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THE BEHAVIOR OF TREASURY SECURITIES;

MONTHLY, 1942-1984

by W. Michael Cox

February 1985

Research Paper

Federal Reserve Bank of Dallas

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The monthly market value statistics on outstanding United States Treasury debt are reported for the 1981-1984 period. In addition, a monthly series on privately held gross federal debt is reported for the extended 1942-1984 period, together with monthly security-price indices for various federal debt aggregates. Examination of the stochastic structure of T-Bill prices indicates that the riskiness of T-Bills has increased dramatically in recent years.

1. Introduction

During the roughly 200 years from the first federal budget in March, 1789 until December, 1980 the market value of Treasury debt in the United States grew to \$567 billion. Over the past four years, Treasury debt has grown by more than that amount. The variability of security prices in recent years has also far exceeded that of any comparable period. For example, the month-to-month standard deviation of T-Bill prices has grown from an average of 12¢ per \$100 of face value during the 1942-1980 period to nearly 32¢ during the 1981-1984 period. In short, the extensive growth in outstanding government debt and the increased variability of interest rates over the past four years have provided a wide variety of experience for testing issues involving public debt.

In earlier work, Seater (1981) calculated annual measures of the market value of outstanding government debt over the time period 1919-1975. Cox and Hirschhorn (1983) later provided monthly series on government debt over

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the period 1942-1980. The purpose of this paper is to report the monthly market value statistics for the period 1981-1984 and to provide several new series which are of widespread interest.¹

Specifically, this paper provides monthly calculations of the market value of privately held gross federal debt over the period 1942-1984. This aggregate most closely measures the total indebtedness of the government to the private sector and is the appropriate series for a variety of empirical tests, but has not been previously available. The paper also reports monthly security-price indices for government debt over the 1942-1984 period -- including disaggregated indices for debt of short-term, intermediate-term, and long-term maturity. These price series are valuable for studies regarding term structure, capital gains and losses on government debt, and portfolio risk, as well as a number of other issues. Finally, the stochastic structure of T-Bill prices is investigated and a comparison is made of forecasting ability during the 1981-1984 period to that during the 1942-1980 period.

2. Calculation of the Series

Marketable Treasury Debt and Gross Federal Debt

The market values of Treasury Bills, Treasury Notes, Treasury Bonds, total marketable Treasury debt, and gross federal debt over the 1981-1984

¹Among the studies using the market-to-par (price) indices are Eisner and Pieper (1984), Vinals and Cuddington (1985), Evans (1985), and Engle (1985). Among those using the market value data are Butkiewicz (1983), Barth, Iden, and Russek (1984), Hirschhorn (1984), Hamilton and Flavin (1985), and Lucke (1985)

period are reported in tables 1-5.² All data are monthly. For each series, the method of calculation used follows that reported in Cox and Hirschhorn (1983).

All data prior to November, 1982 are taken from the Treasury Bulletin. With the release of the November, 1982 issue, however, the Treasury switched from monthly to quarterly publication of the Bulletin. After that time, all data on the outstanding quantity of each issue are taken from the Monthly Statement of the Public Debt of the United States, and all discount or price data are taken from the Wall Street Journal. This change in no way affects the calculated values of the series.³

Private Holdings of Debt

By definition, gross federal debt is made up of marketable Treasury debt plus nonmarketable debt. Marketable Treasury debt consists of Treasury Bills, Treasury Notes, Treasury Bonds, and, prior to 1967, Treasury Certificates of Indebtedness. Examples of non-marketable debt are Savings Bonds and government account series. Gross federal debt can also

²Data on the par value of total marketable Treasury debt may be calculated as described in section 2. Data on the par value of Treasury Bills, Notes, Bonds, and Certificates of Indebtedness, as well as security price indices for each of these debt aggregates are available from the author upon request.

³Bid price or discount data from the Wall Street Journal were matched on a one-to-one basis with quantity outstanding data from the Monthly Statement of the Public Debt of the United States according their stated maturity date and series type (Bill, Note, Bond). In order to insure that the reported series were exactly the same, the quantity outstanding and bid price series reported in the Bulletin were closely examined and compared to their counterparts reported in the Monthly Statement and in the Journal.

Table 1
Market value of treasury bills (millions of dollars)

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
81	211284	219477	233076	216243	215184	210125	208168	210237	205941	220506	227002	236331
82	240929	244232	237002	245428	247199	236706	253579	266053	270864	276935	286458	304098
83	300359	307188	323108	317703	316783	325225	328012	331176	331759	331478	326844	334036
84	337436	339664	339726	336971	333439	332702	336649	348864	345898	349660	355289	365146

Table 2
Market value of treasury notes (millions of dollars)

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
81	301521	301454	317565	314589	315020	324079	324914	324789	331181	340786	368550	359339
82	356972	366375	378342	387136	388400	389542	403555	429667	452255	457629	473091	487255
83	492097	505657	512864	517476	530040	539194	529962	545064	565382	571706	584218	577116
84	605532	609526	600241	621237	612649	608932	644700	654484	655765	693332	738952	720504

Table 3
Market value of treasury bonds (millions of dollars)

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
81	68685	68384	69689	67630	72519	71466	71634	67709	66138	70010	81994	78046
82	78090	78526	79242	80773	80719	78113	80857	86057	93219	98648	99305	101173
83	100624	108237	106856	113032	111760	110357	108271	111757	115832	116796	123716	121148
84	126128	127788	124969	125381	122739	122645	134089	138578	141979	152814	159455	159737

Table 4
Market value of total marketable treasury debt (millions of dollars)

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
81	581490	589315	620330	598462	602723	605670	604716	602735	603260	631302	677546	673717
82	675991	689134	694586	713337	716319	704361	737992	781777	816339	833211	858855	892526
83	893081	921083	942828	948212	958584	974775	966245	987997	1012973	1019980	1034778	1032300
84	1069096	1076979	1064936	1083589	1068827	1064279	1115438	1141925	1143642	1195805	1253695	1245386

Table 5
Market value of gross federal debt (millions of dollars)

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
81	864234	871299	896827	876899	889595	892919	880559	877046	892070	924092	968593	961469
82	966150	979419	991880	1005789	1015874	1008310	1038782	1082010	1130805	1154653	1170453	1212101
83	1206976	1233284	1251235	1264991	1291719	1314002	1300699	1318536	1362367	1365381	1376030	1385655
84	1420407	1426906	1419974	1433500	1415427	1428624	1479713	1504251	1528312	1595704	1669949	1660310

be disaggregated according to whether it is privately or publicly held.⁴ Chart 1 indicates the makeup of gross federal debt, and outlines the construction of various federal debt series.

CHART 1
GROSS FEDERAL DEBT

	Marketable	Non-Marketable
Privately Held	d_{11}	d_{12}
Publicly Held	d_{21}	d_{22}

The market value of gross federal debt reported in table 5 corresponds to the sum of all of the d_{ij} components in the chart. In contrast, data on total marketable Treasury debt reported in table 4 correspond to the sum of d_{11} and d_{21} . Cox and Hirschhorn calculated the privately held debt series d_{11} -- that is, privately held marketable Treasury debt -- using the monthly survey of ownership of federal securities published in the Bulletin. As a part of the Treasury's effort to contain publication production costs, however, that survey was ceased. A contrasting and potentially more valuable private series can nevertheless be constructed using data that continue to be collected by the Treasury. That series is the market value of private holdings of gross federal debt reported in table 6.

⁴By definition, publicly held debt includes marketable and nonmarketable federal securities held by U.S. government accounts and Federal Reserve Banks but excludes debt held by other government bodies (foreign, state, and local governments).

Table 6
Market value of privately held gross federal debt (millions of dollars)

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
42	56609	58526	58686	61235	64321	66641	70381	74285	78663	83588	85653	96443
43	99632	102347	103328	117452	123121	122542	125436	126564	140641	146801	146379	144416
44	148581	160952	159708	158574	158314	171552	178769	178645	176735	176204	179867	194637
45	196911	197331	196876	197246	199870	217891	220069	219565	217324	217386	221024	233277
46	236039	237270	234102	229876	228308	223857	221369	219538	216298	215410	212892	210777
47	210590	212011	211198	210191	210112	209098	210001	209993	208328	207232	205193	202163
48	202160	201062	199578	199662	200051	197758	197928	197204	194504	194442	194429	194631
49	195832	195755	195309	195936	197789	199150	201221	204449	204186	205060	204976	204226
50	204657	204585	204478	204171	205088	204161	204600	204471	201170	200676	200123	198603
51	197104	196135	192452	191689	191318	190395	191172	192344	191167	192310	193277	191935
52	193466	194007	189793	193084	194252	191941	195123	194050	192331	195195	196747	195162
53	195592	195096	191583	190414	190252	189832	196546	196633	198069	199042	200606	200825
54	202798	203783	199541	201125	201609	199333	199928	203383	202743	206364	205380	204778
55	204519	203748	199659	202251	202813	197868	199214	199310	199609	202515	201141	200895
56	202520	202309	196726	196113	197408	192173	190558	190948	190430	191290	191483	189977
57	193570	193333	192030	190509	189868	183233	185364	186344	187163	187056	191444	193169
58	194305	195536	193676	196772	196660	194339	193256	190195	188472	192235	195394	194739
59	197953	198377	194336	196875	196241	193492	197525	197239	195672	200630	198650	198121
60	201350	201710	200703	201564	201123	198764	203418	202325	202230	204069	202415	204875
61	204883	206108	202583	204406	204449	199290	205489	204844	205929	201600	208031	207991
62	209238	210405	209676	211552	211060	208550	208781	211657	210836	213738	214971	215069
63	216427	216748	214486	215022	213982	212592	212110	211864	212700	212393	212858	213523
64	215097	215252	213398	213857	213908	212216	212626	213349	214684	215664	216410	216396
65	218296	218439	215579	215738	214038	211121	211100	209920	208240	211601	212597	210834
66	213723	212468	211352	210817	208449	202527	201596	201862	203570	207578	207859	210295
67	212447	210301	211432	206732	204884	195865	201076	203923	204497	207164	209503	209374
68	213795	217466	214290	211046	213760	207965	213600	215130	215347	217338	215659	216629
69	218174	215381	215914	214198	210568	201060	204023	204379	202016	208231	208069	204370
70	206302	210477	212958	205095	206333	203815	210048	211245	211785	214901	221582	223448
71	225639	227279	227513	223917	224667	220736	225409	235378	233620	237155	238662	245359
72	245662	247436	247169	245861	244298	240184	245123	244364	245413	248083	254178	257043
73	255085	256815	257399	255429	254212	250099	243473	245920	249511	248880	251878	253182
74	252798	252394	251906	247289	247233	243852	246440	244779	248712	251984	256450	263290
75	267643	273842	283198	282037	295316	296010	305280	311373	318141	329379	336328	346081
76	351108	360291	367730	367136	369535	371091	381915	389251	390770	397049	411823	413613
77	413555	420745	426359	423623	423117	420354	423234	432290	434538	443893	451773	453499
78	463736	467192	473042	467641	465985	462246	467769	475260	473069	474436	482321	484741
79	500896	496201	498755	495439	503060	502291	503181	501713	501240	489115	498888	510473
80	509656	496600	507715	535363	546462	544371	551382	548976	549884	546733	553080	572437
81	580449	586354	608688	591628	599198	598731	589202	587426	594876	622650	654414	649123
82	658067	673547	685291	686257	696943	691952	714639	750972	783439	808024	826258	858996
83	865947	889348	911466	917891	923529	944550	938801	954569	972119	989853	999622	1004463
84	1029582	1052898	1041007	1040609	1034232	1040955	1085336	1110217	1121850	1169957	1219747	1210528

The market value of private holdings of gross federal debt corresponds to the sum of d_{11} and d_{12} , and thus includes private holdings of nonmarketable government debt. This series is appropriate for a variety of studies since it most closely measures total indebtedness of the government to the private sector.

The series was calculated in the following way:

- (1) First, data on the par value of private holdings of gross federal debt were obtained from the Treasury Bulletin. This data is available beginning in 1967 from table OFS-2 of the Bulletin. Prior to 1967, a consistent series was tracked backward from various other tables of that publication. Data were confirmed and details of their construction discussed with the Treasury.⁵ The par value series used is essentially private holdings of interest-bearing public debt securities plus matured debt and debt bearing no interest.⁶ As such, it excludes interest-bearing public debt securities held by U.S. government accounts and Federal Reserve Banks, as well as agency securities. The primary component of the series is marketable debt, which now typically averages between 85 and 90 percent of privately held gross federal debt.⁷

⁵Table OFS-2 of the Bulletin, "Estimated Ownership of Public Debt Securities By Private Investors," reports total privately held debt to the nearest \$100 million. With the cooperation and assistance of the Treasury, however, more precise measures were obtained (to the nearest million).

⁶Matured debt and debt bearing no interest is treated entirely as privately held in the Bulletin. In conversations with the Treasury it was learned that, in fact, a small portion of this debt (in particular, matured debt held by Federal Reserve Banks) is sometimes publicly held but only briefly. In any case, this type of debt typically represents less than 0.002 percent of outstanding privately held gross federal debt hence the convention may be ignored.

⁷In the (1951) past nonmarketable debt has made up as much as 41 percent of the total.

- (2) A security-price index for marketable Treasury debt was calculated according to the procedure outlined below.
- (3) For each month, the par value of privately-held gross federal debt was then multiplied by the calculated security-price index in order to obtain the market value series. This calculation employs an assumption that a unit of nonmarketable government debt is valued the same as a unit of marketable debt.⁸

Price Indices for Government Debt

The market value of outstanding government debt is calculated, in practice, as a vector multiple of par value data and bid price data over all issues of all securities outstanding. In principal, market value could be simply calculated as a multiple of one par value aggregate and one price aggregate. Although data on par value aggregates have been traditionally available, price aggregates have not. Previous studies relied on various approximation techniques to estimate the overall price component.⁹ Due to the work of Seater (1981) and Cox and Hirschhorn (1983), however, aggregate security-price indices may now be directly calculated. These price indices are useful in testing a variety of issues involving public debt.

Tables 7-12 report price indices for various marketable debt aggregates.¹⁰ In each case, the respective price index is calculated as a

⁸Errors introduced by this assumption are likely to be small since marketable debt is the increasing bulk of privately held government debt.

⁹See, for example, Tanner (1979) and, more recently, Butkiewicz (1983).

¹⁰Naturally, only marketable-debt price indices are available since, by definition, there is no secondary market for nonmarketable securities.

Table 7

Price index for marketable treasury debt
Years to maturity: all

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
42	105.096	104.530	104.995	105.058	104.516	104.560	103.962	103.598	103.393	103.202	102.862	102.487
43	102.688	102.604	102.494	102.655	102.583	102.733	102.542	102.413	102.195	102.074	101.981	101.966
44	101.971	101.917	101.872	101.862	101.861	101.722	101.772	101.790	101.669	101.632	101.641	101.572
45	102.040	102.236	102.234	102.421	102.371	102.371	102.277	102.193	102.224	102.372	102.525	102.592
46	103.307	103.655	103.685	102.879	102.992	103.167	102.838	102.619	102.346	102.593	102.306	102.710
47	102.757	102.829	102.951	102.819	102.854	102.653	102.621	102.802	102.651	102.651	101.630	101.046
48	101.016	101.150	101.201	101.268	101.667	101.284	101.119	101.094	101.042	100.945	101.086	101.262
49	101.393	101.478	101.558	101.553	101.600	102.033	102.219	102.478	102.459	102.427	102.483	102.662
50	102.287	102.148	101.960	101.761	101.717	101.464	101.485	101.525	101.203	100.998	100.949	100.939
51	101.028	100.918	100.072	99.764	99.498	99.521	99.797	100.145	99.750	99.745	99.529	99.253
52	99.521	99.486	99.722	100.185	100.153	100.016	99.746	99.482	99.152	99.387	99.309	99.140
53	99.027	98.739	98.517	97.938	97.287	97.944	98.191	98.202	99.167	99.452	99.301	99.905
54	100.380	100.854	101.046	101.427	100.707	101.203	101.256	100.961	100.808	100.606	100.397	100.263
55	99.696	99.218	99.276	99.068	99.229	98.801	98.185	98.163	98.577	98.888	98.466	98.330
56	98.805	98.747	97.939	97.598	98.320	98.262	97.478	96.739	96.912	96.761	96.439	96.055
57	97.259	96.947	97.080	96.567	96.203	95.410	95.521	95.739	95.603	95.733	97.779	98.792
58	99.011	99.674	99.966	100.239	100.431	99.604	98.865	96.413	96.074	96.202	96.646	95.984
59	95.789	96.198	95.754	95.258	95.116	94.776	94.895	94.296	94.253	95.091	94.583	94.073
60	94.728	95.020	96.472	95.912	96.184	97.142	98.388	98.156	98.162	98.008	97.460	98.534
61	98.002	98.341	98.284	98.523	98.307	96.803	97.848	97.639	97.915	94.789	97.808	97.605
62	97.515	97.936	98.453	98.658	98.593	98.132	98.020	98.493	98.643	98.815	98.826	98.838
63	98.774	98.728	98.639	98.537	98.412	98.391	98.239	98.129	98.071	97.803	97.858	97.714
64	97.755	97.611	97.444	97.594	97.784	97.972	97.969	97.879	97.890	97.927	97.756	97.873
65	97.959	97.836	97.917	97.932	97.929	98.019	97.934	97.694	97.352	97.296	97.166	96.393
66	96.321	95.769	96.496	96.329	96.119	95.762	95.537	94.726	95.497	95.933	95.758	97.016
67	97.601	97.111	97.934	97.299	97.216	95.902	96.253	95.919	95.973	95.156	95.032	95.133
68	95.864	95.904	95.463	95.379	95.454	95.927	96.676	96.687	96.589	96.302	95.993	94.795
69	94.876	94.556	94.639	94.967	94.183	93.598	93.660	93.481	91.984	93.466	92.983	92.046
70	92.314	94.141	94.290	93.017	93.174	93.478	94.106	94.060	94.879	95.187	97.253	97.184
71	98.148	98.737	99.477	97.730	97.582	96.087	96.091	97.903	98.073	98.794	98.607	98.988
72	98.714	98.907	98.128	98.556	98.806	98.257	98.532	98.024	97.905	98.001	98.282	97.923
73	97.422	96.876	96.618	96.876	96.627	96.290	94.769	95.665	96.918	97.013	96.940	96.730
74	96.769	96.660	95.490	94.838	95.309	95.117	94.895	94.504	95.641	96.011	96.651	97.170
75	97.759	98.198	97.728	96.960	97.893	97.642	97.271	97.191	96.743	98.032	97.785	98.478
76	98.810	98.671	98.939	98.949	98.164	98.596	98.878	99.484	99.643	99.950	100.915	101.011
77	99.492	99.449	99.554	99.516	99.491	99.851	99.241	99.405	99.066	98.509	98.725	98.314
78	98.018	97.920	97.806	97.522	97.145	96.744	96.987	97.191	96.886	95.898	96.016	95.301
79	96.058	95.684	95.992	95.807	96.459	97.229	96.807	96.197	95.662	92.901	94.377	94.443
80	93.193	90.027	90.349	95.088	97.075	97.523	96.234	94.033	93.320	92.156	91.693	92.865
81	92.521	91.667	92.984	90.965	91.853	91.940	90.471	89.458	89.395	91.949	95.588	93.465
82	93.042	93.438	93.459	94.378	94.791	93.997	95.336	97.549	99.020	101.037	100.753	101.253
83	100.498	101.480	100.541	101.370	100.025	99.576	98.025	97.785	98.923	98.612	99.052	98.225
84	98.818	97.901	97.013	101.361	96.461	94.481	94.462	96.173	97.202	99.020	102.388	99.838

Table 8

Price index for marketable treasury debt
Years to maturity: 0-1

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
42	100.287	100.296	100.269	100.140	100.176	100.424	100.212	100.164	100.175	100.379	100.304	100.092
43	100.361	100.304	100.302	100.372	100.342	100.396	100.395	100.341	100.330	100.308	100.308	100.371
44	100.399	100.361	100.380	100.335	100.326	100.334	100.377	100.372	100.313	100.316	100.350	100.309
45	100.362	100.292	100.351	100.324	100.301	100.357	100.308	100.373	100.363	100.362	100.386	100.374
46	100.403	100.337	100.298	100.326	100.353	100.277	100.327	100.274	100.334	100.373	100.431	100.363
47	100.342	100.334	100.358	100.324	100.343	100.444	100.425	100.424	100.418	100.340	100.275	100.320
48	100.234	100.388	100.308	100.431	100.411	100.438	100.396	100.473	100.414	100.326	100.400	100.523
49	100.442	100.443	100.427	100.448	100.535	100.448	100.453	100.546	100.579	100.479	100.508	100.574
50	100.490	100.479	100.492	100.429	100.462	100.440	100.288	100.498	100.362	100.200	100.113	100.184
51	100.262	100.299	100.548	100.494	100.296	100.336	100.410	100.273	100.238	100.331	100.353	100.198
52	100.427	100.503	100.446	100.497	100.513	100.604	100.396	100.419	100.456	100.191	100.134	100.273
53	100.094	100.076	100.056	99.975	99.977	99.942	99.911	99.979	100.140	100.256	100.223	100.245
54	100.409	100.391	100.454	100.532	100.428	100.425	100.397	100.246	100.190	100.141	100.126	100.087
55	99.995	99.898	99.939	99.886	99.927	99.900	99.855	99.781	99.740	99.789	99.690	99.613
56	99.785	99.795	99.730	99.571	99.643	99.714	99.577	99.463	99.594	99.667	99.611	99.629
57	99.717	99.661	99.749	99.768	99.722	99.624	99.562	99.503	99.522	99.620	99.826	100.050
58	100.368	100.503	100.481	100.509	100.574	100.290	100.139	99.332	99.232	99.334	99.336	99.170
59	99.049	99.155	99.082	99.013	98.920	99.194	99.092	98.949	98.915	99.134	98.970	99.125
60	99.251	99.341	99.766	99.628	99.710	99.997	99.869	99.863	99.821	99.815	99.697	99.850
61	97.746	99.751	99.802	99.767	99.796	97.169	99.597	99.533	99.551	91.946	99.538	99.507
62	97.503	99.587	99.635	99.516	99.697	99.684	99.633	99.699	99.725	99.661	99.600	99.600
63	99.546	99.595	99.547	99.489	99.592	99.406	99.270	99.282	99.253	99.153	99.238	99.156
64	99.128	98.993	98.808	98.850	98.864	99.067	98.996	99.028	98.985	98.987	98.924	99.116
65	99.134	99.105	99.165	99.158	99.226	99.228	99.236	99.203	99.197	99.116	98.979	98.829
66	98.909	98.827	99.015	99.078	98.891	98.815	98.811	98.521	98.305	98.393	98.522	98.586
67	98.792	98.722	98.982	98.979	98.986	98.691	98.645	98.476	98.653	98.558	98.446	98.753
68	98.926	98.964	99.000	98.902	98.830	98.901	98.940	98.901	98.951	98.807	98.776	98.445
69	98.579	98.402	98.518	98.544	98.612	98.257	98.187	98.229	98.107	98.096	98.000	97.942
70	98.221	98.583	98.662	98.455	98.409	98.516	98.467	98.449	98.581	98.697	99.260	99.301
71	99.562	99.687	99.593	99.340	99.249	98.902	98.844	99.111	99.005	99.176	99.061	99.154
72	99.281	99.318	99.310	99.418	99.357	99.170	99.290	99.028	99.012	98.965	98.914	98.855
73	98.660	98.604	98.538	98.546	98.323	98.217	97.976	97.851	98.183	98.231	98.008	98.041
74	98.250	98.251	98.008	97.942	97.811	97.856	97.822	97.338	97.943	97.891	97.917	98.185
75	98.542	98.661	98.649	98.548	98.825	98.520	98.413	98.367	98.344	98.735	98.663	98.867
76	99.000	98.877	98.930	98.932	98.771	98.782	98.874	98.989	99.000	99.108	99.309	99.290
77	99.130	99.176	99.192	99.162	99.060	98.992	98.812	98.839	98.689	98.585	98.596	98.539
78	98.500	98.462	98.451	98.356	98.156	98.159	98.245	98.032	97.897	97.716	97.494	97.168
79	97.950	97.445	97.575	97.597	97.606	97.822	97.827	97.570	97.424	96.833</		

Table 9
Price index for marketable treasury debt
Years to maturity: 1-5

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
42	104.408	104.306	104.287	104.215	103.772	103.639	103.397	103.249	102.928	103.022	102.940	102.975
43	103.102	103.028	103.100	103.454	103.599	103.123	102.746	102.630	102.702	102.666	102.673	102.619
44	102.542	102.328	102.368	102.445	102.386	102.187	102.219	102.194	102.315	101.910	101.831	101.944
45	102.451	102.571	102.609	102.326	102.432	102.170	102.271	102.230	102.437	102.516	102.592	102.746
46	103.009	103.175	102.955	102.538	102.476	102.867	102.718	102.520	102.673	102.714	102.466	102.739
47	102.806	102.730	102.919	102.668	102.627	102.738	102.642	102.776	102.562	102.301	102.001	101.571
48	101.646	101.698	101.708	101.733	102.047	101.816	101.548	101.461	101.308	101.147	101.255	101.425
49	101.499	101.458	101.549	101.692	101.731	102.029	102.093	102.104	102.187	102.091	101.989	101.871
50	101.655	101.486	101.631	101.393	101.384	101.124	101.276	101.233	100.865	100.778	100.882	101.789
51	100.703	100.620	99.781	99.936	99.886	99.905	100.075	100.041	100.107	100.156	100.134	99.665
52	99.993	99.968	100.325	100.448	100.283	100.007	99.752	99.569	99.432	99.639	99.547	99.384
53	99.491	99.390	99.297	98.752	98.297	98.667	98.919	98.991	99.841	100.239	100.240	100.684
54	101.284	101.755	102.014	102.273	101.602	101.931	101.843	101.674	101.353	100.969	100.885	100.620
55	100.194	99.511	99.411	99.195	99.397	99.077	98.490	98.129	98.588	98.745	98.134	98.281
56	98.883	98.708	98.005	97.478	98.122	98.239	98.089	96.622	96.879	96.853	96.004	95.944
57	97.046	96.930	96.993	96.602	96.434	95.460	94.906	95.046	95.400	95.457	97.936	99.349
58	99.693	100.615	100.883	101.336	101.657	101.029	100.423	97.035	96.518	96.695	97.054	96.578
59	96.275	96.824	96.413	96.020	95.453	94.269	94.279	93.900	93.858	94.847	94.270	93.275
60	94.051	94.370	95.920	95.222	95.362	96.805	98.676	98.408	98.384	98.498	97.940	99.340
61	98.634	98.801	98.527	98.803	98.450	98.068	98.002	97.900	98.690	98.808	98.549	98.289
62	98.107	98.789	99.319	99.574	99.385	98.536	98.566	98.946	98.900	99.112	99.048	98.804
63	98.854	98.783	98.719	98.586	98.145	98.348	98.070	97.892	97.873	97.608	97.549	97.517
64	97.587	97.637	97.637	97.924	98.060	98.137	98.248	97.991	97.960	98.068	97.774	97.984
65	97.855	97.690	97.785	97.848	97.676	97.880	97.769	97.475	97.158	97.080	97.268	96.113
66	96.116	96.282	96.762	96.629	96.451	96.222	95.953	94.723	95.944	96.385	96.032	97.931
67	98.639	98.345	99.545	98.948	99.012	97.309	97.683	97.299	97.110	96.507	96.467	96.052
68	96.850	96.389	96.049	95.856	95.946	96.427	97.447	97.163	97.242	96.895	96.847	95.453
69	95.780	95.442	95.827	96.146	94.130	93.060	92.977	92.887	91.328	93.486	92.354	90.996
70	91.369	93.829	94.223	92.601	93.149	93.641	94.385	94.578	95.993	96.370	99.074	98.975
71	100.279	101.616	102.390	99.514	99.223	97.140	97.029	100.054	100.204	101.409	101.218	101.821
72	101.405	102.140	100.477	101.269	101.672	100.783	101.110	100.528	100.376	100.411	100.790	100.371
73	99.630	98.867	98.308	98.779	98.615	97.685	95.596	96.816	98.577	98.673	98.588	98.411
74	98.406	98.286	96.355	95.293	96.401	96.003	95.736	95.168	96.908	97.508	98.426	98.922
75	99.816	100.301	99.241	97.889	99.221	98.640	97.931	97.624	99.604	99.026	100.024	
76	100.552	99.963	100.205	100.325	98.904	99.617	100.080	100.766	100.898	101.418	102.841	102.649
77	100.824	100.746	100.913	100.846	100.750	101.262	100.371	100.337	99.889	99.122	99.524	99.174
78	98.825	98.787	98.672	98.320	97.984	97.325	97.592	97.796	97.533	96.166	96.309	95.321
79	96.528	96.081	96.426	96.275	97.055	98.016	97.498	96.466	95.918	92.827	95.075	95.252
80	94.456	89.760	90.327	97.111	99.847	100.072	98.754	95.245	94.725	93.233	92.193	94.500
81	93.991	93.105	94.746	92.528	92.962	93.661	91.783	90.303	90.593	93.845	98.479	95.745
82	95.195	95.322	95.373	96.414	97.144	95.356	97.838	100.081	101.516	103.792	103.722	104.298
83	103.575	104.449	103.001	103.903	102.105	101.403	99.826	99.415	100.628	100.636	100.718	99.985
84	100.829	99.864	98.888	98.503	96.185	95.991	97.760	98.015	98.803	100.717	110.425	102.233

Table 10
Price index for marketable treasury debt
Years to maturity: 5-10

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
42	106.232	105.361	106.340	106.651	105.639	105.889	104.606	104.516	104.495	104.050	103.566	103.177
43	103.417	103.415	103.210	103.471	103.340	103.985	103.784	103.620	103.113	102.701	102.522	102.541
44	102.597	102.869	102.809	102.845	102.861	102.664	102.761	102.763	102.644	102.568	102.362	102.022
45	102.802	103.223	104.193	104.739	104.587	104.937	104.332	104.319	104.500	104.834	105.244	105.905
46	106.220	106.336	106.298	105.316	105.147	105.348	105.107	104.680	104.752	104.887	104.370	104.920
47	105.076	105.131	105.219	104.949	105.029	105.507	105.097	105.929	105.655	104.886	104.035	103.500
48	103.670	104.315	104.728	104.897	105.936	105.439	104.719	104.477	104.433	104.097	104.941	105.376
49	105.851	105.841	106.251	106.394	106.451	105.364	105.490	105.999	105.763	105.789	105.850	105.582
50	104.912	104.748	103.897	103.617	103.585	103.192	103.406	103.376	102.936	102.488	102.346	103.241
51	103.574	103.153	101.253	100.688	99.987	100.013	100.831	101.707	100.450	100.231	99.771	99.429
52	99.824	99.413	100.465	101.294	101.371	100.662	100.140	99.639	98.766	99.567	99.606	99.426
53	98.942	98.614	98.208	96.994	95.083	95.794	96.241	96.055	98.447	98.878	98.917	99.985
54	100.488	101.325	101.758	102.804	101.152	102.247	102.236	101.640	101.430	101.125	100.643	100.375
55	99.437	98.800	98.661	98.250	98.470	97.664	96.556	96.619	97.322	97.945	97.188	96.667
56	97.559	97.411	95.628	95.337	96.597	96.375	94.820	93.294	93.540	92.952	91.435	90.056
57	93.164	92.225	92.631	91.217	90.025	88.080	88.274	89.032	88.185	88.295	93.380	94.943
58	95.014	96.759	97.744	97.961	98.172	97.052	95.679	90.697	90.349	90.176	91.173	89.024
59	88.831	88.298	88.008	86.217	86.141	85.827	85.913	84.353	84.493	86.231	85.375	83.972
60	85.546	84.528	87.475	86.280	87.172	88.745	91.453	91.768	91.892	91.131	90.346	92.837
61	91.850	92.943	94.871	95.463	94.610	93.798	93.469	93.258	94.010	93.981	92.583	92.422
62	92.578	93.752	96.508	97.130	96.991	96.712	96.488	97.558	98.840	99.127	99.322	101.278
63	101.027	100.576	100.427	100.464	100.307	100.055	99.980	99.797	99.626	99.224	99.558	99.235
64	99.141	98.813	98.530	98.653	99.075	99.340	99.212	99.137	99.400	99.353	98.918	98.829
65	99.113	98.906	99.015	98.931	99.005	99.177	99.061	98.687	98.081	97.789	97.266	95.817
66	95.304	93.467	95.447	94.990	94.771	94.033	93.206	91.424	93.652	93.914	93.201	96.127
67	97.005	95.944	97.724	96.199	96.175	93.260	94.105	93.202	93.006	91.276	91.412	91.993
68	93.048	94.547	93.824	93.378	94.900	95.131	96.649	97.669	97.498	97.342	97.051	94.436
69	94.578	94.780	95.345	95.596	94.386	93.423	93.937	92.587	88.773	92.557	91.830	89.469
70	88.794	91.828	91.888	88.352	90.589	91.029	92.334	92.536	94.625	95.125	98.531	98.867
71	100.203	101.421	103.884	99.631	98.136	95.519	95.272	98.028	98.910	100.043	99.338	100.396
72	99.382	97.915	97.007	97.734	98.269	97.395	97.599	96.260	96.242	96.461	97.134	96.485
73	95.767	93.736	93.307	93.559	94.603	95.279	91.673	93.017	96.211	96.225	96.482	96.412
74	95.634	95.857	93.015	90.934	91.501	90.667	89.908	90.794	93.168	94.045	95.826	97.192
75	97.198	99.154	97.930	95.656	96.349	96.260	95.516	94.054	92.492	95.287	95.819	97.558
76	97.745	98.846	99.357	99.503	98.075	98.825	99.330	101.039	101.569	102.427	104.747	105.467
77	101.443	101.601	101.783	101.623	101.741	102.722	101.369	100.309	99.650	98.204	98.518	97.320
78	96.446	95.621	95.155	94.832	94.140	93.096	93.519	94.617	94.043	91.828	92.763	91.129
79	92.597	91.824	92.289	91.719	93.312	95.065	93.841	93.001	91			

Table 11

Price index for marketable treasury debt
Years to maturity: 10+

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
42	105.663	104.797	105.217	105.754	105.282	105.662	106.013	105.260	105.213	105.176	104.617	104.006
43	104.257	104.214	104.128	104.745	104.623	104.811	104.531	104.439	103.825	103.732	103.424	103.382
44	103.357	102.906	102.850	102.744	102.811	102.545	102.604	102.706	102.299	102.509	102.903	102.648
45	103.558	104.002	102.921	103.228	103.397	104.076	103.182	102.843	102.929	103.198	103.395	103.285
46	105.262	106.304	106.529	104.550	104.952	105.147	104.186	103.851	103.084	103.722	103.085	103.939
47	103.976	104.198	104.397	104.231	104.285	103.711	103.656	104.001	103.788	102.634	101.841	100.777
48	100.745	100.803	100.922	100.946	101.613	100.802	100.709	100.682	100.673	100.668	100.757	101.001
49	101.295	101.574	101.684	101.589	101.600	102.563	103.197	103.778	103.897	103.959	104.156	104.684
50	103.928	103.619	103.198	102.827	102.675	102.204	102.235	102.305	101.867	101.656	101.595	101.136
51	101.217	101.031	99.312	97.755	97.319	97.216	97.705	99.163	98.078	97.768	96.985	96.657
52	96.886	96.738	97.184	98.793	98.780	98.239	98.139	97.308	95.960	97.177	96.938	96.059
53	95.948	94.815	94.065	92.750	91.468	93.250	93.652	93.525	96.111	96.548	95.834	97.693
54	98.866	100.188	100.715	101.325	99.740	100.839	101.468	100.775	100.721	100.489	99.852	99.852
55	98.085	97.570	98.263	97.871	98.337	97.425	95.996	96.305	97.155	97.838	96.915	96.966
56	97.380	97.574	96.122	95.266	97.303	97.075	95.001	93.082	93.461	92.536	91.602	89.501
57	93.347	92.418	92.810	90.793	89.741	89.808	88.036	88.222	88.440	89.218	94.148	99.673
58	98.229	100.094	100.949	102.290	102.767	100.505	97.548	93.392	92.067	92.268	93.350	91.250
59	91.053	91.548	99.736	89.873	89.655	89.417	89.856	88.261	88.372	88.164	87.038	84.082
60	85.002	85.771	89.041	87.916	89.290	91.532	94.418	92.627	92.726	92.047	90.502	93.311
61	91.815	93.865	93.242	94.726	93.850	91.582	91.765	90.314	90.620	90.924	90.635	89.802
62	89.719	89.840	91.818	92.986	92.427	91.195	90.345	92.417	93.028	93.748	93.736	93.524
63	93.180	92.883	93.329	93.080	93.139	93.035	93.130	93.086	92.911	92.107	91.947	91.288
64	91.736	91.467	90.906	91.160	91.859	92.405	92.536	92.318	92.254	92.561	91.769	91.669
65	92.689	92.502	92.706	92.729	92.243	92.408	92.151	91.275	90.296	90.074	89.722	88.365
66	87.743	85.047	87.492	86.765	86.116	85.203	85.021	83.638	85.145	86.733	85.216	88.432
67	90.094	87.537	88.926	86.363	85.573	83.140	83.900	83.153	83.674	79.200	78.550	79.151
68	81.542	81.032	81.032	79.593	79.331	81.516	83.148	82.824	81.638	80.605	78.274	75.829
69	74.287	73.858	71.758	74.563	72.173	73.342	72.664	72.807	68.630	71.461	68.894	66.932
70	67.267	70.872	69.812	66.430	63.410	66.698	68.446	67.110	68.739	68.230	71.880	70.357
71	74.043	72.517	75.475	74.210	74.010	73.165	73.314	76.595	77.884	78.955	79.718	79.492
72	78.435	81.716	78.534	78.784	80.263	79.388	80.735	82.922	82.220	83.177	84.197	82.365
73	81.567	79.465	79.297	80.113	79.960	79.462	75.523	79.704	83.138	83.196	83.400	81.233
74	81.041	80.581	77.858	76.791	78.955	79.006	78.102	76.503	76.995	78.625	81.181	82.267
75	83.715	85.002	83.889	83.434	87.002	88.443	88.103	88.397	84.871	87.492	87.285	89.082
76	90.274	90.669	92.205	91.479	89.723	91.837	92.222	94.502	95.264	95.141	97.344	98.856
77	91.956	91.359	91.538	91.691	92.897	94.663	93.825	97.368	96.696	95.220	95.878	93.757
78	92.678	92.841	92.188	91.486	90.987	89.922	91.047	93.114	91.907	89.597	90.967	89.304
79	90.867	89.798	90.254	89.429	91.910	94.062	92.726	92.064	90.350	82.810	85.792	85.440
80	79.460	73.940	73.263	84.056	87.545	89.530	85.116	81.684	78.550	76.161	77.188	79.018
81	77.943	75.063	76.728	72.356	76.614	75.221	72.243	68.838	67.025	72.619	81.376	76.600
82	75.680	76.928	77.789	79.574	79.500	76.715	79.632	85.329	90.562	97.376	95.634	97.564
83	94.418	98.496	97.110	99.956	95.372	94.967	90.236	89.531	93.073	91.170	93.567	91.385
84	92.952	90.510	88.461	86.305	81.748	81.621	87.371	89.074	91.388	96.097	96.669	96.832

Table 12

Price index for treasury bills
Years to maturity: all

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
42	99.968	99.975	99.970	99.961	99.956	99.952	99.946	99.949	99.954	99.948	99.952	99.948
43	99.949	99.949	99.948	99.949	99.950	99.947	99.951	99.954	99.949	99.951	99.955	99.951
44	99.954	99.955	99.951	99.952	99.954	99.949	99.953	99.949	99.951	99.953	99.948	99.952
45	99.955	99.954	99.951	99.953	99.949	99.951	99.954	99.950	99.951	99.955	99.950	99.953
46	99.949	99.949	99.951	99.954	99.950	99.950	99.955	99.950	99.953	99.949	99.951	99.951
47	99.950	99.950	99.953	99.956	99.950	99.953	99.925	99.909	99.902	99.889	99.883	99.889
48	99.871	99.874	99.883	99.865	99.869	99.882	99.868	99.874	99.845	99.849	99.867	99.843
49	99.851	99.859	99.842	99.842	99.859	99.848	99.861	99.870	99.858	99.870	99.865	99.854
50	99.866	99.859	99.846	99.844	99.854	99.841	99.856	99.819	99.822	99.840	99.809	99.817
51	99.838	99.833	99.797	99.817	99.790	99.789	99.800	99.775	99.780	99.791	99.723	99.724
52	99.769	99.789	99.802	99.798	99.769	99.779	99.745	99.749	99.797	99.711	99.618	99.675
53	99.699	99.703	99.737	99.699	99.715	99.758	99.728	99.767	99.826	99.842	99.812	99.814
54	99.874	99.874	99.871	99.897	99.912	99.925	99.901	99.870	99.870	99.878	99.879	99.864
55	99.860	99.839	99.811	99.792	99.840	99.809	99.761	99.754	99.713	99.736	99.731	99.653
56	99.715	99.751	99.693	99.668	99.660	99.683	99.730	99.658	99.625	99.656	99.589	99.609
57	99.547	99.485	99.565	99.626	99.555	99.541	99.375	99.239	99.284	99.339	99.484	99.596
58	99.795	99.846	99.867	99.859	99.938	99.903	99.887	99.712	99.702	99.576	99.408	99.471
59	99.444	99.393	99.450	99.342	99.113	99.104	98.854	98.777	98.785	98.878	98.929	98.799
60	98.819	98.997	99.255	99.110	99.257	99.406	99.228	99.270	99.281	99.230	99.284	99.396
61	99.363	99.379	99.417	99.352	99.416	99.411	99.275	99.268	99.234	99.217	99.225	99.265
62	99.234	99.318	99.282	99.245	99.312	99.284	99.221	99.272	99.322	99.219	99.232	99.295
63	99.180	99.239	99.254	99.195	99.074	99.228	99.123	99.108	99.125	99.026	99.046	99.099
64	99.017	99.029	99.062	99.030	99.054	99.075	99.038	99.060	98.970	98.947	98.921	98.863
65	98.892	98.866	98.907	98.898	98.936	98.938	98.888	98.903	98.806	98.759	98.756	98.640
66	98.689	98.717	98.701	98.715	98.780	98.653	98.612	98.449	98.333	98.354	98.455	98.552
67	98.729	98.763	98.878	98.962	99.021	98.725	98.597	98.543	98.532	98.466	98.378	98.491
68	98.577	98.566	98.551	98.498	98.454	98.414	98.423	98.361	98.464	98.306	98.337	98.118
69	98.233	98.275	98.343	98.355	98.309	98.075	97.865	97.906	97.950	97.833	97.732	97.686
70	97.832	98.128	98.274	98.009	98.082	98.174	97.997	98.110	98.121	98.200	98.529	98.591
71	98.895	99.082	99.009	98.840	98.836	98.505	98.482	98.768	98.664	98.849	98.837	98.908
72	99.039	99.047	98.887	98.959	98.927	98.796	98.900	98.680	98.689	98.621	98.573	98.574
73	98.368	98.344	98.293	98.297	98.137	98.039	97.821	97.783	97.958	97.948	97.777	97.957
74	97.962	97.997	97.829	97.739	97.863	97.894	97.779	97.318	97.921	97.766	97.813	98.079
75	98.370	98.451	98.469	98.340	98.485	98.290	98.043	97.990	98.031	98.331	98.255	98.475
76	98.563	98.436	98.500	98.504	98.301	98.282	98.370	98.453	98.434	98.522	98.684	98.682
77	98.589	98.591	98.618	98.585	98.451	98.448	98.309	98.270	98.191	98.144	98.138	98.103
78	98.108	98.100	98.125	98.002	97.825	97.765	97.857	97.659	97.516	97.387	97.222	97.154
79	97.230	97.191	97.276	97.244	97.137	97.319	97.336	97.107	96.991	96.462	96.657	96.640
80	96.525	95.973	95.977	96.859	97.661	97.643	97.385	97.008	96.776	96.393	96.091	95.999
81</												

simple ratio (indexed to 100) of market value to par value for that aggregate. This method of construction yields the appropriate single price since it is essentially a share-weighted average of the price of each issue of each security outstanding.¹¹

Table 7 reports monthly price indices for total marketable government debt over the period 1942-1984. This index may be used for determining the par value associated with the market value aggregate reported in table 4. It is also the price index used to convert the par value data on gross federal debt and privately held gross federal debt into the market value aggregates reported in tables 5 and 6.

Tables 8-11 report price indices for marketable government debt of various terms to maturity: less than 1 year, 1-5 years, 5-10 years, and over 10 years.¹² The series were constructed as follows:

- (1) For each month, data on the bid price, quantity outstanding, and maturity date of each issue of each type of security were obtained.
- (2) A year was defined as 365½ days (to allow for leap year), days-to-maturity were calculated for each issue outstanding, and issues were separated according to the above maturity categories.¹³

¹¹That is, the weights are equal to the share of that issue in total outstanding par value.

¹²Specifically, the maturities are: 0-365 days (1 year), 366-1826 days (1-5 years), 1827-3652 days (5-10 years), and over 3652 days (10+ years). Price indices of virtually any term to maturity are available from the author upon request.

¹³Unlike Treasury Bills and Treasury Notes, most Treasury Bonds may be retired before their maturity date, either at option of the Treasury on or after a specified redeemable date, or on any date at option of the representative of a deceased owner's estate. In most cases Treasury Bonds are retired at or near their redeemable date, rather than at their stated date of maturity. Therefore, the convention adopted was to treat Treasury Bonds as maturing on their redeemable date unless the redeemable date had passed. In this case the actual maturity date was used.

(3) Within each maturity class, a price index was then calculated as the ratio of market value to par value.

Although the price indices reported in tables 7-11 are useful for a variety of purposes, they are not appropriate for all. This is because Treasury Notes and Treasury Bonds bear a coupon, and the average coupon may in general vary over time and across maturity classes. The effect of the coupon may be eliminated by considering only Treasury Bills, which have historically borne no coupon. Table 12 reports monthly price indices for Treasury Bills alone.

3. The Stochastic Structure of T-Bill Prices

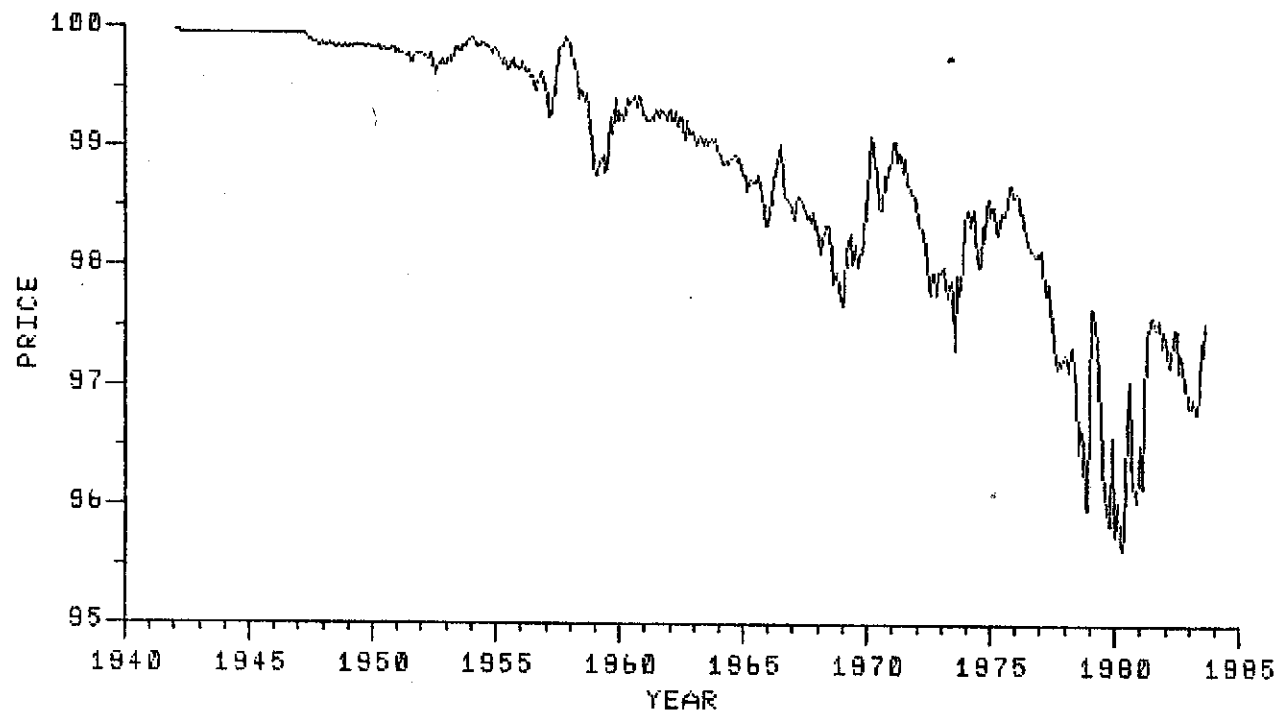
Figure 1 depicts the behavior of the monthly T-Bill price index over the 1942-1984 period. Two aspects of the series are immediately obvious. First, there has been a general decline in the index over time. Second, the variability of security prices has greatly increased. Largely contributing to the decline, of course, has been the general increase in interest rates over that period. Significantly also, the term to maturity of outstanding Bills has grown from an average of 45 days in 1942 to 109 days in 1984.¹⁴

Of particular interest is an examination of security risk over the 1942-1984 period. In order to determine the extent to which the increased price variability has been reflected in higher security risk, the stochastic structure of T-Bill prices is examined. The procedure used is to separate the data into five subperiods: 1942-1949, 1950-1959, 1960-1969,

¹⁴This average was constructed on a share-weighted basis.

Figure 1

PRICE INDEX FOR TREASURY BILLS



1970-1979, and 1980-1984 and apply pure time series techniques to model the processes generating the price variable during each of these periods. Security risk is then evaluated and compared on the basis of (i) the standard error of the estimate, and (ii) out-of-sample forecasting accuracy in each of the periods.

As a first step, the data were plotted and the autocorrelation functions evaluated. During each of the periods, the price variable exhibited significant low order autocorrelations which were slowly declining hence the data were transformed via first-order differencing. The resulting series were each stationary and showed no significant seasonal pattern.¹⁵ With these problems resolved, a variety of ARIMA models were applied to determine the time series structure of the transformed price series for each of the periods. AR orders of 0,1,2,3 together with MA orders of 0,1,2,3 were specifically considered. Models were then chosen on the basis of t-statistics on the individual parameters as well as the Box-Pierce Q statistics calculated at lags of 12,18, and 24 months.¹⁶ Chart 2 shown below gives the indicated ARIMA model and relevant statistics for each of the periods.¹⁷ Calculated t-ratios are generally high and Box-Pierce statistics low, indicating that the chosen models

¹⁵The autoregressive and moving average parameters at or near multiples of 12 were found to be insignificant, indicating no seasonal pattern in the data.

¹⁶Under the null hypothesis of residual white noise the Box-Pierce Q is distributed as a Chi-Square random variable with $n-p-q$ degrees of freedom, where p and q denote, respectively, the order of the autoregressive and moving average components, and n is the number of observations.

¹⁷It is also interesting that in no case was the indicated model a random walk.

CHART 2
DECADE-BY-DECADE ARIMA MODEL OF T-BILL PRICE INDEX

		1942- 1949	1950- 1959	1960- 1969	1970- 1979	1980- 1984
ARIMA MODEL	Con- stant	-0.01 (1.17)	-0.01 (-1.14)	-0.01 (-1.13)	-0.00 (-0.04)	-0.01 (16.55)
	AR1	-1.18 (-63.31) ⁺	-0.68 (-4.37)	-0.87 (-5.54)	1.25 (18.86)	0.58 (5.25)
	AR2	-1.03 (-57.42)	*	-0.83 (-5.84)	-0.76 (-11.45)	*
	AR3	*	*	0.10 (0.96)	*	*
	MA1	-1.08 (-28.96)	-0.90 (-5.25)	-0.93 (-7.19)	1.34 (100.77)	0.78 (119.74)
	MA2	-0.96 (-24.53)	-0.25 (-1.90)	-0.84 (-7.15)	-1.01 (-70.35)	0.45 (59.18)
	MA3	*	-0.27 (-2.52)	*	*	*
BOX-PIERCE	12	8.97 (0.26) [#]	9.95 (0.19)	11.76 (0.07)	13.80 (0.06)	10.46 (0.23)
Q	18	17.57 (0.18)	15.31 (0.29)	19.24 (0.08)	15.22 (0.29)	18.63 (0.18)
STATISTICS	24	23.06 (0.24)	26.53 (0.12)	26.02 (0.10)	16.63 (0.62)	27.22 (0.13)
SEE		0.01	0.06	0.09	0.15	0.28
SSPE		*	0.05	9.88	25.06	39.45

⁺ t-statistics

[#] associated probabilities

reasonably characterize the processes generating the behavior of the price index during each of the periods.

Among the statistics reported in Chart 2 are two measures of forecasting ability in each of periods. The first of these statistics -- the standard error of the estimate (SEE) -- measures within-sample forecasting ability and clearly reveals a steady deterioration decade by decade in forecasting ability. The second statistic measures out-of-sample forecasting ability for two years into each subsequent sample period by calculating the sum of squared prediction errors (SSPE) over those years. These statistics clearly indicate systematic deterioration in out-of-sample forecasting ability throughout the entire period. Overall then, the statistics confirm that the general increase in the variability of T-Bill prices over the 1942-1984 period reflects a steady increase in the riskiness of those securities.

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