



The University of Reading

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Option Pricing of U.S. REITs M&A under Stochastic Volatility

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Objective: To study and analyse emerging compound options during M&As of REITs.

Motivation: Sometimes after M&A of REITs, the merged entity trade far above the initial calculated value after the merger, indicating "extra" hidden value of merged entity.

Data: 37 M&A of only REITs in the US that occurred between mid-1990s and early 2000s provided by SNL Financials.

Methods: Margrabe (1978) model-compound options, REITs Margrabe (1978) model-M&As of REITs, Geometric Brownian motion-share prices and NAVs follow martingale process and GARCH (1;1)-stochastic volatility.

Results: Share prices as opposed to NAVs when calculating option values in M&As in REITs tend to lead to misleading conclusions while NAVs reflect the real situation. : Furthermore, by taking to account stochastic volatility, the option values increase.

- Stochastic volatility increases the value of the option.
- REITs can increase in size without changing any thing operationally.
- Exchange options add extra value to the merged entity.
- Share prices in M&As of REITs lead to misleading conclusions when calculating option values, while NAVS lead to right conclusions.
- M&As in REITs is not a bad thing after all in bull markets.

Implications: Real estate practitioners should be aware that some measures, although accurate can leading to misleading conclusions, i.e. share prices vs. NAVs; therefore, each measure is correct in context and should be used or accepted accordingly. Although, M&A is criticised as not adding value in most industries but lot of academicians, it seems that in bull markets within the REITs industry, M&A adds value when taking the issue of

Normality Test Results

Acquirer	Ticker	Skewness	Kurtosis	Jarque-Berra	Prob
American Campus Communities, Inc.	ACC	-0.137	10.554	2583.26	0.000
Apartment Investment and Management Company	AIV	0.310	5.221	191.94	0.000
Bay Apartment Communities, Inc.	AVB	0.449	4.959	194.67	0.000
Brandywine Realty Trust	BDN	1.844	23.804	78583.21	0.000
Camden Property Trust	CPT	-0.033	5.823	937.62	0.000
Colonial Properties Trust	CLP	-0.198	7.823	2725.56	0.000
Developers Diversified Realty Corporation	DDR_1	0.080	6.368	926.05	0.000
Developers Diversified Realty Corporation	DDR_2	-0.140	5.801	1140.40	0.000
Duke Realty Investments, Inc.	DRE	-0.539	20.710	33657.75	0.000
Equity Office Properties Trust	ELS_1	0.293	7.726	1833.87	0.000
Equity Office Properties Trust	ELS_2	0.304	7.998	2348.59	0.000
Equity One, Inc.	EQY_1	0.342	7.509	970.00	0.000
Equity One, Inc.	EQY_2	0.268	7.358	616.04	0.000
Equity Residential Properties Trust	EQR_1	0.748	9.343	1806.70	0.000
Equity Residential Properties Trust	EQR_2	0.825	9.750	3516.70	0.000
Equity Residential Properties Trust	EQR_3	0.850	9.731	2980.01	0.000
Equity Residential Properties Trust	EQR_4	0.766	9.289	1693.53	0.000
General Growth Properties, Inc.	GGP	0.837	10.150	5034.51	0.000
Health Care Property Investors, Inc.	HR_1	-0.268	7.088	1046.99	0.000
Health Care Property Investors, Inc.	HR_2	-0.412	6.848	2048.52	0.000
Highwoods Properties, Inc.	HIW	0.930	8.608	660.40	0.000
Kimco Realty Corporation	KIM_1	0.222	6.241	1299.13	0.000
Kimco Realty Corporation	KIM_2	0.035	6.340	1732.02	0.000
Lexington Corporate Properties Trust	LXP	0.228	12.671	12565.31	0.000
Liberty Property Trust	LRY	-0.104	5.312	740.14	0.000
Mid-America Apart. Communities, Inc.	MAA	1.884	11.166	835.65	0.000
Penn. Real Estate Investment Trust	PEI	-0.057	5.957	1321.95	0.000
Post Properties, Inc.	PPS	-0.219	6.821	541.20	0.000
ProLogis	PLD_1	2.003	40.977	169830.20	0.000
ProLogis	PLD_2	3.464	56.849	143576.80	0.000
Public Storage, Inc.	PSA	-0.194	11.766	14095.06	0.000
Simon Property Group, Inc.	SPG_1	0.096	9.857	5230.25	0.000
Simon Property Group Inc.	SPG_2	0.183	4.583	63.36	0.000
Simon Property Group Inc.	SPG_3	-0.278	4.076	7.58	0.000
SL Green Realty Corp.	SLG	0.039	9.168	4882.46	0.000
United Dominion Realty Trust, Inc.	UDR	2.650	25.216	6759.66	0.000
Vornado Realty Trust	VNO	7.228	119.537	1672582	0.000

Source: SNL Financials

Note: Results were simulated using Eviews



GARCH (1; 1) Parameters

Ticker	$\bar{\sigma}$	σ_t	ω	$P(\omega)$	α	$P(\alpha)$	ε	$P(\varepsilon)$	λ	$P(\lambda)$	β	$P(\beta)$	$\alpha + \beta$
ACC	0.00913	0.78297	0.0000049	0.0009	0.05932	0.0002	0.00070	0.5757	0.08111	0.0025	0.88242	0.000	0.9417
AIV	0.00255	0.00057	0.0000059	0.0001	0.03538	0.0004	0.00121	0.0904	0.03798	0.8156	0.05847	0.000	0.0938
AVB	0.00989	0.70572	0.0000076	0.0005	0.09234	0.0000	0.00075	0.4654	0.05009	0.0768	0.82975	0.000	0.9221
BDN	0.00973	0.90538	0.0000014	0.0000	0.05257	0.0000	0.00028	0.3045	0.04043	0.0000	0.93265	0.000	0.9852
CPT	0.00867	0.69893	0.0000067	0.0000	0.07034	0.0000	0.00006	0.8720	0.08651	0.0000	0.84096	0.000	0.9113
CLP	0.01001	0.27496	0.0000310	0.0000	0.11632	0.0000	0.00013	0.7995	0.10005	0.0002	0.57418	0.000	0.6905
DDR_1	0.00870	0.86603	0.0000023	0.0000	0.04815	0.0000	0.00006	0.8899	0.04104	0.0001	0.92133	0.000	0.9695
DDR_2	0.01105	0.75187	0.0000075	0.0000	0.08624	0.0000	0.00041	0.3105	0.04038	0.0010	0.85269	0.000	0.9389
DRE	0.01240	0.92067	0.0000011	0.0013	0.05869	0.0000	0.00067	0.0633	0.01753	0.0636	0.93409	0.000	0.9928
ELS_1	0.01458	0.83923	0.0000070	0.0000	0.06925	0.0000	0.00036	0.2405	0.00737	0.4305	0.89766	0.000	0.9669
ELS_2	0.01313	0.82151	0.0000066	0.0000	0.07424	0.0000	0.00021	0.7281	0.02011	0.0354	0.88772	0.000	0.9620
EQY_1	0.01581	0.48664	0.0000375	0.0000	0.17719	0.0000	0.00029	0.7441	0.06062	0.0839	0.67273	0.000	0.8499
EQY_2	0.02148	0.56675	0.0000379	0.0000	0.24555	0.0000	0.00054	0.6418	0.03606	0.4315	0.67231	0.000	0.9179
EQR_1	0.00880	0.89318	0.0000024	0.0000	0.01818	0.0183	0.00086	0.2854	0.02918	0.0094	0.95096	0.000	0.9691
EQR_2	0.00949	0.85990	0.0000033	0.0000	0.03857	0.0000	0.00019	0.7480	0.02919	0.0018	0.92538	0.000	0.9640
EQR_3	0.00965	0.86701	0.0000031	0.0000	0.04022	0.0000	0.00019	0.7605	0.02732	0.0075	0.92691	0.000	0.9671
EQR_4	0.00907	0.89331	0.0000025	0.0001	0.01974	0.0132	0.00076	0.3692	0.02792	0.0158	0.94997	0.000	0.9697
GGP	0.01009	0.56879	0.0000147	0.0000	0.07953	0.0000	0.00030	0.2120	0.08962	0.0000	0.77608	0.000	0.8556
HR_1	0.01216	0.59021	0.0000199	0.0000	0.07770	0.0000	0.00037	0.6870	0.05569	0.0458	0.78772	0.000	0.8654
HR_2	0.01392	0.25381	0.0000591	0.0000	0.16983	0.0000	0.00054	0.4359	0.02335	0.3548	0.52516	0.000	0.6950
HIW	0.00600	0.77712	0.0000026	0.0370	0.02332	0.0880	0.00085	0.3318	0.13671	0.0000	0.90373	0.000	0.9270
KIM_1	0.00973	0.59008	0.0000116	0.0000	0.11111	0.0000	0.00038	0.4207	0.03171	0.0551	0.76631	0.000	0.8774
KIM_2	0.00981	0.66207	0.0000094	0.0000	0.08940	0.0000	0.00022	0.5994	0.03708	0.0068	0.81295	0.000	0.9024
LXP	0.01333	0.74202	0.0000134	0.0000	0.05655	0.0000	0.00014	0.8120	0.03950	0.0042	0.86799	0.000	0.9245
LRY	0.01006	0.71966	0.0000088	0.0000	0.04990	0.0000	0.00042	0.4572	0.04204	0.0016	0.86315	0.000	0.9130
MAA	0.01060	0.63217	0.0000174	0.0005	0.04113	0.0000	0.00034	0.7032	0.14386	0.0728	0.88626	0.000	0.8451
PEI	0.01123	0.67902	0.0000127	0.0143	0.05976	0.0000	0.00141	0.0143	0.04292	0.0001	0.83951	0.000	0.8993
PPS	0.00888	0.22494	0.0000269	0.0000	0.14474	0.0000	0.00018	0.8196	0.11251	0.0129	0.51404	0.000	0.6588
PLD_1	0.01124	0.56866	0.0000198	0.0000	0.04407	0.0000	0.00003	0.9554	0.08404	0.0000	0.79921	0.000	0.8433
PLD_2	0.01229	0.50686	0.0000276	0.0000	0.05953	0.0000	0.00013	0.8727	0.08697	0.0060	0.75788	0.000	0.8174
PSA	0.01307	0.59888	0.0000216	0.0000	0.08956	0.0000	0.00086	0.1163	0.06903	0.0000	0.78407	0.000	0.8736
SPG_1	0.01267	0.17717	0.0000583	0.0000	0.19992	0.0000	0.00120	0.0632	0.00161	0.9564	0.43682	0.000	0.6367
SPG_2	0.02037	0.89657	0.0000041	0.0203	0.07584	0.0010	0.03993	0.7849	0.03993	0.1694	0.91437	0.000	0.9902
SPG_3	0.02602	0.99398	0.0000028	0.4832	0.12557	0.1354	0.00289	0.1672	0.10043	0.3094	0.91563	0.000	1.0412
SLG	0.01243	0.15598	0.0000614	0.0000	0.17295	0.0000	0.00103	0.1097	0.02378	0.3856	0.42942	0.000	0.6024
UDR	0.01319	0.31630	0.0000503	0.0002	0.10487	0.0140	0.00060	0.6785	0.31078	0.0144	0.60589	0.000	0.7108
VNO	0.01594	0.39101	0.0000429	0.0000	0.27263	0.0000	0.00000	0.9991	0.13702	0.0000	0.55853	0.000	0.8312

Source: SNL Financials
 Note: Parameters were simulated using Eviews

Model Selection Criteria

Acquirer	Ticker	Durbin-Watson stat	Akaike info criterion	Schwartz criterion	Hannan-Quinn criterion	Adjusted R-Square
American Campus Communities, Inc.	ACC	2.032262	-5.295742	-5.268151	-5.285297	-0.0039
Apartment Investment and Management Company	AIV	1.939354	-6.105223	-6.072217	-6.092591	-0.0047
Bay Apartment Communities, Inc.	AVB	1.959522	-6.145061	-6.115755	-6.133926	-0.0049
Brandywine Realty Trust	BDN	2.343004	-4.46967	-4.460654	-4.466483	-0.0014
Camden Property Trust	CPT	1.940183	-6.262029	-6.249388	-6.257468	-0.0014
Colonial Properties Trust	CLP	2.237751	-6.180139	-6.16739	-6.175536	-0.0014
Developers Diversified Realty Corporation	DDR_1	2.04489	-5.951547	-5.934428	-5.945254	-0.0021
Developers Diversified Realty Corporation	DDR_2	1.977533	-5.951743	-5.941064	-5.947929	-0.0012
Duke Realty Investments, Inc.	DRE	2.42313	-5.185708	-5.172029	-5.180748	-0.0016
Equity Office Properties Trust	ELS_1	1.967536	-5.663663	-5.649312	-5.658385	-0.0021
Equity Office Properties Trust	ELS_2	1.975464	-5.752548	-5.737151	-5.746925	-0.0018
Equity One, Inc.	EQY_1	2.30718	-5.458166	-5.431248	-5.447991	-0.0040
Equity One, Inc.	EQY_2	2.303924	-5.352244	-5.315927	-5.338265	-0.0023
Equity Residential Properties Trust	EQR_1	1.904152	-5.828684	-5.799721	-5.817687	-0.0027
Equity Residential Properties Trust	EQR_2	1.811971	-5.997607	-5.978844	-5.990671	0.0042
Equity Residential Properties Trust	EQR_3	1.805338	-5.936599	-5.91516	-5.928608	-0.0037
Equity Residential Properties Trust	EQR_4	1.910184	-5.797219	-5.767051	-5.785736	-0.0053
General Growth Properties, Inc.	GGP	1.901523	-6.102447	-6.089697	-6.097792	-0.0018
Health Care Property Investors, Inc.	HR_1	2.13147	-5.801344	-5.779835	-5.793325	-0.0102
Health Care Property Investors, Inc.	HR_2	2.041468	-5.742387	-5.730929	-5.738278	-0.0027
Highwoods Properties, Inc.	HIW	2.153194	-6.120363	-6.065939	-6.09892	-0.0013
Kimco Realty Corporation	KIM_1	1.95593	-6.406911	-6.3946	-6.402476	-0.0015
Kimco Realty Corporation	KIM_2	1.916873	-6.318542	-6.308519	-6.314976	-0.0011
Lexington Corporate Properties Trust	LXP	2.35721	-5.540669	-5.529315	-5.536599	-0.0012
Liberty Property Trust	LRY	2.00637	-6.133545	-6.122443	-6.129571	-0.0013
Mid-America Apartment Communities, Inc.	MAA	1.856961	-5.791174	-5.720339	-5.762659	-0.0165
Pennsylvania Real Estate Investment Trust	PEI	2.053791	-5.966254	-5.955994	-5.962599	-0.0012
Post Properties, Inc.	PPS	1.976156	-6.526595	-6.493945	-6.514108	-0.0015
ProLogis	PLD_1	1.979486	-5.862648	-5.849906	-5.858048	-0.0037
ProLogis	PLD_2	1.941065	-5.719726	-5.693735	-5.709923	-0.0046
Public Storage, Inc.	PSA	2.122719	-5.673083	-5.66436	-5.670006	-0.0097
Simon Property Group, Inc.	SPG_1	1.98127	-5.981896	-5.968652	-5.977104	-0.0014
Simon Property Group Inc.	SPG_2	2.071211	-6.1737	-6.128324	-6.156004	-0.0017
Simon Property Group Inc.	SPG_3	2.145803	-5.991437	-5.854971	-5.936001	-0.0070
SL Green Realty Corp.	SLG	1.951291	-5.976134	-5.964382	-5.971912	-0.0347
United Dominion Realty Trust, Inc.	UDR	1.774121	-5.263977	-5.191826	-5.235137	-0.0132
Vornado Realty Trust	VNO	1.718642	-6.006929	-5.994611	-6.002492	-0.0037

Source: SNL Financials
 Note: Results were simulated using Eviews



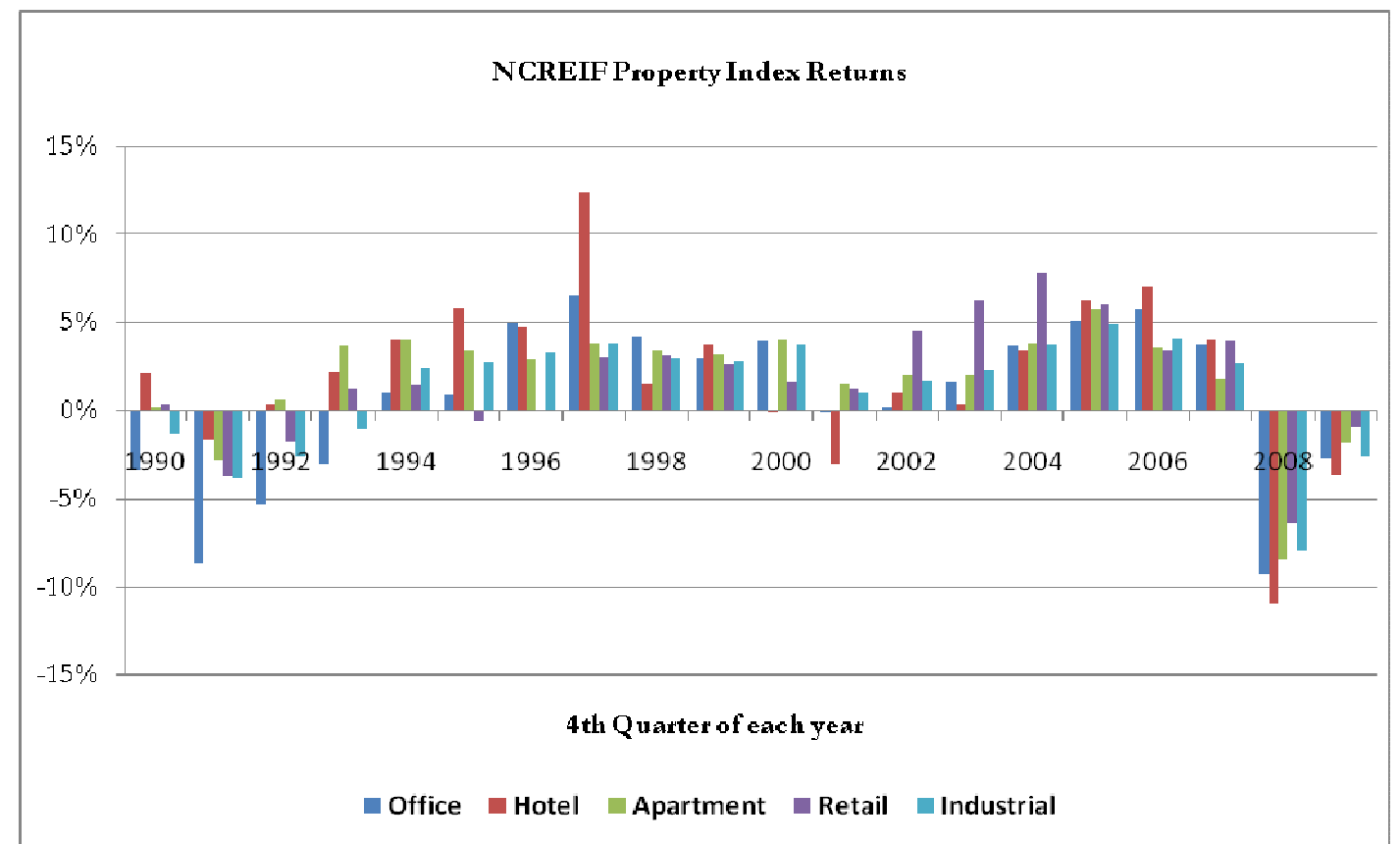
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Call Option Values

Acquirer's Ticker	Target	Acquirer's line of business	Target's line of business	Call (Share Prices)	Call (Share Prices & Funds)	Fund Factor	Call (NAVs)	Call (NAVs & Funds)	Fund Factor
ACC	GMH Communities Trust	Student Housing	Student Housing	21.95	23.35	0.064	21.88	22.78	0.041
AIV	Ambassador Apartments, Inc.	Multi-family	Multi-family	0.00	0.00	1.000	0.00	0.00	0.101
AVB	Avalon Properties, Inc.	Multi-family	Multi-family	4.95	9.94	1.010	267.40	274.14	0.025
BDN	Prentiss Properties Trust	Office	Office	-0.16	-0.67	3.103	45.01	46.52	0.034
CPT	Summit Properties Inc.	Multi-family	Multi-family	9.75	3.67	0.624	28.33	29.15	0.029
CLP	Cornerstone Realty Inc. Trust Inc.	Diversified	Multi-family	29.89	30.98	0.037	5.25	5.40	0.029
DDR_1	American Industrial Pro. REIT	Shopping Center	Industrial	-2.88	-2.54	0.119	55.59	55.94	0.006
DDR_2	Inland Retail Real Estate Trust, Inc.	Shopping Center	Shopping Center	42.68	48.65	0.140	257.11	263.07	0.023
DRE	Weeks Corporation	Office	Industrial	-1.46	-1.52	0.039	11.05	11.21	0.015
ELS_1	Cornerstone Properties, Inc.	Office	Office	7.83	8.42	0.076	17.79	17.92	0.007
ELS_2	Spieker Properties, Inc.	Office	Office	-6.12	-3.39	0.446	15.55	15.72	0.011
EQY_1	IRT Property Company	Shopping Center	Shopping Center	1.44	3.11	1.159	90.83	92.75	0.021
EQY_2	United Investors Realty Trust	Shopping Center	Shopping Center	5.06	6.11	0.207	27.94	28.36	0.015
EQR_1	Evans Withycombe Residential, Inc.	Multi-family	Multi-family	2.55	2.42	0.054	16.23	16.31	0.005
EQR_2	Grove Property Trust	Multi-family	Multi-family	3.77	3.25	0.138	20.32	20.33	0.001
EQR_3	Lexford Residential Trust	Multi-family	Multi-family	0.71	0.17	0.761	19.11	19.14	0.001
EQR_4	Wellsford Residential Pro. Trust	Multi-family	Multi-family	-2.18	-3.14	0.442	4.55	4.60	0.012
GGP	JP Realty, Inc.	Regional Mall	Regional Mall	10.94	11.25	0.028	0.81	0.83	0.020
HR_1	American Health Properties, Inc.	Health Care	Health Care	-1.87	-2.42	0.298	37.94	38.51	0.015
HR_2	CNL Retirement Properties, Inc.	Health Care	Health Care	10.56	11.61	0.100	21.16	21.98	0.039
HIW	Crocker Realty Trust, Inc.	Office	Office	16.86	17.17	0.018	8.76	8.90	0.016
KIM_1	Mid-Atlantic Realty Trust	Shopping Center	Shopping Center	-0.18	-0.05	0.744	76.56	76.83	0.004
KIM_2	Pan Pacific Retail Properties, Inc.	Shopping Center	Shopping Center	-8.62	10.27	0.192	47.94	48.64	0.015
LXP	Newkirk Realty Trust, Inc.	Diversified	Diversified	2.57	3.04	0.184	14.25	14.58	0.023
LRY	Republic Property Trust	Industrial	Office	29.67	31.33	0.056	42.80	43.00	0.005
MAA	America First REIT, Inc.	Multi-family	Multi-family	6.83	7.17	0.049	3.28	3.32	0.012
PEI	Crown American Realty Trust	Regional Mall	Regional Mall	15.40	16.16	0.049	9.68	10.36	0.070
PPS	Columbus Realty Trust	Multi-family	Multi-family	11.26	11.48	0.019	5.69	5.80	0.019
PLD_1	Catellus Development Corporation	Industrial	Industrial	8.64	10.64	0.232	50.73	51.55	0.016
PLD_2	Meridian Industrial Trust, Inc.	Industrial	Industrial	-0.49	-0.61	0.238	40.27	40.52	0.006
PSA	Shurgard Storage Centers, Inc.	Self-Storage	Self-Storage	9.69	21.88	1.259	2004.97	2026.23	0.011
SPG_1	Chelsea Property Group, Inc.	Regional Mall	Outlet Center	-1.01	-0.10	0.897	0.30	0.34	0.139
SPG_2	DeBartolo Realty Corporation	Regional Mall	Regional Mall	7.57	8.49	0.122	7.20	7.28	0.011
SPG_3	MSA Realty Corporation	Regional Mall	Shopping Center	18.80	16.98	0.097	0.54	0.54	0.002
SLG	Reckson Associates Realty Corp.	Office	Office	41.33	40.60	0.018	5.09	7.48	0.470
UDR	American Apartment Com. II, Inc.	Multi-family	Multi-family	-1.55	-1.38	0.106	8.43	8.82	0.046
VNO	Arbor Property Trust	Diversified	Regional Mall	23.67	24.41	0.031	11.43	11.47	0.003

Source: SNL Financials

NICREIF Property Index Returns



Source: National Council of Real Estate Investment Fiduciaries (NCREIF)
Figure 1