Stochastic Trends and Cointegration in the Market for Equities

Lucy F. Ackert* and M. D. Racine

We used a no-arbitrage, cost-of-carry pricing model to examine whether equity spot and futures markets are cointegrated. A stock index and its futures price should be cointegrated if the cost of carry is stationary. Otherwise, the appropriate cointegrating relationship is trivariate. We found that the Standard and Poor’s 500 index, associated futures series, and interest rate are all nonstationary. We further found that the cointegrating relationship includes the index, futures price, and cost of carry. Our findings are consistent with the no-arbitrage pricing model and do not appear to be sensitive to the presence of structural breaks in the series. © 1999 Elsevier Science Inc.

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JEL classification: G12, G13

I. Introduction

Although stock and futures prices may wander widely, the two series may share the same stochastic trend. If so, the series are cointegrated and are not expected to drift too far apart. Thus, cointegrated series will recover from shocks to their long-run equilibrium. The relationship between stock index and stock index futures prices is critical because it has implications regarding predominant financial theory, including market efficiency and no-arbitrage pricing models. Cointegration impacts how forecasting models and optimal hedge ratios should be constructed. Furthermore, models and tests of financial theories are restricted in the presence of stochastic trends. For example, tests of the unbiasedness hypothesis must be modified in the presence of cointegration [Engle and Granger (1987); Brenner and Kroner (1995)]. The theory of cointegration has been used to examine the temporal patterns in equity prices including dividends and stock prices [Campbell and...
whereas many empirical studies have used the theory of cointegration, few have
attempted to provide a theoretical explanation for the existence of cointegration between
financial time-series. A recent exception is Brenner and Kroner (1995), who used a
no-arbitrage, cost-of-carry asset pricing model to explain why some markets are
expected to be cointegrated while others are not. They argued that cointegration depends critically
on the time-series properties of the cost of carry. A stock index and its futures price will
be cointegrated if the cost of carry, or the difference between the dividend yield and
interest rate, is stationary. If this difference is not stationary, the correctly-specified
cointegrating regression would include the stock price, futures price, and spread between
the dividend yield and interest rate.

The purpose of this paper is to address the issue of cointegration between equity spot
and futures markets, a question not previously addressed in the literature. To do so, we
studied the time-series relationship between the Standard and Poor’s 500 index and index
futures price series, while recognizing that the appropriate cointegrating relationship may
involve the cost of carry.

First, the long-run behavior of each series was examined. The index and futures price
series are nonstationary in levels but stationary when first differenced. That is, if a series
is not first differenced, a shock in the current period will have an impact on all future
periods. When nonstationary series move together over time they are cointegrated and a
long-run relationship exists among them. The results support a cointegrating relationship
among the S&P 500 index, index futures price, and cost-of-carry. Thus, a finding of
cointegration in equity markets depends critically on the cost of carry and, as suggested
by a no-arbitrage pricing model, equity spot and futures markets are cointegrated.

The remainder of this paper is organized as follows. Section II discusses cointegration
and the no-arbitrage, cost-of-carry model. Section III describes our test of cointegration in
spot and futures equity markets. Section IV presents the empirical results. The final
section contains concluding remarks.

II. Cointegration in Equity Markets

The theory of cointegration is used extensively in studies of the relationship between
futures or forward prices and spot prices. For example, Hakkio and Rush (1989) used
cointegration theory to test whether the forward exchange rate is an unbiased predictor of
the future spot rate. Current forward and spot rates should be close together, and therefore
cointegrated, in an efficient market. More recently, Brenner and Kroner (1995) showed
that whether spot and futures or forward prices are cointegrated in an efficient market
depends critically on the time-series properties of the cost of carry. If the cost of carry is
stationary, spot and futures prices will be cointegrated.

Brenner and Kroner (1995) presented a no-arbitrage, cost-of-carry asset pricing model
which gives the futures price, \( F_{t,t-k} \), as:

\[
\ln F_{t,t-k} = \ln S_{t-k} + \ln D_{t,t-k} + Q_{t,t-k},
\]

1 See, for example, Baillie and Bollerslev (1989), Hakkio and Rush (1989), Serletis and Banack (1990), Lai
where \( S_{t-k} \) is the spot price at time \( t - k \); \( F_{t,t-k} \) is the futures price at time \( t - k \) for a contract which matures at time \( t \); \( D_{t,t-k} \) is the cost-of-carry or differential over the life of the futures contract, and \( Q_{t,t-k} \) is an adjustment term which reflects marking-to-market. This no-arbitrage model assumes that the spot asset provides a continuous dividend yield and recognizes that an investor should be indifferent between: 1) purchasing the asset and re-investing the dividends, and 2) purchasing a futures contract and investing in a risk-free bond.\(^2\)\(^3\) If equation (1) failed to hold, an arbitrageur could devise a strategy which resulted in a riskless profit.

Because the marking-to-market adjustment \( (Q_{t,t-k}) \) is nonstochastic, equation (1) says that there is a linear relationship between the natural logarithm of the futures price and the spot price. The spot price and its futures price will be cointegrated if the natural logarithm of the differential is stationary. If not, the cointegrating relationship should include the spot price, futures price, and differential. The differential reflects interest rates, dividend yields, storage costs, and convenience yields. For equities that provide a constant dividend yield, the logarithm of the differential is stationary. If not, the cointegrating relationship should include the interest rate and dividend yield. The stock price and its futures price will be cointegrated if the natural logarithm of the cost of carry is stationary, which is the case if the spread between the interest rate and dividend yield is stationary. The spread is stationary if the interest rate and dividend yield are each stationary or if the two series are themselves cointegrated.

III. A Test of the Model in Equity Markets

In order to examine cointegration in equity spot and futures markets, we followed Brenner and Kroner (1995) and used a no-arbitrage, cost-of-carry asset pricing model to determine the appropriate cointegrating relationship. Our model differs, however, in that we did not assume that dividends are paid at a continuous rate. Instead, we recognized that dividends are not constant and have been shown to exhibit distinct patterns. Harvey and Whaley (1991, 1992) showed that large estimation and asset-pricing errors can result from the assumption that the dividend yield on a stock index is constant. If we define \( d_{t,t-k} \) as the discounted value at time \( t - k \) of the non-constant dividend stream paid over the life of the futures contract, a no-arbitrage, cost-of-carry asset pricing model gives the futures price as:

\[
\ln F_{t,t-k} = \ln (S_{t-k} - d_{t,t-k}) + k r_{t,t-k} + Q_{t,t-k},
\]

where \( S_{t-k} - d_{t,t-k} \) is the dividend-adjusted value of the stock index.\(^4\) If the interest rate is nonstationary, then the differential has a stochastic trend and the dividend-adjusted index and its futures price should not be cointegrated. In this case, the appropriate cointegrating relationship contains the interest rate and the natural logarithms of the index

\(^2\) Both portfolios result in one unit of the asset at the futures delivery date. To see this, note that portfolio 1) requires purchase of less than one unit of the asset, which will grow to one unit as a result of the dividends that are paid at a continuous rate.

\(^3\) Forward contracts, rather than futures contracts, are actually priced using these no-arbitrage arguments. However, a relationship similar to equation (1) holds for futures, given additional assumptions [Amin and Jarrow (1991); Heath et al. (1992)].

\(^4\) The model recognizes that an investor should be indifferent between: 1) purchasing the stock index and borrowing at the risk-free rate, and 2) purchasing an index futures contract and investing in a risk-free bond. Both portfolios result in one unit of the stock index at the futures delivery date.
and futures price. A test of the no-arbitrage model involves estimation of the cointegrating regression:

\[ \ln F_{t, t - k} = \alpha + \beta_1 \ln (S_{t, t - k} - d_{t, t - k}) + \beta_2 r_{t, t - k} + z_t, \]  

(3)

where the marking-to-market adjustment is contained in the constant term because it is nonstochastic.\(^5\)

In order to examine the long-run relationships among the stock index, futures price on the index, and interest rate, we first tested whether each series contained a unit root. Tests for cointegration are appropriate if the series are nonstationary, but can be made stationary by differencing. If a linear combination of nonstationary assets is stationary, the assets are cointegrated. According to Brenner and Kroner (1995), the cost of carry or interest rate is likely nonstationary, so that index and futures prices cannot be cointegrated.\(^6\) Tests for cointegration should then include the index and futures price, as well as the interest rate. In the following section, we examine these long-run relationships and review our tests regarding whether or not equity spot and futures prices share a common stochastic trend.

IV. Empirical Results

The sample consisted of daily observations for the S&P 500 stock index and associated futures contract closing prices for January 4, 1988–June 30, 1995, resulting in 1,875 observations. The nearby futures contract with at least 15 days to maturity was used.\(^7\) The S&P 500 index is a broad-based, market-value weighted index containing 500 stocks traded on the New York Stock Exchange. Daily stock index price and dividend data are from the Standard and Poor’s Corporation, closing futures prices are from the Futures Industry Institute Data Center, and three-month Treasury bill rates are from the Federal Reserve Bank of St. Louis. The three-month Treasury bill rate was our measure of the risk-free rate, \(r_{t, t - k}\). The daily dividend data was used to calculate the present value of the dividends \((d_{t, t - k})\) received over the remaining life of the relevant futures contract.

Prior to testing for cointegration, nonstationarity must be established. In order to determine the order of integration of each series, we used Augmented Dickey-Fuller (ADF) tests [Dickey and Fuller (1979, 1981)] with the MacKinnon (1991) critical values. Table 1 reports the results of tests of the null hypothesis of a unit root in the natural logarithms of the S&P 500 index futures price series \((\ln F_{t, t - k})\) and dividend-adjusted price index \((\ln (S_{t, t - k} - d_{t, t - k}))\), as well as the interest rate as measured by the three-month Treasury bill rate \((r_{t, t - k})\). If the test statistic differed significantly from zero, the null hypothesis was rejected and we concluded that the series is stationary. We tested for unit roots in each series in levels and first differences. Lags specifies the number of lagged difference terms allowed in the test regression, and constant indicates whether a constant

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\(^6\) Campbell and Shiller (1987) and Cushing and Ackert (1994) could not reject the hypothesis that the short-term interest rate is nonstationary.

\(^7\) Some researchers, such as Hein et al. (1990) have suggested the use of nonoverlapping data. Brenner and Kroner (1995) recognized that their proposition assumed that the expiration date \((t)\) is changing and the time to expiration of the futures contract \((k)\) is fixed. Given our sampling procedure of rolling to the next contract as maturity approaches, cointegration cannot, in theory, hold because the variance of the regression residual is time-varying. However, cointegration tests have low power in detecting changing variances, as our results suggest.
term was or was not included. The ADF tests indicated that all series are nonstationary, and that they are integrated of order one. Time series graphs also indicate a discontinuity in mean. Unit root tests are biased in favor of the unit root null hypothesis if there is a structural break in the series. We used the Perron (1990) test statistic, which allows for a change in mean in order to ensure that the series is nonstationary after recognizing the structural break. Basically, the Perron (1990) approach involves using an ADF test with demeaned data and Perron’s tabulated critical values to assess statistical significance. This approach assumes that the structural change is exogenous and occurs at a known date. Because Perron (1990) suggested that visual inspection of the series be used to indicate the date of the structural break, we examined time-series graphs. After further investigation, we found that a strong downward movement in U.S. stock markets was reported on the indicated structural break date, October 13, 1989. Chow tests confirmed that the index and T-bill series exhibited structural breaks at this point. Additional investigation revealed that a change in Federal Reserve policy occurred around the time of the discontinuity in mean. Whether or not the Fed’s policy change resulted in the break is an interesting empirical question for future research.

Panel A of Table 2 reports the results of this unit root test with the exogenously-determined structural break. The results again suggested that all the series are nonstationary.

Finally, to further examine the robustness of the nonstationarity conclusion, we used a unit root test procedure proposed by Zivot and Andrews (1992) which is not conditioned on an exogenously-determined breakpoint. The test uses a series of modified Dickey-Fuller regressions and conservatively selects the breakpoint as that which is least favorable to the unit root null hypothesis. The results reported in Panel B of Table 2 are based on this endogenously-determined breakpoint and again confirm that each of the series is nonstationary.

Because all the series are integrated of the same order, cointegration tests are appropriate. Under a no-arbitrage argument, Brenner and Kroner (1995) asserted that if the cost term was or was not included. The ADF tests indicated that all series are nonstationary, and that they are integrated of order one.

Time series graphs also indicate a discontinuity in mean. Unit root tests are biased in favor of the unit root null hypothesis if there is a structural break in the series. We used the Perron (1990) test statistic, which allows for a change in mean in order to ensure that the series is nonstationary after recognizing the structural break. Basically, the Perron (1990) approach involves using an ADF test with demeaned data and Perron’s tabulated critical values to assess statistical significance. This approach assumes that the structural change is exogenous and occurs at a known date. Because Perron (1990) suggested that visual inspection of the series be used to indicate the date of the structural break, we examined time-series graphs. After further investigation, we found that a strong downward movement in U.S. stock markets was reported on the indicated structural break date, October 13, 1989. Chow tests confirmed that the index and T-bill series exhibited structural breaks at this point. Additional investigation revealed that a change in Federal Reserve policy occurred around the time of the discontinuity in mean. Whether or not the Fed’s policy change resulted in the break is an interesting empirical question for future research.

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**We began with a constant, trend, and 100 lags. The constant and trend terms were dropped if they were insignificant using conventional t tests, and the lagged terms were dropped if the t statistic was less than 1 in absolute value. The trend term was excluded from the test regression in all cases because it was consistently insignificant.
of carry is nonstationary, equity spot and futures prices cannot be cointegrated. Table 3 reports the results for this assertion. We tested for cointegration using a framework proposed by Johansen (1988, 1991). The Johansen test is essentially a multivariate Dickey-Fuller test which determines the number of cointegrating equations, or cointegrating rank, by computing a likelihood ratio statistic for each added cointegrating equation in a sequence of nested models. If we cannot reject the hypothesis that the

Table 2. Tests for Unit Roots in Indexes and Index Futures Prices with Structural Breaks

<table>
<thead>
<tr>
<th>Series</th>
<th>Lags</th>
<th>Perron Statistic</th>
<th>Critical Value (1%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln F_{t,k} )</td>
<td>94</td>
<td>-1.416</td>
<td>-3.23</td>
</tr>
<tr>
<td>( \ln (S_{t,k} - d_{t,k}) )</td>
<td>94</td>
<td>-1.433</td>
<td>-3.23</td>
</tr>
<tr>
<td>( r_{t,k} )</td>
<td>100</td>
<td>-1.596</td>
<td>-3.23</td>
</tr>
</tbody>
</table>

Panel B: Endogenously-Determined Structural Break

<table>
<thead>
<tr>
<th>Series</th>
<th>Lags</th>
<th>Zivot and Andrews Statistic</th>
<th>Critical Value (1%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln F_{t,k} )</td>
<td>99</td>
<td>-0.283</td>
<td>-5.34</td>
</tr>
<tr>
<td>( \ln (S_{t,k} - d_{t,k}) )</td>
<td>99</td>
<td>-0.229</td>
<td>-5.34</td>
</tr>
<tr>
<td>( r_{t,k} )</td>
<td>100</td>
<td>-0.191</td>
<td>-5.34</td>
</tr>
</tbody>
</table>

The table reports the results of tests of the null hypothesis of a unit root in the natural logarithms of the S&P 500 index futures price series (\( \ln F_{t,k} \)) and dividend-adjusted price index (\( \ln (S_{t,k} - d_{t,k}) \)), as well as the interest rate as measured by the three-month Treasury bill rate (\( r_{t,k} \)). If the test statistic differed significantly from zero, the null hypothesis was rejected and we concluded that the series is stationary. Lags specifies the number of lagged difference terms allowed in the test regression. Panel A reports the results for unit root tests with an exogenously-determined structural break, and critical values are from Perron (1990). The tests reported in Panel B are based on an endogenously-determined breakpoint with critical values from Zivot and Andrews (1992).

**Denotes rejection of the hypothesis at 1% significance level.

Table 3. Test for Cointegration in Equity Markets: No Cost of Carry

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>Likelihood Ratio</th>
<th>1% Critical Value</th>
<th>Hypothesized No. of CE(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0048</td>
<td>9.9006</td>
<td>16.31</td>
<td>None</td>
</tr>
<tr>
<td>0.0007</td>
<td>1.2085</td>
<td>6.51</td>
<td>At most 1</td>
</tr>
</tbody>
</table>

Normalized Coefficients

\[
\begin{align*}
\ln F_{t,k} \\
\ln (S_{t,k} - d_{t,k}) \\
(0.0001)
\end{align*}
\]

This table reports the results of a test for cointegration between the dividend-adjusted S&P 500 index and associated futures prices. If the null hypothesis of a unit root in the residuals of the cointegrating regression was rejected, there is evidence of cointegration. Lags specifies the number of lagged difference terms allowed in the test regression. The number of lagged difference terms was determined using a likelihood ratio test with a maximum of 100 lags [Enders (1996)]. Critical values are from Johansen (1991). Standard errors are given below coefficient estimates.

*(***)Denotes rejection of the hypothesis at 5% (1%) significance level.
number of cointegrating equations (CE(s)) is none, the series are not cointegrated. If we cannot reject the hypothesis of, at most, one CE, there is one cointegrating vector and the series share a stochastic trend. The results reported in Table 3 suggest that the dividend-adjusted S&P 500 index and futures price series are not cointegrated, which is consistent with the Brenner and Kroner (1995) assertion that the appropriate cointegrating relationship includes the cost of carry when the interest rate is nonstationary.9

Because the cost of carry is nonstationary, a test for cointegration in equity markets should include the dividend-adjusted index, futures price, and interest rate. To allow for the possibility that the cointegrating relationship, should one exist, is changing over time, we employed several estimation methods. First, we applied the Johansen (1991) method to the full sample and the results are presented in Table 4. Because the null hypothesis of, at most, one cointegrating equation (CE) could not be rejected, there is evidence of cointegration in equity markets. Lags specifies the number of lagged difference terms allowed in the test regression. The number of lagged difference terms was determined using a likelihood ratio test with a maximum of 100 lags [Enders (1996)]. Critical values are from Johansen (1991). Standard errors are given below coefficient estimates. *(***) Denotes rejection of the hypothesis at 5% (1%) significance level.

| Table 4. Test for Cointegration in Equity Markets: No Structural Break |
| Lags: 70 |
| Eigenvalue | Likelihood Ratio | 1% Critical Value | Hypothesized No. of CE(s) |
| 0.0133 | 33.4086 | 29.75 | None** |
| 0.0043 | 9.2723 | 16.31 | At most 1 |

This table reports the results of a test for cointegration among the dividend-adjusted S&P 500 index, associated futures prices, and interest rates. If the null hypothesis of, at most, one cointegrating equation (CE) could not be rejected, there is evidence of cointegration in equity markets. Lags specifies the number of lagged difference terms allowed in the test regression. The number of lagged difference terms was determined using a likelihood ratio test with a maximum of 100 lags [Enders (1996)]. Critical values are from Johansen (1991). Standard errors are given below coefficient estimates. *(***) Denotes rejection of the hypothesis at 5% (1%) significance level.

To allow for the possibility of changes over time in the cointegrating relationship, we used the Johansen (1991) framework to examine cointegration over two subsamples. The subsamples were selected using the exogenously-determined structural break identified previously as October 13, 1989. The results reported in Panels A and B of Table 5 for each subperiod suggest that there is one cointegrating relationship among the three variables, so that equity spot and futures markets are cointegrated. Again the coefficient of the dividend-adjusted index is insignificantly different from its hypothesized value of 1.0.

To further examine the robustness of our results to structural breaks, we used a method proposed by Gregory and Hansen (1996), which is based on the Engle-Granger two-step procedure. This method includes dummy variables (DV) in the cointegrating regression to allow for a shift in the intercept or in the slope and intercept of the long-run relationship.

9 The number of lagged difference terms was determined using a likelihood ratio test with a maximum of 100 lags [Enders (1996)].
In the second step, for each possible breakpoint, ADF regressions are run on the residuals from the corresponding cointegrating regression. The minimum ADF statistic endogenously determines the breakpoint and is compared to critical values supplied by Gregory and Hansen (1996). Panel A of Table 6 reports a test of the null hypothesis of no cointegration versus an alternative of cointegration with shift in intercept. The null was rejected at the 5% significance level, which supports a cointegrating relationship with change in intercept. The competing alternative for the test reported in Panel B of Table 6 is cointegration with shift in slope and intercept. In this case, the null was maintained. Taken together, the Gregory and Hansen (1996) tests support a cointegrating relationship in equity markets with a possible shift in mean.

V. Concluding Remarks
Recent theoretical research conjectures that equity spot and futures markets are not cointegrated if the cost of carry is nonstationary and excluded from the cointegrating
relationship. Although this relationship has important implications for tests of financial models, no empirical study has investigated the issue of cointegration in equity markets. This paper provides such an examination. We used a no-arbitrage, cost-of-carry pricing model to examine whether equity spot and futures markets are cointegrated. Using data from the Standard and Poor’s 500 index and index futures price series for January 4, 1988–June 30, 1995, we found that the appropriate cointegrating relationship includes the cost of carry. In testing, we recognized that there are distinct patterns in dividend payments, so that a constant yield may not be a good representation of cash dividend payments for equities. In this case, the differential or cost of carry is the interest rate, which we found to be nonstationary. We conclude that the index, futures price, and interest rate are cointegrated, a result which is consistent with the no-arbitrage pricing model, and suggests that a no-arbitrage assumption is reasonable in models of equity markets.

Table 6. Test for Cointegration in Equity Markets: Endogenous Structural Break

Panel A: Test for Cointegration with Shift in Intercept

<table>
<thead>
<tr>
<th>ADF Statistic</th>
<th>1% Critical Value</th>
<th>5% Critical Value</th>
<th>10% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5.0871*</td>
<td>-5.44</td>
<td>-4.92</td>
<td>-4.69</td>
</tr>
</tbody>
</table>

Cointegrating Coefficients

<table>
<thead>
<tr>
<th>ln(F_{t+k})</th>
<th>Constant</th>
<th>ln(S_{t+k} - d_{t+k})</th>
<th>r_{t+k}</th>
<th>DV_t</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0000</td>
<td>-0.0207</td>
<td>1.0034</td>
<td>0.0019</td>
<td>-0.0014</td>
</tr>
<tr>
<td></td>
<td>(0.0083)</td>
<td>(0.0013)</td>
<td>(0.0001)</td>
<td>(0.0005)</td>
</tr>
</tbody>
</table>

Panel B: Test for Cointegration with Shift in Intercept and Slope

<table>
<thead>
<tr>
<th>ADF Statistic</th>
<th>1% Critical Value</th>
<th>5% Critical Value</th>
<th>10% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4.5465</td>
<td>-5.97</td>
<td>-5.50</td>
<td>-5.23</td>
</tr>
</tbody>
</table>

Cointegrating Coefficients

<table>
<thead>
<tr>
<th>ln(F_{t+k})</th>
<th>Constant</th>
<th>ln(S_{t+k} - d_{t+k})</th>
<th>r_{t+k}</th>
<th>DV_t</th>
<th>r_{t+k}DV_t ln(S_{t+k} - d_{t+k})</th>
<th>DV_t</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0000</td>
<td>-0.0164</td>
<td>1.0027</td>
<td>0.0019</td>
<td>-0.0018</td>
<td>0.0005</td>
<td>-0.0004</td>
</tr>
<tr>
<td></td>
<td>(0.0094)</td>
<td>(0.0016)</td>
<td>(0.0002)</td>
<td>(0.0226)</td>
<td>(0.0038)</td>
<td>(0.0003)</td>
</tr>
</tbody>
</table>

This table reports the results of a test for cointegration among the dividend-adjusted S&P 500 index, associated futures prices, and interest rates. If the null hypothesis of a unit root in the residuals of the cointegrating regression was rejected, there is evidence of cointegration in equity markets. Lags specifies the number of lagged difference terms allowed in the test regression. We began with 100 lags, and lag terms with t statistics less than 1 in absolute value were dropped. Critical values are from Gregory and Hansen (1996). Standard errors are given below coefficient estimates.

*(***) Denotes rejection of the hypothesis at 5% (1%) significance level.

This paper provides such an examination. We used a no-arbitrage, cost-of-carry pricing model to examine whether equity spot and futures markets are cointegrated. Using data from the Standard and Poor’s 500 index and index futures price series for January 4, 1988–June 30, 1995, we found that the appropriate cointegrating relationship includes the cost of carry. In testing, we recognized that there are distinct patterns in dividend payments, so that a constant yield may not be a good representation of cash dividend payments for equities. In this case, the differential or cost of carry is the interest rate, which we found to be nonstationary. We conclude that the index, futures price, and interest rate are cointegrated, a result which is consistent with the no-arbitrage pricing model, and suggests that a no-arbitrage assumption is reasonable in models of equity markets.
We also investigated the robustness of our results to structural breaks or regime shifts in the series. Although the cointegrating relationships may change over time, our results do not appear to be sensitive to the presence of structural breaks in the series. Thus, it seems that these regime shifts do not significantly impact the long-run equilibrium behavior of equity markets. Future research may examine the cause of these structural breaks and the short-run adjustment process in equity markets.

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