

**Table 1: Sample Statistics for Returns on S&P 500 Index Options  
and on Equally Weighted Option Indexes**

This table presents summary statistics for returns on S&P 500 index options and on option indexes. Results are reported for 12 option-return time series (six for calls and six for puts) with different moneyness-maturity categories: (1) CSTOTM (short-term out-of-the-money calls), (2) CSTATM (short-term at-the-money calls), (3) CSTITM (short-term in-the-money calls), (4) CLTOTM (long-term out-of-the money calls), (5) CLTATM (long-term at-the-money calls), (6) CLTITM (long-term in-the-money calls), (7) PSTOTM (short-term out-of-the-money puts), (8) PSTATM (short-term at-the-money puts), (9) PSTITM (short-term in-the-money puts), (10) PLTOTM (long-term out-of-the-money puts), (11) PLTATM (long-term at-the-money puts), and (12) PLTITM (long-term in-the-money puts). These return series are used to construct six equally weighted option indexes. They are equally weighted “market” (EW), equally weighted short-term (EW short-term), equally weighted long-term (EW long-term), equally weighted OTM (EW OTM), equally weighted ATM (EW ATM), and equally weighted ITM (EW ITM) option indexes. Return is defined as logarithmic price change (in %). The sample period extends from June 1, 1988 through May 31, 1994 for a total of 1506 daily observations.

	Return Series	Mean	St. Dev.	25% Quartile	Median	75% Quartile
<b>Calls</b>	CSTOTM	1.085	29.762	-15.708	1.040	16.983
	CSTATM	1.165	21.479	-10.383	0.725	12.345
	CSTITM	0.385	10.181	-4.157	0.335	5.525
	CLTOTM	0.655	12.897	-6.503	0.435	7.307
	CLTATM	0.467	8.054	-4.022	0.265	4.715
	CLTITM	0.278	5.374	-2.572	0.215	3.105
<b>Puts</b>	PSTOTM	-1.121	23.842	-15.290	-2.170	11.797
	PSTATM	-1.176	22.649	-14.110	-1.435	11.138
	PSTITM	-0.589	13.306	-7.712	-0.590	6.263
	PLTOTM	-0.366	9.923	-6.198	-0.300	4.547
	PLTATM	-0.339	9.075	-5.488	-0.420	4.390
	PLTITM	-0.271	6.524	-3.743	-0.370	2.943
<b>Option indexes</b>	EW	0.014	2.950	-1.734	-0.167	1.549
	EW short-term	-0.042	4.716	-2.695	-0.344	2.414
	EW long-term	0.071	2.139	-1.120	0.019	1.163
	EW OTM	0.063	6.488	-3.783	-0.159	3.571
	EW ATM	0.029	2.875	-1.643	-0.178	1.422
	EW ITM	-0.050	1.856	-0.831	-0.051	0.729
<b>Underlying asset</b>	S&P 500 Index	0.035	0.805	-0.355	0.033	0.460

**Table 4: Factor Loadings from the Principal Component Method**

This table presents estimates of the original and rotated factor loadings from the principal component method. Results are reported for the 12 option-return time series: (1) CSTOTM (short-term out-of-the money calls), (2) CSTATM (short-term at-the-money calls), (3) CSTITM (short-term in-the-money calls), (4) CLTOTM (long-term out-of-the money calls), (5) CLTATM (long-term at-the-money calls), (6) CLTITM (long-term in-the-money calls), (7) PSTOTM (short-term out-of-the money puts), (8) PSTATM (short-term at-the-money puts), (9) PSTITM (short-term in-the-money puts), (10) PLTOTM (long-term out-of-the money puts), (11) PLTATM (long-term at-the-money puts), and (12) PLTITM (long-term in-the-money puts). The sample period extends from June 1, 1988 through May 31, 1994 for a total of 1506 daily observations.

		Return Series	Original Factor Loadings			Rotated Factor Loadings		
			$F_1$	$F_2$	$F_3$	$F_1$	$F_2$	$F_3$
<b>Calls</b>	CSTOTM	26.10	9.62	-0.54	25.67	9.56	4.81	
	CSTATM	20.48	3.17	-2.56	20.55	3.63	0.88	
	CSTITM	9.32	0.37	-3.12	9.64	0.96	-1.70	
	CLTOTM	11.26	4.29	2.67	10.68	3.73	4.93	
	CLTATM	7.72	1.01	0.86	7.51	0.85	2.08	
	CLTITM	5.17	0.33	0.53	5.04	0.24	1.29	
<b>Puts</b>	PSTOTM	-21.55	6.42	0.42	-21.58	6.19	-1.31	
	PSTATM	-21.82	2.81	2.61	-22.04	2.23	0.10	
	PSTITM	-12.85	0.38	1.40	-12.93	0.08	-0.30	
	PLTOTM	-8.79	2.90	-2.30	-8.48	3.27	-2.89	
	PLTATM	-8.67	1.58	-0.33	-8.59	1.60	-1.20	
	PLTITM	-6.21	0.77	-0.12	-6.15	0.77	-0.82	

**Table 5: Factor Analysis of S&P 500 Index Option Returns**

Reported below are proportions of the total variance explained by factors 1, 2 or 3, respectively. Results are reported for the 12 option-return time series: (1) CSTOTM (short-term out-of-the money calls), (2) CSTATM (short-term at-the-money calls), (3) CSTITM (short-term in-the-money calls), (4) CLTOTM (long-term out-of-the money calls), (5) CLTATM (long-term at-the-money calls), (6) CLTITM (long-term in-the-money calls), (7) PSTOTM (short-term out-of-the money puts), (8) PSTATM (short-term at-the-money puts), (9) PSTITM (short-term in-the-money puts), (10) PLTOTM (long-term out-of-the money puts), (11) PLTATM (long-term at-the-money puts), and (12) PLTITM (long-term in-the-money puts). The sample period extends from June 1, 1988 through May 31, 1994 for a total of 1506 daily observations. OTM, ATM, and ITM denote out-of-the money, at-the-money, and in-the-money options, respectively.

	Return Series	Original Factor Loadings			Rotated Factor Loadings			Total (%)
		$F_1$ (%)	$F_2$ (%)	$F_3$ (%)	$F_1$ (%)	$F_2$ (%)	$F_3$ (%)	
<b>Calls</b>	CSTOTM	76.89	10.44	0.03	74.36	10.39	2.61	87.37
	CSTATM	90.94	2.17	1.42	91.51	2.85	0.17	94.54
	CSTITM	83.89	0.13	9.39	89.72	0.90	2.78	93.41
	CLTOTM	76.22	11.06	4.31	68.59	8.35	14.64	91.60
	CLTATM	92.01	1.60	1.16	86.95	1.11	6.70	94.77
	CLTITM	92.75	0.39	1.00	88.18	0.19	5.76	94.15
<b>Puts</b>	PSTOTM	81.65	7.26	0.03	81.90	6.74	0.30	88.94
	PSTATM	92.77	1.54	1.33	94.67	0.96	0.00	95.64
	PSTITM	93.33	0.08	1.11	94.48	0.00	0.05	94.53
	PLTOTM	78.46	8.55	5.38	73.03	10.84	8.51	92.40
	PLTATM	91.27	3.05	0.13	89.57	3.12	1.76	94.46
	PLTITM	90.55	1.40	0.03	89.00	1.40	1.58	92.00
<b>Average</b>	All	86.73	3.97	2.11	85.16	3.91	3.74	92.82
	Short-term	86.58	3.60	2.22	87.77	3.64	0.98	92.41
	Long-term	86.88	4.34	2.00	82.56	4.17	6.49	93.23
	OTM	78.30	9.33	2.44	74.47	9.08	6.52	90.08
	ATM	91.75	2.09	1.01	90.68	2.01	2.16	94.86
	ITM	90.13	0.50	2.88	90.35	0.62	2.54	93.52

**Table 6: Regression Analysis of Equally-weighted Option Return Indexes**

This table reports results from the following regression:

$$R_t = \beta_0 + \beta_1 \hat{f}_{1t} + \beta_2 \hat{f}_{2t} + \beta_3 \hat{f}_{3t} + \epsilon_t,$$

where  $R_t$  is an equally-weighted option-index return, and  $\hat{f}_{1t}$ ,  $\hat{f}_{2t}$  and  $\hat{f}_{3t}$  denote estimates of the three common factors. Three equally weighted option return indexes are used as the dependent variable separately. They are equally weighted “market” (EW), equally weighted short-term (EW short-term), and equally weighted long-term (EW long-term) option indexes, respectively. The sample period extends from June 1, 1988 through May 31, 1994 for a total of 1506 daily observations. Panel A reports coefficient estimates and corresponding standard errors. The standard errors (in parentheses) are White’s (1980) heteroskedasticity consistent estimator. Panel B reports proportions of the total variance explained by each of the common factors.

**Panel A: Regression Results**

Return Series	Original Factors				Rotated Factors				Adj. $R^2$ (%)
	$\beta_0$	$\beta_1$	$\beta_2$	$\beta_3$	$\beta_0$	$\beta_1$	$\beta_2$	$\beta_3$	
EW	0.01 (0.02)	0.01 (0.02)	2.80 (0.02)	-0.03 (0.02)	0.01 (0.02)	-0.07 (0.03)	2.09 (0.02)	0.10 (0.00)	90.60
EW short-term	-0.04 (0.07)	-0.05 (0.07)	3.79 (0.07)	-0.29 (0.07)	-0.04 (0.07)	-0.15 (0.09)	2.86 (0.05)	0.09 (0.01)	65.22
EW long-term	0.07 (0.03)	0.08 (0.03)	1.81 (0.03)	0.22 (0.03)	0.07 (0.04)	0.00 (0.03)	1.32 (0.02)	0.12 (0.01)	73.44

**Panel B: Proportion of the Total Variance Explained by Each Factor**

Return Series	Original Factor Loadings			Rotated Factor Loadings			Total (%)
	$F_1$ (%)	$F_2$ (%)	$F_3$ (%)	$F_1$ (%)	$F_2$ (%)	$F_3$ (%)	
EW	0.00	90.59	0.01	0.03	87.83	2.74	90.60
EW short-term	0.01	64.82	0.39	0.06	64.40	0.76	65.22
EW long-term	0.14	72.24	1.06	0.00	66.47	6.97	73.44

**Table 7: Correlations of Changes in Implied Volatility and Factors**

Reported below is the correlation matrix among changes in the Black-Scholes implied volatility, the original factors, the rotated factors, and the option return indexes. For each day, the Black-Scholes implied volatility is obtained by minimizing sum of squared pricing errors. The results under “All” are obtained by using all call and put options on a given day. Those under “Short” and “Long” are obtained by using all call/put options with days to expiration less than 45 days, or more than 180 days, respectively. The estimates of the original and rotated factors are from the factor analysis. “EW”, “EW short-term” and “EW long-term”, respectively, represent equally weighted option return index, equally weighted short-term option return index, and equally weighted long-term option return index. The sample period extends from June 1, 1988 through May 31, 1994 for a total of 1506 daily observations.

	S&P 500 Index	BS Implied volatility			Original Factors			Rotated Factors		
		All	Short	Long	$F_1$	$F_2$	$F_3$	$F_1$	$F_2$	$F_3$
<b>S&amp;P 500</b>										
Index		-0.56	-0.51	-0.44	0.92	-0.02	-0.12	0.93	0.00	0.00
<b>BS Implied volatility</b>										
All			0.71	0.84	-0.56	0.61	-0.03	-0.56	0.60	0.00
Short				0.45	-0.52	0.52	-0.01	-0.53	0.51	0.00
Long					-0.40	0.46	0.06	-0.42	0.44	0.09
<b>Original factors</b>										
Factor 1								0.99	0.00	0.13
Factor 2								-0.02	0.98	0.18
Factor 3								-0.13	-0.18	0.97
<b>Option indexes</b>										
EW	-0.01	0.55	0.56	0.38	0.01	0.95	-0.01	-0.01	0.94	0.16
EW short-term	-0.01	0.42	0.55	0.24	-0.01	0.81	-0.06	-0.02	0.80	0.09
EW long-term	0.00	0.58	0.32	0.52	0.03	0.85	0.10	0.00	0.82	0.26

**Table 8: Regression Analysis of S&P 500 Index Option Returns:  
One-, two- and three-factor models with S&P 500 Index  
Return and Option Index Return as Factors**

This table reports results from the following three regressions:

Regression 1:  $R_{it} = \alpha_{i0} + \alpha_{i1} R_t^{S\&P500} + \epsilon_{it}$ ,

Regression 2:  $R_{it} = \beta_{i0} + \beta_{i1} R_t^{S\&P500} + \beta_{i2} R_t^{EW} + \epsilon_{it}$ ,

Regression 3:  $R_{it} = \gamma_{i0} + \gamma_{i1} R_t^{S\&P500} + \gamma_{i2} R_t^{EWshort-term} + \gamma_{i3} R_t^{EWlong-term} + \epsilon_{it}, \quad t = 1, \dots, T$ ,

where  $R_{it}$  is one of the following option return series: (1) CSTOTM (short-term out-of-the money calls), (2) CSTATM (short-term at-the-money calls), (3) CSTITM (short-term in-the-money calls), (4) CLTOTM (long-term out-of-the money calls), (5) CLTATM (long-term at-the-money calls), (6) CLTITM (long-term in-the-money calls), (7) PSTOTM (short-term out-of-the money puts), (8) PSTATM (short-term at-the-money puts), (9) PSTITM (short-term in-the-money puts), (10) PLTOTM (long-term out-of-the money puts), (11) PLTATM (long-term at-the-money puts), and (12) PLTITM (long-term in-the-money puts).  $R_t^{S\&P500}$  is the S&P 500 index return.  $R_t^{EW}$ ,  $R_t^{EWshort-term}$ , and  $R_t^{EWlong-term}$ , respectively, represent returns on equally weighted “market”, equally weighted short-term, and equally weighted long-term option indexes. Return is defined as logarithmic price change. The sample period extends from June 1, 1988 through May 31, 1994, for a total of 1506 daily observations. The standard errors (reported in parentheses) are White’s (1980) heteroskedasticity consistent estimator.

Return Series	100×		Adj. $R^2$	100×			Adj. $R^2$	100×				Adj. $R^2$
	$\alpha_0$	$\alpha_1$		$\beta_0$	$\beta_1$	$\beta_2$		$\gamma_0$	$\gamma_1$	$\gamma_2$	$\gamma_3$	
CSTOTM	0.07 (0.47)	29.06 (0.58)	61.8	0.01 (0.37)	29.26 (0.46)	3.82 (0.12)	76.2	0.12 (0.36)	29.26 (0.46)	2.35 (0.08)	0.57 (0.18)	77.0
CSTATM	0.33 (0.24)	23.85 (0.31)	80.0	0.31 (0.22)	23.92 (0.28)	1.32 (0.08)	83.3	0.30 (0.22)	23.92 (0.28)	0.61 (0.05)	0.82 (0.11)	83.3
CSTITM	-0.01 (0.11)	11.35 (0.14)	80.6	-0.01 (0.11)	11.36 (0.14)	0.28 (0.04)	81.2	-0.01 (0.11)	11.36 (0.14)	0.17 (0.03)	0.05 (0.06)	81.2
CLTOTM	0.22 (0.20)	12.48 (0.26)	60.7	0.20 (0.18)	12.53 (0.23)	1.19 (0.06)	68.0	0.03 (0.15)	12.53 (0.18)	-0.08 (0.04)	2.68 (0.08)	79.4
CLTATM	0.16 (0.10)	8.74 (0.12)	76.4	0.15 (0.10)	8.76 (0.12)	0.35 (0.03)	78.0	0.10 (0.09)	8.75 (0.11)	-0.04 (0.02)	0.83 (0.05)	80.9
CLTITM	0.07 (0.06)	5.90 (0.08)	78.1	0.07 (0.06)	5.90 (0.08)	0.14 (0.02)	78.6	0.04 (0.06)	5.90 (0.08)	-0.04 (0.01)	0.39 (0.03)	80.2
PSTOTM	-0.27 (0.35)	-24.25 (0.43)	67.1	-0.31 (0.30)	-24.13 (0.38)	2.38 (0.10)	75.8	-0.15 (0.28)	-24.12 (0.35)	1.80 (0.07)	-0.68 (0.14)	78.5
PSTATM	-0.29 (0.26)	-25.26 (0.32)	80.7	-0.31 (0.24)	-25.21 (0.30)	1.06 (0.08)	82.6	-0.23 (0.24)	-25.20 (0.30)	0.86 (0.05)	-0.46 (0.12)	83.4
PSTITM	-0.05 (0.13)	-15.23 (0.17)	85.0	-0.06 (0.14)	-15.22 (0.16)	0.17 (0.04)	85.1	-0.03 (0.13)	-15.22 (0.16)	0.21 (0.03)	-0.29 (0.06)	85.5
PLTOTM	-0.02 (0.15)	-9.86 (0.20)	64.1	-0.03 (0.14)	-9.83 (0.18)	0.68 (0.05)	68.2	-0.10 (0.13)	-9.83 (0.16)	0.05 (0.03)	1.22 (0.07)	71.7
PLTATM	0.01 (0.10)	-10.07 (0.13)	79.9	0.00 (0.10)	-10.05 (0.12)	0.40 (0.03)	81.6	-0.02 (0.09)	-10.05 (0.12)	0.07 (0.02)	0.60 (0.05)	82.4
PLTITM	-0.01 (0.07)	-7.31 (0.09)	81.5	-0.02 (0.07)	-7.30 (0.09)	0.19 (0.02)	82.3	-0.03 (0.07)	-7.30 (0.08)	0.04 (0.02)	0.27 (0.04)	82.5

**Table 9: Regression Analysis of S&P 500 Index Option Returns:  
Two- and three-factor models with S&P 500 Index Return  
and Implied Volatility as Factors**

This table reports results from the following two regressions:

$$\text{Regression 1: } R_{it} = \beta_{i0} + \beta_{i1} R_t^{S\&P500} + \beta_{i2} \log\left(\frac{\sigma_t^{All}}{\sigma_{t-1}^{All}}\right) + \epsilon_{it},$$

$$\text{Regression 2: } R_{it} = \gamma_{i0} + \gamma_{i1} R_t^{S\&P500} + \gamma_{i2} \log\left(\frac{\sigma_t^{short-term}}{\sigma_{t-1}^{short-term}}\right) + \gamma_{i3} \log\left(\frac{\sigma_t^{long-term}}{\sigma_{t-1}^{long-term}}\right) + \epsilon_{it}, \quad t = 1, \dots, T,$$

where  $R_{it}$  is one of the following option return series: (1) CSTOTM (short-term out-of-the money calls), (2) CSTATM (short-term at-the-money calls), (3) CSTITM (short-term in-the-money calls), (4) CLTOTM (long-term out-of-the money calls), (5) CLTATM (long-term at-the-money calls), (6) CLTITM (long-term in-the-money calls), (7) PSTOTM (short-term out-of-the money puts), (8) PSTATM (short-term at-the-money puts), (9) PSTITM (short-term in-the-money puts), (10) PLTOTM (long-term out-of-the money puts), (11) PLTATM (long-term at-the-money puts), and (12) PLTITM (long-term in-the-money puts).  $R_t^{S\&P500}$  is the S&P 500 index return. Return is defined as logarithmic price change.  $\sigma_t^{All}$  is the volatility on day  $t$  implied by the Black-Scholes (BS) model using all call and put options,  $\sigma_t^{short-term}$  is the volatility on day  $t$  implied by the BS model using all short-term call/put options (with days-to-expiration less than 45 days), and  $\sigma_t^{long-term}$  is the volatility on day  $t$  implied by the BS model using long-term call/put options (with days-to-expiration more than 180 days). The sample period extends from June 1, 1988 through May 31, 1994, for a total of 1506 daily observations. The standard errors (reported in parentheses) are White's (1980) heteroskedasticity consistent estimator.

Return Series	100× $\beta_0$	$\beta_1$	$\beta_2$	Adj. $R^2$	100× $\gamma_0$	$\gamma_1$	$\gamma_2$	$\gamma_3$	Adj. $R^2$
CSTOTM	0.07 (0.45)	32.72 (0.69)	2.41 (0.25)	63.9	0.00 (0.45)	33.91 (0.68)	0.86 (0.09)	1.44 (0.24)	65.4
CSTATM	0.31 (0.24)	25.26 (0.36)	0.93 (0.09)	80.6	0.30 (0.24)	25.60 (0.36)	0.32 (0.05)	0.46 (0.13)	80.9
CSTITM	-0.01 (0.11)	11.41 (0.17)	0.04 (0.06)	80.6	-0.01 (0.11)	11.44 (0.17)	0.03 (0.02)	0.01 (0.06)	80.6
CLTOTM	0.19 (0.20)	14.30 (0.30)	1.20 (0.11)	63.5	0.19 (0.20)	14.19 (0.30)	0.10 (0.04)	1.12 (0.10)	64.0
CLTATM	0.15 (0.10)	9.28 (0.14)	0.36 (0.06)	77.0	0.16 (0.10)	9.23 (0.14)	-0.06 (0.02)	0.62 (0.05)	78.4
CLTITM	0.07 (0.06)	5.94 (0.09)	0.03 (0.04)	78.1	0.07 (0.06)	6.00 (0.09)	-0.05 (0.02)	0.26 (0.03)	78.9
PSTOTM	-0.33 (0.32)	-20.08 (0.50)	2.75 (0.18)	71.4	-0.38 (0.31)	-19.50 (0.46)	1.36 (0.06)	-0.19 (0.17)	74.5
PSTATM	-0.32 (0.24)	-23.22 (0.37)	1.34 (0.14)	81.8	-0.36 (0.23)	-22.58 (0.35)	0.87 (0.05)	-0.42 (0.12)	83.9
PSTITM	-0.06 (0.13)	-14.80 (0.19)	0.28 (0.07)	85.1	-0.07 (0.13)	-15.00 (0.20)	0.11 (0.03)	-0.13 (0.07)	85.1
PLTOTM	-0.06 (0.13)	-7.23 (0.20)	1.74 (0.07)	74.1	-0.05 (0.14)	-7.81 (0.21)	0.32 (0.03)	0.74 (0.08)	70.0
PLTATM	-0.01 (0.09)	-8.41 (0.14)	1.10 (0.05)	86.6	-0.01 (0.09)	-8.80 (0.14)	0.20 (0.02)	0.47 (0.05)	82.6
PLTITM	-0.02 (0.06)	-6.53 (0.10)	0.52 (0.03)	83.5	-0.03 (0.07)	-6.75 (0.10)	0.08 (0.02)	0.21 (0.04)	82.5

**Table 10: Mean-Variance Spanning Tests Using Returns on S&P 500 Index and Option Indexes as Benchmark Assets**

This table reports likelihood ratio statistics and p-values (in parentheses) for the mean-variance spanning tests. The null hypothesis is that returns on benchmark assets span the return on the test asset. We estimate the following regression models and test the null hypothesis using Generalized Method of Moments (GMM):

$$\begin{aligned}
 \text{Regression 1: } R_{it} &= \beta_{i0} + \beta_{i1} R_t^{S\&P500} + \beta_{i2} R_t^{EW} + \epsilon_{it}, \\
 &H_0 : \beta_0 = 0, \quad \beta_1 + \beta_2 = 1 \\
 \text{Regression 2: } R_{it} &= \beta_{i0} + \beta_{i1} R_t^{S\&P500} + \beta_{i2} R_t^{EW\text{short-term}} + \beta_{i3} R_t^{EW\text{long-term}} + \epsilon_{it}, \\
 &H_0 : \beta_0 = 0, \quad \beta_1 + \beta_2 + \beta_3 = 1 \\
 \text{Regression 3: } R_{it} &= \beta_{i0} + \beta_{i1} R_t^{S\&P500} + \beta_{i2} R_t^{EW\text{OTM}} + \beta_{i3} R_t^{EW\text{ATM}} + \beta_{i4} R_t^{EW\text{ITM}} + \epsilon_{it}, \\
 &H_0 : \beta_0 = 0, \quad \beta_1 + \beta_2 + \beta_3 + \beta_4 = 1
 \end{aligned}$$

where  $R_{it}$  is the return on a test asset.  $R_t^{S\&P500}$  is the S&P 500 index return,  $R_t^{EW}$ ,  $R_t^{EW\text{short-term}}$ ,  $R_t^{EW\text{long-term}}$ ,  $R_t^{EW\text{OTM}}$ ,  $R_t^{EW\text{ATM}}$ , and  $R_t^{EW\text{ITM}}$ , respectively, represent returns on equally weighted “market”, equally weighted short-term, long-term, OTM, ATM, and ITM option indexes. The sample period extends from June 1, 1988 through May 31, 1994, for a total of 1506 daily observations.

Benchmark Assets			
Test Asset	$R^{S\&P500}, R^{EW}$	$R^{S\&P500}, R^{EW\text{short-term}}, R^{EW\text{long-term}}$	$R^{S\&P500}, R^{EW\text{OTM}}, R^{EW\text{ATM}}, R^{EW\text{ITM}}$
CSTOTM	108.79 ( $< 0.01$ )	171.15 ( $< 0.01$ )	12.16 ( $< 0.01$ )
CSTATM	91.18 ( $< 0.01$ )	111.09 ( $< 0.01$ )	16.45 ( $< 0.01$ )
CSTITM	57.89 ( $< 0.01$ )	71.95 ( $< 0.01$ )	13.67 ( $< 0.01$ )
CLTOTM	97.68 ( $< 0.01$ )	124.55 ( $< 0.01$ )	18.38 ( $< 0.01$ )
CLTATM	100.04 ( $< 0.01$ )	141.25 ( $< 0.01$ )	16.36 ( $< 0.01$ )
CLTITM	90.61 ( $< 0.01$ )	139.77 ( $< 0.01$ )	15.55 ( $< 0.01$ )
PSTOTM	102.91 ( $< 0.01$ )	160.93 ( $< 0.01$ )	14.16 ( $< 0.01$ )
PSTATM	99.63 ( $< 0.01$ )	110.45 ( $< 0.01$ )	16.98 ( $< 0.01$ )
PSTITM	88.46 ( $< 0.01$ )	110.41 ( $< 0.01$ )	13.60 ( $< 0.01$ )
PLTOTM	98.80 ( $< 0.01$ )	127.22 ( $< 0.01$ )	12.74 ( $< 0.01$ )
PLTATM	96.81 ( $< 0.01$ )	129.82 ( $< 0.01$ )	13.99 ( $< 0.01$ )
PLTITM	92.12 ( $< 0.01$ )	129.90 ( $< 0.01$ )	13.77 ( $< 0.01$ )

**Table 11: Mean-Variance Spanning Tests Using Returns on S&P 500 Index and At-the-money Options as Benchmark Assets**

This table reports likelihood ratio statistics and p-values (in parentheses) for the mean-variance spanning tests. The null hypothesis is that returns on benchmark assets span the return on the test asset. We estimate the following regression model and test the null hypothesis using Generalized Method of Moments (GMM):

$$R_{it} = \beta_{i0} + \beta_{i1} R_t^{S\&P500} + \beta_{i2} R_t^{ATM} + \epsilon_{it},$$

$$H_0 : \beta_0 = 0, \quad \beta_1 + \beta_2 = 1,$$

where  $R_{it}$  is the return on a test asset.  $R_t^{S\&P500}$  is the S&P 500 index return, and  $R_t^{ATM}$  is the return on a chosen ATM option. The sample period extends from June 1, 1988 through May 31, 1994, for a total of 1506 daily observations.

Test Asset	Benchmark Assets	LR-statistic (p-value)
CSTOTM	$R^{S\&P500}$ , CSTATM	1.32 (0.52)
CSTITM	$R^{S\&P500}$ , CSTATM	26.22 (0.00)
CLTOTM	$R^{S\&P500}$ , CLTATM	1.64 (0.44)
CLTITM	$R^{S\&P500}$ , CLTATM	9.52 (0.01)
PSTOTM	$R^{S\&P500}$ , PSTATM	1.89 (0.39)
PSTITM	$R^{S\&P500}$ , PSTATM	67.34 (0.00)
PLTOTM	$R^{S\&P500}$ , PLTATM	0.27 (0.87)
PLTITM	$R^{S\&P500}$ , PLTATM	48.78 (0.00)