stand second in line to every holder of a broadcast license in every community in the country.

Despite our vigorous First Amendment challenge to the analog-era must carry rule, a closely divided Supreme Court supported it. The digital era will bring an entirely different set of facts, with a vastly different and greater effect on the satellite delivered programmers if the old must carry rule is simply tacked onto the new regime. If it is, the C-SPAN Networks will be first in line to once again challenge the infringement of our free speech right.

Fortunately, there is still time for everyone involved in the move toward digital television to avoid that particular battle. As you will no doubt hear from other witnesses there is a lot about this technology that is simply unknown, even to the so-called experts. For that reason alone, Congress and the FCC should slow down the fast track we are all on. For our part, the C-SPAN Networks prefer to trust the free market to solve most of the emerging digital television problems, just as the cable industry did when it created us. The government would do well by taking the same approach.

A C-SPAN Status Report:
Current Subscriber Losses from the
Must Carry/Retransmission Consent Rule

July-98

Nearly 10 million households have lost some or all of their access to either one or both of C-SPAN or C-SPAN 2 as a result of the 1992 Cable Act. Six million of those households have had the service restored. Today however, there are still 4 million homes in 129 communities with less access to the C-SPAN Networks as a result of the Act. The lists below identify the 45 communities with 1.5 million subscribers,where there is still less access to our services for reasons directly related to the must carry/retransmission consent rule.

City	State	Subscribers	Type
Montgomery	AL	18,000	MC
Rohnert Park	CA	47,400	MC
Alhambra/Pasadena	CA	103,000	MC
Union City	CA	9,200	MC
S.Pasadena	CA	7,000	MC
Century	FL	1,500	MC
Comer	GA	1,500	MC
N. DeKalb County	GA	25,000	MC
Chicago	IL	118,900	MC
Chicago Suburbs	IL	45,000	MC
Naperville	IL	21,000	MC
Minneapolis	MN	101,000	MC
Bellevue/La Vista	NE	35,000	MC
Vineland	NJ	35,000	MC
Rockland	NY	47,800	MC
Portland	OR	118,000	MC
Philadelphia	PA	55,000	MC
Clearfield	PA	7,400	MC
Waynesboro	PA	9,000	MC
San Juan	PR	97,000	MC
Harris/Houston	TX	48,000	MC
Irving	TX	30,000	MC
Chesterfield	VA	50,000	MC
Moses Lake	WA	7,000	MC
Wauwatosa	WI	48,000	MC
Menomonee Falls	WI	7,800	MC
		1,093,500	
Current total must-carry:		**1,093,500**	

MC - must-carry

City	State	Subscribers	Type
Des Moines	IA	86,700	RTC
Belmond	IA	1,700	RTC
Hampton	IA	1,300	RTC
Audubon	IA	1,000	RTC
Osage	IA	900	RTC
Pocahontas	IA	900	RTC
Laurens	IA	700	RTC
Council Bluffs	IA	16,200	RTC
Boise	ID	62,000	RTC
Highland Park	IL	19,000	RTC
Mt. Prospect	IL	100,000	RTC
Ocean City	MD	29,400	RTC
Traverse City	MI	19,200	RTC
Crookston	MN	2,500	RTC
Crookston	MN	2,500	RTC
St. Charles	MO	39,000	RTC
Carlsbad	NM	9,300	RTC
Rio Grande Valley	TX	42,000	RTC
Sweetwater	TX	3,800	RTC
		438,100	
Current total retrans-consent:		**435,600**	

RTC - retransmission-consent

CS Docket No. 98-120
Comments of the C-SPAN Networks

Exhibit B

A Probability Model of the Effects of Digital Must Carry Rules on the C-SPAN Networks

October 8, 1998

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Washington, DC

I. Introduction

The purpose of this analysis is to determine the potential effect of digital must carry rules on the decision of individual cable operators to carry or not to carry the C-SPAN networks.[1] The form of the analysis is a probability model, where the dependent variable denotes the decision of each individual cable operator whether or not to carry the C-SPAN networks. This decision is assumed to be related to a set of exogenous explanatory variables which essentially measure viewer interest in the C-SPAN networks, as perceived by the decision maker. The estimated model provides a marginal probability associated with each of these explanatory variables which measures the strength of that factor in the decision of the cable operator. The estimation process can isolate the marginal effect of channel capacity from the other factors which influence the cable operator's decision. A numerical estimate of this marginal effect allows concrete predictions to be made regarding the effect of the Commission's proposed rules.

II. Background on digital must carry

In its effort to promote adoption of broadcast digital television, the Commission is considering broadening the scope of the current must carry rules[2] to include the newer digital signals. Many cable operators face the prospect of

[1] The C-SPAN networks include C-SPAN, C-SPAN2, and as of 1997, C-SPAN Extra.
[2] As a result of the 1992 Cable Act, current law requires cable systems to carry most local television signals, including major network affiliates as well as weaker UHF independents, shopping channels, and noncommercial educational channels.

having to drop some cable networks to all subscribers in order to deliver digital broadcast signals which can be viewed, at the outset, by only a handful of subscribers with digital television sets. The Commission explicitly recognizes this effect in its current NPRM on this issue:

> To the extent that the Commission imposes a digital must carry requirement, cable operators could be required to carry double the amount of television stations, that will eventually carry identical content, while having to drop various and varied cable programming services where channel capacity is limited. The central question addressed in this section is how must carry should be initiated during the transition to digital television.[3]

The effect of the proposed must carry rules is that some cable systems must cease carriage of certain cable networks which they otherwise would carry. The purpose of this project is to assess the likely specific effects of a future digital must carry obligation on the C-SPAN family of networks.

III. Building the Model[4]

The purpose of a probability model is to explain dependent variables which have a finite number of distinct outcomes. The specific type of probability model employed in this analysis is a *binary choice model,* that is, a model in which there are only two possible outcomes. The dependent variable Y_i is a binary variable which takes the value 0 if one choice made and 1 if the alternate choice is made. Classic examples of binary choice models include labor models of an

[3]Report No. CS 98-12, CABLE SERVICES ACTION, July 9, 1998, CS Docket No. 98-120, FCC 98-153.

[4]A more detailed background on probability models is given at Appendix A.

individual's decision whether or not to work, a commuter's decision whether or not to take public transportation, and a student's decision whether or not to attend college.[5]

As in standard econometric models with continuous dependent variables, it is assumed that the decision maker's choice is related to a set of explanatory variables X_i. In this analysis, the unit of observation is each individual cable system i. The decision variable Y_i represents the decision of that cable system to carry or not carry C-SPAN (or, in a separate analysis, C-SPAN2). The latent variable Y^*_i in this case represents the net benefit to the cable operator of the decision to carry C-SPAN, taking into account all factors including the decision not to carry the channel perceived by that system's operator as the next best option.

Of course, the benefit to the cable system operator from carrying any particular cable network is derived from subscription fees, which are in turn related to the desire of that system's subscribers to view that network. Thus, the determinants of Y_i are expected to arise from two principal sources: factors specific to cable system i, such as channel capacity, number of subscribers, etc., and factors specific to the locale in which cable system i operates, such as median income and demographic factors. Decisions about which variables most strongly influence the desire for C-SPAN carriage in particular are based on surveys of C-SPAN viewers and previous econometric work regarding the demand for cable services.

For example, surveys conducted by Statistical Research Inc. (SRI) consistently indicate that, relative to non-viewers, C-SPAN (and C-SPAN2) viewers:

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[5]See William E. Griffiths, R. Carter Hill, and George G. Judge, *Learning and Practicing Econometrics*, New York: John Wiley and Sons, 1993 Ch. 23.7 for a list of other examples and references.

1) are younger,

2) have higher household income,

3) have more education,

4) are more likely to use computers,

5) are more likely to vote, and

6) are more likely to be employed outside the home.

These survey results provide some guidance in the selection of explanatory variables for the analysis. However, the analysis here is a reduced form analysis, that is, the underlying theoretical model of the demand for C-SPAN is implicit rather than explicit here. Goodness-of-fit criteria were also given weight in the selection of explanatory variables.

The analysis is divided into two sections, one for C-SPAN and one for C-SPAN2. The decision whether to carry the two networks is not a completely independent one, however. Carriage of C-SPAN is a prerequisite for carriage of C-SPAN2. Likewise, if a system carries both C-SPAN and C-SPAN2, it must drop C-SPAN2 before it can drop C-SPAN. Because of this interdependence, the set up of the analyses is as follows: For the C-SPAN analysis, the universe of observations is only those cable systems which carry C-SPAN alone or neither of the two networks. For the C-SPAN2 analysis, the universe is restricted to only those cable systems which carry both C-SPAN and C-SPAN2 or only C-SPAN. In this way, only the marginal decision to carry or not carry one of the two networks is examined in each analysis.[6]

Given that the focus of this analysis is the marginal effect of channel capacity, the question arises how precisely to model channel capacity. The

[6]This setup also more closely matches the experience of the C-SPAN networks during the implementation of must carry rules after the 1992 Cable Act. During this period, some of those systems which carried C-SPAN but not C-SPAN2 dropped C-SPAN, and other systems which carried both C-SPAN and C-SPAN2 dropped C-SPAN2 only. The number of systems which dropped both networks, however, was minimal.

measure which will be used in this analysis is *effective channel capacity,* which is defined as total channel capacity minus the number of off-air broadcast signals. Because of the current must carry rules (coupled with retransmission consent), cable operators normally have little choice about which off-air broadcast signals to carry.[7] Thus, the number of channels available for discretionary satellite delivered programming is limited to those which are not currently used for broadcast signals. Two systems with identical channel capacity will have different effective capacities based on the number of off-air broadcast signals in each locale.

It is also possible that the effect of channel capacity on the decision to carry the C-SPAN networks varies by total effective channel capacity. In other words, a reduction in effective channel capacity of one channel may affect a system with 30 channels of effective capacity differently than a system with 100 channels of effective capacity. To account for this possible nonlinearity, a piecewise linear form for effective channel capacity is employed. The marginal effect of channel capacity is subdivided into three ranges: 0-25 effective channels, 26-50 effective channels, and greater than 50 effective channels, and a different marginal effect is estimated for each range.

IV. The Data

Warren Publishing reports detailed information on 10,774[8] U.S. cable systems in the U.S. in its 1998 *Television and Cable Factbook.* All information

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[7]The effect of must carry and retransmission consent is limited by the so-called "one-third cap," which dictates that no more than one-third of any cable system's capacity must be devoted to off-air broadcast signals.

[8]Cable systems with fewer than 200 subscribers (3,191 systems) have been excluded from the analysis. Also excluded are a small number of systems for which one or more of the variables listed in Appendix B (Warren Publishing data) were missing. The final analysis reported in Section V includes 6116 cable systems for the C-SPAN analysis and 4,061 systems for the C-SPAN2 analysis.

regarding cable systems used in this study is taken from the electronic version of this data source. A detailed list of the variables considered for analysis which are specific to cable systems is given at Appendix B. The Warren data are augmented with C-SPAN's own information on which systems carry C-SPAN and C-SPAN2.

Information on the demographic and socioeconomic variables for the locale in which each cable system operates is taken from U.S. Census data. These variables have been updated to 1998 values by Claritas. These data were merged with the data on cable systems at the county level. A detailed list of the census and demographic variables considered for analysis is given at Appendix C.

V. Results

A. C-SPAN

The results of logit estimation for C-SPAN appear in Table 1 below. The raw coefficients are presented, as well as their standard errors and significance levels. Several overall measures of fit for the model are presented as well.

Table 1 - Logit Estimation for C-SPAN					
	Parameter Estimate	**Standard Error**	**Wald χ^2**	**Pr $>\chi^2$**	**Marginal Effect**
Intercept	-3.06126	0.17909	292.17	0.0001	-0.70504
MSO in Top 50?	0.77897	0.066242	138.28	0.0001	0.17940
Total Subscribers	2.17048E-4	1.73236E-5	156.99	0.0001	4.99883E-5
Effective Channel Capacity (0-25 Channels)	0.030969	0.0081942	14.28	0.0002	0.0071326
Effective Channel Capacity (25-50 Channels)	0.049845	0.0047194	111.55	0.0001	0.011480
Effective Channel Capacity (50-100 Channels)	0.037294	0.0032691	130.15	0.0001	0.0085892
Number of Communities Served	0.032332	0.012344	6.86	0.0088	0.0074465
Number of Broadcast Stations	0.081549	0.012076	45.61	0.0001	0.018781
Persons Living in Rural Area	-4.28356E-6	1.69701E-6	6.37	0.0116	-9.8655E-6
Median Home Value	3.52796E-6	1.03886E-6	11.53	0.0007	8.12525E-7

Overall Model Test:

-2 · Log Likelihood including intercept only (restricted)=7976.65

-2 · Log Likelihood including intercept and all covariates (unrestricted)=6432.47

Difference = 1544.18 $\sim\chi^2(9) \Rightarrow$ p-value=0.0001

Pseudo-R^2:

(a) Correlation $(Y_i, Y_i)^2 = 0.507$

(b) Percentage of correct predictions = 4168/5769 = 72.24%

There are several indications that the estimated model in Table 1 provides an excellent overall fit to the data. First is the overall log likelihood test for the model given above, which is identical in interpretation to the overall joint F-test for the slopes of an ordinary linear regression. The test is based on the result

that the difference between -2 times the log likelihood of the estimated model with a constant only and -2 times the log likelihood of the estimated model with the constant and explanatory variables is distributed as a χ^2 random variable with degrees of freedom equal to the number of explanatory variables. The idea is that if the explanatory variables add very little to the model, the log likelihood for the estimated model with the explanatory variables will not differ significantly from the log likelihood with a constant only. For this model, however, the difference between the two values is highly significant, and thus the null hypothesis that the independent variables X_i have no explanatory power is easily rejected.

In addition, column 3 of Table 1 lists the χ^2 test of significance for each of the individual explanatory variables. All are significant at or above the 99% confidence level. Although there is no direct counterpart in logit models to the usual R^2 measure from ordinary linear models, one measure which has been used is the square of the correlation between the actual Y_i's and the predicted Y_i's. Another suggested measure for R^2 is the percentage of correct predictions, based on the rule that if $Y_i > 0.5$, then $Y_i=1$ is predicted, if $Y_i < 0.5$, then $Y_i=0$ is predicted.[9] The high values of 0.507 and 0.722 for these two R^2 measures is further indication of the strength of the model.

Some care must be taken when interpreting the parameter estimates of the logit estimation. Unlike in linear estimation procedures, the raw parameter estimates of the estimated logit model in column 2 of Table 1 do not represent the marginal probability associated with that variable. The raw parameter estimates must be adjusted by a scale factor which in turn depends on the values of the explanatory variables.[10] It is customary to compute the scale factor at the

[9]These measure have the desirable property that, like the standard R^2 in linear models, they are constrained to lie between 0 and 1.

[10]In the standard linear model in which $Y=X'\beta$, the marginal effect on Y due to a change in X = $dY/dX = \beta$. In the logit model (or any other nonlinear model, for that matter) where $Y=f(X'\beta)$,

means of the explanatory variables. The last column of Table 1 gives the true marginal probabilities or slopes associated with each of the explanatory variables.[11]

Each of the estimated marginal effects has plausible sign and magnitude, based on prior expectations. Systems owned by one of the top 50 MSOs are more likely to carry C-SPAN,[12] as are systems with more subscribers. Of course, the marginal effect associated with total subscribers is small due to the scale of that variable: The largest cable systems have many thousands of subscribers. Systems which cover a broader area are also more likely to carry C-SPAN, as are communities with higher median home values. Also, the number of broadcast channels in each locale has a positive effect on the probability of carrying C-SPAN. This could reflect the size and sophistication of markets with a large number of broadcast outlets.[13] Systems in locales with a higher rural population are less likely to carry C-SPAN.

Of particular note is the result that cable systems with higher effective channel capacity are more likely to carry C-SPAN. Each of the coefficients on the three effective channel capacity variables is positive and among the most statistically significant. The effect of channel capacity is expressed in the form of an estimated marginal probability (given in the last column of Table 1) associated with each of the three types of systems. The interpretation of these

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the marginal effect $dY/dX = \beta \cdot f'(X'\beta)$, where $f'(\cdot)$ represents the derivative of the nonlinear function f (the logit distribution function, in this case).

[11]Because the dummy variable RANKED is discrete, there is no marginal effect per se. The marginal effect reported here is the difference between the effect when RANKED=0 and the effect when RANKED=1, holding the values of the other explanatory variables at their means.

[12]This is not a surprising result, given that C-SPAN was created and is governed by cable operators, including the top 15 MSOs.

[13]It has also been suggested that this positive relationship may be due to *simultaneity* between the number of broadcast stations and cable demand. In other words, areas with a larger number of broadcast stations will have less demand for cable channels, and thus system operators must offer a more enticing package in these areas to increase demand. However the measure of broadcast stations used here includes weaker UHF channels, shopping channels, and noncommercial educational channels. While simultaneity may be an argument for networks such as ESPN, it seems unlikely to be the sole factor behind this empirical result, and in any case raises no formal econometric problems.

marginal probabilities is that each extra channel of effective capacity raises the probability that a cable system will carry C-SPAN by that amount or, alternatively, each channel lost to digital must carry reduces the probability that a cable system will carry C-SPAN by that amount. For example, each channel lost to digital must carry reduces the probability of C-SPAN carriage by 0.0071326 for systems with 0-25 channels of effective capacity.

To make concrete predictions regarding the possible effects of the Commission's proposed rule changes, the reduction in marginal probability must be multiplied by the total number of systems to derive the expected number of systems which will drop C-SPAN. To translate this into a number of subscribers, the average number of subscribers for each type of system is multiplied by the expected number of affected systems. Table 2 displays the calculation of the total number of subscribers affected.

Table 2 - Calculation of Total Number of C-SPAN Subscribers Affected for Each Channel Lost to Digital Must Carry

System Capacity (Effective Channels)	Reduction in Probability	Total Number of Systems	Expected Number of Affected Systems	Average Subscribers	Expected Number of Affected Subscribers
0-25	0.713%	1,202	9	1,474	12,633
26-50	1.148%	4,042	46	3,966	184,013
51+	0.859%	525	5	9,650	43,515
			60		**240,161**

For example, based on the total universe of 5,769 systems which carry either C-SPAN only or neither of the two networks, there are 1,202 systems with 0-25 channels of effective capacity. For these systems, the estimated reduction in probability of 0.007132 indicates that for each channel lost to digital must carry, the percentage of systems which carry C-SPAN will be reduced by 0.7132%, or roughly 9 cable systems. The average cable system in this sample with 0-25 channels of effective capacity has 1,474 subscribers, and thus each channel lost to

digital must carry would reduce the number of subscribers who can view C-SPAN at these systems by 12,633.[14] Similar calculations for systems with 26-50 and greater than 51 channels of effective capacity yield expected subscriber losses of 184,013 and 43,515 respectively. Thus, each channel lost to digital must carry would reduce the number of subscribers who can view C-SPAN by a total of 240,161.

B. C-SPAN2

The results of logit estimation for C-SPAN2 appear in Table 3. The raw coefficients are presented, as well as their standard errors and significance levels. Several overall measures of fit for the model are presented as well.

Table 3 - Logit Estimation for C-SPAN2

	Parameter Estimate	Standard Error	Wald χ^2	Pr $>\chi^2$	Marginal Effect
Intercept	-4.11855	0.20746	394.10	0.0001	-0.87377
Total Subscribers	2.11451E-5	2.10667E-6	100.77	0.0001	4.48605E-6
Effective Channel Capacity (0-25 Channels)	0.080017	0.010408	59.11	0.0001	0.016976
Effective Channel Capacity (25-50 Channels)	0.053722	0.0052515	104.65	0.0001	0.011397
Effective Channel Capacity (50-100 Channels)	0.048935	0.0034302	203.52	0.0001	0.010382
Number of Broadcast Stations	0.049846	0.011917	17.50	0.0001	0.010575
Median Income	1.56569E-5	3.85642E-6	16.48	0.0001	3.32169E-6

[14]The exact number of affected systems is used in this calculation rather than the rounded number displayed in Table 2 and in the text.

Overall Model Test:

-2 · Log Likelihood including intercept only (restricted) = 5599.13

-2 · Log Likelihood including intercept and all covariates (unrestricted)= 4710.74

Difference = 888.39 $\sim\chi^2(6) \Rightarrow$ p-value=0.0001

Pseudo-R^2:

(a) Correlation $(Y_i, Y_i)^2 = 0.450$

(c) Percentage of correct predictions = 3332/4480 = 74.4%

Like the estimated model for C-SPAN, the model for C-SPAN2 produces an excellent fit to the data. The overall model test soundly rejects the null hypothesis that the independent variables provide no explanatory power, and each of the individual coefficients is significant at well above the 99% level. The significant percentage of correct predictions of 74.4% is further evidence of the ability of the explanatory variables to explain the variations in Y_i.

Each of the estimated marginal effects has plausible sign and magnitude, based on prior expectations. Systems with more subscribers are more likely to carry C-SPAN2, similar to the previous results for C-SPAN. Systems in communities with higher median income are also more likely to carry C-SPAN2. Also, the number of broadcast channels in each locale has a positive effect on the probability of carrying C-SPAN2. This could reflect the size and sophistication of markets with a large number of broadcast outlets.[15]

Like the results for C-SPAN, cable systems with higher effective channel capacity are more likely to carry C-SPAN2. Each of the coefficients on the three effective channel capacity variables is positive and statistically significant. The effect of effective channel capacity is expressed in the form of an estimated

[15]See footnote 12.

marginal probability (given in the last column of Table 3) associated with each of the three types of systems. The interpretation of these marginal probabilities is that each extra channel of effective capacity raises the probability that a cable system will carry C-SPAN2 by that amount or, alternatively, each channel lost to digital must carry reduces the probability that a cable system will carry C-SPAN2 by that amount. For example, each channel lost to digital must carry reduces the probability of C-SPAN2 carriage by 0.01177 for systems with 26-50 channels of effective capacity.

To make concrete predictions regarding the possible effects of the Commission's proposed rule changes, the reduction in marginal probability must be multiplied by the total number of systems to derive the expected number of systems which will drop C-SPAN. To translate this into a number of subscribers, the average number of subscribers for each type of system is multiplied by the expected number of affected systems. Table 4 displays the calculation of the total number of subscribers affected.

Table 4 - Calculation of Total Number of C-SPAN2 Subscribers Affected for Each Channel Lost to Digital Must Carry

System Capacity (Effective Channels)	Reduction in Probability	Total Number of Systems	Expected Number of Affected Systems	Average Subscribers	Expected Number of Affected Subscribers
0-25	1.698%	411	7	4,852	33,855
26-50	1.140%	3,147	36	10,623	381,020
51+	1.038%	922	10	26,057	249,425
			53		**664,300**

For example, based on the total universe of 4,480 systems in the C-SPAN2 analysis, there are 411 systems with 0-25 channels of effective capacity. For these systems, the estimated reduction in probability of 0.016976 indicates that for each channel lost to digital must carry, the percentage of systems which carry C-SPAN2 will be reduced by 1.6976%, or roughly 7 cable systems. The average

cable system in our sample with 0-25 channels of effective capacity has 4,852 subscribers, and thus each channel lost to digital must carry would reduce the number of subscribers who can view C-SPAN2 by 33,855. Similar calculations for systems with 26-50 and greater than 51 channels of effective capacity yield expected subscriber losses of 381,020 and 249,425 respectively. Thus, each channel lost to digital must carry would reduce the number of subscribers who can view C-SPAN2 by a total of 664,300.

VI. Partial Carriage

One further potential effect arising out of a digital must carry obligation relates to *partial carriage*. Rather than simply carrying or not carrying C-SPAN and C-SPAN2, some cable operators have elected to change to partial carriage, in which C-SPAN or C-SPAN2 is carried for portions of the day while another channel is carried for the remainder of the day.[16] Another possible effect of a proposed digital must carry rule is that cable operators, faced with a reduction in effective channel capacity, might elect to change from full carriage to partial carriage of C-SPAN or C-SPAN2. Indeed, after the implementation of must carry rules after the 1992 Cable Act, there were significant increases in partial carriage for both C-SPAN and C-SPAN2.

Although in principle the decision to move from full carriage to partial carriage can be modeled using a binary choice model in the same way as the decision to move from full carriage to no carriage is modeled above, the highly unbalanced nature of the data make this estimation infeasible.[17] Out of the total of 7,191 cable systems in the final dataset, only 50 currently carry C-SPAN

[16]The sharing of C-SPAN and C-SPAN2 on one channel is not permitted under C-SPAN's carriage policies.

[17]All three options (full carriage, partial carriage, and no carriage) could also in principle be modeled simultaneously via an ordered multinomial logit model, but the unbalanced nature of the data make this option infeasible as well.

partially and only 51 carry C-SPAN2 partially. The small numbers of total partial carriage should not, however, be interpreted to mean that this is not an important phenomenon. Indeed, the increases in partial carriage after the 1992 Cable Act are on par with the increases in the number of systems which dropped the C-SPAN networks. After the 1992 Cable Act, 51 cable systems representing 2,337,400 subscribers cut C-SPAN to partial carriage, while 42 systems dropped C-SPAN entirely. Also, 25 systems representing 1,635,300 subscribers cut C-SPAN2 to partial carriage, while 32 systems dropped C-SPAN2 entirely.[18] Given this previous experience, it is not unreasonable to expect that the number of systems and therefore subscribers potentially affected by a change to partial carriage of C-SPAN and C-SPAN2 will be roughly equal to the numbers affected by a decision to drop C-SPAN or C-SPAN2.

Although a formal econometric model cannot be estimated, Table 5 below clearly demonstrates that the incidence of partial carriage is inversely related to effective channel capacity, for both C-SPAN and C-SPAN2. Thus, the effects of the potential movement to partial carriage must also be taken into consideration by the Commission when considering whether to promulgate a digital must carry rule.

[18] These numbers include drops and cutbacks to partial carriage due to the must carry and retransmission consent provisions o the 1992 Cable Act.

Table 5 - Partial Carriage by Channel Capacity											
	Effective Channel Capacity										
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	100+
C-SPAN:											
Full Carriage	26	127	1336	1221	802	556	199	117	7	8	30
Partial Carriage	0	2	17	23	4	2	0	3	0	0	0
No Carriage	167	418	1189	660	149	104	11	7	2	1	3
C-SPAN2:											
Full Carriage	1	19	226	253	361	291	117	68	6	7	23
Partial Carriage	0	1	5	14	17	3	8	2	0	0	0
No Carriage	192	527	2311	1637	577	368	85	57	3	2	10

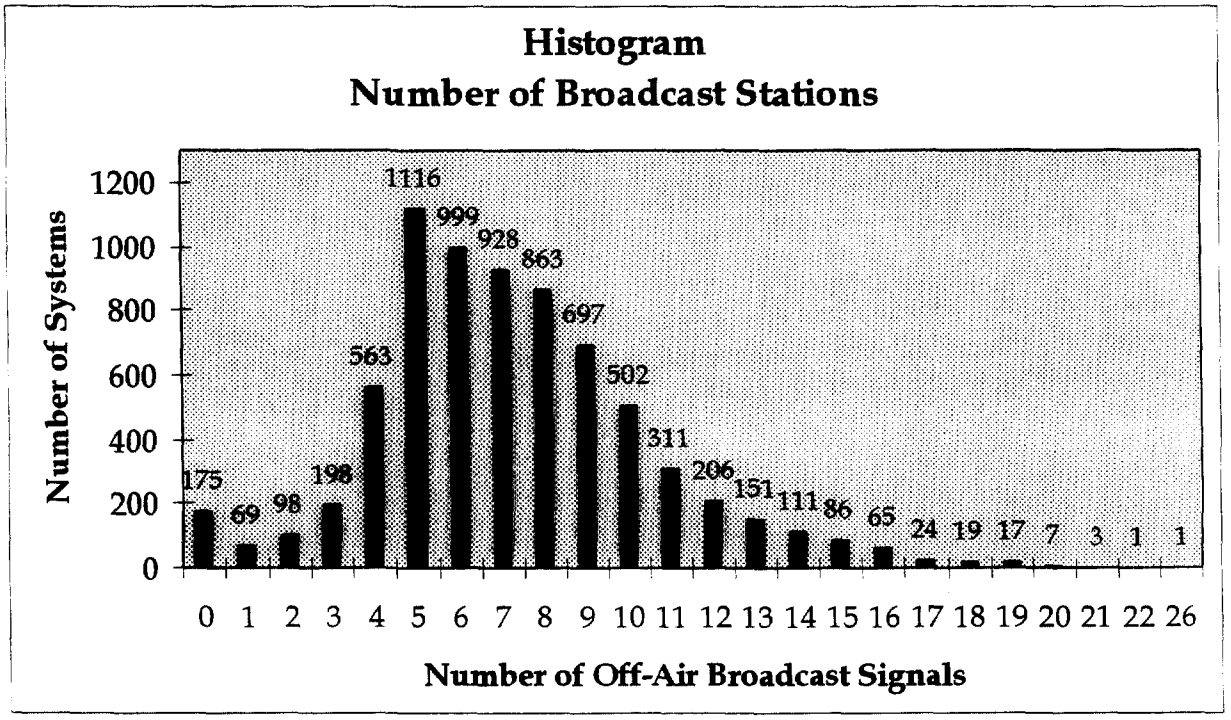
VII. Number of Broadcast Stations

A logical question arises as to the number of channels which will actually be lost to a digital must carry obligation. The answer will depend on the final form of the Commission's proposed rules, the timetable for implementing them, and the interplay of the rules with cable system channel capacity and the so-called "one-third cap."

However, inferences can be drawn based on the number of broadcast stations currently carried at each cable system. Since each broadcaster will eventually be required to broadcast a digital counterpart, each cable operator will be required to double the number of broadcast signals carried under a "full" digital must carry obligation during the transition period. Under this scenario, the number of channels lost to digital must carry would equal the number of broadcast signals currently carried.

The chart below represents a histogram of the number of off-air broadcast signals for each of the cable systems used in this analysis. As the chart shows, the number of broadcast stations is quite substantial. The average number of

broadcast stations is 7.27, and almost 70% of the systems used in the final analyses carry six or more broadcast signals. Almost 14% carry greater than ten broadcast signals.



VIII. Conclusion

The Commission has invited comments on the likely effects of proposed changes in its must carry rules during the so-called "transition period" to a comprehensive digital broadcast standard. This analysis constructs a probability model of cable operators' decision whether or not to carry C-SPAN and C-SPAN2. The channel lineups of each cable system reflect the implicit tradeoff between the desire to carry a particular network and limited channel capacity. The model presented here isolates the marginal effect of channel capacity on the cable operators' decision. The model predicts that for each channel lost to digital must carry, C-SPAN will be dropped at approximately 60 U.S. cable systems, reducing C-SPAN viewership by 240,161 viewers. For C-SPAN2, the model

predicts that for each reduction in channel capacity, 53 cable systems will eliminate C-SPAN2 carriage, reducing its audience by 664,300 viewers. The distribution of off-air broadcast signals at the cable systems used in this analysis indicates that a future digital must carry obligation would entail substantial reductions in channel capacity at many systems. In addition, there is strong evidence that reductions in effective channel capacity will increase the incidence of partial carriage of both networks by the same order of magnitude as the incidence of termination of carriage of the two networks. Table 6 summarizes the numerical results of this analysis.

Table 6 - Likely Effects of Proposed Must Carry Rules on C-SPAN Networks

Number of Channels Lost to Digital Must Carry	Effect on C-SPAN		Effect on C-SPAN2[19]	
	Systems	Subscribers	Systems	Subscribers
1	60	240,161	53	664,300
2	120	480,322	106	1,328,600
3	180	720,483	159	1,992,900
4	240	960,644	212	2,657,200
5	300	1,200,805	265	3,321,500
6	360	1,440,966	318	3,985,800
7	420	1,681,127	371	4,650,100
8	480	1,921,288	424	5,314,400
9	540	2,161,449	477	5,978,700
10	600	2,401,610	530	6,643,000

[19]Fewer systems are affected for C-SPAN2 than for C-SPAN, but the C-SPAN2 systems have more subscribers, on average (See Tables 2 and 4).

Appendix A - Detailed Background on Probability Models[20]

Assume that a binary decision variable Y_i consists of a systematic component, denoted by $E[Y_i]$[21], and a random component, denoted by the random error term u_i:

(1) $Y_i=E[Y_i] + u_i$

The systematic component $E[Y_i]$ is in turn assumed to be a function of the exogenous variables X_i via a set of regression coefficients β:

(2) $Y_i=X_i'\beta+u_i$

This allows the *probability* that $Y_i=1$ (rather than Y_i itself) to be related to a set of explanatory factors which reflect both information about the two alternatives as well as characteristics about the individual decision maker. For example, the analysis might find that commuters with higher annual income are less likely to use public transportation, but the farther commuters live from work, the more likely they are to choose public transportation.

However, the simple least squares model which relates the dependent variable Y_i to the explanatory variables X_i in a linear fashion (as in equation (2) above) is inappropriate in this context for several reasons, the foremost of which

[20]See William H. Greene, *Econometric Analysis, Second Edition*, New York: Macmillan, 1993, William E. Griffiths, R. Carter Hill, and George G. Judge, *Learning and Practicing Econometrics*, New York: John Wiley and Sons, 1993, Jack Johnston and John DiNardo, *Econometric Methods, Fourth Edition*, New York: McGraw-Hill, 1997, and G.S. Maddala, Introduction to Econometrics, Second Edition, Englewood Cliffs: Prentice Hall, 1992 for detailed discussions of probability models and discrete choice models in particular.

[21]The $E[\cdot]$ notation denotes the mathematical expectation.

is that the predicted probabilities Y_i generated by the estimated model are not guaranteed to lie between 0 and 1.[22]

The solution to the problems raised by the linear approach is to model the relationship between the decision variable Y_i and the explanatory factors X_i through a "latent" variable. The latent variable model assumes that there is an underlying unobservable variable Y^* which is continuous, and measures the net benefit to the agent from choosing a particular alternative:[23]

(3) $Y^*_i = X_i'\beta + u_i$

In the transportation example cited above, Y^*_i would represent the perceived net benefit for commuter i from choosing public transportation. In this analysis, Y^*_i represents the net benefit to cable operator i from choosing to carry C-SPAN.

The decision variable Y_i is in turn related to the latent variable Y^*_i via the following rule:

(4) $Y_i = 1$ if $Y^*_i > 0$

$Y_i = 0$ otherwise

The natural question then arises, what is the probability that $Y_i=1$? Based on equations (3) and (4) above, and denoting P_i = probability$\{Y_i=1\}$,

P_i = probability$\{Y^*_i > 0\}$

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[22]The model estimated in this fashion is known as the linear probability (LP) model. The other major drawback to the LP model is that it is heteroskedastic by construction. For detailed discussions of the LP model, see the references listed in footnote 19.

[23]In the economic literature, this benefit is often referred to as *utility*, and such models are referred to as *net utility* models. See William E. Griffiths, R. Carter Hill, and George G. Judge, *Learning and Practicing Econometrics*, New York: John Wiley and Sons, 1993, Ch. 23 (Appendix) for a survey.

$= \text{probability}\{u_i > -X_i'\beta\}$

$= F(X_i'\beta)$[24]

where $F(\cdot)$ is the cumulative distribution function of the random disturbance u_i. Thus, the relationship between the choice variable Y_i and the explanatory variables X_i can now be expressed as follows:

(5) $P_i = \text{probability}\{Y_i=1\} = F(X_i'\beta)$

The formulation expressed in equation (5) has several desirable properties. First, since $F(\cdot)$ must satisfy the rules for all probability distribution functions, the predictions Y_i based on it are guaranteed to lie between 0 and 1.

Although in theory any proper distribution function $F(\cdot)$ can be used to estimate the regression coefficients β, the two which have been utilized in practice are the *normal* and the *logistic* distributions, which in turn give rise to the probit and logit models, respectively:

(6) Probit (Normal Distribution): $$P_i = \int_{-\infty} \frac{1}{\sqrt{2\pi}} \cdot e^{-z^2/2} \cdot dz$$

(7) Logit (Logistic Distribution): $$P_i = \frac{1}{1+e^{X_i'\beta}}$$

The popularity of the probit model is in large part due to the popularity of the normal distribution itself. The logit produces results which are almost always virtually identical to the probit,[25] but is analytically and computationally

[24]The last equality relies on the assumption that the probability density function of the random disturbance u_i is symmetric about 0.

[25]The only significant difference between the two distributions is that the logit distribution has slightly fatter tails than the normal. Thus the only models likely to yield different results between the two methods are those with a wide dispersion in explanatory variables.