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Trading volume and contract rollover in futures contracts

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Abstract

Futures trading volume data display strong quarterly seasonality due to the 'rolling over' of positions close to the expiry date of the near contract. This undermines the use of volume as a proxy for information arrival. By making explicit the relationship between trading volume and change in open interest, we provide an upper bound for this rollover. Empirical analysis of the S&P500, the UK Long Gilts and the Brent Crude contracts shows that our upper bound can be used to remove expiry-related seasonality from trading volume data.

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1. Introduction

Trading volume has been widely used as a measure for the rate of information arrival and as a means to gain insight into the precision of information. Unfortunately,

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unlike volume data for stock trading, that relating to futures trading is affected not only by information arrival but also by 'rollover' activity. Investors wanting to maintain a position in futures across the near contract expiry date will simultaneously close their position in the near contract and open an identical position in the next contract. This effect shows up in trading volume, in individual contract open interest, but not in total open interest. The impact of rollover has important implications for studies using futures trading data as a proxy for information arrival.

In this paper, we show how a series representing 'nonrollover trading volume' can be constructed from trading volume and open interest data. As Bessembinder et al. (1996, p. 117, emphasis added) argue, it is "crucial to recognize the existence of *mechanical links* between futures trading volume and open interest". To derive our series, we make explicit these links, considering not only the relationship between trading volume and the change in open interest for an individual contract, but also *across* contracts. The new series will be of considerable use to researchers examining any aspects of the price–volume relationship, but particularly news-related models. If trading volume is to be used as a proxy for information arrival, it is important that rollover effects be removed, since they are systematically related to the contract life cycle rather than to news arrival.

The outline of the paper is as follows. Section 2 provides a brief discussion of previous work using volume data. Section 3 explains the 'mechanical link' between trading volume and the change in open interest in the near and next-to-near (referred to here as the 'next') contracts. From this, we are able to determine an upper bound on the number of contracts rolled over each day. The analysis is generalised in Section 4 to determine an upper bound when rollover into more than one contract and from more than one contract is allowed to take place. In Section 5, we use data on S&P500, the UK Long Gilts and Brent Crude futures contracts to examine the use of this upper bound in practice. Section 6 concludes.

2. Trading volume in empirical analysis

Considerable empirical analysis of trading volume data has been undertaken in an attempt to gain insight into the operation of both stock and futures markets. Karpoff (1987) summarises the findings of 19 empirical studies of the relationship between volume and the absolute value of price changes over the period 1964–1987 and of 16 empirical studies of the relationship between volume and price changes *per se* carried out between 1963 and 1987. Since this review, several further studies of the role of volume have been undertaken (see, e.g., Lamoureux and Lastrapes, 1990; Gallant et al., 1992; Bessembinder and Seguin, 1992, 1993; Locke and Sayers, 1993; Hiemstra and Jones, 1994; Blume et al., 1994; Bessembinder et al., 1996; Anderson, 1996; Smith et al., 1997; Easley et al., 1998; Daigler and Wiley, 1999; Chordia and Swaminathan, 2000; Lee and Swaminathan, 2000; Chan and Fong, 2000; Chordia et al., 2001; Chen et al., 2001; Gervias et al., 2001).[1] While many of the studies use data from stock markets, there are a substantial number that relate to futures markets: five of the studies reviewed by

Karpoff relate to futures, as do those of Bessembinder and Seguin (1992), Bessembinder and Seguin (1993), Locke and Sayers (1993), Bessembinder et al. (1996) and Daigler and Wiley (1999).[2]

A common theme in the empirical literature, and arguably a *raison d'être* for many of the studies, is that volume data provide important insights about the rate of news arrival. Indeed, in many of the studies volume is viewed as a proxy for new information. For example, such a relationship between volume and information is consistent with the sequential information model of Copeland (1976) and the mixture of distributions hypothesis of Clark (1973), as developed by Epps and Epps (1976), Tauchen and Pitts (1983) and Harris (1987). In other studies, volume data have been used to examine the precision of information (Blume et al., 1994) and to investigate the stabilisation–destabilisation debate regarding the impact of futures trading (Bessembinder and Seguin, 1992).

There are undoubtedly problems associated with the view that the volume of trade is a direct proxy for the rate of information arrival, since the volume of trade in stock and futures markets will, in part, be determined by the effects of noise trading. This provides the rationale for the work of Blume et al. (1994). However, in the absence of an alternative proxy for information and given the new areas of research using volume data that have been mentioned, the analysis of data on volume will continue to be a key area of research.

In examining the price–volume relationship, futures data can be seen to be superior to cash data in two ways. First, the transactions costs associated with futures trading are substantially lower than those for stock markets, suggesting that futures markets may respond more rapidly to the arrival of information than will cash markets. Analysis of the lead–lag relationship between cash and futures markets supports this view (see, e.g., Kawaller et al., 1987; Chan, 1992). Second, traders in stock markets face asymmetric costs in relation to long and short positions, whereas futures market participants do not. As Jennings et al. (1981) note, the fact that short sales are more costly than undertaking long positions in stock markets means that investors going short face a demand curve which is less responsive to price changes compared with that faced by investors going long. This

[1] While some of these later studies are directly comparable with those reviewed by Karpoff, in that they are attempting to examine the relationship between prices and volume, others are not directly comparable, as they are examining other aspects relating to volume data. For example, Blume et al. (1994) provide information on the quality of information, Bessembinder and Seguin (1992) investigate whether increased futures trading activity (as measured by volume and open interest) is associated with greater equity volatility; Bessembinder et al. (1996) analyse relationships between trading volume, proxies for information flows and divergences in opinions; Daigler and Wiley (1999) categorize volume data by type of trader to examine the volatility–volume relationship in futures markets; Chordia et al. (2001) analyse the relation between expected equity returns and the level and volatility of trading activity; and Gervias et al. (2001) investigate the role of trading activity in terms of the information that it contains about the direction of future price movements.

[2] In addition to the studies reported, there are a number of others that have applied the methods used in stock markets to examine futures markets; for example, Najand and Yung (1991) apply the Lamoureux and Lastrapes (1990) approach to futures, while Foster (1995) uses both the Lamoureux and Lastrapes (1990) and the Blume et al. (1994) approaches to investigate futures volume data.

advantage of futures data is supported by the findings of Karpoff (1987), who points out that, while there is empirical support for a positive correlation between trading volume and price changes in stock markets, there is no evidence of such a correlation in futures markets where costs are symmetric.

However, while futures data can be viewed as superior to cash data in some regard, there are two problems associated with the use and analysis of futures data. First, by their very nature, all futures contracts expire, and thus, price and volume data on any contract ceases at maturity. This problem can be overcome by splicing together volume data on successive contracts.[3] Studies of futures often obtain a volume series by summing the volume figures for all contracts for each (typically daily) period. The second problem faced when using futures data relates to volume, which is the result of expiration-induced rollover effects. In financial futures, market participants typically use the near contract due to the greater liquidity in that contract. However, as maturity approaches, investors who wish to preserve their position will 'rollover' from the near to the next contract. Such activity generates volume that is independent of any information arrival, while leaving total open interest unchanged.[4]

Clearly, rollover volume presents researchers with problems if they are concerned with the information content of volume data. The cyclical nature of futures trading has been recognised by Bessembinder and Seguin (1992, p. 2016), who point out that "futures-trading activity varies throughout the contract life cycle, with systematic increases in volume and open interest as the expiration date nears". Similarly, "it is observed that, in many futures as we move into the delivery month, trading volume (and open interest) shifts gradually to the contract with the next nearest delivery date" (Grammatikos and Saunders, 1986, p. 323). Attempts to deal with the problems caused by rollover trading have been varied, but they all suffer from shortcomings. For example, Grammatikos and Saunders (1986) seek to control for what they refer to as 'delivery complications' by omitting the delivery month from their analysis. While such an approach will mitigate the effects of delivery complications, it results in a considerable loss of information. Furthermore, this approach fails to recognise that, while most rollover is likely to take place in delivery month, some rollover may be undertaken earlier, and, additionally, any rollover has a knock-on effect to volume of the next contract.

Bessembinder and Seguin (1992, 1993) and Bessembinder et al. (1996) have adopted more sophisticated approaches, including additional measures of trading activity in their analysis. In addition to volume data, Bessembinder and Seguin (1992, 1993) include measures of open interest in their regression analysis, arguing that there may be a correlation between open interest and the number of active informed traders. In both papers, open interest is found to have a significant role in the relationship between trading volume and price volatility. In Bessembinder and Seguin (1993), the relation between futures price volatility and volume is examined, and the authors conclude that "the effect of volume on volatility depends on whether volume generates

[3] Rougier (1996) proposes a method for constructing a contiguous *price* index from successive contracts.

[4] Arguably, the precise timing of rollover may be related to information arrival. However, given that there is a limited time in which rollover must take place, the majority of rollover volume is likely to be unrelated to information.

changes in open interest. . .Trades that result in changes in open interest appear to have a larger impact on prices than do trades that leave open interest unaltered" (Bessembinder and Seguin, 1993, p. 38). While the inclusion of open interest figures in the analyses provides additional information on the volume–volatility relationship, the volume figure that is being used remains contaminated by rollover. Indeed, the conclusions that the authors draw fail to recognise the impact of rollover. Rollover from one contract to the next will have no impact on open interest. The finding that volume associated with no change in open interest has less impact than does volume associated with changes in open interest is consistent with the view that rollover is independent of information arrival.

Bessembinder et al. (1996) include measures of open interest in their analysis of relations between trading volume, proxies for information flows and divergences in opinion. They also include two control variables to take account of expiration effects. The first of these is the number of days to expiration, while the second is a zero–one dummy, where the dummy takes the value one on expiration days and zero otherwise. Both variables are found to be significantly negative when the dependent variable is futures volume, while only the expiration day dummy is significant when the dependent variable is stock volume. Again, while these control variables are providing some additional information, the futures volume figures still include rollover-related volume, and the methods for controlling for life-cycle effects are arbitrary and unsophisticated. The findings that volume of trading in futures is statistically related to days to expiration and that volume in the stock market is not is consistent with the view that futures volume is contaminated by rollover.

If sensible conclusions regarding, for example, information arrival are to be drawn on the basis of futures volume data, it is desirable to remove the contamination that exists in the volume series as a result of rollover. While the attempts that have been made to deal with life-cycle effects to date indicate that problems exist, they are ad hoc and fail to remove rollover effects. It is therefore necessary to seek an alternative approach. Previous studies suggest a way forward. Open interest data have been widely used as a means of gaining further insight into activity in futures markets. While the use of these data has not overcome the problem of rollover, it does provide a means, when used in conjunction with volume data, by which the effect of rollover activity can be bounded. It is then possible to obtain a volume series that is effectively uncontaminated by rollover activity.

3. An upper bound for rollover

For each trading day, we can observe the amount of trading volume that occurs during the day, and the amount of open interest at the end of the day, for each available futures contract. The open interest is a stock variable representing the number of contracts outstanding at any point in time. The flow variable that accompanies trading volume is therefore the *change* in open interest over the course of the day. In this section, we concentrate on the near contract and the next contract for each day, denoted by a single and double prime, respectively. Since all variables relate to the same day, the

t subscript is unnecessary and will be suppressed. Therefore, our four observations for each day are v' and v'' for trading volume, and Δ' and Δ'' for the change in open interest.

These four variables are related, in that they are simultaneously determined by five quantities. We can categorise every trade in futures as being one of (i) opening a position, (ii) closing a position, or (iii) rolling over a position. In the first two cases, we must also specify the contract: near or next. The five quantities are therefore the number of contracts opened and closed for each of the two futures, and the number of contracts which are rolled over between the near and the next futures; all five quantities are clearly nonnegative.

The relationship between the four observed variables and the five unobserved variables is then

$$\begin{aligned} v' &= o' + c' + r \\ v'' &= o'' + c'' + r \\ \Delta' &= o' - c' - r \\ \Delta'' &= o'' - c'' + r \end{aligned} \tag{1}$$

where o and c denote the number of contracts opened and closed, respectively, and r is the number of contracts rolled over from the near to the next futures. These four equations specify explicitly the mechanical link suggested by Bessembinder et al. (1996), with the addition of the link between contracts provided by rollovers. As Bessembinder et al. (1996) observe, we can have trading volume but no change in open interest, i.e., $o'=c'$ and $r=0$ in the near contract, say. We can also have trading volume and no news, i.e., $o'=c'=0$, but $r>0$. In this latter case, we would have offsetting changes in the open interest of the two contracts. In general, of course, we would expect all five unknowns to be positive, resulting from a combination of news and rollovers. Our objective is to find r, to identify the level of trading volume that would have occurred in the absence of rollovers—what we term 'nonrollover trading volume'.

These four linear equations in the five unknowns have a coefficient matrix of rank 4, which implies that Eq. (1) can be solved for four of the unknowns in terms of the fifth. The solution (e.g., by Gaussian elimination) is

$$\begin{aligned} o' &= \frac{1}{2}(v' + \Delta') \\ c' &= \frac{1}{2}(v' - \Delta') - r \\ o'' &= \frac{1}{2}(v'' + \Delta'') - r \\ c'' &= \frac{1}{2}(v'' - \Delta''). \end{aligned} \tag{2}$$

These relations allow the amount of rollover to be bounded, since all four unknowns must be nonnegative. It follows from the second and third relations in Eq. (2) that

$$0 \le r \le \min\left\{\frac{1}{2}(v' - \Delta'), \frac{1}{2}(v'' + \Delta'')\right\}. \tag{3}$$

This is an accounting identity and must always be true. Therefore, it is possible to place bounds on the amount of rollover on any day without having to impose any assumptions on the way in which the market for futures contracts operates.

To gain an understanding of this upper bound, consider the behaviour of the first term in the right hand side of the bounds [i.e., $1/2(v' - \Delta')$] in response to a change in each of the five unknowns. From the matrix, we see that, for each extra contract rolled over, v' increases by one and Δ' decreases by one, for a net increase in the first term of one. For each near contract closed, the net impact is also one. Changes in the other three terms, o', o'' and c'', have no impact on this term. In the second term in Eq. (3), [$1/2(v''+\Delta'')$], one-contract increases in r and o'' have net impacts of one, while o', c' and c'' have no net impact. Therefore, r has an impact on both terms, while c' and o'' have an impact on the first and second terms, respectively. It follows that bounds will overstate the amount of rollover only when both c' and o'' are nonzero, i.e., when market participants choose to close out positions in the near contract on the same day as *different* market participants open positions in the next contract. However, the amount of overestimation by the upper bound is the smaller of c' and o''. Thus, while the upper bound will overestimate true rollover, the extent of any such overestimation is strictly limited, and we might therefore expect that true rollover will be close to the upper bound.

4. Rollover with more than two contracts: two generalisations

The paper thus far has considered rollover for the case where rollover occurs only when there are two contracts traded on the same asset. An analysis of the volume data suggests that this is a reasonable approximation for some contracts (for example, trading in many stock index futures contracts is very largely concentrated in the near and next contracts). However, for many contracts, particularly commodity futures, constraining the analysis of rollover to only the two nearest contracts is inconsistent with actual trading activity. For example, some futures have monthly contract expirations (e.g., Brent Crude), with as many as 10 contracts actively trading at the same time. In such a situation, it is necessary to consider how adjustments can be made for rollover across all contracts traded. In this section, we generalise the previous analysis in two ways: by allowing rollover into more than one contract and by allowing rollover out of more than one contract.

4.1. Rolling into more than one contract

If there are n contracts available, then the data on a given day comprise the volumes v', v'',..., $v^{(n)}$ and the changes in open interest Δ', Δ'',..., $\Delta^{(n)}$. We now define a rolled-over contract to be a situation where an agent simultaneously undertakes a closing transaction in the near contract and an opening transaction in another contract. While this does not allow for contracts to be rolled over from anything other than the near contract, this point will be addressed in the next subsection. As was the case in Section 3, using aggregate data does not allow us to obtain a precise measure of rollover, and we must be content with an upper bound on the amount of rollover.

Using a similar approach to that used in Section 3, the unobserved quantities that relate the data on volume and change in open interest across contracts are the number of non-rolled-over opening contracts o', o'',…, $o^{(n)}$, the number of non-rolled-over closing contracts, c', c'',…, $c^{(n)}$, and the number of rollovers from the near contract into the other contracts, r'', r''',…, $r^{(n)}$, where $r^{(i)}$ is the number of near contracts rolled into the ith contract. It follows immediately that the relation between the $2n$ data and the $3n-1$ unobserved variables is, for the near contract,

$$v' = o' + c' + r'' + \cdots + r^{(n)}$$

$$\Delta' = o' - c' - r'' - \cdots - r^{(n)} \quad (4)$$

and for the other contracts, i.e., i=2,…, n,

$$v^{(i)} = o^{(i)} + c^{(i)} + r^{(i)}$$

$$\Delta^{(i)} = o^{(i)} - c^{(i)} + r^{(i)}. \quad (5)$$

Our interest is in the sum of the rollover transactions, $r=r''+\cdots+r^{(n)}$. The lower bound for r must be 0. The value of r can be upper-bounded in two ways. First, by adding together $v^{(i)}$ and $\Delta^{(i)}$ for i=2,…, n; the constraint $o^{(i)}\geq 0$ implies that, for each $r^{(i)}$,

$$r^{(i)} \leq \frac{1}{2}\left(v^{(i)} + \Delta^{(i)}\right) \quad i = 2,\ldots,n. \quad (6)$$

Second, by subtracting Δ' from v', the constraint $c' \geq 0$ implies that, for the sum r,

$$r \leq \frac{1}{2}(v' - \Delta'). \quad (7)$$

Putting these two bounds together gives the result

$$\max r <= \min\left\{\frac{1}{2}(v' - \Delta'), \frac{1}{2}\sum_{i=2}^{n}\left(v^{(i)} + \Delta^{(i)}\right)\right\}. \quad (8)$$

It can easily be seen that Eq. (3) of the previous section is a special case of this formula with n=2. Thus, Eq. (3) has been generalised to the case where rollover occurs from the near contract into i contracts with later expiration dates.

4.2. Rolling out of more than one contract

Now, let us consider the situation where rollover out of a contract is not limited solely to the near contract. Suppose, for example, that it is common for both the near and the next contracts to be rolled over (that is, some agents choose to roll out of the next contract before it becomes the near contract). Denote rollover from the near contract as $r_1^{(i)}$ for

i=2,..., n, and from the next as $r_2^{(i)}$ for i=3,..., n. Following the same procedure as before gives the relations

$$\begin{aligned} v' - \Delta' &= 2c' + 2\left(r_1'' + \cdots + r_1^{(n)}\right) \\ v'' - \Delta'' &= 2c'' + 2\left(r_2''' + \cdots + r_2^{(n)}\right) \\ v'' + \Delta'' &= 2o'' + 2r_1'' \\ v^{(i)} + \Delta^{(i)} &= 2o^{(i)} + 2\left(r_1^{(i)} + r_2^{(i)}\right) \quad \text{for } i = 3,\ldots,n. \end{aligned} \tag{9}$$

Letting r be the sum of both rollovers, we now derive the bound

$$\max r <= \min\left\{\frac{1}{2}(v' - \Delta' + v'' - \Delta''), \frac{1}{2}\sum_{i=2}^{n}\left(v^{(i)} + \Delta^{(i)}\right)\right\}. \tag{10}$$

As might be expected, this bound can never be smaller than that of Eq. (8) because the first term can never be smaller and the second term is identical. The upper bound on r generalises immediately to rollover out of any number of contracts. For rollover out of the first k contracts with n contracts in total, the expression is

$$\max r <= \min\left\{\frac{1}{2}\sum_{i=1}^{k}\left(v^{(i)} - \Delta^{(i)}\right), \frac{1}{2}\sum_{i=2}^{n}\left(v^{(i)} + \Delta^{(i)}\right)\right\}. \tag{11}$$

Thus, we can now place an upper bound on rollover when rollover (in and out) takes place across i contracts.

5. The upper bound in practice

The previous section showed that it is possible to derive an upper bound on the amount of rollover that occurs each day by considering trading volume and the change in open interest. This leaves open the question of how to derive a point estimate from within the admissible range. There are two possible approaches. First, we may introduce a 'nonaccounting' assumption. This would be a behavioural statement to provide the fifth equation for Eq. (1), which would allow the solution of these equations for all five unknowns. In the general framework, we would need a number of additional equations. Alternatively, we may determine the value within the admissible range for r that is best empirically. We follow the latter approach.

To determine the most appropriate value of r, we consider three different futures contracts, on the S&P500, on UK Gilts and on Brent Crude. The markets are chosen for analysis because, while they are all liquid contracts, they represent a range of futures with widely differing characteristics. In addition to the fact that they are traded on different exchanges, they differ markedly in terms of how many contracts are available simultaneously and the time to expiration. Specifically, while both the S&P500 and the

UK Gilts contracts expire quarterly, for the S&P500 there are up to nine contracts available at any one time, while for the UK Gilts there are usually no more than three available simultaneously. In contrast, the Brent Crude contract expires monthly and there are typically at least 10 contracts available at any one time.

To summarise our findings, discussed in more detail below, we find that our upper bound appears to perform well as a point estimate for rollover in the case of the two financial futures, where trading is concentrated in the near and next contracts. In the case of the commodity contract, where trading is less concentrated in the two nearest contracts, some fixed proportion of the upper bound performs well. In each of these contracts, it is

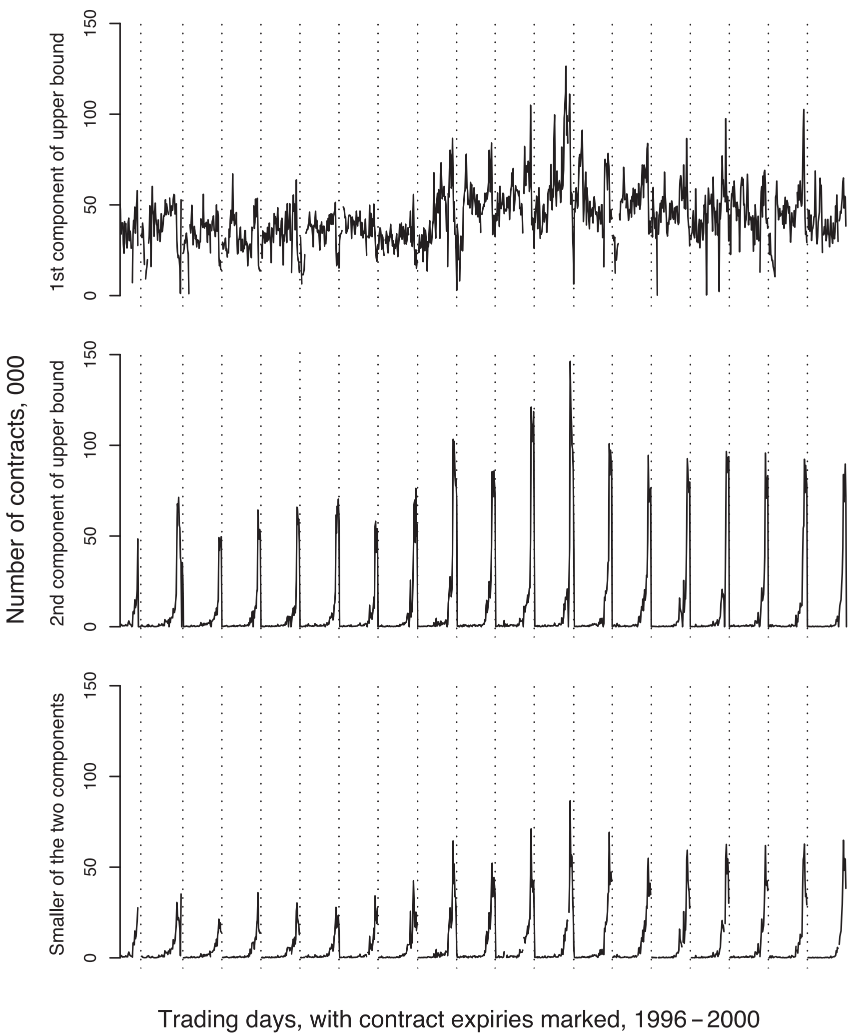

Fig. 1. S&P500 futures contracts, 1996–2000. The two components of the upper bound on rollover, as given in Eq. (8), and their minimum.

easy to identify, graphically, spikes in trading volume that correspond in their frequency and timing to contract expiry. When we adjust trading volume for rollover, we find that the spike has been effectively eliminated. This can be confirmed by examining the autocorrelation function for the adjusted volume data, which, if correctly adjusted, should show no special features at multiples of the contract expiry interval. We conclude that an adjustment based on our upper bound is therefore a good measure of rollover relative to the randomness inherent in the daily evolution of news-related trading volume. We now turn to the analysis and consider each contract in turn.

5.1. The S&P 500 contract

To analyse rollover for the contract, we use data relating to the period January 1996–December 2000. Fig. 1 shows the behaviour of the two components of the upper bound on rollover, and their minimum, in the case where rollover is out of the near contract only

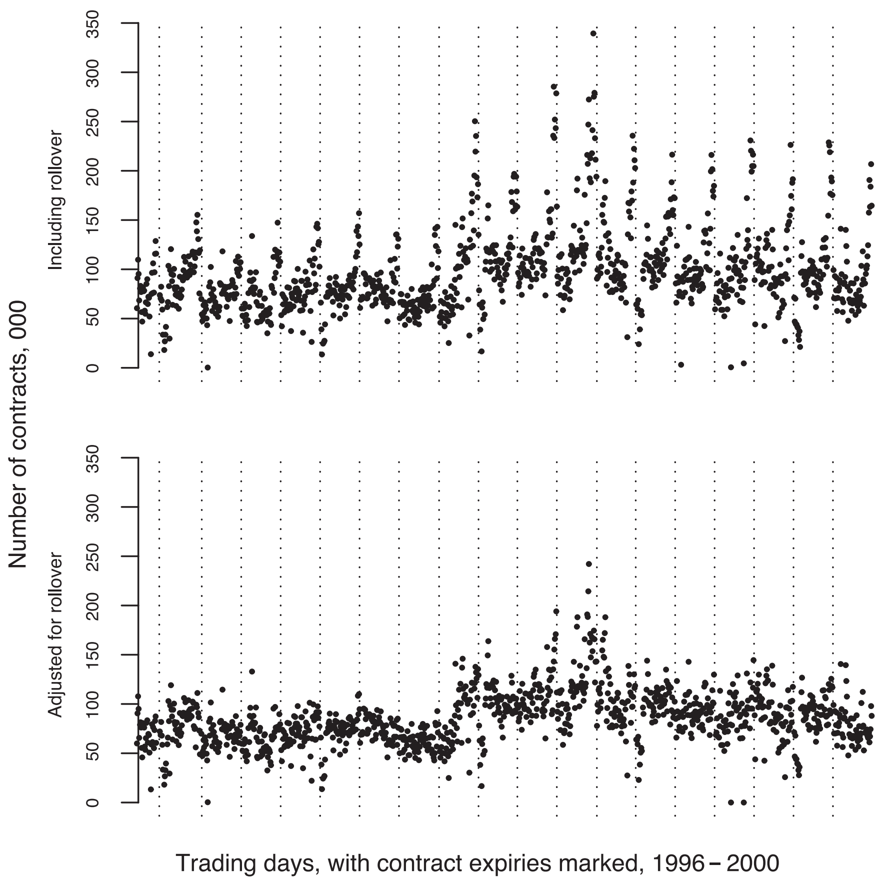

Fig. 2. S&P500 futures contracts, 1996–2000. Total volume and total volume adjusted for rollover using the upper bound.

(that is, we use the method from Section 4.1). There is a very distinct pattern in which the rollover upper bound grows rapidly prior to expiry and falls to near-zero just after. Typically, this pattern arises because the second term in Eq. (8) is close to zero, except just prior to expiry, when it grows rapidly and surpasses the first term.

This pattern of rollover is consistent with our expectations for a highly liquid market, such as the S&P500. In such a market, agents are unlikely to face problems in closing out near contracts, even on days near to the expiration date. Thus, given the high liquidity in this market, and the advantages associated with trading in a liquid market, we would expect rollover activity to be concentrated in the days leading up to expiration of the contract. This is what is clearly seen in Fig. 1.

Fig. 2 shows the total volume (top panel) and total volume adjusted for rollover using the upper bound (lower panel). It is obvious from this figure that there is rapid growth in total volume just prior to expiry. This pattern corresponds to that in Fig. 1. However, in the lower panel, the seasonal effect has been removed after adjusting by the upper bound given in Eq. (8). It is important to note that an examination of the lower panel of Fig. 2 suggests that, in the adjusted volume, there is no undershooting just prior to contract expiry, indicating that the upper bound appears to be a good proxy for rollover at this time.

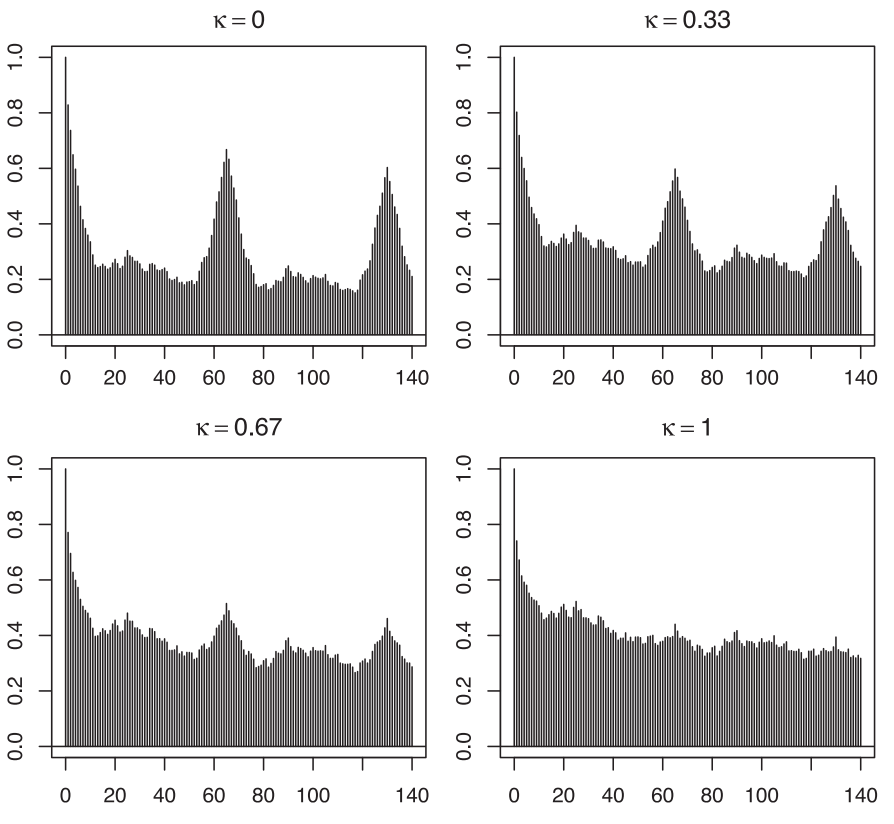

Fig. 3. S&P500 futures contracts, 1996–2000. Autocorrelation function for four different values of κ in Eq. (12).

The adjustment used in Fig. 2 uses the upper bound on rollover, i.e., sets κ=1 in the general expression

$$\hat{v} = v - 2 \times \kappa \times \max\ r \tag{12}$$

where v is total volume across contracts. We can investigate the effect of different values of κ by examining the autocorrelation function of the adjusted volume data for the different values. Fig. 3 shows this function for the values κ=0, 1/3, 2/3 and 1. The spikes at about 65 and 130 days show the effect of contract-expiry-related trading. The size of the spike reduces as κ increases from 0. While the spikes are still evident for κ=0.67, at κ=1, these spikes have been removed, clearly suggesting that the upper bound is a good proxy

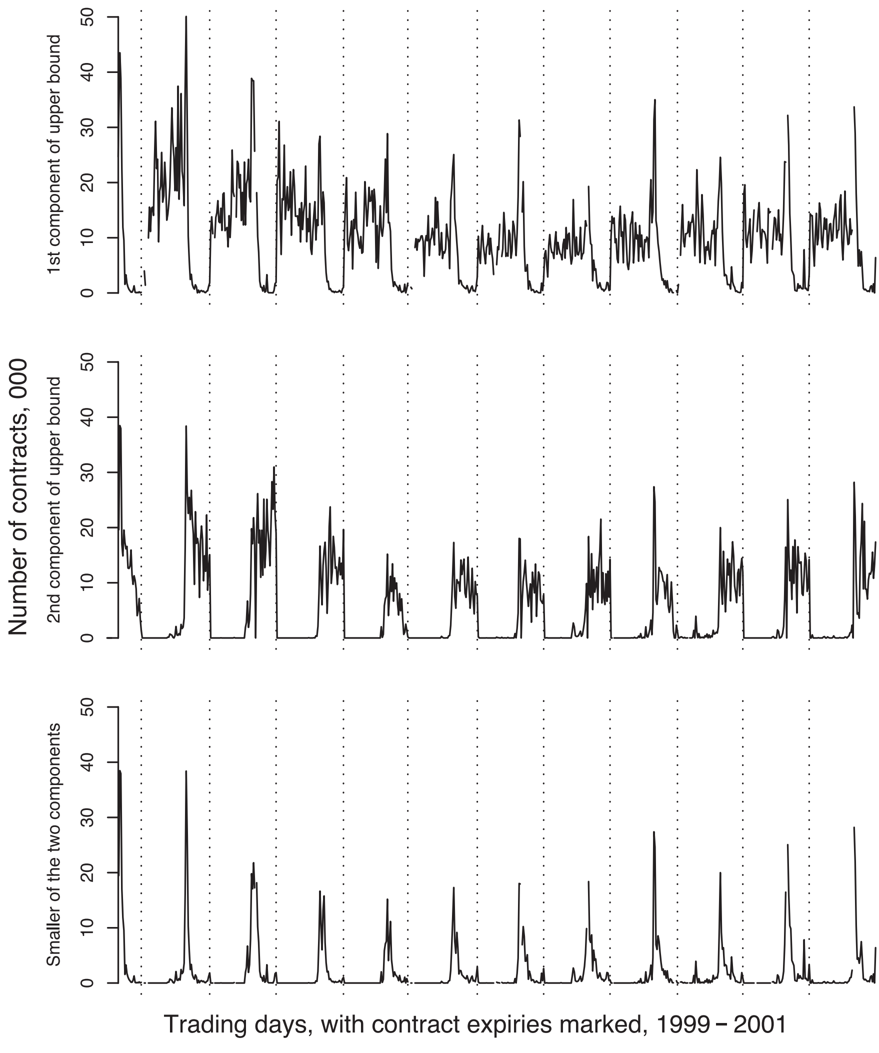

Fig. 4. UK Gilts Futures contracts, 1999–2001. See caption to Fig. 1 for details.

for rollover. Note that, if κ=1 were systematically too large, then we would expect to see the spike reappear at κ=1 due to undershooting (an example of this effect is found in the Brent Crude data, below).

Having illustrated the usefulness of the upper bound for the S&P500 contract, we extend the analysis to two other contracts. For these contracts, we use data for the period 1999–2001.

5.2. The UK Gilts contract

Given that trading is highly concentrated in the near and next contracts for UK Gilts, we again use the method of Section 4.1 and assume rollover out of the near contract only. Figs. 4, 5 and 6 present the same information for UK Gilts as Figs. 1, 2 and 3 did for the S&P500. Again, expiry-induced effects are clear in the figures, and once again, it is clear that the upper bound is a good proxy for rollover. However, the pattern of effects is markedly different from that of the S&P contract. The general impact of rollovers appears

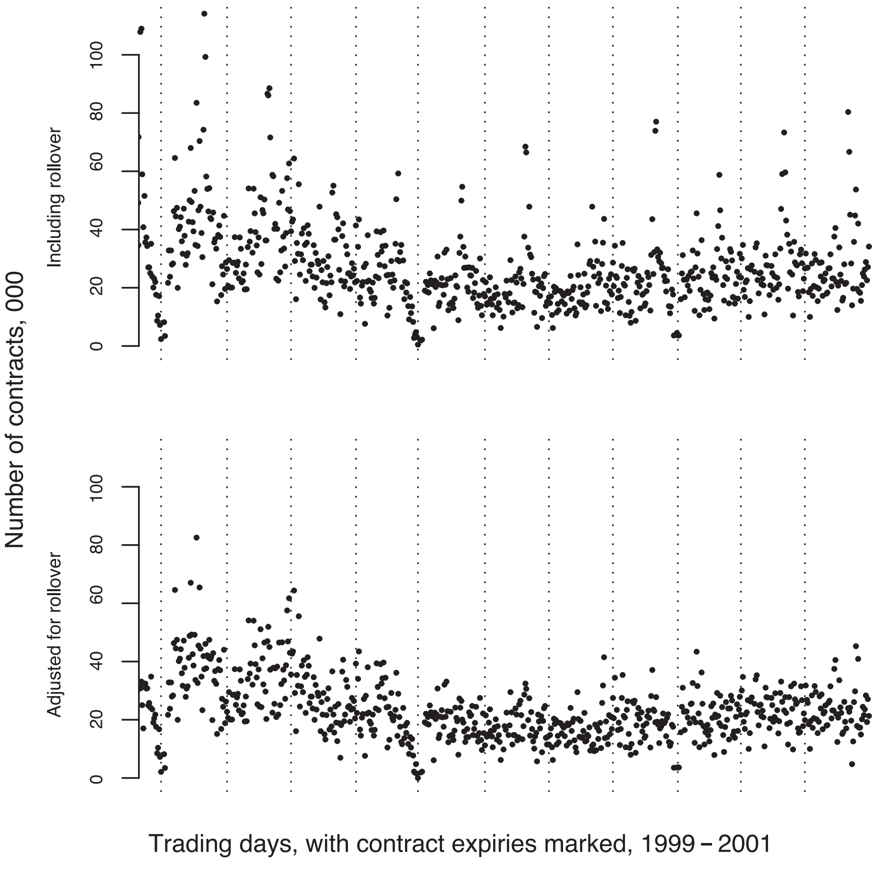

Fig. 5. UK Gilts Futures contracts, 1999–2001. See caption to Fig. 2 for details.

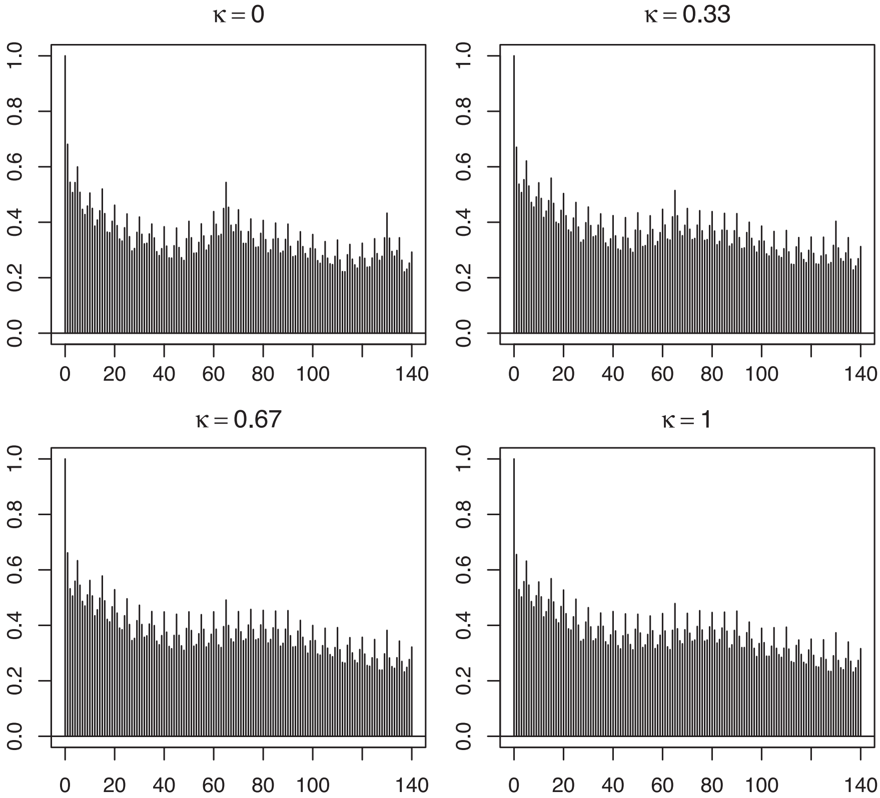

Fig. 6. UK Gilts Futures contracts, 1999–2001. See caption to Fig. 2 for details.

to be less for Gilts than for the S&P500 contracts. Rather than peaking at contract expiry, for Gilts, the peak in rollover activity appears to happen earlier and then reduce. Before and during the peak, it is the second term in Eq. (8) that is the smallest, while after the peak, it is the first term.

The different pattern in rollover activity is both interesting and reassuring. It is interesting because the pattern of rollover activity suggested by the upper bound has different characteristics to that of the S&P500 contract. In addition, it is reassuring in that a different pattern is to be expected given the different trading characteristics of the UK Gilts and S&P500 contracts. Specifically, the UK Gilts contract is much less liquid than is the S&P500, with both the volume of trade and open interest in UK Gilts falling substantially in the last few days before contract expiry, when liquidity moves to the next contract. This occurs, in part, because in the period immediately prior to contract expiry, it is possible to deliver underlying Gilts against the contract. However, there is a range of Gilts that can be delivered, and market participants typically do not wish to be exposed to the risk of receiving bonds, potentially on unfavourable terms. Hence, liquidity falls substantially ahead of this delivery period. On this basis, those wishing to rollover their positions will tend to move out of the near contract prior to the reduction in volume and open interest and, hence, will rollover earlier than will their counterparts in the S&P500 contract. Thus, the ‘window’ in which substantial rollover activity will take place will tend to be some time before contract expiry. Hence, the peaks in rollover activity will tend to be earlier in the contract cycle for UK Gilts than for the S&P500 (compare the bottom panels of Figs. 1 and 4). Again, an examination of the figures suggests that κ=1 is most appropriate, with no spikes being evident in the adjusted traded volume (see Fig. 5).

Note that in Fig. 6, the autocorrelation function shows evidence of both contract expiry effects (for example, for κ=0, there are peaks at approximately 65 and 130 days) and also weekly effects (peaks at multiples of 5 days). By adjusting volume for the upper bound (i.e., κ=1), the contract expiry effects are removed while the weekly effects remain.

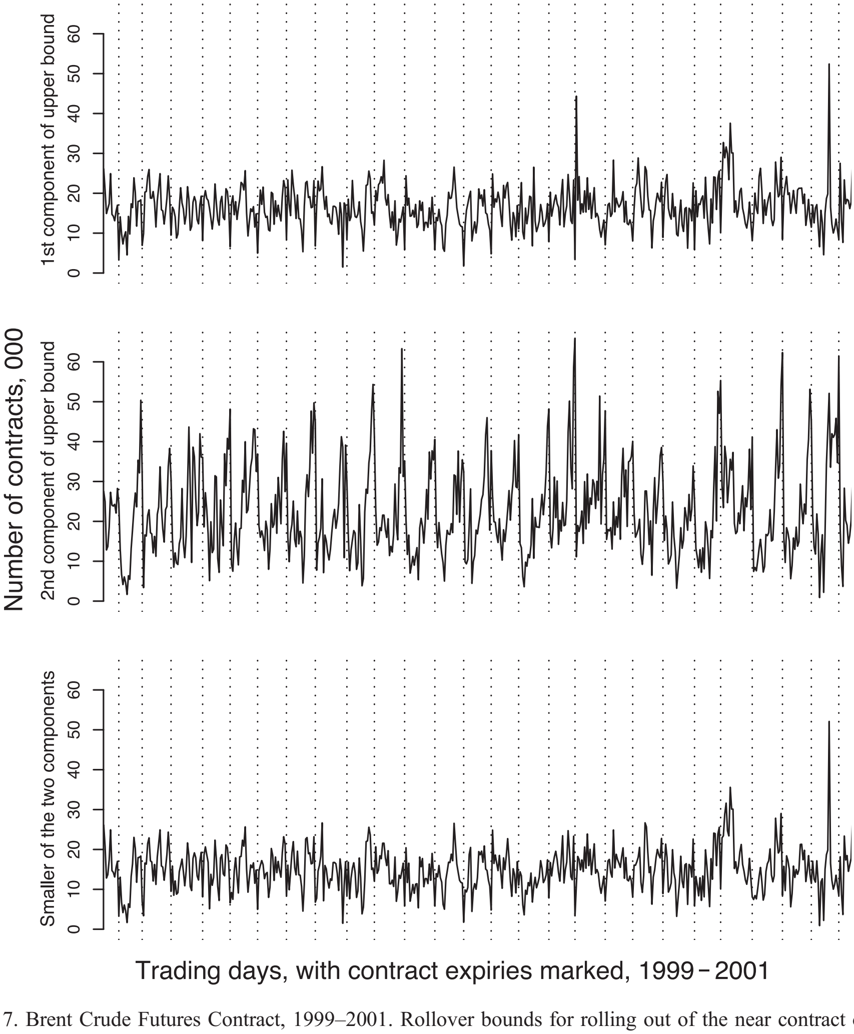

Fig. 7. Brent Crude Futures Contract, 1999–2001. Rollover bounds for rolling out of the near contract only.

5.3. The Brent Crude contract

As stated above, the Brent Crude contract is issued monthly, and there are typically at least 10 contracts available at any one time. As such, we might expect that the pattern of rollover activity for this commodity will be very different from that for the two financial assets considered thus far. In particular, there is considerable liquidity in more than just the near contract, and therefore, rollover may well occur out of and into a number of contracts. This is borne out by the comparison of rollover activity using the special case of rolling out of only one contract with that out of a number of contracts. When we allow rolling out of the near contract only we do not see a marked expiry effect in the upper bound (Fig. 7). However, when we allow for rolling out of the nearest three contracts (using the method of

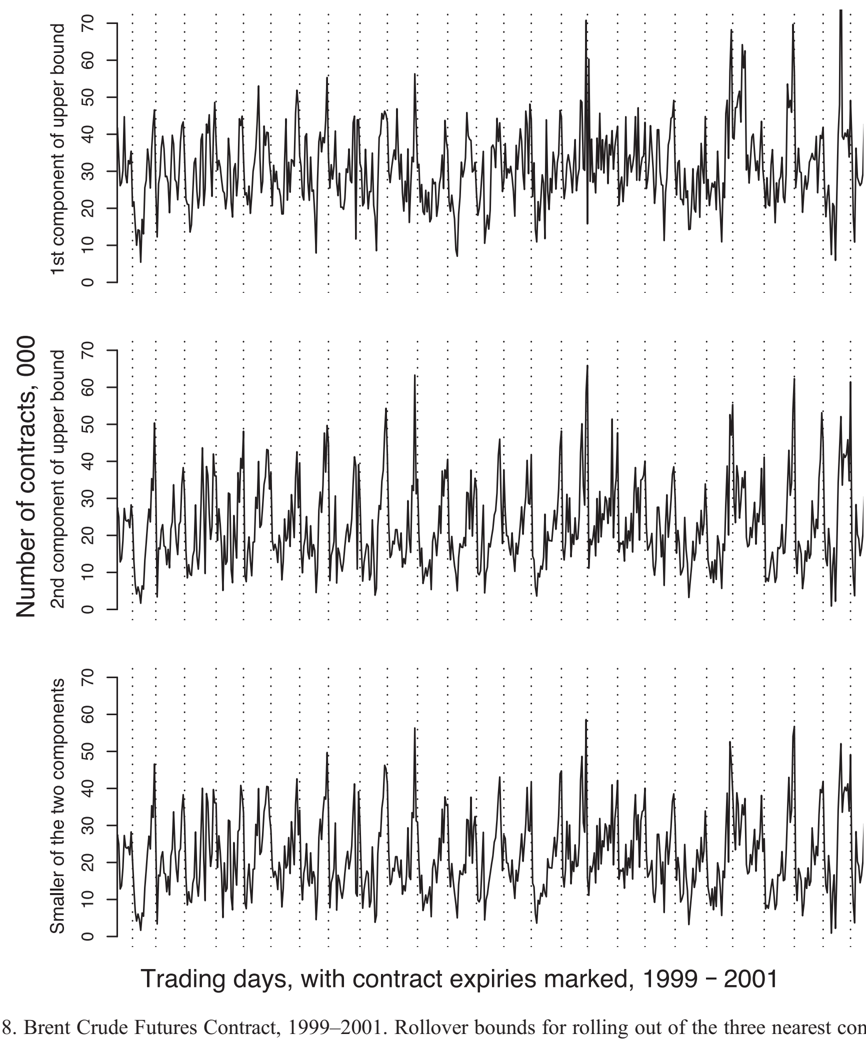

Fig. 8. Brent Crude Futures Contract, 1999–2001. Rollover bounds for rolling out of the three nearest contracts.

Section 4.2), we do observe the familiar pattern of the upper bound peaking at expiry and falling away rapidly (Fig. 8). Unlike the other two contracts, the upper bound does not fall to zero, and the second term in Eq. (11) appears to be the binding term for most of the time. Again, this finding is both interesting and reassuring, given the different nature of trading in the Brent Crude contract compared with that in the S&P500 and UK Gilts contracts.

The original and adjusted volumes in Fig. 9 show that adjusting for near contract rollover does not remove the expiry-related seasonality, but that adjusting for rolling out of the nearest three does a better job. However, in this contract, there is some evidence of undershooting in the bottom panel, and this is confirmed in the two autocorrelation

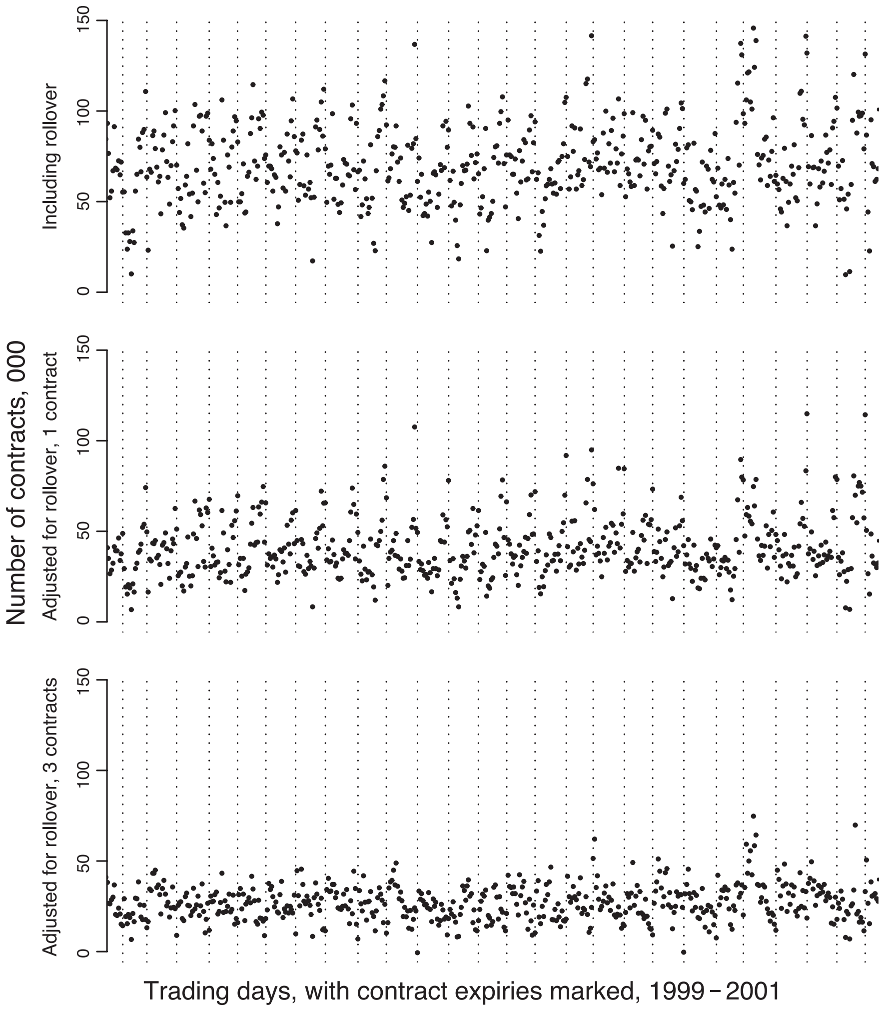

Fig. 9. Brent Crude Futures Contract, 1999–2001. Original and adjusted trading volume, rolling out of the near contract and the three near contracts.

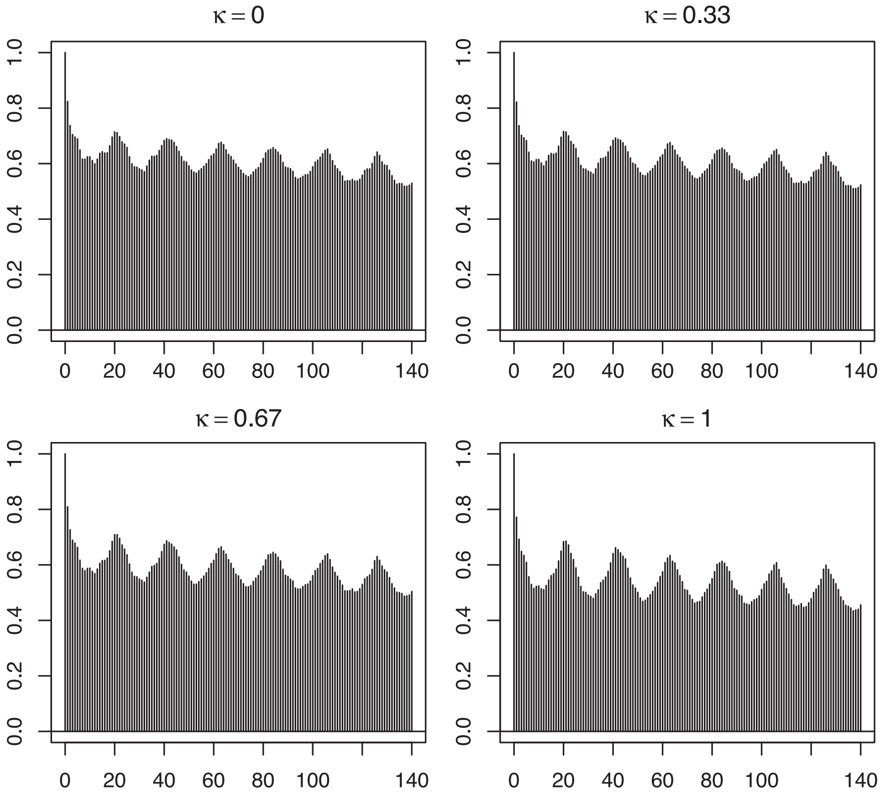

Fig. 10. Brent Crude Futures Contract, 1999–2001. Autocorrelation function for rolling out of the near contract.

plots (Figs. 10 and 11). Clearly, rolling out of the near contract alone does not remove seasonality, no matter what value of κ is chosen. For rolling out of three contracts, the value κ=1 is too strong, with a value of κ=2/3 being better at removing expiry-induced seasonality. Given the lack of concentration of volume in the near and next contracts, the finding that κ<1 is not surprising. With trading spread over several contracts, it is to be expected that market participants will choose to close out positions in the three near contracts at the same time as different market participants open positions in the other contracts. Since the upper bound incorporates such activity, it is likely to overestimate rollover for contracts with such a pattern of trading volume.

6. Conclusion

In this paper, we have shown how to derive a series for nonrollover trading volume for futures contract data. This has been achieved by making explicit the links between trading volume and the change in open interest and adding in the important activity of contract rollover. Consideration of these links has led to an assumption-free upper bound on the

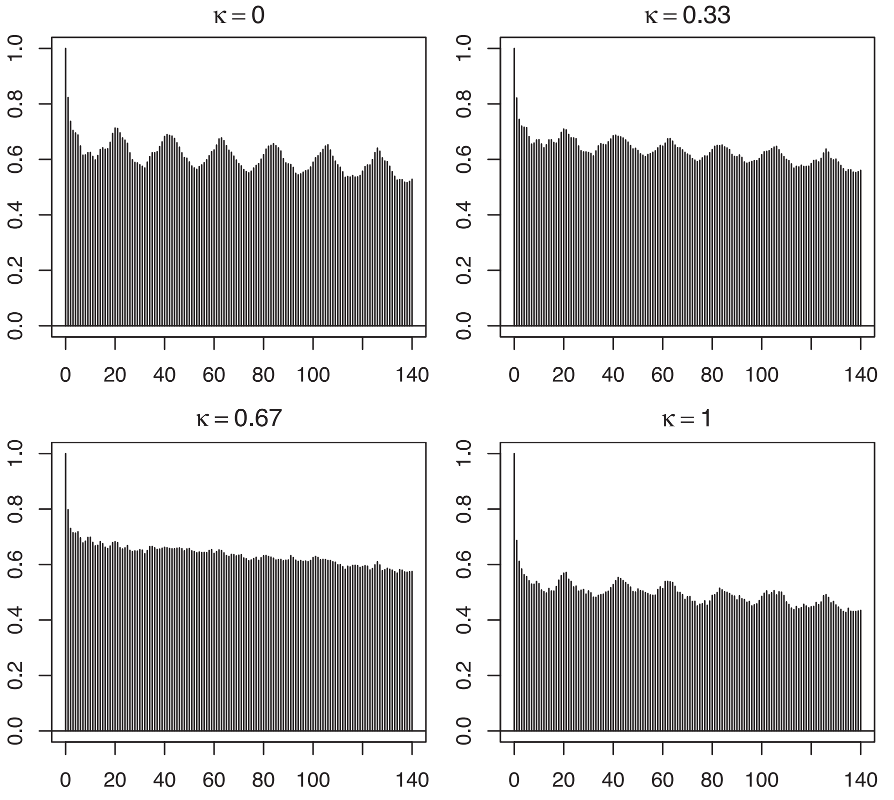

Fig. 11. Brent Crude Futures Contract, 1999–2001. Autocorrelation function for rolling out of the three near contracts.

amount of rollover activity per trading day. The upper bound has been derived for the special case where rollover only takes place from the near to the next contract, which is likely to be appropriate for many financial futures contracts and for the more general case where rollover takes place from, and to, a number of contracts.

Using data on the S&P500, the UK Gilts and the Brent Crude contracts, it has been shown that the upper bound, or some proportion of it, provides an appropriate measure, being effective in eliminating life-cycle seasonality in trading volume. It has been shown that adjusted volume is substantially different from unadjusted volume. The analysis shows different patterns of rollover activity across the three contracts, consistent with the different characteristics of trading in these markets. For the two financial assets, measuring rollover from the near contract only appears to capture rollover activity adequately, and the upper bound is shown to be a good proxy for rollover activity. For the commodity, rollover appears to be best measured, allowing rollover to occur from the three nearest contracts, and in this case, using a fixed proportion of the upper bound provides a good proxy for rollover activity.

Our results suggest that the volume series adjusted for rollover will provide a far more effective proxy for news arrival than does simple trading volume, for many contracts. In its ability to disaggregate trading volume data, it will also be of considerable utility for more general investigations of futures market microstructure. The results presented here should be of great benefit in most areas of research utilising futures volume data.

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References

Anderson, T., 1996. Return volatility and trading volume in financial markets: an information flow interpretation of stochastic volatility. Journal of Finance 51, 169–204.

Bessembinder, H., Seguin, P.J., 1992. Futures-trading activity and stock price volatility. Journal of Finance 47, 2015–2034.

Bessembinder, H., Seguin, P.J., 1993. Price volatility, trading volume, and market depth: evidence from futures markets. Journal of Financial and Quantitative Analysis 28, 21–39.

Bessembinder, H., Chan, K., Seguin, P.J., 1996. An empirical examination of information, differences of opinion, and trading activity. Journal of Financial Economics 40, 105–134.

Blume, L., Easley, D., O'Hara, M., 1994. Market statistics and technical analysis: the role of volume. Journal of Finance 49, 153–181.

Chan, K., 1992. A further analysis of the lead–lag relationship between the cash market and stock index futures market. Review of Financial Studies 5, 123–152.

Chan, K., Fong, W.M., 2000. Trade size, order imbalance, and the volatility–volume relation. Journal of Financial Economics 57, 247–273.

Chen, J., Hong, H., Stein, J.C., 2001. Forecasting crashes: trading volume, past returns, and conditional skewness in stock prices. Journal of Financial Economics 61, 345–381.

Chordia, T., Swaminathan, B., 2000. Trading volume and cross-autocorrelations in stock returns. Journal of Finance 55, 913–935.

Chordia, T., Subrahmanyam, A., Anshuman, V.R., 2001. Trading activity and expected stock returns. Journal of Financial Economics 59, 3–32.

Clark, P.K., 1973. A subordinated stochastic process model with finite variance for speculative prices. Econometrica 41, 135–159.

Copeland, T.E., 1976. A model of asset trading under the assumption of sequential information arrival. Journal of Finance 31, 1149–1168.

Daigler, R.T., Wiley, M.K., 1999. The impact of trader type on the futures volatility–volume relation. Journal of Finance 54, 2297–2316.

Easley, D., O'Hara, M., Srinivas, P.S., 1998. Option volume and stock prices: evidence on where informed traders trade. Journal of Finance 53, 431–465.

Epps, T.W., Epps, M.L., 1976. The stochastic dependence of security price changes and transaction volumes: implications for the mixture of distributions hypothesis. Econometrica 44, 305–321.

Foster, A.J., 1995. Volume–volatility relationships for crude oil futures markets. Journal of Futures Markets 15, 929–951.

Gallant, A.R., Rossi, P.E., Tauchen, G., 1992. Stock prices and volume. Review of Financial Studies 5, 199–242.

Gervias, S., Kaniel, R., Mingelgrin, D.H., 2001. The high-volume return premium. Journal of Finance 56, 877–919.

Grammatikos, T., Saunders, A., 1986. Futures price variability: a test of maturity and volume effects. Journal of Business 59, 319–330.
Harris, L., 1987. Transaction data tests of the mixture of distributions hypothesis. Journal of Financial and Quantitative Analysis 22, 127–141.
Hiemstra, C., Jones, J.D., 1994. Testing for linear and nonlinear Granger causality in the stock price–volume relation. Journal of Finance 49, 1639–1664.
Jennings, R.H., Starks, L.T., Fellingham, J.C., 1981. An equilibrium model of asset trading with sequential information arrival. Journal of Finance 36, 143–161.
Karpoff, J.M., 1987. The relation between price changes and trading volume: a survey. Journal of Financial and Quantitative Analysis 22, 109–126.
Kawaller, I., Koch, P., Koch, T., 1987. The temporal price relationship between S&P 500 futures and S&P index. Journal of Finance 42, 1309–1329.
Lamoureux, C.G., Lastrapes, W.D., 1990. Heteroskedasticity in stock return data: volume versus GARCH effects. Journal of Finance 45, 221–229.
Lee, C.M.C., Swaminathan, B., 2000. Price momentum and trading volume. Journal of Finance 55, 2017–2069.
Locke, P.R., Sayers, C.L., 1993. Intra-day futures price volatility: information effects and variance persistence. Journal of Applied Econometrics 8, 15–30.
Najand, M., Yung, K., 1991. A GARCH examination of the relationship between volume and price variability in futures markets. Journal of Futures Markets 11, 613–621.
Rougier, J.C., 1996. An optimal price index for stock index futures contracts. Journal of Futures Markets 16, 189–199.
Smith, B.F., White, R., Robinson, M., Nason, R., 1997. Intraday volatility and trading volume after takeover announcements. Journal of Banking and Finance 21, 337–368.
Tauchen, G.E., Pitts, M., 1983. The price variability–volume relationship on speculative markets. Econometrica 51, 485–505.