FORECASTING COMPETITION UNDER THE EFFICIENT MARKET

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INTRODUCTION

Fama's 1965 paper states that in a strong (or semi-strong) efficient market, the future path of the price level of a security is no more predictable than the path of a series of cumulative random numbers. In statistical terms, this theory states that successive price changes are independent, identically distributed (i.i.d.) random variables. That is, if Y_t and Y_{t-1} represent the security price at time t and t-1 respectively, then $Y_t - Y_{t-1} = \varepsilon_t$, where $Y_0=0$, and ε_t's are i.i.d. for t=1, 2, 3, … Box and Jenkins (2008) refer to this model as an Autoregressive Integrated Moving Average (0,1,0), or ARIMA(0, 1, 0).

In the simulation study in this paper, we assume ideal conditions for illustrative purposes; i.e., ε_t are i.i.d. from the standard normal distribution. 30,000 random numbers are generated from EXCEL. The sample is grouped into 1,000 sets, with 30 observations in each group. The first 15 data points treated as historical (in-sample) observations and the subsequent 15 data points treated as actual realization (out-sample) observations. Simple Moving Average (MA) Methods with moving periods p = 1, 3, 5, 7, 9, 11, 13, 15, and Exponential (EXP) Smoothing Methods with smoothing constants α = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9 with initial forecasts from MA(15) were applied for forecasting. However, because of the limited space, we only present the results for p=1, 3, 11, 15, and α = 0.1, 0.3, 0.7, 0.9 in the Talbes in this paper.

In 2000, Makridakis and Hibon (2000) applied 24 major forecasting methods to 645 yearly, 756 quarterly, 1,428 monthly, and 174 other time spanned, to a total of 3,003 different time series. The scope of the time series was also ranged from 828 Micro, 519 Industry, 731 Macro, 308 Finance, 413 Demographic, and 204 other different types of data. The authors utilized five accuracy measures in their study: the Symmetric Mean Absolute Percentage Error (sMAPE), Average Ranking, Percentage Better, Median Symmetric Absolute Percentage Error (sMdAPE), and Median Relative Absolute Error (MdRAE). Highlights of the major results from their study are as follows:

(a) Statistically sophisticated or complex methods do not necessarily provide more accurate forecasts than simpler ones;
(b) The relative ranking of the performance of the various methods varies according to the accuracy measure being used;
(c) The accuracy of the various methods depends upon the length of the forecasting horizon involved.

When a series follows the ARIMA(0, 1, 0) model, under the ideal conditions simulated in the time series, the simplest naïve forecast, MA(1), will perform the best. The forecast from MA(1) model is the previous actual observation.

DATA ANALYSIS

Table 1 provides the means and standard deviations from various forecasting models, and the p-values from pair-wise T-test of MA(1) model v.s. the rest other forecasting models. As shown, MA(1) is the best forecasting method under the accuracy measures Mean Absolute Deviation (MAD), Average Ranking, Percentage Better, and MdAPE for the forecasting horizons k=3, 6, 9, 12, and 15.

The same analysis from the simulation above to 3,000 security prices for AT&T, proven to be under the efficient market in Fama 1965. The natural logarithms, which take into account the continuous compounding, increasing price level, and the percentage price change of the daily prices are also studied as suggested in equation (1), P. 45 of Fama 1965.

CONCLUSION

The conclusion that MA(1) is the best forecasting model is not true according to the accuracy measures sMAPE and MdRAE.

Table 2 and 3 show that the outcome is not consistent with previous results obtained from the ideal simulation time series, especially for sMAPE and MRAE.

It implies that the market may not follow the strong efficient market as the simulation outcomes.

Table 1: The p-value for the pair-wise T-test of MA(1) v.s. others from Excel simulation data

			MA(1)	MA(3)	MA(11)	MA(15)	Exp(0.1)	Exp(0.3)	Exp(0.7)	Exp(0.9)
MAD	k=3	Mean	**0.8025**	0.9984	1.6706	1.9326	1.0368	0.9372	0.8264	0.8066
		s.d.	0.3519	0.5196	1.1028	1.3105	0.6159	0.5091	0.3803	0.3556
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0023**
	k=6	Mean	**0.7987**	0.9905	1.6490	1.9130	1.2507	1.0137	0.8283	0.8022
		s.d.	0.2498	0.3799	0.9645	1.1953	0.6756	0.4518	0.2738	0.2510
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0011**
	k=9	Mean	**0.7926**	0.9825	1.6195	1.8784	1.3584	1.0340	0.8250	0.7963
		s.d.	0.2100	0.3230	0.8388	1.0624	0.7035	0.4040	0.2310	0.2111
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0001**
	k=12	Mean	**0.7957**	0.9855	1.6167	1.8684	1.4454	1.0541	0.8287	0.7992
		s.d.	0.1761	0.2730	0.7421	0.9567	0.7063	0.3592	0.1952	0.1774
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	k=15	Mean	**0.7949**	0.9878	1.6173	1.8664	1.5104	1.0662	0.8297	0.7989
		s.d.	0.1607	0.2457	0.6742	0.8791	0.6972	0.3280	0.1788	0.1624
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
sMAPE	k=3	Mean	**0.0744**	0.0885	0.2872	0.2840	0.1765	0.0945	0.3903	0.0754
		s.d.	0.3494	0.4044	4.3639	2.3524	2.4255	0.4963	7.1830	0.3585
		p-value	-----	0.0704	0.0586	0.0016	0.0833	0.0008	0.0785	0.2155
	k=6	Mean	**0.0760**	0.0838	0.2322	0.2735	0.1799	0.1078	0.2316	0.2520
		s.d.	0.3133	0.3039	2.3190	1.8104	1.5594	0.5582	3.6431	5.4600
		p-value	-----	0.0672	0.0136	0.0001	0.0114	0.0020	0.0798	0.1495
	k=9	Mean	**0.0797**	0.1261	0.1957	0.2862	0.1656	0.1132	0.2098	0.2112
		s.d.	0.3495	1.0633	1.5899	2.4530	1.1295	0.5507	2.7707	3.6840
		p-value	-----	0.0603	0.0080	0.0027	0.0030	0.0008	0.0556	0.1231
	k=12	Mean	**0.1052**	0.1284	0.3021	0.4169	6.2293	0.1292	0.2316	0.2012
		s.d.	0.6822	0.9479	3.9061	5.2461	191.3148	0.6207	2.5899	2.8304
		p-value	-----	0.2192	0.0554	0.0293	0.1556	0.1341	0.0445	0.1342
	k=15	Mean	**0.1056**	0.1801	0.2848	0.3838	5.0249	0.1325	0.2244	0.1848
		s.d.	0.6158	1.4435	3.2548	4.2740	153.0756	0.5752	2.2229	2.3058
		p-value	-----	**0.0436**	**0.0403**	**0.0187**	0.1546	0.0679	**0.0262**	0.1270

Table 1(Continued): The p-value for the pair-wise T-test of MA(1) v.s. others from Excel simulation data

			MA(1)	MA(3)	MA(11)	MA(15)	Exp(0.1)	Exp(0.3)	Exp(0.7)	Exp(0.9)
sMdAPE	k=3	Mean	**0.0572**	0.0769	0.1253	0.1556	0.0853	0.0702	0.0659	0.0587
		s.d.	0.1876	0.3053	0.4412	0.6528	0.3631	0.2495	0.3544	0.2141
		p-value	-----	**0.0027**	**0.0000**	**0.0000**	**0.0004**	**0.0020**	0.0961	0.1202
	k=6	Mean	**0.0579**	0.0670	0.1247	0.1454	0.1081	0.0703	0.0585	0.0583
		s.d.	0.2113	0.2058	0.4454	0.5093	0.4519	0.2093	0.2185	0.2172
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.4147	0.3149
	k=9	Mean	**0.0566**	0.0662	0.1099	0.1319	0.0989	0.0704	0.0552	0.0563
		s.d.	0.2166	0.2130	0.3033	0.4125	0.3348	0.2051	0.1763	0.2161
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0001**	0.6515	0.6504
	k=12	Mean	**0.0519**	0.0661	0.1089	0.1320	0.1035	0.0697	0.0550	0.0523
		s.d.	0.1489	0.1999	0.2925	0.4131	0.3604	0.1950	0.1693	0.1538
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0186**	0.2003
	k=15	Mean	**0.0480**	0.0620	0.1027	0.1288	0.1036	0.0676	0.0525	0.0485
		s.d.	0.1168	0.1761	0.2581	0.3913	0.3126	0.1761	0.1470	0.1189
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0080**	0.1313
MdRAE	k=3	Mean	**0.9976**	1.5045	3.1433	3.7617	1.4263	1.2422	1.0401	-----
		s.d.	0.0608	1.2622	4.1633	5.1295	1.1626	0.6907	0.1695	-----
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	-----
	k=6	Mean	**0.9972**	1.3466	2.7362	3.3004	1.7370	1.3304	1.0406	-----
		s.d.	0.0460	0.5450	2.5331	3.3893	1.1233	0.5521	0.1118	-----
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	-----
	k=9	Mean	**0.9955**	1.2858	2.4208	2.9075	1.8339	1.3326	1.0403	-----
		s.d.	0.0402	0.4132	1.7790	2.5653	1.1133	0.5144	0.1016	-----
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	-----
	k=12	Mean	**0.9952**	1.2686	2.2981	2.7390	1.9416	1.3419	1.0397	-----
		s.d.	0.0366	0.3044	1.2703	1.7651	1.1121	0.4228	0.0837	-----
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	-----
	k=15	Mean	**0.9949**	1.2603	2.2185	2.6363	1.9834	1.3402	1.0394	-----
		s.d.	0.0337	0.2742	1.0821	1.5137	1.0635	0.3980	0.0771	-----
		p-value		**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	-----

Table 2: The p-value for the pair-wise T-test of MA(1) v.s. others from Fama's data

			MA(1)	MA(3)	MA(11)	MA(15)	Exp(0.1)	Exp(0.3)	Exp(0.7)	Exp(0.9)
MAD	k=3	Mean	0.3528	0.4374	0.7076	0.7962	0.4600	0.4127	0.3604	0.3531
		s.d.	0.2877	0.4031	0.5827	0.6790	0.4570	0.3981	0.3169	0.2946
		p-value	-----	**0.0001**	**0.0000**	**0.0000**	**0.0000**	**0.0015**	0.1849	0.4626
	k=6	Mean	0.3268	0.4159	0.7088	0.8106	0.5377	0.4260	0.3391	0.3279
		s.d.	0.2049	0.2936	0.5447	0.6450	0.4672	0.3168	0.2163	0.2055
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0140**	0.2581
	k=9	Mean	0.3197	0.3869	0.6750	0.7858	0.5610	0.4104	0.3256	0.3191
		s.d.	0.1951	0.2555	0.4953	0.5905	0.4523	0.2806	0.2006	0.1945
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.1238	0.6433
	k=12	Mean	0.3193	0.3909	0.6468	0.7479	0.5620	0.4125	0.3284	0.3197
		s.d.	0.1918	0.2588	0.4587	0.5332	0.4273	0.2816	0.2026	0.1930
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0328**	0.3961
	k=15	Mean	0.3210	0.3926	0.6342	0.7251	0.5690	0.4155	0.3310	0.3216
		s.d.	0.1900	0.2511	0.4314	0.4876	0.4005	0.2708	0.1998	0.1911
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0104**	0.3335
sMAPE	k=3	Mean	0.0150	0.0188	0.0301	0.0338	0.0196	0.0177	0.0154	0.0151
		s.d.	0.0113	0.0160	0.0231	0.0265	0.0183	0.0159	0.0126	0.0117
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	k=6	Mean	0.0142	0.0182	0.0308	0.0349	0.0235	0.0187	0.0148	0.0143
		s.d.	0.0083	0.0125	0.0230	0.0263	0.0195	0.0135	0.0091	0.0084
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	k=9	Mean	0.0139	0.0170	0.0295	0.0342	0.0246	0.0180	0.0143	0.0139
		s.d.	0.0083	0.0112	0.0218	0.0252	0.0196	0.0124	0.0087	0.0083
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	k=12	Mean	0.0138	0.0171	0.0283	0.0326	0.0246	0.0181	0.0143	0.0139
		s.d.	0.0079	0.0111	0.0198	0.0229	0.0185	0.0121	0.0086	0.0080
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	k=15	Mean	0.0139	0.0172	0.0278	0.0317	0.0251	0.0182	0.0144	0.0139
		s.d.	0.0077	0.0106	0.0183	0.0209	0.0173	0.0114	0.0083	0.0078
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**

Table 2 (Continued): The p-value for the pair-wise T-test of MA(1) v.s. others from Fama's data

			MA(1)	MA(3)	MA(11)	MA(15)	Exp(0.1)	Exp(0.3)	Exp(0.7)	Exp(0.9)
Average Ranking	k=3	Mean	**5.8133**	8.7033	11.7233	12.9700	7.1733	6.3267	5.7433	5.7433
		s.d.	3.0906	2.5288	3.6903	4.2535	2.8429	2.0689	2.1952	2.8391
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0028**	0.0937	0.6595	0.8424
	k=6	Mean	**6.1750**	8.3650	11.6267	12.7150	9.4050	7.5417	6.0917	6.0483
		p-value	2.4201	1.7497	2.6591	3.3604	2.5253	1.3842	1.6561	2.2079
		s.d.	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.7294	0.9887
	k=9	Mean	**6.1333**	8.5200	11.5433	12.4656	10.0189	7.9533	6.3056	6.0567
		s.d.	2.0099	1.6036	2.0347	2.8747	2.2921	1.0298	1.3402	1.8392
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.0728	0.9314
	k=12	Mean	**6.2508**	8.4517	11.5608	12.4475	10.2733	8.1367	6.3717	6.1683
		s.d.	1.8365	1.4703	1.7232	2.5165	2.1119	0.9294	1.2601	1.6360
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.1351	0.9611
	k=15	Mean	**6.4920**	8.5593	11.3360	12.3007	10.4447	8.1933	6.5513	6.4087
		s.d.	1.6984	1.5183	1.6368	2.4132	2.2077	0.8784	1.2318	1.5373
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.2715	0.9787
Percentage Better	k=3	Mean	**0.0067**	0.2467	0.5200	0.5067	0.2200	0.1800	0.0600	-----
		s.d.	0.4494	0.4983	0.5999	0.6113	0.4475	0.4327	0.4554	-----
		p-value	-----	0.0012	0.0000	0.0000	0.0039	0.0159	0.2687	-----
	k=6	Mean	**-0.0400**	0.2433	0.5233	0.5433	0.3567	0.2400	0.0833	-----
		s.d.	0.3538	0.3277	0.4375	0.4281	0.3639	0.3435	0.3429	-----
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0312**	-----
	k=9	Mean	**-0.0178**	0.1822	0.4933	0.5400	0.4111	0.2222	0.0622	-----
		s.d.	0.3106	0.2893	0.4143	0.3780	0.3505	0.3079	0.3144	-----
		p-value	-----	**0.0001**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0887**	-----
	k=12	Mean	**-0.0267**	0.1983	0.4783	0.5100	0.4100	0.2367	0.0783	-----
		s.d.	0.2597	0.2677	0.3463	0.3332	0.3077	0.2780	0.2747	-----
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0193**	-----
	k=15	Mean	**-0.0293**	0.1947	0.4640	0.4987	0.4160	0.2480	0.0787	-----
		s.d.	0.2279	0.2456	0.2990	0.2875	0.2782	0.2550	0.2479	-----
		p-value	-----	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0088**	-----

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