel, G. Galli and A. Giovannini (eds), *The Microstructure of Foreign Exchange Markets*, Cambridge: National Bureau of Economic Research, 41-65.

Lindley, D.V., 1957, "A statistical Paradox," *Biometricka* 44, pp 187-192

Merton, R., 1971, "Optimum Consumption and Portfolio Rules in A Continuous-time Model," *Journal of Economic Theory* 3, 373-413.

Ronn, E.I and Sheikh, A., "A Characterization of the Daily and Intraday Behavior of Returns on Options," *Journal of Finance*, N 2, June, (1994), 557-79.

Shanken, J., 1987, "A Bayesian Approach to Testing Portfolio Efficiency," *Journal of Financial Economics* 18, pp195-215

Stoll, H. and Whaley, R., 1990, "Stock Market Structure and Volatility," *Review of Financial Studies*, 3, 37-71

Solnik, B., 1990, "The Distribution of Daily Sock Returns and Settlement Procedures: The Paris Bourse," *Journal of Finance*, 5, December, 1601-1609.

Webb, R.I. and Smith, D.G., 1994, "The Effect of Market Opening and Closing on the Volatility of Eurodollar Futures Prices," *Journal of Futures Markets*, Vol 14, N 1, pp 51-78

Appendix:

Proof of Proposition 1:

We consider a quantity $\tilde{\lambda} > \lambda^*$ the original optimum. Since it is assumed that $\frac{\partial B}{\partial \lambda}(\lambda) > 0$, $\frac{\partial A}{\partial \lambda}(\lambda) < 0$, and A2($\tilde{\lambda}$) < A2(λ*), B($\tilde{\lambda}$) > A2(λ*), then the spread narrows with respect to the spread at λ*, that is : A2(λ*)- B(λ*)> A2($\tilde{\lambda}$)- B($\tilde{\lambda}$).

Using the assumption (3), the difference between MR2 and MC narrows more quickly, that is:

$$(A2(\lambda^*) - B(\lambda^*)) - (A2(\tilde{\lambda}) - B(\tilde{\lambda})) < (MR2(\lambda^*) - MC(\lambda^*)) - (MR2(\tilde{\lambda}) - MC(\tilde{\lambda}))$$

Since this result holds for all $\tilde{\lambda} > \lambda^*$, it is also valid for $\lambda^*_2 > \lambda^*$. So,

$$(A2(\lambda^*) - B(\lambda^*)) - (A2(\lambda^*_2) - B(\lambda^*_2)) < (MR2(\lambda^*) - MC(\lambda^*)) - (MR2(\lambda^*_2) - MC(\lambda^*))$$

Using the Lemma:

$$(A2(\lambda^*) - B(\lambda^*)) - (A2(\lambda^*_2) - B(\lambda^*_2)) < MR2(\lambda^*) - MR2(\lambda^*) \leq (A2(\lambda^*) - A1(\lambda^*)),$$

and since λ^*_2 corresponds to the equilibrium quantity, $MR2(\lambda^*_2) = MC(\lambda^*_2)$, $MR1(\lambda^*) = MC(\lambda^*_2)$ then $A1(\lambda^*) - B(\lambda^*) < A2(\lambda^*_2) - B(\lambda^*_2)$.

Proof of Proposition 2:

At $\lambda^*_2 > \lambda^*$, $B(\lambda^*_2) > B(\lambda^*)$. However, since by the first proposition,
$(A1(\lambda^*) - B(\lambda^*)) < (A2(\lambda^*_2) - B(\lambda^*_2))$, it follows that: $A2(\lambda^*_2) > A1(\lambda^*)$