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THE VALUE OF TELEVISION TIME: SOME PROBLEMS AND ATTEMPTED SOLUT--ETC(U)
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THE VALUE OF TELEVISION TIME: SOME PROBLEMS AND ATTEMPTED SOLUTIONS

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THE VALUE OF TELEVISION TIME: SOME PROBLEMS AND ATTEMPTED SOLUTIONS*

I. INTRODUCTION

One seldom sees an equation of such apparent high statistical quality as Stanley Besen's estimate of the value of television time.** Besen specifies a clever single equation model:

$$
\begin{aligned}
\text{RATE} = \beta_0 &+ \beta_1 \frac{\text{TVH}}{\text{N}} \\
&+ \beta_2 \,\text{NU}\left(\frac{\text{TVH}}{\text{N}}\right) + \beta_3 \frac{\text{NCNU}}{\text{N}-1}\left(\frac{\text{TVH}}{\text{N}}\right) \\
&+ \beta_4 \,\text{IV}\left(\frac{\text{TVH}}{\text{N}}\right) + \beta_5 \frac{\text{NCIV}}{\text{N}-1}\left(\frac{\text{TVH}}{\text{N}}\right) \\
&+ \beta_6 \,\text{IU}\left(\frac{\text{TVH}}{\text{N}}\right) + \beta_7 \frac{\text{NCIU}}{\text{N}-1}\left(\frac{\text{TVH}}{\text{N}}\right) \\
&+ \beta_8 \,\text{NCED}\left(\frac{\text{TVH}}{\text{N}}\right) , \qquad (1)
\end{aligned}
$$

where RATE is the asking price for an hour of prime time; TVH is the number of television households in the ADI*** (in hundreds); N is the number of commercial television stations in the market; NU, IV, IU are station class dummies (network UHF, independent VHF, and independent UHF, respectively); and NCNU, NCIV, NCIU, NCED are the number of stations in each class that compete with the station that the observation is for (NCED is the number of competing noncommercial stations).

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*The author gratefully acknowledges the support of the John and Mary R. Markle Foundation to Rand's Communications Policy Program and the comments and suggestions of Stanley Besen, Barry Fishman, and Bridger Mitchell.

**Besen (1976), equation (5), p. 438. Reproduced in column 1 of Table 1.

***Area of dominant influence, defined as those counties in which a market's stations attract a plurality of viewing hours.

The first line of equation (1) would be the specification if all stations were equal. We expect RATE to increase with TVH/N, so β_1 should be positive. The remaining lines allow for the fact that all stations are not equal. The terms to the left of the next three lines reflect the handicaps of UHF transmission, lack of network affiliation, or both; we expect β_2, β_4, and β_6 to be negative. The terms to the right reflect our expectation that a station will have a higher time value if some of its competitors are handicapped; we expect β_3, β_5, and β_7 to be positive. The final term allows for the possibility that competition from noncommercial stations reduces commercial stations' time rates; if so, β_8 is negative. For a more extensive discussion and justification of equation (1), see Besen (1976, pp. 436-437).

Besen estimates (1) for a 1972 sample of 390 commercial stations in 114 markets, with spectacularly good results (reproduced here in Table 1, column I). The R-squared of .92 is not surprising for an equation with high-variance scale variables on both sides, but the t statistics--ranging from 3.00 to 24.89 on all of the important variables--are awe-inspiring.

Impressed by the performance of (1) in explaining station time values, we adopted it in an attempt to explain reported station profits. Our results* look almost as good as Besen's; t-statistics are about the same, and overall explanatory power is not much lower (R-squared is .822). However, a closer look reveals two serious problems. (1) The estimated equation produces some counter-intuitive results that strongly suggest that it is not legitimate to treat numbers of stations as exogenous variables. A simple simultaneous equation estimating technique produces much more plausible results. (2) The high R-squared is due entirely to the ability to explain profits of network affiliated VHF stations. The equation does a very poor job of explaining profits of the other three (handicapped) classes of stations.

In this note, I use Besen's data** to check whether these two problems

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*In Park, Johnson, and Fishman (1976), Appendix E. See particularly line (2), Table E.3, p. 271.

**Which he very generously made available to me.

Table 1

ORDINARY LEAST SQUARES REGRESSION RESULTS:
DEPENDENT VARIABLE IS RATE

	Equation and Sample				
Variable	I OLS-All[a]	II OLS-NV	III OLS-NU	IV OLS-IV	V OLS-IU
Constant	252 (5.44)	274 (5.78)	298 (6.46)	-27 (.08)	73 (.66)
$\frac{TVH}{N}$	.724 (13.94)	.609 (11.20)	.155 (1.94)	.843 (2.64)	.447 (5.13)
$NU(\frac{TVH}{N})$	-.446 (5.12)				
$\frac{NCNU}{N-1}(\frac{TVH}{N})$	.329 (3.00)	.462 (3.27)	.346 (6.05)		-.270 (1.03)
$IV(\frac{TVH}{N})$	-.486 (18.74)				
$\frac{NCIV}{N-1}(\frac{TVH}{N})$	.705 (9.66)	.906 (10.13)		-.114 (.31)	-.560 (4.76)
$IU(\frac{TVH}{N})$	-.760 (24.89)				
$\frac{NCIU}{N-1}(\frac{TVH}{N})$	.971 (12.19)	1.080 (13.46)	1.546 (8.13)	.795 (1.39)	-.553 (3.74)
$NCED(\frac{TVH}{N})$	-.035 (2.25)	-.013 (.58)	-.012 (.27)	-.151 (3.42)	-.007 (.29)
R-Squared	.920	.944	.663	.899	.723
SEE	370	377	118	495	194
Sample size	390	276	61	22	31

[a]SOURCE: Besen (1976), eq. (5), p. 438.

characterize his estimates as well. I find that to a large extent they do. The results should be of substantive interest to anyone who cares about the value of station time. More generally, they point some methodological morals that, though not new, are sufficiently important to bear repeating.

II. SOME PROBLEMS WITH THE OLS ESTIMATES

IMPLAUSIBLE RELATIVE MAGNITUDES OF ESTIMATED COEFFICIENTS

Despite high significance levels, there are a number of problems with the relative magnitudes of the estimated coefficients in I. Besen himself points out that it is implausible for the capture effect to exceed the handicap in absolute value as it does for independent Vs. The implication of such a result is that changing a network VHF station into an independent would *increase* the sum of RATEs for all stations in the market, since other stations' RATEs would go up by more than that station's RATE would go down. It seems to me, however, that this is too stringent a criticism of the estimates, since it deals with transformations that are not reflected in the data. There are exactly three network stations in each sample observation. The only observed tradeoffs are NVs for NUs and IVs for IUs; for these tradeoffs, the relationship of the estimated coefficients is correct.* To require that the effect of unobserved tradeoffs between network stations and independents be reflected in the estimates seems too much to ask.

However, another implausible result concerns a kind of variation that *is* reflected in the data. Equation I implies, for quite a number of common situations, that adding a station to a market will *increase* time RATEs of stations already in the market. The easiest way to see this is to note that, once one specifies the type of station whose RATE one is interested in and the competition that that station faces, equation I reduces to RATE = 252 + SLOPE*TVH. Values of SLOPE are shown in Table 2 for markets with three network VHF stations and various numbers of independents. For example, the upper left-hand corner of the table shows that a network V in a market with no independents has

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*If an NV becomes an NU, it loses .446 (TVH/N) and other stations in aggregate gain .329 (TVH/N). If an IV becomes an IU, it loses (.760 - .486) = .274(TVH/N) and others gain (.971 - .705) = .266(TVH/N). In both cases, the sum of RATEs for all stations in the market declines as it should.

Table 2

EQUATION I -- OLS ESTIMATES OF SLOPE[a] IN 3NV MARKETS

Number of VHF Independents	Number of UHF Independents 0	1	2	3	4	5
SLOPE[a] for Network VHF Stations						
0	.241 ?	.262	.242	.218	.196	.177
1	.240	.229	.209	.190	.172	.158
2	.215	.200	.183	.168	.154	.142
3	.191	.177	.163	.150	.139	.129
4	.171	.158	.147	.136	.127	.118
SLOPE[a] for Independent VHF Stations						
1	.060 ?	.096 ?	.104	.103	.099	.094
	?					
2	.083 ?	.096 ?	.097	.094	.090	.086
	?					
3	.087 ?	.091	.090	.086	.083	.079
4	.084 ?	.085	.083	.080	.076	.073
SLOPE[a] for Independent UHF Stations						
0		-.009 ?	.041 ?	.059 ?	.064 ?	.065
		?	?			
1		.028 ?	.050 ?	.058 ?	.060	.060
		?	?			
2		.041 ?	.052 ?	.055 ?	.056	.055
		?				
3		.045 ?	.051 ?	.052	.052	.051
		?				
4		.046 ?	.049	.049	.049	.048

[a]RATE = 252 + SLOPE*TVH.

? indicates anomalous increase in SLOPE when a station is added to the market.

a SLOPE value of .241, while one in a market with one independent U has SLOPE equal to .262. That is, adding a UHF independent *increases* the time value of the network V, an implausible result highlighted by the question mark in the table. Similar anomalous results hold for the RATEs of independent Vs (8 question marks) and independent Us (19 question marks).

POOR FIT TO DATA FOR INDEPENDENT UHF STATIONS

Although equation I fits the data quite well overall, it does nothing to explain time RATEs for independent UHF stations. Coefficients of determination for equation I, for the full sample and for four natural subsamples, are shown in Table 3.* All are quite respectable except the -1.615 for UHF independents.

How can R-squared be negative for IUs? That simply means that the squared residuals from equation I exceed the squared deviations from the mean value of RATE for IUs. That this is so should not be particularly surprising; there is simply no guarantee that a regression equation will have positive explanatory power for any particular subsample. Nevertheless, it *does* seem surprising in this case. The reason is probably that the equation includes the dummy variable IU, that the IU term turns out to be highly significant (t = 24.89), and that this creates the illusion that the equation is fitting the IU subsample well. But of course one IU term in the equation does not suffice.

Figure 1 illustrates the situation. The sample consists of two subsamples, A (solid dots) and B (hollow dots). One wants to estimate a linear relationship between Y and X. Recognizing that the two subsamples differ, one might specify an equation with separate intercepts:

$$Y = \alpha_0 + \alpha_1 B + \beta_0 X \ , \tag{2}$$

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*The coefficient of determination (or R-squared) for each subsample is calculated as (SS - SSE)/SS. SS is the sum of squared deviations from the subsample mean. SSE is the sum of squared errors from using equation (I) to predict RATE for the subsample.

Table 3

COEFFICIENTS OF DETERMINATION FOR SUBSAMPLES

		Equation			
Sample	Size	I OLS	II-V OLS	VI TSLS[a]	VII-X TSLS[a]
All	390	.920	.944	.889	.917
NV	276	.940	.944	.922	.919
NU	61	.604	.663	.277	.188
IV	22	.775	.899	.535	.890
IU	31	-1.615	.723	-1.640	-.178

Note:
[a]Coefficients of determination for TSLS are calculated using actual rather than predicted values of right-hand side endogenous variables to calculate sums of squared errors.

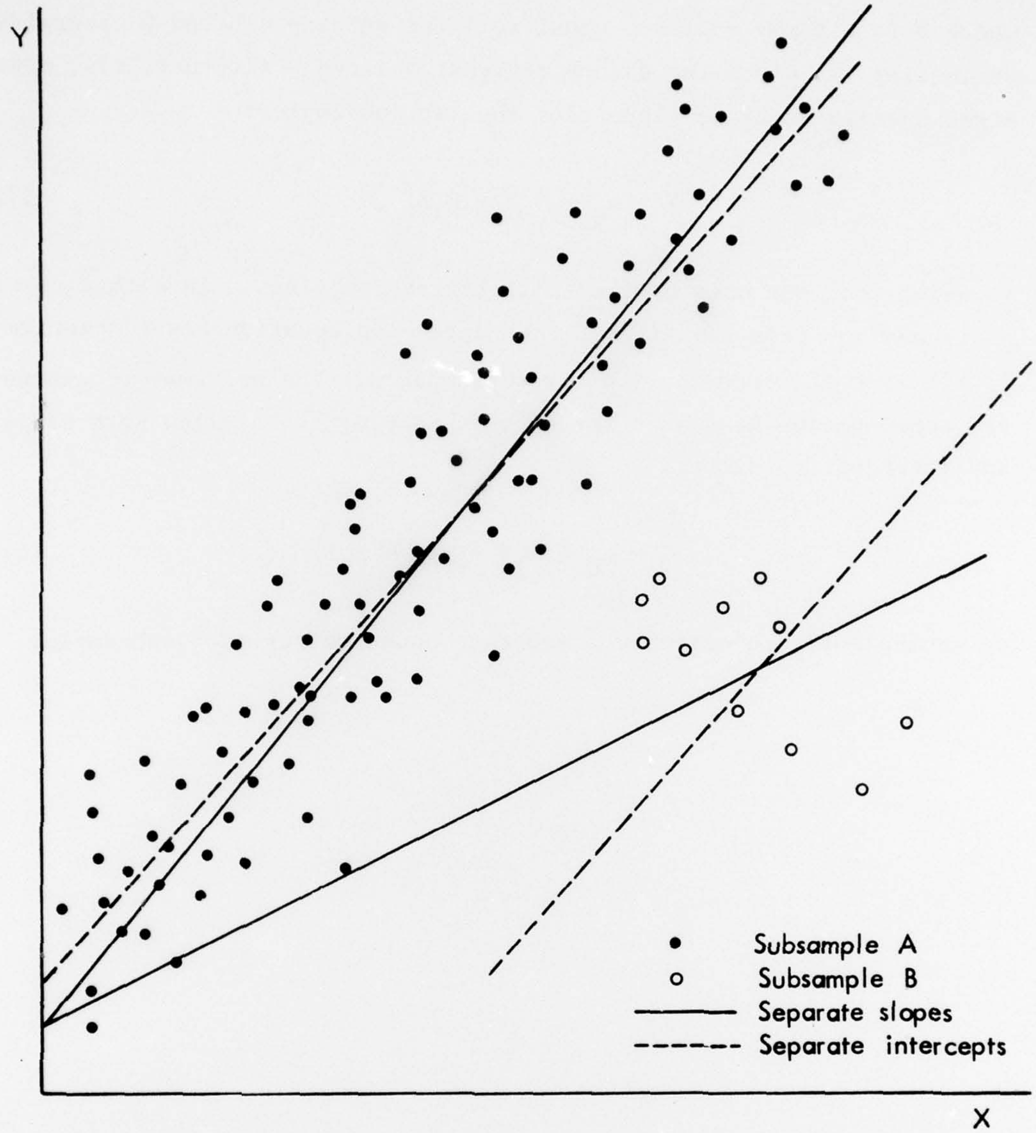

Fig. 1 — Illustration of the possibility of negative coefficient of determination with separate slopes or separate intercepts in the regression equation

where B is a dummy variable equal to 1 for subsample B and 0 otherwise. Estimating (2) gives the dashed regression lines. Alternatively, one might specify separate slopes for the two subsamples:

$$Y = \alpha_0 + \beta_0 X + \beta_1 BX \ , \qquad (3)$$

in which case one obtains the solid regression lines. In eitner case, as is obvious from the figure, the regression equation has a negative coefficient of determination for subsample B. The only way to guarantee non-negative R-squared for both subsamples is to allow both slope and intercept to differ:

$$Y = \alpha_0 + \alpha_1 B + \beta_0 X + \beta_1 BX \ , \qquad (4)$$

or equivalently to estimate a separate equation for each subsample.

III. SOME ATTEMPTED SOLUTIONS

A SIMULTANEOUS EQUATIONS APPROACH

The first problem noted in the previous section is that OLS equation I implies, contrary to expectations, that adding a station to a market will sometimes increase time RATEs of stations already in the market. One possible interpretation is this: The results reflect the fact that time RATEs tend to be higher in markets with more stations. The problem is in interpreting this as a causal relationship. The presence of more stations does not *cause* higher time rates; arbitrarily plunking down an independent U in a 3NV market would not increase the NVs' time RATEs. Instead, it is more reasonable to suppose that the same forces lead to the presence of both independent stations and high time RATEs in some markets. In short, the number of stations is not really exogenous.

I attempt to take account of the simultaneous determination of RATE and number of stations by using a two-stage procedure that should produce asymptotically unbiased estimates. The number of stations is first estimated as a function of exogenous variables, and then the RATE equation is estimated using observations on predicted rather than actual numbers of stations. The number-of-stations equation has a very simple form:

$$\underset{}{NUHF} = \underset{(22.72)}{2.68} + \underset{(11.20)}{.0000892\ TVH} - \underset{(18.01)}{.844\ NVHF}\ , \qquad (5)^{*}$$

R-squared = .747, SEE = .509, sample size = 114. NUHF is the number of UHF stations in the market and NVHF is the number of VHF stations. We find as expected (other things being equal) more UHF stations in larger markets and fewer UHF stations where VHF competition is greater.

Note that I treat NVHF as an exogenous variable. There are no unused VHF allocations in sample markets, so it seems legitimate to treat NVHF as being set exogenously by frequency allocation decisions

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*Equation (5) is equivalent to one of the forms used in Besen and Hanley (1975).

rather than determined endogenously by economic forces. In applying (5) I take both the number of network Vs (NNV) and the number of independent Vs (NIV) as exogenously determined by VHF allocations according to the following relationships:

$$NNV = \min(3, NVHF)$$
$$\text{and } NIV = NVHF - NNV.$$

That is, I assume, consistent with reality, that VHF stations have first chance at network affiliation in each market and that any Vs left after all affiliations are taken operate as independents. The numbers of affiliated and independent UHF stations, NNU and NIU, are determined endogenously by economic factors, so I use predicted values (indicated by hats) rather than actual values:

$$\widehat{NNU} = \min(3 - NNV, \widehat{NUHF})$$

$$\text{and } \widehat{NIU} = \widehat{NUHF} - \widehat{NNU}.$$

That is, if affiliations are still available after VHF stations have first choice, Us will take them, and any remaining Us will operate as independents. To get the values that actually enter equation (1), I simply calculate

$$NCNV = NNV - NV,$$
$$NCIV = NIV - IV,$$
$$\widehat{NCNU} = \widehat{NNU} - NU,$$
$$\widehat{NCIU} = \widehat{NIU} - IU,$$
$$\text{and } \hat{N} = NVHF + \widehat{NUHF}.$$

Column VI in Table 4 shows the second stage estimate of the RATE equation. Most of the anomalies disappear in this estimate. The implausible result that concerned Besen is not present in VI: None of the capture coefficients exceeds the corresponding handicap in absolute

Table 4

TWO-STAGE LEAST SQUARES REGRESSION RESULTS:
DEPENDENT VARIABLE IS RATE

Variable	Equation and Sample				
	VI TSLS-all	VII TSLS-NV	VIII TSLS-NU	IX TSLS-IV	X TSLS-IU
Constant	89 (1.73)	435 (6.99)	318 (3.09)	-37 (.10)	-139 (.40)
$\frac{TVH}{N}$	.884 (14.28)	.177 (2.10)	-.089 (.29)	.851 (4.25)	.338 (2.24)
$NU(\frac{TVH}{N})$	-.426 (4.23)				
$\frac{NCNU}{N-1}(\frac{TVH}{N})$	.330 (2.92)	.634 (3.83)	.584 (2.89)		-.195 (.69)
$IV(\frac{TVH}{N})$	-.5333 (15.48)				
$\frac{NCIV}{N-1}(\frac{TVH}{N})$	.290 (3.00)	1.256 (8.76)		-.068 (.24)	-.564 (2.17)
$IU(\frac{TVH}{N})$	-.827 (18.62)				
$\frac{NCIU}{N-1}(\frac{TVH}{N})$	.329 (2.51)	1.734 (9.33)	3.166 (1.84)	.856 (1.19)	-.600 (1.67)
$NCED(\frac{TVH}{N})$	.064 (3.21)	.061 (2.36)	-.015 (.24)	-.175 (1.59)	.763 (1.61)
R-Squared	.889	.919	.188	.890	-.178
SEE	415	405	176	517	401
Sample size	390	276	61	22	31

NOTES:

N, NCNU, and NCIU are treated as endogenous. See text for a description of procedure used.

R-squared, SEE, and t-statistics are based on variance estimates using actual rather than predicted values for endogenous variables.

value. Further, when I use VI to calculate SLOPEs as before, I find (Table 5) a much lower incidence of anomalous increases in RATE when independent stations are added to the market. There are no question marks at all for VHF stations' RATEs, and only 9 instead of 19 for UHF independents. These results provide some support for the conjecture that the anomalies in I result from simultaneous equations problems.

However, the two-stage procedure does nothing to improve the fit for independent UHF stations. As noted in Table 3, using equation VI to predict RATE for independent Us results in an R-squared of -1.640, which is not a bit better than that for OLS equation I.

A DISAGGREGATED APPROACH

The poor fit of both OLS equation I and TSLS equation VI to data for UHF independents suggests a disaggregated approach. Besen's specification (1) constrains most of the coefficients--the constant term and all of the capture coefficients--to be the same for all classes of stations. There is certainly no strong reason to believe that they must be the same. In particular, it seems unlikely that stations as different as network Vs and independent Us would "capture" equal proportions of another station's handicap.

To test the hypothesis that the coefficients are the same for all classes of stations, I estimate separate equations for each station class (OLS columns II-V, Table 1 and TSLS columns VII-X, Table 4). The separate equations are the basis for the analyses of variance in Table 6. There we see that the individual subsample regressions explain significantly more variance than do the pooled equations at far beyond the .01 significance level. Thus we must decisively reject the pooled hypothesis that the coefficients of equation (1) are the same for all four subsamples.

I check for anomalous relationships among the coefficients by calculating SLOPE values as before. SLOPEs implied by the separate OLS equations (Table 7) exhibit only two anomalous increases with added competition for NVs, two for IVs, and none at all for IUs. Those for the TSLS equations (Table 8) are less satisfactory: eight anomalous

Table 5

EQUATION VI--TSLS ESTIMATES OF SLOPE[a] IN 3NV MARKETS

Number of VHF Independents	Number of UHF Independents 0	1	2	3	4	5
SLOPE[a] for Network VHF Stations						
0	.295	.248	.210	.180	.158	.140
1	.295	.208	.179	.157	.139	.125
2	.206	.178	.156	.138	.125	.113
3	.176	.555	.138	.125	.113	.103
4	.154	.137	.123	.112	.103	.095
SLOPE[a] for Independent VHF Stations						
1	.088	.087	.080	.074	.067	.062
2	.085	.079	.073	.067	.061	.057
3	.078	.072	.066	.061	.056	.052
4	.071	.065	.060	.056	.052	.048
SLOPE[a] for Independent UHF Stations						
0		.014 ?	.028 ?	.031 ?	.032	.031
		?	?			
1		.206 ?	.030 ?	.031	.030	.029
		?				
2		.029 ?	.030	.029	.028	.027
3		.029	.029	.028	.026	.025
4		.028	.027	.026	.025	.024

[a]RATE = 89 + SLOPE*TVH.

? indicates anomalous increase in SLOPE when a station is added to the market.

Table 6

ANALYSIS OF VARIANCE COMPARING POOLED EQUATIONS WITH SEPARATE EQUATIONS

Source	Fraction of Variance	Degrees of Freedom	Mean Square	F-statistic
Explained by I	.920	8		
Additional explained by II-V	.024	13	.00185	12.2[a]
Explained by II-V	.944	21		
Unexplained	.056	368	.000152	
Total	1.000	389		
Explained by VI	.889	8		
Additional explained by VI-X	.028	13	.00212	9.3[a]
Explained by VI-X	.917	21		
Unexplained	.083	368	.000227	
Total	1.000	389		

[a] $F_{13,368,\ .01} \simeq 2.2$.

Table 7

EQUATIONS II-V OLS ESTIMATES
OF SLOPE IN 3NV MARKETS

Number of VHF Independents	Number of UHF Independents: 0	1	2	3	4	5
SLOPE[a] for Network VHF Stations						
0	.203	? .242	.230	.210	.190	.173
1	? .228	.221	.204	.186	.169	.155
2	.212	.198	.182	.166	.153	.141
3	.192	.177	.163	.150	.139	.129
4	.173	.160	.148	.137	.128	.119
SLOPE[b] for Independent VHF Stations						
1	.211	.208	.194	.177	.162	.149
2	.163	.163	.156	.146	.136	.127
3	.133	? .134	.130	.124	.117	.111
4	.112	? .113	.111	.107	.102	.098
SLOPE[c] for Independent UHF Stations						
0		.112	.062	.038	.024	.016
1		.061	.037	.024	.016	.011
2		.037	.024	.016	.011	.008
3		.024	.016	.011	.008	.005
4		.016	.011	.008	.005	.004

NOTES:

[a]RATE = 274 + SLOPE*TVH

[b]RATE = -27 + SLOPE*TVH

[c]RATE = 73 + SLOPE*TVH

? indicates anomalous increase in SLOPE when a station is added to the market.

Table 8

EQUATIONS VII-X TSLS ESTIMATES
OF SLOPE IN 3NV MARKETS

Number of VHF Independents	Number of UHF Independents 0	1	2	3	4	5
<u>SLOPE[a] for Network VHF Stations</u>						
0	.059 ?	.189 ?	.209	.203	.190	.177
	?					
1	.149 ?	.185 ?	.187	.179	.168	.158
	?					
2	.161 ?	.171	.168	.160	.151	.142
3	.155 ?	.156	.151	.144	.137	.129
4	.145	.143	.138	.131	.125	.118
<u>SLOPE[b] for Independent VHF Stations</u>						
1	.214	.213	.199	.183	.168	.154
2	.167	.168	.161	.151	.141	.132
3	.137	.139	.134	.128	.122	.115
4	.117	.118	.115	.111	.107	.102
<u>SLOPE[c] for Independent UHF Stations</u>						
0		.084	.038	.016	.005	-.001
1		.039	.017	.006	.000	-.004
2		.019	.007	.001	-.003	-.005
3		.008	.001	-.003	-.005	-.006
4		.002	-.002	-.005	-.006	-.007

NOTES:

[a]RATE = 435 + SLOPE*TVH

[b]RATE = -37 + SLOPE*TVH

[c]RATE = -139 + SLOPE*TVH

? indicates anomalous increase in SLOPE when a station is added to the market.

increases for NVs and a batch of negative slopes for IUs. The coefficients of determination (Table 3) are another reason for preferring the separate OLS estimates to the separate TSLS estimates. The TSLS equations fit the IU and NU data very poorly.

IV. CONCLUSION

Superficially, Besen's OLS estimate of equation (1) looks about as good as it possibly could, yet we saw in Section II that it has two hidden problems: (1) The relative magnitude of the estimated coefficients is such that the equation anomalously implies that adding a station to a market sometimes increases time RATEs of stations already in the market. (2) The equation does nothing at all to explain time RATEs for independent UHF stations.

In Section III, I tried two different ways to correct these problems. A simultaneous equations (TSLS) approach produces an estimated equation that looks even better than Besen's, and pretty well straightens out the anomalous implications. However, it too fails completely to explain time RATEs for independent Us. Testing and rejecting the hypothesis that the coefficients of the equations are the same for four natural subsamples of stations--network Vs, network Us, independent Vs and independent Us--lead to a second approach: estimating separate equations for each station class. The separate TSLS equations also fail to have any explanatory power for independent Us, but the separate OLS equations appear to solve both of the problems. They may, however, have other hidden problems of their own.

It seems to me that this exercise points up two important lessons. (1) High R-squared and t-statistics do not guarantee a problem-free equation. We all know this, but it is still easy to be lulled by surface appearances. (2) Coefficients may (probably do) differ between natural subsamples. The hypothesis that they are the same should always be tested.

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