

# SPOT AND PERIOD RATES IN THE DRY BULK MARKET

*Some Tests for the Period 1980 - 1986*

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## INTRODUCTION

An important feature of shipping markets is the availability of a wide variety of contracts (charters) for leasing ships or shipping space. In particular, in addition to voyage or spot charters, in which the vessel is leased for a specified voyage, it is generally possible to charter on a time or period basis. The market for spot charters is generally regarded as a typical example of a competitive market, in which freight rates are determined by the interplay of supply and demand; but hitherto the period market has received little theoretical attention. Certainly a fully comprehensive theory of the market for period charters and its relationship to the spot market has yet to be developed. A corollary of this is that there has been little empirical work on the relationship between spot and period rates. Notable exceptions to both statements are Strandenes (1984) and Glen, Owen and van de Meer (1981).

However, even without a fully articulated theory, there is a strong presumption that spot rates ought to be related to period rates in some systematic way. Moreover, elementary theorising suggests that the spot/period relationship in shipping markets is similar to the short/long one in bond markets, and hence that the "term structure" of freight rates ought to have properties analogous to the term structure of interest rates. The most popular explanation of the latter is the expectations hypothesis, which asserts that the long rate must be equal to some suitable average of expected future short rates. With modifications to allow for certain technical differences, application of the expectations hypothesis to shipping markets would imply that we should find period rates which can be expressed as an average of expected future spot rates.

The expectations hypothesis has a strong attraction at the theoretical level

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but we are not aware of any attempt to test it empirically for shipping markets. Thus, while both Glen, Owen and van de Meer (1981) and Strandenes (1984) note the similarity between the structures of the bond and shipping markets, their applied work is concerned with finding "best fit" equations on the assumption that some version of the expectations hypothesis works for shipping markets. By contrast, in studies of financial markets there have been numerous tests of it, some leading to its rejection (see Shiller, 1979, or Mankiw and Summers, 1986). Accordingly we feel that the expectations hypothesis should not be accepted as valid for shipping markets simply on the basis of its theoretical appeal.

In this paper we derive, from the expectations hypothesis, an explicit model of the relationship between spot and period rates for the dry-bulk market. We then apply some of the tests of the hypothesis developed in the financial literature to data for the period 1980–1986. We find that the results provide little or no support for the expectations hypothesis – in some cases they clearly reject it, and in others they are inconclusive.

### THE MODEL

The central relationship of our model is

$$R_t^n = \theta \sum_{i=0}^{n-1} \delta^i E_t S_{t+i} + \alpha \quad (1)$$

where

$R_t^n$  is the spot equivalent of the period rate,

$E_t S_{t+i}$  is the expectation of the spot rate in period  $t+i$ , given information available in period  $t$  (all rates are expressed in \$/ton),

$\delta$  is the discount factor,

$\theta$  and  $\alpha$  are constants, and

$n$  is the length in months of the time charter.

We shall show that  $\theta = (1 - \delta)/(1 - \delta^n)$  and hence equation (1) asserts that the period rate is a weighted average of expected future spot rates plus the constant  $\alpha$ , which may be interpreted as a risk premium.

Equation (1) may be derived from the principle that the "value" of a time charter must be equal to the present value of a sequence of spot charters over the number of periods which make up the duration of the time charter. If this were not so, then arbitrage opportunities would exist and would generate forces which would move spot and period rates in such a way that the value equation would be satisfied. Let  $V_t^n$  be the value in money terms, in period  $t$ , of an  $n$ -period charter – that is, the lump sum which would secure the charter. Further let  $E_t C_{t+i}$  be the voyage costs per ton expected in period  $t+i$ , conditional upon information available in period  $t$ ; let  $Q$  be the capacity of the vessel, and  $N$  the number of voyages possible each period (month). Then we must have

$$V_t^n = \sum_{i=0}^{n-1} \delta^i [(E_t S_{t+i} - E_t C_{t+i})(N \cdot Q)] \quad (2)$$

Voyage costs are included on the right-hand side of equation (2) because they

are normally paid by the owner in spot charters but by the charterer in time charters, so they must be subtracted from spot rates in order to make them comparable with reported period rates. Thus the RHS of (2) expresses the present value of net receipts from operating the vessel in the spot market over  $n$  periods.

In practice the payment for a time charter is not made in a single lump sum, but normally in a series of equal monthly payments over the duration of the charter. Let  $r_t^n$  be the monthly payment for an  $n$ -period charter agreed in period  $t$ . Then we must have

$$\begin{aligned} V_t^n &= \sum_{i=0}^{n-1} \delta^i r_t^n \\ &= \frac{(1 - \delta^n)}{(1 - \delta)} r_t^n \end{aligned} \quad (3)$$

and hence

$$r_t^n = \frac{(1 - \delta)}{(1 - \delta^n)} \sum_{i=0}^{n-1} \delta^i (E_t S_{t+i} - E_t C_{t+i}) (N \cdot Q) \quad (4)$$

Ideally we would wish to test equation (4) directly, but the lack of a suitable data series for voyage costs has made this impossible. Instead we have used the "voyage equivalents" of time charter rates made available to us by *Lloyd's Shipping Economist*. Voyage equivalents are period rates which have been adjusted to take into account voyage costs, on the assumption that the chartered vessel is operated over the route to which the reported spot rates apply. We can rewrite (4) in terms of voyage equivalents by assuming that expected future voyage costs are constant and equal to current voyage costs; that is,  $E_t C_{t+i} = C_t$ . Hence we have

$$r_t^n = \frac{(1 - \delta)}{(1 - \delta^n)} \sum_{i=0}^{n-1} \delta^i (E_t S_{t+i} - C_t) (N \cdot Q) \quad (5)$$

or

$$[r_t^n / (N \cdot Q) + C_t] = \frac{(1 - \delta)}{(1 - \delta^n)} \sum_{i=0}^{n-1} \delta^i E_t S_{t+i} \quad (6)$$

Defining  $R_t^n = [r_t^n / (Q \cdot N)] + C_t$  and  $\theta = (1 - \delta) / (1 - \delta^n)$  gives

$$R_t^n = \theta \sum_{i=0}^{n-1} \delta^i E_t S_{t+i} \quad (7)$$

which on the addition of the risk premium  $\alpha$  is precisely equation (1).

It is worth noting that equation (7) (or (1)) represents a very general condition on the relationship between spot and period rates. We would therefore expect it to apply in almost any specific model of rate determination. Essentially it is an implication of the assumption that, in competitive markets, arbitrage opportunities cannot persist for very long.<sup>1</sup>

<sup>1</sup> Strictly speaking, the model assumes that arbitrage opportunities do not occur at all. Rates always adjust instantaneously so as to remove them.

To make equation (1) operational it is necessary to specify a mechanism for the formation of expectations. We assume rational expectations; this implies that, for any expected variable, the expectation error is not forecastable with the information available at the time when the expectation is formed. We feel that for modelling purposes this provides the appropriate benchmark. Any other assumption would mean on the one hand that market participants arbitrage away any perceived profit opportunities, but on the other that they systematically fail to use the information pointing them in the direction of such opportunities. In practice of course such consistency may not be observed.

### TESTING THE EXPECTATIONS HYPOTHESIS

Mankiw and Summers (1984) present a simple test of the expectations hypothesis for models where  $n$  is infinite. We shall adapt their approach for models, like that in (7), where the time horizon is finite. A finite time horizon makes testing more difficult, but we are able, with some additional assumptions, to modify their procedure to our case.<sup>2</sup>

Beginning with (1), it follows that

$$\begin{aligned} E_t R_{t+1}^n &= \theta \sum_{i=0}^{n-1} \delta^i E_t (E_{t+1} S_{t+1+i}) + \alpha \\ &= \theta \sum_{i=0}^{n-1} \delta^i E_t S_{t+1+i} + \alpha \end{aligned} \quad (8)$$

and hence subtracting  $\delta E_t R_{t+1}^n$  from (1) gives

$$R_t^n = \delta E_t R_{t+1}^n + \theta E_t S_t - \theta \delta^n E_t S_{t+n} + (1 - \delta)\alpha \quad (9)$$

Under the assumption of rational expectations, forecast errors will be uncorrelated, and so it is possible to write

$$R_{t+1}^n - E_t R_{t+1}^n = u_{t+1} \quad (10)$$

where  $u_t$  is white noise. We can now use (10) to replace  $E_t R_{t+1}^n$  in equation (9). Noting that  $E_t(S_t) = S_t$ , we have

$$R_t^n = \delta R_{t+1}^n + \theta S_t - \theta \delta^n E_t S_{t+n} + \alpha(1 - \delta) - \delta u_{t+1} \quad (11)$$

Equation (11) may be rearranged to give an expression for  $R_{t+1}^n$ . When this is lagged one time period, the resulting equation for  $R_t^n$  is

$$R_t^n = \delta^{-1} R_{t-1}^n - \delta^{-1} \theta S_{t-1} + \theta \delta^{n-1} E_{t-1} S_{t+n-1} - \alpha(1 - \delta) + u_t \quad (12)$$

Subtracting  $R_{t-1}^n$  from both sides of (12)<sup>3</sup> and rearranging gives

<sup>2</sup> The shipping case differs from the bond market because in the bond market the equivalent of equation (7) involves a relationship between rates per unit of time, whereas we have a relationship between sums of money per unit time. This makes things rather easier in some respects, and permits an exact representation of the restrictions implied by equation (7).

<sup>3</sup> See Appendix.

$$(R_t^n - R_{t-1}^n) = \frac{1 - \delta}{\delta} (R_{t-1}^n - S_{t-1}) - \frac{1 - \delta}{\delta} \left( \frac{\delta^n}{1 - \delta^n} \right) (S_{t-1} - E_{t-1} S_{t+n-1}) - \alpha(1 - \delta) + u_t \quad (13)$$

In the financial literature the equivalent of the first term on the right hand side,  $(R_{t-1}^n - S_{t-1})$ , is referred to as the spread between the long and short rates. Here it may be interpreted in a similar way as the spread between period and spot rates. Equation (13) is similar to equation (4) on page 227 in Mankiw and Summers (1984), except that in the finite horizon model the situation is complicated by the presence of the second term on the right hand side, involving the expectation of the  $n$  period ahead of spot rate from the previous time period; that is,  $E_{t-1} S_{t+n-1}$ . In order to test the hypothesis we need data on these expectations, which, of course, cannot be directly observed.

In this paper we deal with this problem in three alternative ways. Firstly we assume the following model for  $S_t$ :

$$S_t = \alpha_0 + \alpha_1 S_{t-n} + \dots + \alpha_n S_{t-2n+1} + \beta_1 R_{t-n}^n + \dots + \beta_n R_{t-2n+1}^n + V_t \quad (14)$$

Thus from (14)  $E_{t-1} S_{t+n-1}$  is a linear function of  $S_{t-1}, \dots, S_{t-n}, R_{t-1}^n, \dots, R_{t-n}^n$ , the information available at time  $t-1$ .

If  $E_{t-1} S_{t+n-1}$  in (13) is replaced by  $S_{t+n-1} - v_{t+n-1}^*$  it becomes

$$(R_t^n - R_{t-1}^n) = \frac{1 - \delta}{\delta} (R_{t-1}^n - S_{t-1}) - \frac{1 - \delta}{\delta} \left( \frac{\delta^n}{1 - \delta^n} \right) (S_{t-1} - S_{t+n-1}) - \alpha(1 - \delta) + u_t - v_{t+n-1}^* \quad (15)$$

where  $v_{t+n-1}^*$  is  $[(1 - \delta)/\delta][\delta^n/(1 - \delta^n)]v_{t+n-1}$ . Since the term involving  $S_{t+n-1}$  is correlated with the disturbance  $u_t - v_{t+n-1}^*$ , we will estimate (15) by using instrumental variables. For  $S_{t-1} - S_{t+n-1}$  an instrument is constructed using  $\hat{S}_{t+n-1}$ , the ordinary least squares (OLS) estimate of  $E_{t-1} S_{t+n-1}$  from (14).

Our second approach is simply to replace  $E_{t-1} S_{t+n-1}$  in equation (13) by  $\hat{S}_{t+n-1}$  and then estimate it by OLS.

Thirdly we assume that the  $n$  period ahead expectation is equal to the actual value in period  $t-1$ ; that is,  $E_{t-1} S_{t+n-1} = S_{t-1}$ . This leads to a simplification of equation (13), which again may be estimated by OLS:

$$(R_t^n - R_{t-1}^n) = \frac{1 - \delta}{\delta} (R_{t-1}^n - S_{t-1}) - \alpha(1 - \delta) + u_t \quad (16)$$

Equation (16) differs from (13) and (15) in that the term involving  $S_{t+n-1}$  or its expectation has disappeared.

Our test is based upon coefficient of the spread term. As  $\delta$  is the discount factor, that is,  $\delta = 1/(1 + i)$  where  $i$  is the monthly interest rate, if the expectations hypothesis is correct the coefficient of the spread is theoretically greater than 0. We test this by estimating models based on each of our three assumptions concerning  $E_{t-1} S_{t+n-1}$  (equations (13), (15) and (16)) and find that the results are broadly consistent.

## THE DATA: DEFINITIONS AND SOURCES

We tested the hypothesis, using monthly data from October 1980 to December 1986 on spot rates and voyage equivalent time charter rates for three categories of dry bulk carriers: 30,000 dead weight tonnes (DWT), 55,000 DWT, and 120,000 DWT.

The spot rate series was obtained from various issues of *Lloyd's Shipping Economist*. While they do not publish voyage equivalent time charter rates, they do calculate such a series for twelve-month time charters, and this they kindly made available to us. This means of course that in what follows  $n = 12$ .

## RESULTS AND ANALYSIS

The results of estimating the models in equations (13), (15) and (16) for the three weight categories are presented in Tables 1 to 3.

For the 30,000 DWT class the results lead to a clear rejection of the hypothesis, whichever of the models is used. For each equation in Table 1 we see that the estimated coefficient of the spread is negative. In all models the null hypothesis that the coefficient of the spread is 0 would be decisively rejected. As the expectations hypothesis requires the true value of this coefficient to be strictly positive, the probability of obtaining such results if the hypothesis were true is extremely small.

The expectations hypothesis is also rejected, if slightly less strongly, for the 55,000 DWT dry bulk carriers (Table 2). Again for all models the estimated coefficient of the spread, the lagged difference between the time charter voyage equivalent rate and the spot rate, is less than 0, rather than positive as required by the expectations hypothesis. In equation (A) the null hypothesis that the coefficient on the spread is zero would be rejected in favour of the alternative that it is less than zero at the 10 per cent level, while using the constructed expectation series in (B) leads to the rejection at the 5 per cent level. The third alternative of setting the expectation equal to its current value leads to the null hypothesis being rejected at the 1 per cent level. Again, no matter which assumption concerning the future expectations is used, there is no evidence that the coefficient of the spread is positive.

The results for 120,000 DWT (Table 3) are less clear in rejecting the expectations hypothesis. In each of the three estimated equations the coefficient of the spread is positive, but in no case does it come anywhere near being statistically significantly different for zero. At the best these results provide very poor evidence in support of the hypothesis.

To conclude, we see that the expectations hypothesis lacks empirical support in the dry bulk shipping market. Only in the 120,000 DWT category do our results point to some (weak) support for it. In the other weight categories we would emphatically reject the hypothesis.

TABLE 1

*Ships of 30,000 DWT\**

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$$(R_t^{12} - R_{t-1}^{12}) = 1.797 - 0.315(R_{t-1}^{12} - S_{t-1}) - 0.095(S_{t-1} - S_{t+11}) \quad (\text{A})$$

(2.893) (-3.752) (-0.935)

$$RSS = 36.29 \quad N = 49$$

$$CHI^2(1) = 1.57$$

$$(R_t^{12} - R_{t-1}^{12}) = 1.980 - 0.339(R_{t-1}^{12} - S_{t-1}) - 0.177(S_{t-1} - E_{t-1}S_{t+11}) \quad (\text{B})$$

(3.171) (-3.986) (-2.123)

$$R^2 = 0.239 \quad RSS = 56.539 \quad N = 61$$

$$CHI^2(1) = 0.021 \quad CHI^2(12) = 13.427$$

$$(R_t^{12} - R_{t-1}^{12}) = 0.7381 - 0.193(R_{t-1}^{12} - S_{t-1}) \quad (\text{C})$$

(3.073) (-4.654)

$$R^2 = 0.231 \quad RSS = 67.988 \quad N = 73$$

$$CHI^2(1) = 0.006 \quad CHI^2(12) = 15.436$$


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\* In Tables 1 to 3 the figures in brackets are the standard errors of the coefficient estimates,  $R^2$  is the usual coefficient of multiple determination,  $\sigma$  the equation standard error, and  $RSS$  the residual sum of squares. None of the parameter estimates is significantly different from zero. The  $CHI^2$  statistics are Lagrange multiplier test statistics for residual autocorrelation, which unlike the Durbin-Watson  $d$  statistic, are valid for models with lagged dependent variables (see Godfrey, 1978). The figure in brackets shows the order of error autocorrelation which is being tested.

In each table equation (A) is obtained by estimating equation (15) by instrumental variables, equation (B) from (13) using the constructed forecast series and OLS, and (C) from OLS applied to (16).

## CONCLUSIONS

Though our results suggest that the expectations theory does not hold for the dry bulk market in the early 1980s (at least for the 30,000 and 55,000 DWT classes), a satisfactory explanation of the reason for its failure is distinctly elusive. Since our test procedure involves the joint hypothesis of the term structure relationship, equation (1), and rational expectations, equation (10), our negative results could be accounted for by the failure of either (or both) of these assumptions. We also carried out the test under the alternative assumption of adaptive expectations, but the results were unsatisfactory. This did not

TABLE 2

*Ships of 55,000 DWT*

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$$(R_t^{12} - R_{t-1}^{12}) = 0.035 - 0.077(R_{t-1}^{12} - S_{t-1}) - 0.067(S_{t-1} - S_{t+11}) \quad (\text{A})$$

(1.374) (-1.620) (-1.037)

$$RSS = 34.158 \quad N = 49$$

$$CHI^2(1) = 1.18$$

$$(R_t^{12} - R_{t-1}^{12}) = 0.348 - 0.094(R_{t-1}^{12} - S_{t-1}) - 0.005(S_{t-1} - E_{t-1}S_{t+11}) \quad (\text{B})$$

(0.987) (-1.822) (-0.078)

$$R^2 = 0.059 \quad RSS = 55.511 \quad N = 61$$

$$CHI^2(1) = 1.315 \quad CHI^2(12) = 10.616$$

$$(R_t^{12} - R_{t-1}^{12}) = 0.328 - 0.110(R_{t-1}^{12} - S_{t-1}) \quad (\text{C})$$

(1.412) (-2.590)

$$R^2 = 0.085 \quad RSS = 84.757 \quad N = 73$$

$$CHI^2(1) = 1.981 \quad CHI^2(12) = 10.548$$


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surprise us, as we feel that the assumption of rational expectations is plausible *a priori* for the dry bulk market. Equation (10) asserts that forecast errors of future freight rates cannot be predicted on the basis of information available when the forecasts are made – that is, available information is used efficiently. Since considerable resources are expended by ship brokers, consultants and other participants in the market in gathering and disseminating very detailed and up to the minute shipping market data, we believe equation (10) is more likely to hold than not to hold.

It therefore seems likely that the failure of the expectations theory resides in the term structure equation. If this is so, there are a number of possible explanations. For example, in the financial literature it has sometimes been found that a possible solution is to drop the assumption of a time-invariant risk premium. We have not yet tried this approach, but consider it a possible area for future investigation. The drawback of assuming time-varying risk premiums is that they introduce an essentially *ad hoc* element which is difficult to justify in the present state of theoretical knowledge.

A further possibility might be that the dry bulk market is myopic, as is commonly believed of many competitive markets, and overreacts to current events such as the spot rate. Again we have not explicitly tested this possibility, but our results do not point towards it. For example, one way of capturing the



TABLE 3

*Ships of 120,000 DWT*

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$$(R_t^{12} - R_{t-1}^{12}) = -0.035 + 0.032 (R_{t-1}^{12} - S_{t-1}) - 0.117 (S_{t-1} - S_{t+11}) \quad (\text{A})$$

(-0.242) (0.416) (-0.117)

$$RSS = 3.94 \quad N = 49$$

$$CHI^2(1) = 0.02$$

$$(R_t^{12} - R_{t-1}^{12}) = -0.136 + 0.052 (R_{t-1}^{12} - S_{t-1}) - 0.080 (S_{t-1} - E_{t-1}S_{t+11}) \quad (\text{B})$$

(-1.157) (0.739) (-2.755)

$$R^2 = 0.114 \quad RSS = 36.856 \quad N = 61$$

$$CHI^2(1) = 0.976 \quad CHI^2(12) = 12.61$$

$$(R_t^{12} - R_{t-1}^{12}) = -0.111 + 0.012 (R_{t-1}^{12} - S_{t-1}) \quad (\text{C})$$

(-0.908) (0.170)

$$R^2 = 0.001 \quad RSS = 10.211 \quad N = 73$$

$$CHI^2(1) = 2.15 \quad CHI^2(12) = 15.525$$


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idea of overreaction might be to suppose that agents discount the future more heavily than is warranted by market interest rates: that is, a smaller  $\delta$  and hence a higher  $i$ . If anything our results indicate precisely the opposite – the estimated coefficients for  $R_{t-1}^{12}$  in Tables 1 and 2 are consistent with a large *negative* discount factor. It is tempting to suppose that it is the negative real interest rates of the very early part of our sample period which are being picked up in our equations. However, we consider this is probably not true – the implied negative interest rates are much too large (infeasible, given that  $\delta$  is a monthly discount factor).

Our work is therefore preliminary, and much more waits to be done on both theoretical and empirical levels. The kind of data we have used in this study have only recently become widely available, and we are conscious of the fact that during the period covered the spot market has been dominated by a decline from its cyclical peak in 1980–81, which has caused the period market to be relatively thin. It would therefore be interesting to test the model on data from periods when the market is more buoyant. The major, albeit negative, conclusion of our work still remains, however, – researchers such as those quoted above, who *assume* that the expectations hypothesis holds for shipping markets, are proceeding on the basis of an apparently false hypothesis. The important immediate issue is still the structure of the dry bulk shipping market.

## APPENDIX

Equation (12) may be derived directly by considering the one-period options available to a shipper. The first of these is to charter spot; then the monthly cost will be given by  $S_t(Q \cdot N)$ , that is, the spot rate per ton times the monthly volume. The other is to charter in the period market; in that case the expected one-month cost is given by

$$V_t^n - \delta E_t V_{t+1}^{n-1} + C_t(Q \cdot N) \quad (1')$$

the cost of the  $n$ -period charter, plus the cost of operating the vessel for a month, less the expected value of an  $(n-1)$ -period charter next month. Market efficiency requires that shippers be indifferent between these alternatives, so that

$$(1/Q \cdot N)(V_t^n - E_t V_{t+1}^{n-1}) + C_t = S_t$$

But, since

$$E_t V_{t+1}^{n-1} = E_t V_{t+1}^n - \delta^{n-1} E_t (S_{t+n} - C_{t+n})(Q \cdot N)$$

(1') may be rewritten

$$(1/Q \cdot N)(V_t^n - \delta E_t V_{t+1}^n) + \delta^n E_t (S_{t+n} - C_{t+n}) + C_t = S_t \quad (2')$$

However

$$V_t^n = r_t^n / \theta = [(R_t^n - C_t) / \theta] (Q \cdot N)$$

Substituting in (2') and using  $E_t(C_{t+n}) = C_t$  gives

$$[R_t^n - \delta E_t R_{t+1}^n - (1 - \delta)C_t] / \theta + C_t(1 - \delta^n) + \delta^n E_t S_{t+n} = S_t \quad (3')$$

or since  $\theta = (1 - \delta) / (1 - \delta^n)$

$$R_t^n - \delta E_t R_{t+1}^n + \theta \delta^n E_t S_{t+n} = \theta S_t \quad (4')$$

Finally, again assuming

$$E_t R_{t+1}^n - R_{t+1}^n = u_{t+1}$$

and substituting yields equation (12).

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