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wP 76

THE THOMSON-PIERCE MONTHLY MODEL: A TEST FOR STRUCTURAL CHANGE

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Early in the summer of 1971, the FOMC decided to take up once more the issue of whether to use the Federal funds rate or some reserves aggregate as its operating or proximate target variable (or as what has come to be known as its "handle"). When it did so, we decided to have a try at determining experimentally which of two possible operating variables, the funds rate or unborrowed reserves, would give the Committee greater control over M_1, perhaps the most important of its intermediate target variables. At that time, there was literally no acceptable evidence at all which could help the Committee.

More specifically, what we decided to do was take the Thomson-Pierce monthly model of the financial sector and, using a previously developed procedure, calculate variances of monthly average M_1 for each of a set of values for the funds rate and each of a set of values of unborrowed reserves.1/ Comparing our calculated M_1 variances, we would then have been

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1/ For a description of the model, see T. Thomson and J. Pierce, "A Monthly Econometric Model of the Financial Sector" (Board of Governors of the Federal Reserve System, Washington, D.C.). For a description of our procedure, see J. Kareken, T. Muench, T. Supel and N. Wallace, "Determining the Optimum Monetary Instrument Variable" in Open Market Policies and Operating Procedures (Board of Governors of the Federal Reserve System, Washington, D.C., July 1971). Our choice of the Thomson-Pierce model was dictated partly by the press of time. Also, we recognized that a comparison of M_1 variances can be convincing only if the model used to generate the variances is credible. And the FOMC has for some time been using Thomson-Pierce model in determining policy.

able to set out a tentative conclusion about which of our two possible operating variables would better serve the Committee.

We never did get around, though, to calculating M_1 variances. Indeed, we never got beyond the preliminary task of testing the Thomson-Pierce model for structural change and updating parameter estimates in a way consistent with our test results. This, by the way, seemed to us a reasonable thing to do, for the model was mostly estimated from data for the period ending June 1968 and we had data through May 1971. Anyway, we did test the model and from the results concluded that it is unacceptable as a representation of the U.S. financial sector. Of course, having come to this conclusion, we had to forget about calculating and then comparing M_1 variances.

What we therefore do in this short note is first explain our test and give the results. Then, in a brief concluding section, we speculate on the meaning of our results for the conduct of open market policy.

A TEST OF THE MODEL

We refer herein to the period through June 1968, the original sample period, as period 1. And we refer to the period from July 1968 through May 1971, the post-sample period, as period 2. Period 3 is periods 1 and 2 combined.

Now, then, for what we actually did. We began by reestimating the equations of the model over period 2.[2/] Then we tested in two steps

2/ There was one equation--the fifth, explaining the public's holdings of negotiable CD's--which for want of data we could not reestimate.

for changes in parameter estimates or, alternatively, for structural change. We first tested for equality of residual variances, using the original parameter estimates for period 1 and the best fitting estimates for period 2.[3/] After doing that, we tested those equations passing the equality-of-variances test for whether a single set of coefficient estimates fit the data for periods 1 and 2.

Our thought was originally that for those equations passing our test for structural change we would, in calculating M_1 variances, use the parameter estimates obtained from the data for period 3. And for those equations failing the test, we were going to use the parameter estimates obtained from the data of period 2. So it was never our intention to give up on calculating M_1 variances if one or two or even several equations of the Thomson-Pierce model failed our test for structural change. We decided to give up only after discovering that all the equations failed our test and, what is no less important, seeing how strange were some of our period 2 parameter estimates.

We denote by s_{ij} the residual variance of equation i for the parameter estimates obtained from period j data. And n_{ij} is the corresponding degrees of freedom. For the equality-of-variances test, the test statistic is

$$R_i = \frac{s_{i1}}{s_{i2}}$$

3/ M_1 variances are importantly influenced by residual variances. That is one reason why we tested for equality. In addition, though, for the Chow test to have certain optimal properties, there must be equality of residual variances.

Under the null hypothesis $s_{i1} = s_{i2}$, R_i is distributed as F with n_{i1} and n_{i2} degrees of freedom.[4/] For the Chow test, the test statistic is

$$C_i = \frac{(n_{i3}s_{i3} - n_{i1}s_{i1} - n_{i2}s_{i2})\ (n_{i1} + n_{i2})}{(n_{i1}s_{i1} + n_{i2}s_{i2})\ (n_{i3} - n_{i1} - n_{i2})}$$

Under the null hypothesis of unchanged coefficient estimates, it is distributed as F with $(n_{i3} - n_{i1} - n_{i2})$ and $(n_{i1} + n_{i2})$ degrees of freedom.

Test results are given in the table. As can be seen, eight of the ten equations, all except equations 7 and 9, failed the test for equality of variances. And equations 7 and 9 failed the Chow test.

We might have interpreted our test results optimistically, saying in effect "Well, there has been considerable structural change, but there is not going to be any more or, if there is, it will be very slow." But evidence of structural change can be interpreted, less optimistically, as indicating faulty specification. That is how we have interpreted our test results. It is simply that in reestimating, using period 2 data, we obtained puzzling parameter estimates. Thus, we obtained many larger residual variances. But why should banks and households and firms have become more erratic in their behavior? Any why should asset holders have become generally less sensitive to changes in interest rates?

In reestimating, we also obtained many insignificant parameter estimates and, among the significant ones, a not inconsiderable number of

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4/ This requires normally distributed and serially independent residuals.

the wrong sign.[5/] That did not exactly encourage us in the belief that Thomson-Pierce managed an adequate specification.

THE CONDUCT OF OPEN MARKET POLICY

With the Thomson-Pierce model having decisively failed our test for structural change, it is perhaps not altogether outrageous to doubt the wisdom of within-quarter changes in open market policy. Suppose that at the beginning of the quarter, the FOMC decided on a target annual rate of increase of M_1 for the quarter of, for example, 6 percent. Now, however, one month into the quarter, it observes for the month just past an actual rate of, let us say, 10 percent. There having been no revision of the economic outlook, what should the committee do? Should it make a within-quarter change in policy? Suppose that it has been using some reserves aggregate as its operating variable. Should it then go to a new rate of increase for that aggregate, a lower rate presumably than it decided on at the beginning of the quarter? To us, it is not exactly obvious that it should, since it has no way, except by guessing, of determining the appropriate new rate of increase. It does not, that is, have a satisfactory structural or reduced-form "explanation" of monthly or weekly observations.[6/] And this being so, there would seem to be considerable risk in responding within the quarter to any observed discrepancy between actual and desired rates of increase of M_1 or, for that matter, any other aggregate.

5/ The period 2 estimates are given in the appendix.

6/ We offer this judgment that the Committee is too deeply in the dark with considerable hesitation, for we are not sure how far the research staffs of the Board of Governors and the Federal Reserve Bank of New York have come with their respective weekly models.

The committee does have a quarterly model and is able (using some judgment, if it wants) to calculate the quarterly average rate on three-month Treasury bills which is associated with or implied by given values of ultimate target variables.[7/] It might, therefore, operate by deciding on a target average bill rate and then, whatever happens, sticking to that rate straight through the quarter. The committee is also able to calculate the associated average stock of unborrowed reserves, so it could operate by deciding on a desired average stock at the beginning of the quarter and then, independently of whatever it may observe, trying over the quarter for equality between this desired stock and the actual stock.

But there would seem to be no other way in which the committee might reasonably operate, at least over the immediate future. Using the funds rate, whether as an instrument variable or as an operating variable or as an intermediate variable, could be quite risky. For one thing, the funds rate does not appear in the quarterly model, so the committee would have to guess the target value implied by given values of its ultimate target variables.

The committee is able to calculate the associated or implied value of M_1. This is not to say, though, that it can reasonably use M_1 as an intermediate target variable, although it has been for some time. Using M_1 as an intermediate target variable necessarily involves making within-quarter changes in open market policy and, therefore, in the absence of a satisfactory explanation of monthly or weekly observations, considerable risk.

7/ We are not aware that the quarterly model has ever been tested for structural change. Here, though, we accept for purpose of argument that when it is tested it will do well enough.

TEST RESULTS: THOMSON-PIERCE MONTHLY MODEL[1/]

Equation[2/]	$s_{i1}^{1/2}$ (n_{i1})	$S_{i2}^{1/2}$ (n_{i2})	R_i[4/]	C_i[4/]
1. Currency of public	83 (74)	156 (20)	3.52 (1.75)	
2. Demand deposits of public	578 (73)	1,216 (23)	4.42 (1.70)	
3. Time deposits of public	403 (25)	935 (18)	5.39 (2.03)	
4. Treasury bill holdings of public	908 (45)	2,389 (22)	6.91 (1.79)	
6. Borrowing from Federal Reserve[3/]	61 (75)	195 (20)	10.39 (1.73)	
7. Excess reserves of banks	56 (77)	60 (19)	1.19 (1.73)	3.49 (1.78)
8. Federal funds rate	23 (71)	65 (18)	7.89 (1.75)	
9. Negotiable CD rate	10 (47)	13 (3)	1.61 (2.80)	11.31 (2.08)
10. Six-month Treasury bill rate	13 (92)	21 (32)	2.77 (1.60)	
11. Commercial paper rate	9 (79)	14 (27)	2.57 (1.65)	
Memorandum				
5. Negotiable CDs of public	950 (31)	(-7)		7.88[5/] (2.09)

1/ For a complete listing of our estimates, see the appendix.

2/ For equations 1-7, the dimension is millions of dollars; for equations 8-11, it is basis points.

3/ In reestimating with period 2 data, borrowing totals were adjusted to exclude certain "unusual" loans. This had very little effect.

4/ Numbers in parentheses are five percent critical values.

5/ Since $n_{52} \leqq 0$, the test statistic is $(n_{53}s_{53} - n_{51}s_{51}) / s_{51}(n_{53} - n_{51})$.

APPENDIX

In this appendix, we present our estimates of 11 of the 12 structural equations of the Thomson-Pierce model.[1/] Estimates are reported for three sample periods: (1) the original sample period, through June 1968; (2) the post-sample period, July 1968 through May 1971; and (3) the total sample. The period 1 estimates differ slightly from those reported by Thompson and Pierce. But since we were able to verify, by way of the solution routine, that we had correctly identified the Thomson-Pierce specification, the differences must be attributed to minor differences between their original sample period and ours.

We duplicated the Thomson-Pierce estimation procedure except when reestimating the serial correlation coefficients for periods 2 and 3.[2/] (For period 1, we used the coefficients reported by Thomson and Pierce.) Instead of using the Cochran-Orcutt procedure, we searched over different values of the serial correlation coefficients by steps of .02 in the range (0,1). We picked that value which minimized the residual variance.

[1/] Since we were planning to perform our experiment in periods when the Q ceiling was not effective, we did not reestimate or test the CD run-off equation.

[2/] Although seasonal dummies appear in the first seven equations, we do not report their coefficients. We can, however, supply them to anyone who may be interested.

ALPHABETICAL LISTING OF VARIABLES[3/]

1.	B	borrowings from the Fed
2.	BR	ratio of 4-7 month to total Treasury bills
3.	CUR	currency holdings of the public
4.	D	deposits at all commercial banks less required reserves
5.	DDMS	demand deposit components of the money supply
6.	DM	deposits of FR members less required reserves
7.	EX	excess reserves
8.	IPI	FRB industrial production index
9.	OT&S	public holdings of other time and savings deposits
10.	QCD	quantity of CDs
11.	QTBB	quantity of Treasury bills held by banks
12.	QTBP	quantity of Treasury bills held by the public
13.	r_{Baa}	Moody's Baa corporate bond rate
14.	r_{CD}	market rate on CDs
15.	r_{cp}	commercial paper rate
16.	r_D	FR discount rate
17.	r_{FF}	Federal funds rate
18.	r_{180}	180-day bill rate
19.	$r_{OT\&S}$	rate paid on other time and savings deposits
20.	r_{30}	30-day bill rate
21.	RS	retail sales
22.	W	wealth held by public

[3/] All quantities are in millions of current dollars, all rates in percents.

EQUATION 1: PUBLIC DEMAND FOR THE CURRENCY COMPONENT OF THE MONEY STOCK (ΔCUR)

PERIOD[a]	ΔRS^{p}[b]	μ_{t-1}[c]	S.E.
1: 1/61-6/68	0.9846	.2484	83
2: 7/68-5/71	1.8062	.36	156
3: 1/61-5/71	1.2342	.40	115

ALMON DISTRIBUTED LAG WEIGHTS

		t	t-1	t-2	t-3	t-4	t-5	t-6	t-7	t-8	t-9
	1:	0.27	.103	.147	.165	.161	.143	.113	.079	.045	.017
ΔRS	2:	.053	.089	.115	.131	.137	.134	.122	.103	.075	.041
	3:	.046	.113	.151	.163	.157	.136	.106	.073	.040	.014

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[a] The data period refers to observations on the dependent variable.

[b] The p superscript indicates that retail sales enter as a polynomial distributed lag. The entry is the sum of the distribution lag weights. The individual weights, each expressed as a fraction of the sum, are presented below.

[c] The term μ_{t-1} represents last periods residual; its coefficients is the serial correlation adjustment.

EQUATION 2: PUBLIC DEMAND FOR THE DEMAND DEPOSIT COMPONENT OF THE MONEY STOCK (DDMS)

PERIOD	$r_{30}^{p}\cdot W$	RS^{p}	μ_{t-1}	S.E.
1: 7/60-1/68	-.0014	3.730	.99	578
2: 2/68-5/71	-.0010	4.759	.92	1216
3: 7/60-5/71	-.0009	3.840	.98	890

ALMON DISTRIBUTED LAG WEIGHTS

		t	t-1	t-2	t-3	t-4	t-5	t-6	t-7	t-8
	1:	.073	.122	.149	.158	.152	.133	.106	.072	.036
r_{30}	2:	.029	.064	.098	.129	.152	.162	.157	.130	.080
	3:	.033	.068	.102	.131	.152	.160	.153	.126	.076
	1:	.172	.131	.112	.106	.108	.111	.108	.093	.059
RS	2:	-.080	.021	.100	.155	.188	.198	.184	.147	.086
	3:	.054	.079	.105	.128	.145	.152	.145	.119	.072

EQUATION 3: PUBLIC DEMAND FOR OTHER TIME AND SAVINGS DEPOSITS (OT&S)

PERIOD	$r^p_{CD} \cdot W$	$r^p_{OT\&S} \cdot W$	W^p	μ_{t-1}	S.E.
1: 12/64-6/68	-.0012	.0025	.0653	.9745	403
2: 7/68-5/71	-.0015	.0038	.0638	.98	935
3: 12/64-5/71	-.0014	.0039	.0622	.98	636

ALMON DISTRIBUTED LAG WEIGHTS

		t	t-1	t-2	t-3	t-4	t-5	t-6	t-7	t-8	t-9	t-10
	1:	.269	.254	.219	.165	.092						
r_{CD}	2:	.177	.235	.247	.212	.129						
	3:	.236	.247	.229	.182	.106						
	1:	.394	.300	.203	.103							
$r_{OT\&S}$	2:	.031	.300	.384	.284							
	3:	.034	.300	.383	.283							
	1:	.034	.064	.088	.107	.120	.126	.125	.117	.100	.076	.043
W	2:	.013	.033	.057	.082	.106	.126	.139	.142	.132	.107	.064
	3:	.019	.042	.066	.090	.110	.126	.135	.134	.123	.098	.058

EQUATION 4: PUBLIC DEMAND FOR TREASURY BILLS ($\Delta QTBP$)

PERIOD	$\Delta(r_{180}-r_{CD})^{p}.W$	S.E.
1: 9/63-6/68	.00324	908
2: 7/68-5/71	.00027	2389
3: 9/63-5/71	.00050	1566

ALMON DISTRIBUTED LAG WEIGHTS

		t	t-1	t-2	t-3	t-5
	1:	.073	.215	.278	.263	.171
$\Delta(r_{180}-r_{CD})$	2:	-.442	.112	.432	.521	.377
	3:	-.448	.110	.434	.524	.379

EQUATION 5: PUBLIC DEMAND FOR NEGOTIABLE CERTIFICATES OF DEPOSITS (QCD)

PERIOD[a]	$r^p_{CD} \cdot W$	$r^p_{cp} \cdot W$	$r^p_{30} \cdot W$	$r_{Baa} \cdot W$	S.E.
1: 6/63-6/68	.0097	-.0057	-.0020	-.0016	950
3: 6/63-5/71	.0055	-.0031	-.0011	-.0004	1623

ALMON DISTRIBUTED LAG WEIGHTS

		t	t-1	t-2	t-3	t-4	t-5
r_{cp}	1:	.202	.210	.202	.176	.134	.075
	3:	-.210	.073	.257	.341	.326	.213
r_{cp}	1:	.329	.300	.236	.136		
	3:	-1.046	.300	.923	.823		
r_{30}	1:	.131	.300	.335	.235		
	3:	-.025	.300	.412	.312		

(a) We dropped all observations where the CD's secondary offering rate was greater than the bank's offering rate.

EQUATION 6: BANK DEMAND FOR BORROWINGS (B)

PERIOD[a]	$r_{30} \cdot DM$	$r_{30_{t-1}} \cdot DM$	$r_D \cdot DM$	μ_{t-1}	S.E.
1: 12/60-6/68	.00116	.00009	-.00053	.88105	61
2: 7/68-5/71	.00037	.00081	-.00028	.72	195
3: 12/60-5/71	.00056	.00049	-.00050	.80	.07

(a) In reestimating with period 2 data, borrowing totals were adjusted to exclude certain "unusual" loans. This had very little effect.

EQUATION 7: BANK DEMAND FOR EXCESS RESERVES (EX)

PERIOD	r_D.DM	r_{FF}.DM	r_{30}^p.DM	μ_{t-1}	S.E.
1: 9/60-6/68	.00072	-.00025	-.00086	.8026	56
2: 7/68-5/71	.00056	.00031	-.00074	.64	60
3: 9/60-5/71	-.00026	.00016	-.00042	.84	66

ALMON DISTRIBUTED LAG WEIGHTS

		t	t-1	t-2	t-3	t-4	t-5
	1:	.205	.211	.201	.175	.133	.075
r_{30}	2:	.550	.326	.155	.037	-.028	-.040
	3:	.260	.230	.194	.153	.107	.056

EQUATION 8: BANK DEMAND FOR TREASURY BILLS (r_{FF})

PERIOD	QTBB/D	r^p_{30}	$r^p_{FF_{-1}}$	μ_{t-1}	S.E.
1: 2/61-6/68	-19.83	2.26	-1.14	.35289	.23
2: 7/68-5/71	-20.99	2.99	-.91	.32	.65
3: 2/61-6/68	-12.52	1.84	-.52	.72	.42

ALMON DISTRIBUTED LAG WEIGHTS

		t	t-1	t-2	t-3	t-4	t-5	t-6	t-7	t-8	t-9	t-10	t-11
r_{30}	1:	.150	.141	.131	.120	.108	.096	.082	.067	.052	.036	.018	
	2:	.030	.064	.092	.111	.123	.128	.125	.115	.098	.073	.040	
	3:	.279	.223	.173	.129	.092	.060	.035	.015	.002	-.005	-.005	
$r_{FF_{-1}}$	1:		.101	.110	.115	.116	.114	.109	.099	.087	.070	.050	.027
	2:		-.413	-.217	-.053	.079	.180	.249	.286	.292	.267	.209	.120
	3:		.017	.056	.087	.110	.125	.132	.130	.120	.103	.077	.042

EQUATION 9: COMMERCIAL BANK CERTIFICATE OF DEPOSIT RATE SETTING EQUATION (r_{CD})

PERIOD[a]	r_{30}	r_{Baa}	r_D	$(r_{180}-r_{30})$	D^P/D	S.E.
1: 12/62-6/68	.604	.266	.537	0.65	-1.30	.099
2: 7/68-5/71	1.182	.068	.397	1.06	-2.30	.125
3: 12/62-5/71	1.121	.008	.057	1.06	-0.24	.155

ALMON DISTRIBUTED LAG WEIGHTS

	t	t-1	t-2	t-3	t-4	t-5
1:	1.460	2.990	1.922	-.327	-2.341	-2.704
2:	1.324	.868	.279	-.272	-.617	-.583
3:	-2.669	9.865	9.074	1.325	-7.015	-9.579

[a] We dropped all observations where the CD's secondary offering rate was greater than the bank's offering rate.

EQUATION 10: TERM STRUCTURE EQUATION RELATING THE 30 DAY AND 180 DAY TREASURY BILL RATE (r_{180})

PERIOD	BR	r^p_{30}	μ_{t-1}	S.E.
1: 7/60-6/68	1.876	.933	.83689	.13
2: 7/68-5/71	0.175	1.048	.80	.21
3: 7/60-5/71	0.297	1.050	.44	.16

ALMON DISTRIBUTED LAG WEIGHTS

		t	t-1	t-2	t-3
	1:	.568	.300	.116	.016
r_{30}	2:	.742	.300	.029	-.071
	3:	.622	.300	.089	-.011